ITS Logical Architecture -Volume I

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EDL# 5402 – “National ITS Architecture Documents: Implementation Strategy; U.S. Department of Transportation”

EDL# 5403 - "National ITS Architecture Documents: Standards Requirements; U.S. Department of Transportation"

EDL# 5404 – “National ITS Architecture Documents: Standards Development Plan; U.S. Department of Transportation”

EDL# 11863 - "National ITS Architecture Documents: Market Packages - A Tool for Viewing, Accessing and Utilizing the National ITS Architecture; U.S. Department of Transportation".

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1.1. Introduction

The Logical Architecture is based on a high level Computer Aided Systems Engineering (CASE) model of the functional requirements for the flow of data and control through the Intelligent Transportation System (ITS). Structured Data Flow Diagrams and Specifications are presented in this section to illustrate the decomposition of the Department of Transportation User Services Requirements (see reference 1.1.9.1) as well as specific strategic requirements to processes and information flow. The Logical Architecture CASE model further depicts the input (source) terminators and output (sink) terminators of the entire ITS and defines the information flow into and out of the system. It is the formal representation of the ITS operational concept described in the Theory of Operations Document - see reference 1.1.9.2.

The Logical Architecture is first illustrated as a single function to show the external inputs (sources) and outputs (sinks) by the System Context Diagram. This is then decomposed in the highest level of Data Flow Diagram (DFD) to show the highest level process bubbles in the ITS. These bubbles are then further decomposed into lower levels. At the lowest level of this decomposition are the actual Process Specifications (P-Specs).

For each P-Spec a structured English specification is composed which defines how the P-Spec output data flows are constructed from its input data flows. It is the P-Specs that represent the sources (and sinks) of data flows inside the ITS. Technically, a “data store” can also source and sink flows, however all stores in the Architecture are tightly coupled to a “store controlling” process, which can be considered logically to be the source and sink for data to/from the store.

The Logical Architecture is at the same time being mapped into a Physical Architecture which assigns the logical processes to physical subsystems and service packages. This mapping is documented in the Physical Architecture Document - see reference 1.1.9.7.

1.1.1. Architecture Strategies and Principles

The following are the strategies and principles that the Architecture Development Team has followed in developing its ITS Logical and Physical Architecture so as best to achieve the goals of ITS and the User Service Requirements.

1. Permit a low entry cost.
2. Provide choices in price/performance for travelers to receive user services.
3. Protect traveler privacy.
4. Accommodate increasing levels of system integration.
5. Assure equity.
6. Promote detailed, open standardization to maximize interoperability and reduce market risk.
7. Leverage the existing and emerging open infrastructures.
8. Facilitate profitability for private industry to speed early deployment.
9. Maintain an open architecture, unbiased towards any particular products.
10. Avoid new public agency liabilities.

11. Encourage public-private infrastructure cooperation.

12. Enhance traveler safety.

13. Provide locally determined demand management capabilities for congestion and pollution management.

A summary of the strategies and principles is given below.

1. Permit a low entry cost.

   The architecture provides immediate service to all users, regardless of the degree of special instrumentation available to them. It does so by using all the information available from all terminators in order to devise the management strategy, and then disseminate the necessary information to the users through the information channels available to them. The fact that users having access to advanced channels can receive improved service will provide incentives for deployment of ITS instrumentation, but will not totally deny service to those users who do not own such channels. Reduced service will be provided to the latter users through publicly available channels such as DMS, RDS, HAR and conventional media.

   The Joint Development Team is concerned that ITS benefits should be available to large numbers of commercial and private travelers at no cost or a small cost. Some examples of how we have designed this into the architecture are:

   a. CVO with an ID tag. The architecture allows a commercial vehicle to have only an inexpensive electronic ID-tag in order to participate in the basic electronic clearance at roadside stations.

   b. Low/no cost traveler information services.

      Travelers will benefit from better regional travel information broadcast by commercial AM/FM/Cable operators if these operators use the travel information that is available from local traffic management centers and information service providers via ITS media interfaces.

   c. Toll-tag services. The ITS architecture supports the current deployment of toll-tags.

2. Provide choices in price/performance for travelers to receive user services.

   The ITS architecture provides not just a single implementation of each user service, but in many cases supports a multiplicity of implementations with varying performance and associated costs to the user.

   For example, in the area of route guidance, the architecture supports three distinct modes of operation:

   a. Traveler-based route selection, where all route selection processing equipment as well as the navigable database that route selection is based on is included in equipment located with the traveler (either in their vehicle or in their portable computer). This approach provides a high degree of autonomy in both equipment usage and design.

   b. Traveler-based route selection coupled to infrastructure-based and provided link/queue-times. In this method, the traveler-based route selection system is augmented by data from the infrastructure about current and possibly estimated future (predicted) link transit times and intersection queue delays. Using this type of data, the traveler will be able to use his equipment to compute better routes since his static navigable road database will be augmented with dynamic information about current and predicted congestion conditions.

c. In-vehicle route guidance coupled to infrastructure based route processing. In this approach the infrastructure (i.e., an ISP) processes the route based upon the traveler route request. The mobile equipment is simplified since it no longer requires a navigable map database, or the processing power to calculate a best route (only the processing power to display the route guidance).

3. Protect traveler privacy.

   In the area of privacy the ITS Architecture takes into account that travelers have many distinct needs and preferences with respect to privacy and the architecture provides the capability for these needs to be met:

   a. Traveler Choice. The route selection choices above offer a spectrum of options with respect to privacy for the traveler using ITS. The traveler can select routes totally independently of any infrastructure based entity, or they can choose a higher level of service that requires allowing the infrastructure to provide personalized service which requires sending personalized messages to their specific mobile equipment. An ISP has the option to provide "cash" based accounts for travelers that wish to be completely anonymous, even with infrastructure based service.

   b. Architectural Privacy in the Private Domain. The ITS Architecture specifies that when personal or confidential data needs to be stored in the infrastructure (to provide a selected user service), it is stored at an ISP. By limiting personal or confidential information to the records of an ISP, which can be a privately held organization, this information is protected from access by federal or state Freedom of Information Act (FOIA) inquiries.

   c. Architectural Information Security. The ITS Architecture allows state-of-the-art processes for message exchange using public key encryption and authentication, assuring that personal or confidential information is protected from unauthorized access.

4. Accommodate increasing levels of system integration.

   The ITS Architecture is designed not only to support the introduction of new technologies, but has been designed to incorporate advances in technology to provide higher levels of system integration and performance. Advanced concepts such as Dynamic Traffic Assignment can be supported by the architecture. Through the coupling of Traffic Control and infrastructure based Route Selection the architecture can, when the technology permits, approach optimum performance.

   By clearly separating the ITS application layer (i.e., the Transportation Layer) and the more commodity communication layer, the ITS Architecture can rapidly incorporate the frequent advances in communications and computing technology.

5. Assure equity.

   Providing an equitable division of benefits and costs is a key design strategy for the ITS Joint Development Team. By splitting the key ITS infrastructure elements between private and public entities, the ITS Architecture is able to assure equity in expenditures/payments. Public funds are used by public agencies to benefit all travelers equally, and private funds (and fees) are used to supply additional "value add" services to those individuals willing to pay for those services.

6. Promote detailed, open standardization to maximize interoperability and reduce market risk.

   One of the most important requirements of the ITS architecture is interoperability -- the ability for the user to obtain user services nationwide with a single set of equipment. To do this the architecture effort must choose limited areas of detailed national standardization to maximize interoperability and market breadth for travelers and manufacturers.

Certain areas of the architecture should be the focus of only limited standardization where possible to protect existing investments and to allow market forces to come into play.

The issue of existing investments is particularly important with regard to current public infrastructure investment for TMS (Traffic Management Subsystem) to roadside communications and for TMS and roadside equipment. We have designed the architecture's roadside and TMS subsystems so that current equipment can coexist with most features of the architecture. We have also designed the architecture so that messages from one subsystem to another are not dependent on the particular path that they take, media or protocols.

In the area of market forces, some portions of ITS are already being deployed and in some of these areas we believe it is most appropriate to let the market forces drive the standards. Dedicated Short Range Communications (DSRC) interfaces are currently hotly contested in the marketplace. (E.g., in the area of toll/id tags, there are competing "standards" from the American Trucking Association (ATA), International Standards Organization (ISO), and California Title 21.) We believe that the market and the participants in these markets will determine the applicable communication standards.

7. Leverage the existing and emerging open infrastructures.

   Communications is key to providing ITS user services to a wide range of users. The ITS Architecture employs a strategy to maximize use of the existing (and planned future) communications infrastructure. This approach has the following benefits:

   a. Minimized capital investment. A national communications infrastructure to support ITS would be costly to deploy if it were only to be used for ITS. The capital formation necessary for this hypothetical ITS only infrastructure could substantially limit or slow the deployment of ITS.

   b. Expedited deployment. The ITS Architecture makes use of existing, operational, commercially available wired and wireless data communications services. This does not preclude the continued use of dedicated services where they make sense, such as some public safety, transit, and regional trucking/dispatch services.

   c. Elimination of dependence on new spectrum allocations. New spectrum requirements dependent on FCC approval could delay and add considerable risk to the ITS evolutionary deployment.

8. Facilitate profitability for private industry to accelerate early deployment.

   New travel information technologies will require capital investments to deploy. The private sector is best prepared to rapidly form capital and efficiently deploy advanced technologies where a profit model can be identified.

   The Information Service Provider (ISP) concept in the ITS Architecture allows for a multiplicity of vendors (public or private) to compete for the traveler's business. Travelers will benefit from a competitive environment of many ISPs that will supply choices of service levels, privacy levels, and cost levels.

   a. Enable opportunities for advertising. In addition to ITS services for sale, any ISP will be able to use the ITS Architecture to communicate advertising to their traveling customers. The purpose of this feature is to enable an additional revenue stream to an ISP to subsidize the cost of providing infrastructure based traveler services. The amount that travelers will be willing to pay for ITS services is still unknown. By subsidizing the cost of the services with advertising, the number of travelers who will have access to personalized ITS services will increase.

   b. Combine with the sale of other services. Cellular data services are anticipated to be used for supplying a range of information services to mobile users (e.g., e-mail, news services). By

combining ITS services and these other commercially viable services, the ITS user community is broadened. The revenue to an ISP providing other services will subsidize the cost of supplying ITS services.

9. Maintain an open architecture, unbiased towards any particular products.

   Use of open standards is a priority of the architecture. All subsystems in the architecture will support a range of existing or anticipated product offerings from an unlimited range of hardware or service providers.

   Exceptions to this approach were made in the case of DSRC where the markets are currently dominated by a small number of offerings which use proprietary communication interface standards. The Architecture encourages this community to eventually migrate to open standards to the mutual benefit of all participants.

10. Avoid new public agency liabilities.

    Liability is managed differently by public and private entities. Private entities have several alternative mechanisms for managing liability (e.g., insurance, legal disclaimers of liability) that are not available or as readily available to public agencies. As a result, public agency officials (e.g., at a TMS) may be reluctant to take on new liability associated services, especially pertaining to vehicle control. Alternative provision of user services by an ISP is an architectural feature arising from this strategy.

    One of the areas of public liability that is under study is in the Automated Highway System (AHS) services. The level of infrastructure involvement, and the liabilities associated with this are currently under study in other FHWA efforts. In the current architecture we have chosen to implement a form of AHS which minimizes (but does not preclude) the infrastructure component. This is consistent with the view of AHS as an evolution from the Advanced Vehicle Safety User Services. In this way, new safety liabilities continue to reside primarily with private companies (that manufacture the equipment or offer the services) that are best prepared to manage the new liabilities.

11. Encourage public-private infrastructure cooperation.

    By carefully allocating processes to public and potentially private subsystems, the ITS Architecture has been designed to encourage mutually beneficial cooperation between public and private institutions through exchange of surveillance and predictive model data.

    Examples of this are:

    a. TMSs providing surveillance data to ISPs which will allow the ISPs to compute better routes for their clients.

    b. The ISPs providing (anonymous) probe data to the TMSs so that their surveillance of non-instrumented roadways is enhanced and thus their ability to manage traffic for all travelers is enhanced.

    c. Similarly, TMSs can access traffic data stored at neighboring TMSs over the data network.

12. Enhance traveler safety.

    The ITS Joint Development Team believes that enhancing traveler safety is a key requirement for the architecture. There are many ways in which the ITS Architecture will enhance safety. Some of these are:

a. Reduce emergency response time. Early safety analysis leads us to believe that any reduction in time between the occurrence of an injury accident and the arrival of medical help has a substantial impact on survivability. In the high-end state architecture, the routes of emergency vehicles will be selected by the infrastructure, and those routes will be communicated to the TMS Traffic Management service package for priority signal service for the emergency vehicles (with minimal disruption to the rest of the transportation network). In addition, rapid data based deployment of emergency response vehicles via the Emergency Management Subsystem will provide help to incidents faster, and will enhance traveler safety as a direct consequence.

b. Augment 9-1-1. The Joint Development Team has developed an interface between the Emergency Management Subsystem (EM) function and the existing 9-1-1 services. This will enable rapid coordination between existing telecommunication public safety interfaces, emergency fleet management, and traffic control.

c. Reduce congestion. By using available and future demand management tools that the architecture makes available to local public agencies, congestion can be reduced and controlled, thus reducing the number of transitions from free-flow to stop-and-go traffic conditions. These transitions have been identified in our preliminary safety analysis as a cause of traffic accidents as well as a source of excess pollution.

d. Fail-safe infrastructure architecture. The ITS Architecture has not allocated any new life threatening functions to the infrastructure. Vehicle control (for collision avoidance) remains primarily within the vehicle subsystem (and in the case of platoon operation and AHS related functions, is based on communication directly between adjacent vehicles). In the event of a total infrastructure failure, signals would fall back to local sensor based signal control or fixed time plans, exactly as they do today. Only in the case of intersection collision avoidance are safety critical surveillance processes allocated to the infrastructure.

13. Provide locally determined demand management capabilities

For ITS to be desirable in some areas and in some time frames it must be able to address demand management (in addition to supply management). The architecture gives local agencies (and ultimately elected officials) enormous latitude to decide how limited transportation resources are to be allocated.

The Joint Development Team has designed the architecture so that any particular form of demand management is optional, and a local decision is required to deploy.

a. Congestion Pricing. The ITS Architecture can support DSRC based pricing on any link in the transportation infrastructure. The architecture can support the long term predictive models upon which congestion pricing decisions can be made.

b. Vehicle Class Preferences. The ITS Architecture supports DSRCs associated with vehicle classes, and vehicle classes can be verified by roadside sensors. Thus roads can be restricted to specific classes of vehicles by time-of-day or day-of-week and lanes and signals can give preferential service to different classes of vehicles.

   This mechanism would allow the exclusion of classes of vehicles from links or areas (e.g., commercial or public-transport vehicle only areas or vice-verse). This is basically the same mechanism used at the ITS Architecture Roadside subsystem deployed for toll operation.

c. Extensions of Ramp Metering and Mainline Metering. Ramp metering and mainline metering, both supported in the ITS Architecture, have been shown to be effective methods for maintaining free flow of traffic on otherwise congested highways. The ITS Architecture can be used to

extend the "metering" paradigm to all links, and allow the route selection process to suggest alternate routes or trip start times.

1.1.2. Methodology

1.1.2.1. Representation of Functionality

The ITS Joint Development Team has chosen to use a Structured Analysis methodology to develop the ITS Architecture. The approach was originally set forth by Tom DeMarco and later enhanced to include real-time extensions by a host of other authors. The main source of methodology for the Team's work on the Architecture has been based on the work of Hatley/Pirbhai in logical and physical architecture analysis - see reference 1.1.9.5. Every attempt has been made (within the constraints of the CASE tool) to utilize the methodology as stated.

The Hatley/Pirbhai method of logical architecture analysis uses Data Flow Diagrams (DFDs) to show the flow of data between the functional elements the make up the architecture. These functional elements are of three types, Terminators, Process Specifications (P-Specs) and Stores. Terminators provide the sources and sinks for external information that flows to and from the Architecture. Terminators appear on the top level Context Diagram and also on DFD 0. Placement of Terminators on DFD 0 is a departure from the Hatley-Pirbhai methodology but the Team feels it enhances the reader's ability to understand the relationships among the top level processes and the external world. Stores are internal place holders for data and may appear on any DFD.

The P-Specs are provided as structured English descriptions that use "will" statements to describe the way in which they transform input information into desired outputs. In this Architecture the P-Specs have also been "starved", that is, their input and output data flows represent all those to/from that process. There are no spurious or missing flows. This is essential to the goal of an open architecture: that modules designed and produced by different manufacturers will interoperate and interface seamlessly.

On a DFD, anything other than a store or data flow is shown as a circular object or bubble. A bubble may be a P-Spec or may further decompose into a lower level DFD. These bubbles are so identified by the notation "(dfd)" inside the bubble after the title. If no "(dfd)" is present in a bubble then that bubble is a P-Spec.

1.1.2.2. Configuration Control

Strict configuration control throughout the Architecture development process and beyond is an absolute requirement of the Joint Development Team. This long term strategy is essential to ensure that the Architecture implementation and deployment will be open and support seamless integration and interoperability across geography, and that systems deployed by different manufacturers using parts of this documentation as a design guide will interface and work together as intended. This requirement dictates that the Data Flow Diagrams (DFDs) and Data Dictionary Entries (DDEs) shown in this document be automatically accessible to the Team's publishing system directly from the CASE database. In this way, as changes are made to the Architecture model, they can be applied to a new version of the architecture database, the checking tools available in the CASE tool can be applied to assure consistency, and quality documentation can be accurately generated.

1.1.3. Document Organization

This document is organized to conform to the guidelines provide by the Department of Transportation. To manage the shear bulk of the document, it has been divided into three volumes. This document,

Volume I, completely describes the Logical Architecture through Data Flow Diagrams and narrative overviews of each process (DFD and P-Specs). Volume I also includes several appendices: Appendix A, a List of Acronyms, Appendix B, a hierarchical listing of DFDs and process specifications, and Appendix C, a hierarchical listing of all the data flows and their components. The other two volumes are intended as references for technical users of the Architecture. Volume II of the Logical Architecture provides a complete printed set of the Teamwork Structured Analysis model P-Specs while Volume III provides the complete Data Dictionary model. The Reference Volumes provide primarily technical details not necessary for a general understanding of the Architecture.

1.1.3.1. Description of this Volume

Section 1.1 is an introduction and contains background information that is intended to allow the reader to understand the Architecture in its context. This includes a discussion of strategic principles and of methodologies.

Section 1.1.1 addresses strategy.

Section 1.1.2 addresses the methodology that has been refined from Phase 1 to automate the design of a combined Logical and Physical Architecture, as well as automating most of the related architecture data loading analysis.

Section 1.1.3 discusses the organization of the Logical Architecture document.

Section 1.1.4 describes the convention followed in defining the names of the data flows appearing on the Context Diagram and all DFDs.

Section 1.1.5 describes the way in which size, frequency, and scale attributes have been assigned to both P-Specs and Data Flows. These are illustrated by examples of both a P-Spec and a Data Dictionary Entry data flow taken from the Teamwork model.

Section 1.1.6 discusses the way in which the CASE, spreadsheet, publishing, and e-mail tools used by the Team have been integrated.

Section 1.1.7 discusses the concept of abstract flows and the way in which they have been used within the Architecture.

Section 1.1.8 provides a roadmap to finding information on the components of the Logical Architecture, indicating where to go in the various architecture documents for the information.

Section 1.1.9 contains a list of references used in this Document.

Section 1.2 contains the Context Diagram and its description.

Section 1.3 contains a table describing the function and purpose of each of the Terminators found in the Context Diagram.

Section 1.4 contains all the DFDs in the ITS Architecture. Narrative descriptions of their content and purpose are found later in Section 1.5.1. Note that the lowest level DFDs are each described by a P-Spec. These descriptions can also be found later in Section 1.5.2.

Section 1.5 presents the rationale for data-driven control and, following the guidelines of Hatley-Pirbhai, why explicit control flows do not appear in this architectural model.

Section 1.6 provides narrative descriptions of each of the DFDs (1.6.1), including overviews of each P-Spec.

1.1.3.2. Description of Volume II and Volume III

These two parts of the Logical Architecture document are basic reference volumes. The Logical Architecture Reference Volumes contain detailed reference material from the Teamwork CASE model.

Volume II: Process Specifications provides the actual P-Specs for each lowest level specification. Contained in each P-Spec are the inputs, body (functional requirements) and the output. An example P-Spec is shown in section 1.1.5 of this volume.

Volume III: Data Dictionary is the complete Logical Architecture Data Dictionary. It contains the definitions of all the data flows developed in the structured decomposition process. Each data flow is hierarchically composed of other data flows and/or primitive data flows (primitive data flows may not be decomposed further). Another form of the Data dictionary is appended to this document (Appendix C). It provides only DDE names (no description or sizing assumptions) but it is organized to show each and every component and sub-component of each DDE. It provides a "rabbit trail" for tracing high level flows down to their most primitive elements, a task that is tedious at best in the normal Data Dictionary format.

The data flow sizes and frequencies between P-Specs, terminators (and stores) are parametrically defined in the P-Specs and in the Data Dictionary. The CASE model thus includes "extensions" that describe physical attributes of the data flows, which when combined with various parametric assumptions about the environment in which ITS will be used, allows quantitative estimation of message sizes (in 8-bit bytes) and frequencies (in messages/second).

Since a key requirement of the decomposition is to allocate the User Service Requirements to the Architecture, we have also mapped the user requirements to the Logical Architecture Process(es) which satisfy each requirement. This is found in the ITS Architecture Traceability Document - see reference 1.1.9.4.

1.1.4. Data Flow Naming Convention

So as to easily identify the many data flows with terminations external to the ITS, i.e., those flows that originate or terminate on the System Context Diagram, the Team has adopted the following convention when naming these messages:

To_TerminatorName and From_TerminatorName - this is the convention that has been adopted for data that flows towards and from a terminator.

Because the messages flowing to and from terminators on the System Context Diagram are generally compound messages that will split into data flows at lower levels, the following additional convention has been adopted for the immediate constituents of these messages:

txx-data_name and fxx-data_name - this is the convention for data flows that are elements of messages that flow to and from a terminator. The data_name text string is a free form expression to describe the particular data flow. Teamwork does not allow spaces but the underscore character may be used to improve readability.

Note that these data flows always begin with a lowercase "t" or "f", and that "xx" consists of one or more letters that indicate a unique abbreviation for the terminator name. The actual selection of names can be seen in the DDE for any individual terminator message. For example, the entry from the Data Dictionary in Figure 1 demonstrates both of the aforementioned naming conventions. Note that each of the components of From_Travelers may be decomposed further through entries in the data dictionary.

Figure 1. Example Data Dictionary Entry for Data to/from Terminators

```
From_Traveler (data flow) =
        ft-extra_trip_data
        + ft-guidance_data
        + ft-guidance_map_update_request
        + ft-guidance_request
        + ft-guidance_route_accepted
        + ft-remote_emergency_request
        + ft-personal_emergency_request
        + ft-personal_extra_trip_data
        + ft-personal_map_display_update_request
        + ft-personal_trip_planning_requests
        + ft-trip_planning_requests
```

When consulting the Traceability Document, the reader should be aware that the Teamwork hyphen character "-" has been replaced with the underscore "_" to avoid conflicts in the Excel analysis models used for data loading estimates. This substitution is also apparent in the Data Dictionary and P-Spec descriptions found in Volumes II and III of this document. The reader should assume that *data_flow_name* is identical to *fx_data_flow_name* throughout the documentation.

1.1.5. Assignment of Size, Frequency, and Scale Attributes

In order to support the data loading analysis, a method was developed to identify a size and frequency for each data message in the architecture. This has been implemented by adding attributes to the P-Specs and to the DDEs that either identify a size or frequency with each flow. An example of the P-Spec content and format within Teamwork is illustrated below. All of the P-Specs from Teamwork are presented in Volume II of this document in a more readable format, but contain the same information.

Estimated frequency attributes are documented within the P-Specs as it is the process itself that controls the rate at which data will be produced. An example of a typical P-Spec is shown in Figure 2 on the next page. The data flows into and out of the P-Spec are listed first in the INPUT/OUTPUT section. They are followed by the data transformation process, which is described in "will" language. This is used to reflect firm requirements and is itemized to aid testability. The User Service requirements served by the P-Spec are then listed to justify its existence and are used to construct the tables in the Traceability Matrix Document - see reference 1.1.9.4.

The Dynamic Attributes expressions that follow apply to all "data_out" types that are listed in the Input Flows/Output Flows section. They are used to estimate data loading and to identify potential performance issues. Most of these expressions are dependent on external (to the CASE model) variables or other CASE model flows (e.g., P-Spec inputs). External variables are represented by a set of defined Parameters. Other flows are referenced by their CASE model flow name.

Figure 2. Example Teamwork P-Spec

```
NAME:
7.2.5

TITLE:
Detect Vehicle for Parking Lot Payment

INPUT/OUTPUT:

vehicle_parking_lot_characteristic_data : data_out
From_Vehicle_Characteristics : data_in

BODY:
Overview: This process shall be responsible for producing a vehicle's characteristics from data
received by sensors located at or near the parking lot entry and exit lanes. The data shall be sent
by the process to another process in a form suitable for use in calculating the parking lot charge
for the vehicle. The process shall ensure that the data includes such things as vehicle size,
type, identifiable features , etc.

Data Flows: All input data flows are unsolicited and all output flows are solicited.

Functional Requirements: This process shall meet the following functional requirements:
(a) continuously monitor for receipt of the input flows listed above;
(b) when the inputs are received, generate the outputs identified above.
------------------------
REQUIREMENTS ATTRIBUTES:
USR = 3.0;
USR = 3.1;
USR = 3.1.3;
USR = 3.1.3.1;
USR = 3.1.3.3;

-------------------
DYNAMIC ATTRIBUTES:
vehicle_parking_lot_characteristic_data = 12/(60)*PARKING_LANES;
```

In the Data Dictionary, every data flow has a "SIZE" extended attribute. For primitive elements this represents the size of this specific data flow or data flow component. It may be expressed as a constant integer quantity (e.g., "SIZE = 6"), or as an expression involving external parameters (e.g., "SIZE + 6 {CVO_VEHS}").

Non-primitive elements (compound flows) are usually sized simply as the sum of their primitive constituents. In that case, the size expression will be "SIZE=0" and the actual size will be computed externally to the CASE model. Note that the "SIZE=0" statement does not mean the size is zero; it is used as a flag to the parsing program, telling it to use the formal definition above to compute the size. Not all non-primitive flow sizes can be computed from their formal definition and these will also have size expressions other than 0. When such a size expression exists within a DDE for a compound flow, it takes precedence over any other size computation based solely on its constituents. The typical Teamwork CASE model DDE below is an example of such a case. In Volume III of this document the entire Teamwork model Data Dictionary is provided in a more readable printed format.

Figure 3. Example Data Dictionary Entry with Sub Elements

```
crossing_data (data flow) =
* This data flow is used within the Manage Traffic function and contains data received from a
multi-modal crossing about when it is going to close and for how long. It consists of the
following data items each of which is defined in its own DDE:*

crossing_list
+ 1{crossing_close_time
   + crossing_close_duration}list_size.

--------
SIZING ATTRIBUTES

SIZE=crossing_list+CROSSINGS{crossing_close_time+crossing_close_duration};
```

Both size and frequency attributes can be expressed algebraically as functions of external "parameters", other flows, and assumptions. These expressions are evaluated (i.e., converted to numeric values) in the Data Loading Analysis process itself. A more complete discussion of this methodology is presented in the Communications Analysis document - see reference 1.1.9.3.

The variety of external assumption "parameters" that are used in the algebraic functions from which the data flow sizes and frequencies are determined is large. The current list of defined parameters is tabulated below. Parameters identified as type "D" (Dependent) are actually determined as a function of those identified as type "I" (Independent). This has been done in an attempt to keep the multitude of assumptions as "consistent" as possible by minimizing the number of independent assumptions. Values for independent parameters are estimated or assumed using statistical, demographic historical, etc. data. These parameters are estimated separately for the various scenarios (e.g., Urban 5 year, rural 20 year, etc.). This use of parameters within the CASE model allows the logical architecture to remain reasonably independent of the myriad external non-architectural assumptions and scenario dependencies.

Table 1. External Parameter Definitions

Name	Description	Basis	Type
ACT_ERMS_VEHS	The total number of emergency services vehicles that are active for any particular emergency call. This will be a proportion of the total number of emergency services vehicles (ERMS_VEHS). Note that it is assumed that they will all be capable of utilizing ITS functions.	= 0.1 * ERMS_VEHS	Dependent
ADJACENT_TMS	The average number of adjacent or cooperating Traffic management centers that a TMS within the ITS area under study will communicate with on a regular basis	Unsubstantiated assumption	Independent
AHS_MILES	The total number of ITS roadway miles being operated under some form of AHS system.	Unsubstantiated assumption	Independent
AHS_SAMPLE_RATE	An arbitrary sample rate constant used to facilitate data loading estimates for AHS operations.	= 1 / DAY	Dependent

Name	Description	Basis	Type
AHS_SEGMENT_LENGTH	The average length on an AHS segment.	Unsubstantiated assumption	Independent
AHS_TRIPS_per_DAY	The assumed average number of trips each AHS capable vehicle will make each day.	Unsubstantiated assumption	Independent
AHS_VEHS	The total number of vehicles that are utilizing AHS functions to obtain dynamic in-vehicle route guidance. Based on an assumed market penetration (MPAHS) and the general vehicle population.	= MPAHS * VEHS	Dependent
AIR_RATE	The proportion of ITS traveler interactions that involve AIR as an alternative transportation mode..	Unsubstantiated assumption	Independent
AUTOINFRA	The assumed which all ITS users prefer autonomous versus infrastructure based route guidance.	SWAG	Independent
AUTONOMOUS_TRAVS	The total number of travelers that are utilizing autonomous route guidance. Based on an assumed ratio (AUTOINFRA) and the number of guided travelers (ITS_GUIDED_TRAVS).	= AUTOINFRA * ITS_GUIDED_TRAVS	Dependent
BROADCAST_ITEMS	The number of broadcast data items typically contained in a specific ITS advisory broadcast.	Siemens estimate.	Independent
CAMERA_DENSITY	The ratio of intersections equipped with cameras to the total, (i.e. the percentage of intersections instrumented).		Independent
COM_VEHS	The total number of commercial vehicles operable within the ITS area under study.	Unsubstantiated assumption	Independent
CONTROLLERS_PER_HIGHWAY_CORRIDOR	The average number of traffic controllers per highway corridor within the jurisdiction being studied.	Unsubstantiated assumption	Independent
CONTROLLERS_PER_ROAD_CORRIDOR	The average number of traffic controllers per road corridor within the jurisdiction being studied.	Unsubstantiated assumption	Independent
CORRIDORS	The total number of traffic corridors.	= HIGHWAY_CORRIDORS + ROAD_CORRIDORS	Dependent
CROSSINGS	The total number of multimodal HIGHWAY_CROSSINGS and ROAD_CROSSINGS	= HIGHWAY_CROSSINGS + ROAD_CROSSINGS	Dependent
CVC_SAMPLE_RATE	An arbitrary sample rate constant used to facilitate data loading estimates for CVC operations.	= 1 / DAY	Dependent
CVI_RATE	The rate at which an average Commercial vehicle Inspector actually performs inspections, expressed as Inspections per second. The numbers shown represent an average inspection time of approximately 30 minutes, to include preparation, rest periods, paperwork, etc.	Unsubstantiated assumption	Independent
CVO_BDR_PER_ROUTE	A typical number of border crossings on a typical CVO route through the ITS area under	Unsubstantiated assumption	Independent

Name	Description	Basis	Type
	study.		
CVO_BORDERS	The typical number of CVO border crossing facilities in the ITS area under study. It is based on the assumed number of Border Crossings per route (CVO_BDR_PER_ROUTE) and the number of routes "executed" (CVO_TRIPS_PER_DAY_PER_VEH).	= CVO_BDR_PER_ROUTE*CVO_TRIPS_PER_DAY_PER_VEH	Dependent
CVO_DVR	The total number of Commercial Vehicle Drivers who also act as their own Fleet Managers. This will be a proportion of the number of Commercial Vehicles (CVO_VEHS). It is assumed that all of the vehicles belonging to these owner drivers will be equipped to utilize ITS functions.	=0.5 * CVO_VEHS	Dependent
CVO_FAC	The total number of Commercial Vehicle Roadside facilities that are operating in the ITS area under study.	Unsubstantiated assumption	Independent
CVO_FAC_PER_ROUTE	The average number of CVO facilities on a typical CVO route. Dependent on the assumed total number of facilities (CVO_FAC) and the relative number of segments in a typical route (NUM_SEGS/ROADWAY_SEGS).	= (NUM_SEGS / ROADWAY_SEGS) * CVO_FAC	Dependent
CVO_FAULT_RATE	The assumed rate at which commercial vehicles fail roadside inspections for all reasons to include safety, permits, driver credentials etc.	Unsubstantiated assumption	Independent
CVO_INSP	The total number of Commercial Vehicle Inspectors who can have simultaneous direct access to ITS at any one time in the ITS area under study. This will be dependent on the number of Commercial Vehicle Roadside facilities (CVO_FAC).	=2.5 * CVO_FAC	Dependent
CVO_MAN	The total number of Commercial Vehicle Fleet Managers who can have simultaneous direct access to ITS at any one time. This will be less than the actual number of such Managers employed within the ITS area if they are working shifts, and/or other staff such as supervisors, etc. are also employed.	Unsubstantiated assumption	Independent
CVO_TRIPS_PER_DAY_PER_VEH	The assumed number of discrete trips a typical CVO vehicle makes in a 24 hour period.	Unsubstantiated assumption	Independent
CVO_VEHS	The total number of commercial vehicles operable within the ITS area under study.		Independent
DAILY_TRAINS	The average number of trains operating through the ITS area under study in a 24 hour period.	Unsubstantiated assumption	Independent
DAY	Constant used in rate calculations, 24 hours	=24 * HOUR	Dependent
DYNAMIC_TRAVS	The total number of travelers that are utilizing autonomous route guidance. Based on an assumed ratio (AUTOINFRA) and the number of guided travelers (ITS_GUIDED_TRAVS)	= (1 - AUTOINFRA) * ITS_GUIDED_TRAVS	Dependent

Name	Description	Basis	Type
EP_MONITOR_DENSITY	The expected number of environmental pollution monitoring points (i.e. roadside transponders) normalized to intersections.	Unsubstantiated assumption	Independent
ERMS_CALL_RATE	The daily rate at which EMS departments receive calls as a function of total population. The numbers for the Urban environment are based on a study of fire department EMS calls in 1994, reported by the Journal of Emergency Medical Services. The numbers shown are all based on the 'average' value of a 1994 study of 7 urban areas and are normalized to "per unit population" basis.	Statistical study	Independent
ERMS_CALLS	The rate, in calls per second, at which EMS calls are received over an average 24 hour period.	= ERMS_CALL_RATE * (POPULATION) / DAY	Dependent
ERMS_ROUTE_LENGTH	The average length of an emergency vehicle route, in miles.	Unsubstantiated assumption	Independent
ERMS_VEHS	The total number of emergency services vehicles available for operation in the ITS area under study. This takes no account of whether the vehicles are active or not.	Unsubstantiated assumption	Independent
EVENT_RATE	The daily rate at which special events are scheduled which require ITS notifications.	Unsubstantiated assumption	Independent
FERRY_RATE	The proportion of ITS traveler interactions that involve FERRY operations as an alternative transportation mode..	Unsubstantiated assumption	Independent
GRADE_CROSSINGS	The number of active grade crossings within the ITS area under study.	FRA Data Report	Independent
GW_SIZE	Size of a green wave expressed as a number of route segments.	= ERMS_ROUTE_LENGTH / LINK_LENGTH	Dependent
HIGHWAY_CORRIDORS	The total number of primary highway traffic corridors under ITS strategic planning and control within the jurisdiction being studied.	Unsubstantiated assumption	Independent
HIGHWAY_CROSSING_CONTROLLERS	The total number of multimodal highway crossing controllers in traffic corridors.	= HIGHWAY_CORRIDORS * CONTROLLERS_PER_HIGHWAY_CORRIDOR	Dependent
HIGHWAY_CROSSINGS	The total number of controlled or monitored multimodal crossings of roads within the ITS environment under study. Based on data available for "typical" urban, interurban and rural areas.	Unsubstantiated assumption	Independent
HIGHWAY_INDICATORS	Total number of indicators (dynamic message signs and multimodal crossing signals) along freeways controlled/monitored within the ITS area under study. Assumed to be proportional to the total freeway mileage.	= HIGHWAY_MILES / 10	Dependent
HIGHWAY_LINKS	The total number of navigable freeway links	=	Dependent

Name	Description	Basis	Type
	within the ITS area under study.	HIGHWAY_MILES/LINK_LENGTH	
HIGHWAY_MILES	Total freeway (limited access) mileage in the ITS area under study.	Unsubstantiated assumption	Independent
HIGHWAY_SIGN_CONTROLLERS	The total number of highway sign controllers, assumed to be proportional to the number of highway signs.	= 6 * HIGHWAY_SIGNS	Dependent
HIGHWAY_SIGN_PLANS	The number of distinct plans used for highway sign activation..	Siemens ROM	Independent
HIGHWAY_SIGN_SEQUENCES	The number of distinct sequences used for highway sign activation..	Siemens ROM	Independent
HIGHWAY_SIGNS	Total number of dynamic message signs along freeways controlled/monitored within the ITS area under study. Assumed to be proportional to the total number of freeway ramps.	= RAMPS / 4	Dependent
HOUR	Constant used in rate calculations, 60 minutes	=60 * MINUTE	Dependent
HOV_LANES	The total number of high-occupancy links being controlled/monitored within the ITS area under study. Based on the total number of its freeway links.	= .05 * HIGHWAY_LINKS	Dependent
HRI_EVENTS_PER_DAY	An HRI event is one train encountering one grade crossing. The number of HRI events that occur in a 24 hour period is estimated as a function of the number of trains (DAILY_TRAINS), the number of active grade crossings (GRADE_CROSSINGS) and the number of rail corridors through the ITS area under study (RAIL_ROUTES).	= DAILY_TRAINS * GRADE_CROSSINGS / RAIL_CORRIDORS	Dependent
HRI_INCIDENT_RATE	The statistical rate at which incidents occur normalized to the number of trains crossing highways or roads.	FRA '95 Bulletin	Independent
HRI_INCIDENTS	The average number of HRI incidents expected in a single 24 hour period within the ITS area under study.	= HRI_INCIDENT_RATE * GRADE_CROSSINGS	Dependent
HRI_MAINT_PER_DAY	An estimated number of maintenance events, based on a percentage of the number of active grade crossings within the ITS system under study.	= .001 * GRADE_CROSSINGS	Dependent
IMAGE_LARGE	A large (or high resolution) image, typically used for automated surveillance (as opposed to human visual) processes. Roughly equivalent to a 256 color (or gray scale) image of 1024 X 1024 picture elements (pels).	Engineering estimate.	Independent
IMAGE_SMALL	A small (or low resolution) image, typically used for visual identification (as opposed to automatic) purposes. Roughly equivalent to a 256 color (or gray scale) image of 640 X 480 picture elements (pels).	Engineering estimate.	Independent
INCIDENT_RATE	An assumed average incidents per vehicle in a day, normalized to general vehicle population	Unsubstantiated	Independent

Name	Description	Basis	Type
	(VEHS).	assumption	
INCIDENTS	The average number of incidents in a 24 hour period, based on the incident rate (INCIDENT_RATE) and general vehicle population (VEHS).	= INCIDENT_RATE * VEHS	Dependent
INDICATORS	Total number of indicators (intersection controllers, pedestrian controllers, dynamic message signs and multimodal crossings) controlled/monitored within the ITS area under study. Assumed to be proportional to the number of intersections.	= HIGHWAY_INDICATORS + ROAD_INDICATORS	Dependent
INT_CONTROLLERS	The total number of roadway intersection controllers in traffic corridors.	= CORRIDORS * INTERSECTIONS_PER_CORRIDOR	Dependent
INTERSECTIONS	The total number of controlled or monitored intersections within the ITS environment under study. Based on data available for "typical" urban, interurban and rural areas.		Independent
INTERSECTIONS_PER_CORRIDOR	The average number of roadway intersections per corridor within the jurisdiction being studied.	Unsubstantiated assumption	Independent
ITS_CVO_TRIPS_PER_DAY	Number of ITS guided commercial vehicle trips that occur in a single day.	=MPCV * CVO_VEHS * CVO_TRIPS_PER_DAY_PER_VEH	Dependent
ITS_CVO_VEHS	The total number of commercial vehicles within the ITS area under study that are equipped to utilize ITS functions.	= MPCV * COM_VEHS	Dependent
ITS_GUIDED_TRAVS	The total number of travelers who can utilize ITS personal traveler guidance functions. This will be a proportion of the number of travelers who can simultaneously utilize ITS functions (ITS_TRAVS).	= 0.3 * ITS_TRAVS	Dependent
ITS_GUIDED_VEHS	The total number of vehicles that are utilizing ITS functions to obtain dynamic in-vehicle route guidance. This is a subset of the subset of all types of vehicles equipped to utilize ITS functions (ACT_ERMS_VEHS, ITS_CVO_VEHS, ITS_PVT_VEHS, ITS_PTRANSIT_VEHS, ITS_TRANSIT_VEHS)	= ACT_ERMS_VEHS + 0.9 * ITS_CVO_VEHS + 0.25 * ITS_PVT_VEHS + 0.8 * ITS_PTRANSIT_VEHS + 0.2 * ITS_TRANSIT_VEHS	Dependent
ITS_PTRANSIT_TRAVS	The total number of travelers who are utilizing ITS functions to obtain information on flexible transit services and (possibly) make reservation for one of those services. This is a proportion of the total number of travelers who can utilize ITS functions (ITS_TRAVS).	= MPPTT*ITS_TRAVS	Dependent
ITS_PTRANSIT_VEHS	The total number of Paratransit vehicles operating within the ITS area under study that are equipped to utilize ITS functions. This will be a proportion of the total number of Paratransit vehicles (PTRANSIT_VEHS).	=0.9 * PTRANSIT_VEHS	Dependent

Name	Description	Basis	Type
ITS_PVT_VEHS	The total number of private vehicles within the ITS area under study that are equipped to utilize ITS functions.	= MPPV * PVT_VEHS	Dependent
ITS_RS_TRAVS	The total number of travelers who are utilizing ITS functions to obtain Ridematching information and (possibly) make Ridematching reservations. This is a proportion of the total number of travelers who can utilize ITS functions (ITS_TRAVS).	= 0.1 * ITS_TRAVS	Dependent
ITS_TRANSIT_USERS	The total number of transit users operating within the ITS area under study that utilize ITS functions. This will be a proportion of the total number of transit users (TRANSIT_USERS).	=MPTU * TRANSIT_USERS	Dependent
ITS_TRANSIT_VEHS	The total number of transit vehicles operating within the ITS area under study that are equipped to utilize ITS functions. This will be a proportion of the total number of transit vehicles (TRANSIT_VEHS).	=MPTV * TRANSIT_VEHS	Dependent
ITS_TRAVS	The total number of travelers who can simultaneously utilize ITS functions. This is a proportion of the total population (POPULATION).	= MPTR * POPULATION	Dependent
ITS_VEHICLES	The total number of vehicles within the ITS area under study that are equipped to utilize ITS functions.	= ACT_ERMS_VEHS + ITS_CVO_VEHS + ITS_PVT_VEHS + ITS_PTRANSIT_VEHS + ITS_TRANSIT_VEHS	Dependent
JPEG	Images are assumed to be compressed for the purposes of estimating data flow sizes. Still images are assumed to be compressed using the Joint Photographic Experts Group (JPEG) methodology. The algorithms defined by this industry group can generally achieve compression ratios between 10:1 and 160:1. This parameter establishes the ratio assumed in this analysis.	JPEG	Independent
KIOSK_EMERGENCIES	Number of emergency calls per second being transmitted from ITS Kiosks. This assumed to be proportional to the number of ITS travelers (ITS_TRAVS), the expected rate of emergency calls within the general population (ERMS_CALL_RATE) and the market penetration of ITS Travelers using Kiosks (MPKIOSK).	= MPKIOSK * ERMS_CALL_RATE * ITS_TRAVS	Dependent
KIOSKS	Estimated number of traveler information Kiosks.	Unsubstantiated assumption	Independent
LANE_FLOW_RATE	Average traffic flow rate (Vehicles/second) on a single traffic lane. Based on a 24 hour period, this value should be adjusted as required to quantify time-of-day and incident specifics.	Unsubstantiated assumption	Independent

Name	Description	Basis	Type
LAST_PMODEL_UPDATE	This parameter is defined to provide a record of when the last time this table was updated. It is the Excel time serial corresponding to the last time this table was updated by PMODEL.XLS	= NOW()	Dependent
LINK_LENGTH	The average length, in miles, of a navigable route link, for the ITS area under study. This parameter is quantified for roadway links. Pedestrian travelers may require shorter links.		Independent
LINKS	The total number of navigable links within the ITS area under study.	= ROAD_LINKS + HIGHWAY_LINKS	Dependent
LOCAL_DATA	The typical number of data items containing advisory data that will be relevant to the local area surrounding a particular vehicle. This parameter is used to "filter" the advisory data list for data loading analysis..	Engineering Estimate	Independent
MAX_ADJ_PLANNED_EVENTS	The subset of maximum number of planned events for a 24 hour period that will impact traffic conditions in another area,	= .2 * MAX_PLANNED_EVENTS	Dependent
MAX_ADV_CHARGES	The maximum number of advanced charges, Assumed to be 1% of the general ITS population, i.e. it is proportional to the general market penetration of ITS (MP).	= .01 * MP * POPULATION	Dependent
MAX_ADV_FARES	The maximum number of advanced fares, Assumed to be 1% of the general ITS population, i.e. it is proportional to the general market penetration of ITS (MP).	= .01 * MP * POPULATION	Dependent
MAX_ADV_TOLLS	The maximum number of advanced tolls, Assumed to be 1% of the general ITS population, i.e. it is proportional to the general market penetration of ITS (MP).	= .01 * MP * POPULATION	Dependent
MAX_AHS_CHECKS	The maximum number of AHS check-in/check-out facilities.	= AHS_MILES / AHS_SEGMENT_LENGTH	Dependent
MAX_AHS_SEGS	The maximum allowable number of segments into which a valid AHS route may be divided. This is an arbitrary assumption and is highly dependent on system design constraints.	Unsubstantiated assumption	Independent
MAX_BAD_PAYERS	The expected number of travelers who are known to the ITS system as bad credit risks, assumed to be a percentage of all ITS_TRAVELERS.	= .0001 * ITS_TRAVS	Dependent
MAX_CUR_INCIDENTS	The maximum number of incidents for a 24 hour period,	= INCIDENTS	Dependent
MAX_HIGHWAY_SEGS	The typical number of segments into which a valid freeway route is divided. This is an arbitrary assumption and is highly dependent on system design constraints.	Unsubstantiated assumption	Independent
MAX_LINKS	The maximum allowable number of segments into which a valid route may be divided.	= MAX_SEGS	Dependent

Name	Description	Basis	Type
MAX_PARKING_SENSORS	The maximum number of parking lot sensors, Assumed to be proportional to the number of PARKING_LOTS.	= 10 * PARKING_LOTS	Dependent
MAX_PARKING_DMS	The maximum number of parking dynamic message signs, Assumed to be proportional to the number of PARKING_LOTS.	= 4 * PARKING_LOTS	Dependent
MAX_PLANNED_EVENTS	The maximum number of planned events for a 24 hour period,	= INCIDENTS	Dependent
MAX_ROAD_SEGS	The typical number of segments into which a valid route over surface streets is divided. This is an arbitrary assumption and is highly dependent on system design constraints.	Unsubstantiated assumption	Independent
MAX_SEG_WPS	The maximum allowable number of waypoints which a valid segment may utilize. This is an arbitrary assumption and is highly dependent on system design constraints.	Unsubstantiated assumption	Independent
MAX_SEGS	The total number of navigable links within the ITS area under study.	= LINKS	Dependent
MAX_SENSORS	The maximum number of ITS sensors, Assumed to be proportional to the number of intersections in the ITS area under study.	= 10 * INTERSECTIONS	Dependent
MAX_STRATEGIES	The maximum number of traffic management strategies that can be specified for use in a single day.	Siemens estimate	Independent
MEDIA_OPS	The number of Media Operators who can have simultaneous direct access to the TMC at any one time. This will be less that the actual number of Media Operators who actually access the ITS if they are working shifts.	Unsubstantiated assumption	Independent
MILES	Total freeway and street mileage under ITS influence.	=HIGHWAY_MILES+ROAD_MILES	Dependent
MINUTE	Constant used in rate calculations, 60 seconds	=60	Dependent
MONTH	Constant used in rate calculations, 1/12 of a year	=YEAR / 12	Dependent
MP	Market penetration assumption for ITS capabilities. It is used where a specific market penetration (e.g. MP_CVO) is not available or appropriate.	Unsubstantiated assumption	Independent
MPAHS	The assumed AHS Market Penetration, i.e. the percentage of vehicles that are equipped to operate on AHS lanes.	Unsubstantiated assumption	Independent
MPCV	The assumed Commercial Vehicle Market Penetration, i.e. the percentage of commercial vehicles that are equipped to utilize ITS functions.	Unsubstantiated assumption	Independent
MPEG	Images are assumed to be compressed for the purposes of estimating data flow sizes. Full motion images are assumed to be compressed using the Motion Pictures Experts Group	MPEG	Independent

Name	Description	Basis	Type
	(MPEG) methodology. This parameter establishes the ratio assumed in this analysis.		
MPKIOSK	The market penetration of ITS Travelers using Kiosks.	Unsubstantiated assumption	Independent
MPPDA	The market penetration of ITS Travelers using PDA devices.	Unsubstantiated assumption	Independent
MPPTT	The assumed Paratransit Traveler Market Penetration, i.e. the percentage of travelers that utilize paratransit operations.	Unsubstantiated assumption	Independent
MPPV	The assumed Private Vehicle Market Penetration, i.e. the percentage of private vehicles that are equipped to utilize ITS functions.	Unsubstantiated assumption	Independent
MPSP	Market penetration factor for smart probe equipped vehicles. This parameter is tied to the Marker penetration for private vehicles (MPPV).	= .01 * MPPV	Dependent
MPTR	The assumed Traveler Market Penetration, i.e. the percentage of travelers that will utilize ITS functions.	Unsubstantiated assumption	Independent
MPTU	The assumed Transit User Market Penetration, i.e. the percentage of transit users that utilize ITS functions.	Unsubstantiated assumption	Independent
MPTV	The assumed Transit Vehicle Market Penetration, i.e. the percentage of transit vehicles that are equipped to utilize ITS functions.	Unsubstantiated assumption	Independent
NUM_CVO_RECORDS	The estimated number of records in the average CVO roadside database. It is based on an estimate of the total number of vehicles legally enrolled to operate in the ITS area under study. This will include all enrolled vehicles registered in the jurisdiction AND extra-jurisdictional enrolled vehicles that have paid apportioned fees and taxes.	=MPCV*CVO_VEHS	Dependent
NUM_PLANNED_EVENTS	The planned number of events in a 24 hour period,	= INCIDENTS	Dependent
NUM_SEGS	The number of individual route segments included in an average route.	Unsubstantiated assumption	Independent
NUM_TRANSIT_ROUTES	The average total number of transit routes included within the ITS environment being analyzed. Does not include transit routes of "other TMS" environments. This is a assumption of a "typical" value derived from demographic data of U.S, urban, interurban and rural areas.		Independent
NUM_TRANSIT_SERVICES	The maximum number of vehicle schedules for a typical transit route. This is determined by the TRANSIT_WAIT_TIME, i.e. an average wait time of 60 minutes requires 24	= 24 * 60 / TRANSIT_WAIT_TIME	Dependent

Name	Description	Basis	Type
	TRANSIT_SERVICES per 24 hour period,		
OTHER_SEGS	The total number of navigable non-vehicular segments within the ITS area under study.	= .1 * ROAD_LINKS	Dependent
PARATRANSIT_USERS	The number of paratransit users, assumed to be a percentage of the total transit user population.	= .05 * TRANSIT_USERS	Dependent
PARKING_LANES	The maximum number of parking lot payment lanes that are operating at a single parking lot in the ITS area under study. It is assumed that these lanes will only be used by vehicles that are equipped to utilize ITS functions. Any that are not equipped in this way will be flagged as violators.	Unsubstantiated assumption	Independent
PARKING_LOT_PROVIDERS	The average number of independent parking service providers in the ITS area under study.	= PARKING_PROVIDER_RATE * POPULATION	Dependent
PARKING_LOTS	The average total number of parking lots that are being operated by a single parking lot service provider in the ITS area under study.	= PARKING_LOTS_PER_PROVIDER * PARKING_LOT_PROVIDERS	Dependent
PARKING_LOTS_PER_PROVIDER	The average total number of parking lots that are being operated by a single parking lot service provider in the ITS area under study.	Unsubstantiated assumption	Independent
PARKING_PROVIDER_RATE	Number of independent parking providers, normalized to general vehicle population (VEHS).	Unsubstantiated assumption	Independent
PARKING_SAMPLE_RATE	An arbitrary sample rate constant used to facilitate data loading estimates for parking lot operations.	= 1 / DAY	Dependent
PARKING_SPACE_RATE	Number of independent parking spaces, normalized to general vehicle population (VEHS).	Unsubstantiated assumption	Independent
PARKING_SPACES	The total average number of parking spaces available in the ITS area under study.	= PARKING_SPACE_RATE * VEHS	Dependent
PED_CONTROLLERS	The total number of pedestrian activated signal controllers within the ITS area under study. This is dependent on the total number of intersections.	= .1 * INTERSECTIONS	Dependent
PEDESTRIAN_SIGNAL_CONTROLLERS	The total number of pedestrian activated signal controllers within the ITS area under study. This is dependent on the total number of intersections.	= .1 * INTERSECTIONS	Dependent
PEDESTRIANS	The total number of controlled or monitored pedestrian crossings that are not also intersections within the ITS environment under study. Based on data available for "typical" urban, interurban and rural areas.	Unsubstantiated assumption	Independent
PERSONAL_EMERGEN	Number of emergency calls per second being transmitted from Personal Data Assistant	= MPPDA * ERMS_CALL_RATE *	Dependent

Name	Description	Basis	Type
CIES	(PDA) type devices. This assumed to be proportional to the number of ITS travelers (ITS_TRAVS), the expected rate of emergency calls within the general population (ERMS_CALL_RATE) and the market penetration of ITS Travelers using PDAs (MPPDA).	ITS_TRAVS	
POLLUTION_POINTS	The expected number of environmental pollution monitoring points (i.e. roadside transponders) . This number is assumed to be proportional to the number of intersections (INTERSECTIONS) in the area under study, and to a installed rate (EP_MONITOR_DENSITY).	= EP_MONITOR_DENSITY * INTERSECTIONS	Dependent
POPULATION	The total population of the ITS environment under study.		Independent
PTRANSIT_VEHS	The total number of Paratransit vehicles operating within the ITS area under study. A Paratransit vehicle is one that is used to carry one or passengers on a non-scheduled transit service that may not follow a fixed route.	Unsubstantiated assumption	Independent
PVT_VEHS	The total number of vehicles excluding commercial and transit vehicles, operable within the ITS area under study.		Independent
RAIL_CORRIDORS	The average number of routes over which DAILY_TRAINS are distributed within the ITS area under study.	Unsubstantiated assumption	Independent
RAIL_RATE	The proportion of ITS traveler interactions that involve heavy or light RAIL as an alternative transportation mode..	Unsubstantiated assumption	Independent
RAMP_CONTROLLERS	The total number of ramp controllers, based on the number of ramps, within the ITS area under study.	= 2 * RAMPS	Dependent
RAMPS	The total number of controlled or monitored highway access ramps within the ITS environment under study. Based on data available for "typical" urban, interurban and rural areas.	Unsubstantiated assumption	Independent
ROAD_ADAPTIVE_PLANS	The maximum number of indicator adaptive data (adaptive plans) that are available from the Manage Traffic Function.	Siemens Estimate	Independent
ROAD_CORRIDORS	The total number of primary road traffic corridors under ITS strategic planning and control within the jurisdiction being studied.	Unsubstantiated assumption	Independent
ROAD_CROSSING_CONTROLLERS	The total number of multimodal road crossing controllers in traffic corridors.	= ROAD_CORRIDORS * CONTROLLERS_PER_ROAD_CORRIDOR	Dependent
ROAD_CROSSINGS	The total number of controlled or monitored multi-modal crossings of roads within the ITS	Unsubstantiated assumption	Independent

Name	Description	Basis	Type
	environment under study. Based on data available for "typical" urban, interurban and rural areas.		
ROAD_FIXED_PLANS	The maximum number of fixed time indicator control sequences (fixed time plans) that are available from the Manage Traffic Function.	Siemens Estimate	Independent
ROAD_INDICATORS	Total number of indicators (intersection controllers, pedestrian controllers, dynamic message signs and multimodal crossings) along roads controlled/monitored within the ITS area under study. Assumed to be proportional to the number of intersections.	= 4 * INTERSECTIONS	Dependent
ROAD_LINKS	The total number of navigable surface street links within the ITS area under study.	= ROAD_MILES/LINK_LENGTH	Dependent
ROAD_MILES	The total mileage of ITS usable roads and streets (as distinct from highways) within the area under analysis.		Independent
ROAD_SIGN_CONTROLLERS	The total number of road sign controllers, assumed to be proportional to the number of road signs.	= 6 * ROAD_SIGNS	Dependent
ROAD_SIGNS	Total number of dynamic message signs along roads controlled/monitored within the ITS area under study. Assumed to be proportional to the number of intersections.	= INTERSECTIONS / 10	Dependent
ROADWAY_SEGS	The total number of navigable route segments within the ITS area under study.	= LINKS	Dependent
ROUTE_SEGS	The typical number of segments into which a valid route is divided. This is an arbitrary assumption and is highly dependent on system algorithm designs and assumptions.	Unsubstantiated assumption	Independent
SIGNS	The total number of HIGHWAY_SIGNS and ROAD_SIGNS	= HIGHWAY_SIGNS+ROAD_SIGNS	Dependent
SMART_PROBE_RATE	The rate at which Smart Probe vehicles report to roadside smart probe beacons. This assumption sets this parameter proportional to the number of smart probe vehicles (VEH_SMART_PROBES) and an average vehicle flow rate (LANE_FLOW_RATE)	= VEH_SMART_PROBES * LANE_FLOW_RATE	Dependent
TAG_DEFECT_RATE	The assumed average rate at which tags will be rejected by ITS equipment INCLUDING bad credit, stolen tags and system failures.	Unsubstantiated assumption	Independent
TOLL_LANES	The maximum number of toll lanes that are operating at an average toll plaza in the ITS area under study. It is assumed that these lanes will only be used by vehicles that are equipped to utilize ITS functions. Any that are not equipped in this way will be flagged as violators.	Unsubstantiated assumption	Independent

Name	Description	Basis	Type
TOLL_MILES	The total number of ITS roadway miles being operated under some form of toll system. Based on available data for typical urban, interurban and rural areas.		Independent
TOLL_PLAZAS	The total number of toll collection points within the ITS area under study. Based on available data for typical urban, interurban and rural areas.		Independent
TOLL_SAMPLE_RATE	An arbitrary sample rate constant used to facilitate data loading estimates for toll road operations.	= 1/DAY	Dependent
TOLL_SEGS	Total number of Toll Segments within the ITS area under study. A Toll Segment is associated with the roadway between Toll Plazas and may consist of one or more Links. A Toll segment may be one or more Route segments, and vice versa.	= TOLL_PLAZAS	Dependent
TRAFFIC_COORDINATION_RULES	The number of road-freeway coordination rules that are available from the Manage Traffic Function. These rules define the actions in the other system (Freeway or Surface street) needed when a particular road fixed time, adaptive, or freeway sign plan is not in control.	Siemens Estimate	Independent
TRAFFIC_OPS	The number of Traffic Operations Personnel who can have simultaneous direct access to the TMC at any one time. This will be less than the actual number of Traffic Operations Personnel employed at the TMC if they are working shifts, and/or other staff such as supervisors, traffic planners, etc. are also employed.	Unsubstantiated assumption	Independent
TRAFFIC_VIDEO_CAMERAS	The total number of traffic video cameras operating in the ITS area under study, assumed to be proportional (CAMERA_DENSITY) to the number of intersections (INTERSECTIONS)	= CAMERA_DENSITY * INTERSECTIONS	Dependent
TRANSIT_DEVS	The total number of transit vehicles that are running late, i.e. deviating from their routes and/or schedules at any particular moment within the ITS area under study. This will be proportional to the total number of transit vehicles currently running under deviated schedules (TRANSIT_VEH_DEVS) and the number of stops on their routes. (TRANSIT_STOPS).	= .5 * TRANSIT_VEH_DEVS * TRANSIT_STOPS	Dependent
TRANSIT_DRIVERS	The total number of transit drivers available to operate the transit vehicles within the ITS area under study.	Unsubstantiated assumption	Independent
TRANSIT_FLEETS	The total number of transit fleets operating in the ITS area under study. The fleets may be operating the same type of service, e.g. buses,	Unsubstantiated assumption	Independent

Name	Description	Basis	Type
	or differing types, e.g. one for buses, another for light rail (trams).		
TRANSIT_ROUTE_SEGS	The average (typical) number of route segments in a typical (average) transit route..	= TRANSIT_STOPS / NUM_TRANSIT_ROUTES	Dependent
TRANSIT_SAMPLE_RATE	An arbitrary sample rate constant used to facilitate data loading estimates for transit operations.	= 1 / DAY	Dependent
TRANSIT_SEGS	The average (typical) number of route segments in a typical (average) transit route..	= TRANSIT_STOPS / NUM_TRANSIT_ROUTES	Dependent
TRANSIT_STOPS	The total number of transit stops on all transit routes within the ITS area under study. It is assumed that as a minimum, they are all capable of receiving and displaying data about the next services due to arrive at the stop.	Unsubstantiated assumption	Independent
TRANSIT_TECH_ACTS	Transit Technician Activities, assumed to be proportional to the number of TRANSIT_VEHS.	= 2 * TRANSIT_VEHS	Dependent
TRANSIT_TECH_WR	The average number of transit vehicles that one transit maintenance technician can service in an hour.	Unsubstantiated assumption	Independent
TRANSIT_TECHS	The total number of transit service technicians available to maintain the transit fleet within the ITS area under study. This number is assumed to be proportional to the size of the transit system as measured by the number of TRANSIT_VEHS	= TRANSIT_VEHS / 50	Dependent
TRANSIT_USAGE_RATE	Number of transit users, normalized to total population (POPULATION).	Unsubstantiated assumption	Independent
TRANSIT_USERS	The average number of travelers in the general population (POPULATION) using transit facilities on a daily basis.	= TRANSIT_USAGE_RATE * POPULATION	Dependent
TRANSIT_USERS_PER_ROUTE	The number of transit users served by an average transit route, in a 24 hour period. Based on the number of transit users (TRANSIT_USERS) and the number of routes (NUM_TRANSIT_ROUTES)	= TRANSIT_USERS / NUM_TRANSIT_ROUTES	Dependent
TRANSIT_USERS_PER_STOP	The number of transit users at an average transit stop, in a 24 hour period. Based on the assumed number of transit users (TRANSIT_USERS) and the number of stops (TRANSIT_STOPS)	= TRANSIT_USERS / TRANSIT_STOPS	Dependent
TRANSIT_VEH_DEVS	The total number of transit vehicles that are running late, i.e. deviating from their routes and/or schedules at any particular moment within the ITS area under study. This will be proportional to the total number of transit vehicles (TRANSIT_VEHS).	= 0.1 * TRANSIT_VEHS	Dependent
TRANSIT_VEHS	The total number of transit vehicles available	Unsubstantiated	Independent

Name	Description	Basis	Type
	for operation within the ITS area under study. A transit vehicle is a special type of vehicle that is designed and equipped to carry a number of passengers on a scheduled route.	assumption	
TRANSIT_WAIT_TIME	The average waiting time between regularly scheduled transit vehicles.	Engineering estimate of an acceptable average for each environment.	Independent
TUNNELS	An arbitrary assumption about the number of tunnel segments being managed by the ITS system under study..	Assumption	Independent
VEH_PROBE_SITES	The number of smart probe capable beacons in the ITS area under study. This assumption is directly tied to the assumption of the number of DMS signs (ROAD_SIGNS).	= ROAD_SIGNS	Dependent
VEH_SMART_PROBES	The total number of ITS equipped vehicles with Smart Probe reporting capability.	= MPSP * ITS_VEHICLES	Dependent
VEHICLE_SIGN_OUTPUT_DENSITY	The expected number of in-vehicle signage transmission points (i.e. roadside transponders) per intersection.	Unsubstantiated assumption	Independent
VEHICLE_SIGN_OUTPUTS	The expected number of in-vehicle signage transmission points (i.e. roadside transponders). This number is assumed to be proportional to the number of intersections (INTERSECTIONS) and to the rate of implementation (VEHICLE_SIGN_OUTPUT_DENSITY)	= VEHICLE_SIGN_OUTPUT_DENSITY * INTERSECTIONS	Dependent
VEHS	The assumed total number of vehicles in the ITS area under study, based on the general population of the same area.	= .63 * POPULATION	Dependent
WEEK	Constant used in rate calculations, 7 days	= 7 * DAY	Dependent
YEAR	Constant used in rate calculations, 365.24 days	= 365.24 * DAY	Dependent
YP_GLOBAL_ITEMS	The typical number of items of "yellow pages" type of information that will be available from throughout the geographic and/or jurisdictional area served by the ITS under study.	Engineering estimate.	Independent
YP_LOCAL_ITEMS	The typical number of items of "yellow pages" type of information that will be available in the local area of a particular vehicle.	Engineering estimate.	Independent

1.1.6. Integration of CASE, Database, Spreadsheet, and Publishing Tools

To develop and document the ITS Logical Architecture, The Joint Development Team has chosen the CASE tool Teamwork by Cadre. This choice of CASE tool was made for several reasons including:

1. It supports full implementation of a complex requirements model.
2. It supports many analysts working on components of the same model simultaneously.

3. It is easily integrated into a distributed computing environment so that the model database is accessible from remote sites using the team's networks and the Internet, and system management including automatic backup is provided by a central service organization.
4. It can be integrated with other tools including the Interleaf publishing system.
5. We have been able to extend the basic Logical Architecture model supported by Cadre to a full Logical/Physical Architecture model using extended attributes in the P-Specs and Data Dictionary entries, and custom software to generate the resultant Physical Architecture flows and data loading analysis.

The CASE tool is able to generate an ASCII encoded representation of the model in CASE Data Interchange Format (CDIF), which we are able to process using a variety of software tools.

These include COTS applications such as Microsoft Access and Excel, as well as developed code (in various languages). All of these tools were specifically customized to support this application. Together, they generate the tables from which we do the concurrent Physical Architecture development and the Data Loading Analysis. This collection of tables is contained in a set of interlocked Access databases:

LOGICAL.MDB	Contains the extracted Teamwork model data in relational table form. This database includes queries to resolve the source/destination of all the data flows that pass between P-Specs and Terminators. The resulting table of from/to flows is the basis for data loading analysis and Physical Architecture interface specification. This database also holds the Parameter definition tables.
PHYSICAL.MDB	This is the Physical Architecture counterpart to logical.mdb and contains the tables that define how logical entities (processes, flows) are mapped into physical entities (Subsystems, Equipment Packages, Architectural Flows).
TRACE.MDB	This database contains no source data. It uses the "attached table" concept in Microsoft Access to gain access to the source data in both the logical and physical databases above. The trace database is primarily a set of queries and reports designed to compare the logical and physical architectures. It generates traceability tables mapping out the complex interrelationships between the logical and physical views of the National Architecture. It also generate reports when inconsistencies between the two views occur as the result of changes being made to one or both source databases. The trace tables are can be found in the Traceability Document deliverable.
DATALOAD.MDB	Interfaces the logical and physical databases to a Microsoft Excel based model that resolves the parameter, message rate, and flow size expressions into numeric values. Dataload.mdb uses attached tables from logical.mdb and physical.mdb to build an input dataset for the Excel spreadsheet model. It exports expressions to Excel, initiates a suite of Excel Visual Basic macros, and then imports the resultant values back from Excel.

The publishing software that we use, Microsoft Word, has an import capability to incorporate the CASE tool output as well as spreadsheets (in Microsoft Excel format) and it also is able to import files from a large number of other word processing and publishing packages. Other documents take advantage of the report capability of Access and its integration with Word.

All these tools run in a distributed computing environment and files from the various tools can be sent to and from remote locations using the Internet.

1.1.7. Abstract Flows

In developing the ITS Logical and Physical Architectures, the Architecture Development Team followed the principle that if any equipment or process has cost to a stakeholder in ITS, then it should be "inside" the Manage ITS top level process. The consequence of this is that many of the data flows to and from terminators are now "abstract", that is, it is not meaningful to discuss their characteristics in terms of "messages/sec" or "bytes" or bandwidth. For example, loop detectors are inside the Roadside physical subsystem, but a terminator "Traffic" interacts with the loop detectors to generate useful data. Thus, we have an "abstract flow" from the vehicles to the sensors. The majority of terminator flows are of this nature, with the notable exception of the type "Other XXX" flow. The flows to "Other TMS" are used to characterize the flows from one Traffic Management Subsystem to another. Another example includes flows to "Other Vehicle", which are used to characterize vehicle-to-vehicle communications for AHS operations.

1.1.8. Roadmap to Logical Architecture Components

The Logical Architecture, Physical Architecture, and Traceability Documents provide a complete description of the ITS National Architecture which is internally consistent. Using the sections and Appendices of these documents, the reader can navigate from the highest to the lowest levels of detail in the architecture. Table 2 identifies how to locate key information about the components of the Logical Architecture.

Table 2. Roadmap to Logical Architecture Components

Information	Where to find it.
User Service Requirements	Trace Appendix A
Data Flow Diagrams	LA Volume 1, Section 1.4 contains graphical DFDs; LA Volume 1 Section 1.6.1 contains the complete descriptions of the DFDs; LA Volume 1 Appendix B has a hierarchical listing of the DFDs and Pspecs.
Process Specifications	LA Volume 1, Section 1.6 has the pspec overviews. Volume 2 has the complete pspec descriptions including input/output flows, User Service Requirements satisfied by each pspec and the dynamics of each output dataflow.
Data flow definitions	Contained in the Data Dictionary which is in LA Volume 3; LA Volume 1 Appendix C has a summary hierarchical listing of the dataflows.
Mapping of Logical to Physical Architecture: pspecs to Subsystems	Trace Appendices D and E show the mapping of pspecs to Subsystems. The PA Sections 2.4 -2.22 show the pspecs in each subsystem.
Mapping of Logical to Physical Architecture: pspecs to equipment packages	Trace Appendices F and G show the mapping of pspecs to equipment packages (and vice versa). The PA Sections 2.4 -2.22 also contains this information in each subsystem section.
Source and Destination of a Data Flow in the Logical Architecture	Trace Appendix I provides an alphabetical listing of dataflows which have a pspec or terminator as a source or sink.
Mapping of Physical Architecture flows to Logical Architecture dataflows	Trace Appendix L has a mapping organized by Subsystem (or Terminator) to Subsystem (or Terminator)
LA=Logical Architecture Document; PA= Physical Architecture Document	

1.1.9. References

1.1.9.1 ITS User Service Requirements

1.1.9.2 ITS Architecture Theory of Operations Document

1.1.9.3 ITS Architecture Communications Analysis Document

1.1.9.4 ITS Architecture Traceability Matrix Document

1.1.9.5 Hatley, D., and Pirbhai, I., "Strategies for Real-Time System Specification", Dorset House, 1988.

1.1.9.6 ITS Architecture Performance and Benefits Study Document

1.1.9.7 ITS Physical Architecture Document

1.2. Context Diagram

The ITS Logical Architecture Context Diagram, shown in Figure 4, provides a precise definition of the ITS Architecture boundary. It is made up of the ITS functional process and a large number of terminators. Terminators provide system interface to support all of the User Services Requirements.

1.2.1. Types of Terminator

Each of the terminators represents an external entity that communicates data to, or receives data from the ITS functional process. The terminators have been grouped into four categories: Users (Center Personnel, Roadside Personnel, Vehicle Operator, or Traveler), Systems (Center System, Roadside System, and Vehicle System), Environment, and Other Subsystems (Other Center and Other Vehicle).

User Terminators. These are the personnel at ITS Center subsystems and Roadside subsystems as well as Drivers and Travelers who interact with ITS subsystems.

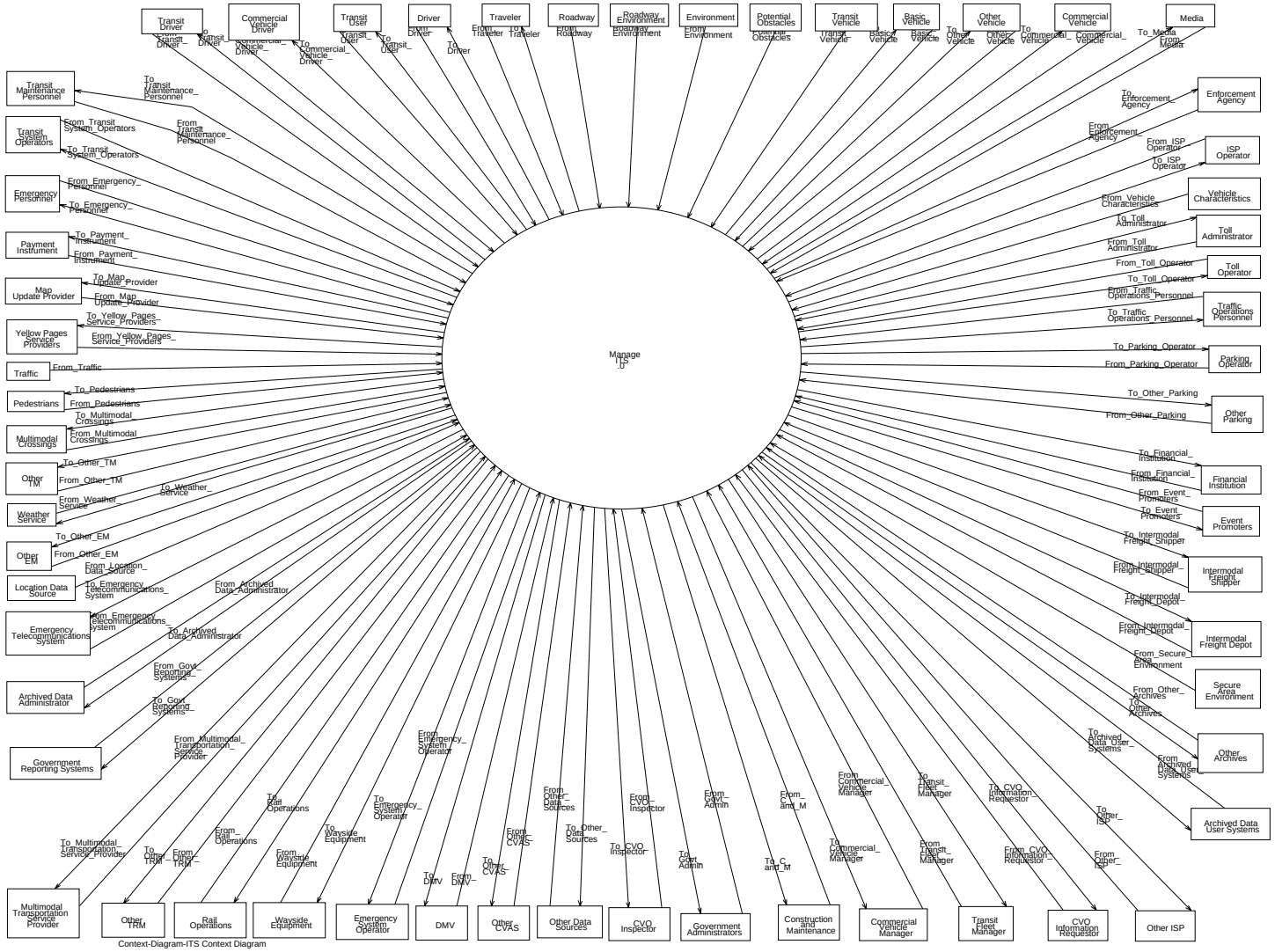
System Terminators. These are the non-ITS Centers (e.g., Government Agencies that ITS will interact with), Roadside systems (e.g., traditional signals and sensors), and Vehicle Systems (e.g., braking and steering systems) that ITS will interact with.

Environment Terminators. The environment is sensed by ITS subsystems. Examples are air quality and obstacles.

Other Subsystem Terminators. This is a representation the architecture development team has adopted to indicate the interactions between multiple, similar subsystems. For example, vehicle-to-vehicle messages and Traffic Management Center-to-Traffic Management Center messages.

The above definitions encompass most of the terminators defined for the architecture, but there are one or two that do not fit easily into these categories. This method of classification helps with understanding the function of each terminator and is useful in developing the Physical Architecture.

It should be noted that, in general, the Physical Architecture must use the same set of Terminators as does the Logical Architecture, but that two exceptions are allowed. First, it is possible that additional Terminators are required in the development of a Physical Architecture from the more abstract and idealistic Logical Architecture. Such Terminators reflect interfaces and physical entities that are not "essential" to satisfying the functional requirements, but that are required to realize a system solution to those requirements. Secondly, some terminators that represent very generic entities in the Logical Architecture (e.g., Other Traffic Centers) may represent very specific entities in the Physical Architecture (e.g., Other Traffic Management Subsystem). Functionally these are the same entities but, as might be expected, they represent slightly different views in the two architectural views.



Context-Diagram-ITS Context Diagram

Figure 4. Context Diagram for ITS

1.2.2. Classes of Terminator

Many of the terminators on the Context Diagram may be considered as part of the Architecture. For instance, the various forms of human operators, travelers, and vehicles may all be considered as part of the Architecture and yet they are presented as terminators. The reason for this is that, while these terminators are certainly relevant to ITS, they are not completely encompassed by ITS. The Vehicle terminator includes both ITS systems, such as advanced information, control, and communications systems, and non-ITS systems, such as propulsion and suspension systems. Humans similarly perform functions that are subject to influences that fall outside the scope of ITS. It is not intended to develop a set of Architecture modules that implement a human or vehicle in its entirety. Since the Team approach is to develop a Physical Architecture that governs the implementation of all elements within the ITS boundary, it is important to view both vehicles and humans as external.

The terminators can also be divided up into several classes depending on the form in which they are expected to appear. These are described below.

Humans -- those that interface to the ITS Architecture are expected to fall into the following two general groups:

1. System users, such as Drivers, Travelers, Pedestrians, and Transit Users;
2. System operators, such as Traffic Operations Personnel, Transit Operators, Fleet Managers, Toll Operators, Emergency System Operators, Transportation Engineers, etc.

The data flowing from the various users/operators represents queries and requests for ITS services. The flows to users/operators represent responses to the requests and unsolicited notification of ITS status. Pedestrians are in fact not direct ITS users or operators. This external was included to allow the traffic control model to take into account pedestrian right-of-way requirements.

Though humans are shown as terminators to the ITS, all functionality has been included within the boundary of the system, even function that would normally be allocated to the human operator in many deployment scenarios. For example, both incident management and vehicle control functions are modeled as part of the ITS Architecture functionally though these functions would be allocated to human operators in many cases. The model explicitly shows the Traffic Operations personnel and Drivers associated with these functions on the Context Diagram, and models as internal to the ITS all functions that might be performed by the automated system in a high-end state scenario. This approach requires some redundancy in modeling, e.g., both the Driver terminator and the system functionality can “step on the brake”, but it results in a model that is robust to a wide range of deployment scenarios and implementations.

Vehicles -- those that interface to the ITS are shown in several contexts to support differing views of vehicles by the various User Services. The highest level perspective represents large groups of vehicles as the Traffic and Basic Vehicle terminators. Interface with the Traffic terminator reflects the monitoring of overall traffic conditions through surveillance and regulation of right-of-way for roadway vehicles. Depicting the external interface as Traffic includes the various potential traffic detectors and actuators as part of the Architecture. Interface with the Basic Vehicle terminator reflects the monitoring of actual generic on-board conditions and the provision of generalized functions such as speed control and route guidance.

The various types of individual vehicles (Commercial, Emergency, and Transit) are included as interfaces to illustrate their unique connectivity to the Architecture. These special interfaces primarily reflect additional fleet management, administration requirements, and preferential traffic control requirements that may be accommodated by these different types of vehicles. To model advanced vehicle control

services, a separate “Other Vehicle” terminator has been introduced. This enables modeling of potential information transfers between vehicles as part of the Architecture.

The final class of vehicle terminator that is represented on the Context Diagram covers those providing alternate modes of transport, e.g., ships, rail vehicles, airplanes, etc., that are not directly controlled by the ITS services. These vehicles are interfaced as Alternate Mode Freight Shippers, Alternate Transportation Service Providers, Multimodal Transportation Providers and Multimodal Crossings to reflect the ITS goal to efficiently integrate multimodal transport of people, goods, and services.

Environment -- both environmental and roadway conditions are reflected as terminators to the ITS Architecture. This is to support the monitoring of real-time changes in roadway and environmental conditions to enable advanced control and traveler information functions.

Other -- the Context Diagram contains several other miscellaneous externals that are oriented towards specific User Services. In general, they are external systems to which the ITS Architecture must interface to enable it to provide the functionality required to support the User Services. However these systems will be provided by organizations that may not be directly concerned with transportation and therefore not part of ITS.

1.3. Terminator Descriptions

The following table contains descriptions of each terminator used in the Architecture. These terminators and their descriptions were selected to provide the most rigorous, yet flexible, system boundary acceptable within the constraints of the ITS requirements.

Table 3. National ITS Architecture Terminators

Entity Name	Entity Description
Archived Data Administrator	This terminator represents the human operator who provides overall data management, administration, and monitoring duties for the ITS data archive. Unlike the manager of the operational databases, the archive data administrator's role is focused on the archive and covers areas such as establishing user authentication controls, monitoring data quality, and initiating data import requests.
Archived Data User Systems	This terminator represents the systems users employ to access archived data. The general interface provided from this terminator allows a broad range of users (e.g. planners, researchers, analysts, operators) and their systems (e.g. databases, models, analytical tools, user interface devices) to acquire data and analyses results from the archive.
Basic Vehicle	This terminator represents the basic vehicle platform that interfaces with and hosts ITS electronics. The Basic Vehicle terminator provides an interface to drive train, driver convenience and entertainment systems, and other non-ITS electronics on-board the vehicle. This interface allows general vehicle systems (e.g., the stereo speaker system) to be shared by ITS and non-ITS systems. It also allows monitoring and control of the vehicle platform for advanced vehicle control system applications.
Commercial Vehicle	The actual commercial vehicle along with the special aspects of large commercial vehicles and vehicles designed to carry cargo that extend beyond the characteristics defined for the Basic Vehicle. This terminator thus represents a special type of Basic Vehicle that is used to transport goods or services which are operated by professional drivers, typically administered as part of a larger fleet, and regulated by a Commercial Vehicle Manager. This classification applies to all such vehicles ranging from small panel vans used in local pick-up and delivery services to large, multi-axle tractor trailer rigs operating on long haul routes.

Entity Name	Entity Description
Commercial Vehicle Driver	This terminator represents the human entity that operates vehicles transporting goods including both long haul trucks and local pick up and delivery vans. This terminator is complementary to the Driver terminator in that it represents those interactions that are unique to Commercial Vehicle Operations. In general, a "real world" commercial vehicle driver will interact as both a Driver and a CVO Driver. Data flowing from the Commercial Vehicle Driver terminator will include those system inputs specific to Commercial Vehicle Operations, such as information back to the Commercial Vehicle Manager. Data flowing to the Commercial Vehicle Driver may include system outputs such as commands to pull into a roadside safety inspection facility. Showing the Driver as the external interface includes the user interface devices within the ITS architecture boundary. The CVO Driver will be expected to interact with the ITS with interface devices designed to provide support for their usage.
Commercial Vehicle Manager	This terminator represents the human entities that are responsible for the dispatching and management of Commercial Vehicle fleets (e.g. traditional Fleet Managers). It may be many people in a large tracking organization but it can also be a single person (owner driver) in the case of single vehicle fleets. The Commercial Vehicle Manager provides instructions and coordination for Commercial Vehicles, including electronic clearance and tax filing, and receives the status of the Vehicles in the fleet that they manage. The Commercial Vehicle Manager is expected to interface with ITS on a regular basis to enhance productivity. Many interfaces with the system are also provided through normal user interfaces This interface is specific to CVO and is intended to complement these other interfaces.
Construction and Maintenance	This terminator represents the information systems that are used to manage and track construction and maintenance of the roadway infrastructure. These Construction and Maintenance systems are used by roadway maintenance personnel, roadway construction personnel, or other work crew personnel assigned to highway construction and maintenance. Coordination with these systems allows the ITS Architecture to rapidly correct deficiencies noted through its advanced surveillance capabilities and also improves the quality and accuracy of information available to Travelers regarding closures and other roadway construction and maintenance activities.
CVO Information Requestor	This terminator represents any organization requesting information from the CVO Information Exchange network. It typically represents insurance companies requesting safety information on carriers etc.
CVO Inspector	This terminator represents the human entities who perform regulatory inspection of Commercial Vehicles in the field. CVO Inspectors support the roadside inspection, weighing, and checking of credentials either through automated preclearance or manual methods. The CVO Inspector is an inspection and enforcement arm of the regulatory agencies with frequent direct interface with the Commercial Vehicles and their Drivers.
DMV	This terminator represents a specific (state) public organization responsible for registering vehicles, e.g., the Department of Motor Vehicles. The DMV terminator is a special case of the Government Administrators terminator but in some areas is identified separately to emphasize the specific nature of the data being exchanged, i.e. vehicle identification.
Driver	This terminator represents the human entity that operates a licensed vehicle on the roadway. Included are operators of private, Transit, Commercial, and Emergency vehicles where the data being sent or received is not particular to the type of vehicle. Thus this external originates driver requests and receives driver information that reflects the interactions that might be useful to all drivers, regardless of vehicle classification. The Driver terminator is the operator of the Basic Vehicle terminator. Information and interactions that are unique to drivers of a specific vehicle type (e.g., fleet interactions with transit, commercial, or emergency vehicle drivers) are covered separately.

Entity Name	Entity Description
Emergency Personnel	This terminator represents personnel that are responsible for police, fire, emergency medical services, towing, and other special response team (e.g., hazardous material clean-up) activities at an incident site. These personnel are associated with the Emergency Vehicle Subsystem during dispatch to the incident site, but often work independently of the Emergency Vehicle Subsystem while providing their incident response services. Emergency personnel may include an Officer in Charge (OIC) and a crew. When managing an incident following standard Incident Command System practices, the on-site emergency personnel form an organizational structure under the auspices of an Incident Commander.
Emergency System Operator	This terminator represents the human entity that monitors all ITS emergency requests, (including those from the E911 Operator) and sets up pre-defined responses to be executed by an emergency management system. The operator may also override predefined responses where it is observed that they are not achieving the desired result. This terminator includes dispatchers who manage an emergency fleet (police, fire, ambulance, HAZMAT, etc.) or higher order emergency managers who provide response coordination during emergencies.
Emergency Telecommunications System	This terminator represents the telecommunications systems that connect a caller with a Public Safety Answering Point (PSAP). These systems transparently support priority wireline and wireless caller access to the PSAP through 9-1-1 and other access mechanisms like 7 digit local access numbers, and motorist aid call boxes. The calls are routed to the appropriate PSAP, based on caller location when this information is available. When available, the caller's location and call-back number are also provided to the PSAP by this interface.
Enforcement Agency	This terminator represents an external entity which receives reports of violations detected by various ITS facilities, e.g. individual vehicle emissions, toll violations, CVO violations, etc.
Environment	This terminator is the operational setting in which the ITS interfaces and operates. This setting consists of weather effects such as snow, rain, fog, pollution, dust, temperature, humidity, solar radiation, and man made electromagnetic (RF) effects. Environmental conditions must be monitored by the ITS Architecture so that Travelers may be informed and control strategies can reflect adverse environmental conditions in a timely fashion.
Event Promoters	This terminator represents external Special Event Sponsors that have knowledge of events that may impact travel on roadways or other modal means. Examples of special event sponsors include sporting events, conventions, motorcades/parades, and public/political events. These promoters interface to the ITS to provide event information such as date, time, estimated duration, location, and any other information pertinent to traffic movement in the surrounding area.
Financial Institution	This terminator represents the organization that handles all electronic fund transfer requests to enable the transfer of funds from the user of the service to the provider of the service. The functions and activities of financial clearinghouses are subsumed by this entity.
Government Administrators	This terminator represents those public organizations responsible for regulating commercial vehicle operations, e.g., the Interstate Commerce Commission, state commerce offices, state Department of Motor Vehicles, state Department of Revenue, and Department of Transportation. Regulatory Agencies are envisioned to be an integral part of the ITS Commercial Vehicle Operations (CVO) as they will be directly involved with issuance of licenses, permits and other credentials for preclearance, provide database information to support most CVO services, and will receive, distribute, and audit CVO related taxes.
Government Reporting Systems	This terminator represents the system and associated personnel that prepare the inputs to support the various local, state, and federal government transportation data reporting requirements (e.g. Highway Performance Monitoring System, Fatal Analysis Reporting System) using data collected by ITS systems. This terminator represents a system interface that would provide access to the archived data that is relevant to these reports. In most cases, this terminator would manually combine data collected from the ITS archives with data from non ITS sources to assemble and submit the required information.
Intermodal Freight Depot	A Depot operated either by an ITS Freight manager or an alternate mode freight shipper which is capable of tracking cargo as it is moved from one mode to another.

Entity Name	Entity Description
Intermodal Freight Shipper	This terminator represents specialist organizations that engage in the shipment of freight by means other than road. They enable ITS to move goods as opposed to people on routes that require the use of other modes of transportation such as heavy rail, air, sea, etc. An example is a shipping agency that interfaces with Fleet and Freight Managers to transfer cargo from one mode to another.
ISP Operator	This terminator is the human entity that may be physically present at the ISP to monitor the operational status of the facility and provide human interface capabilities to travelers and other ISP subsystems.
Location Data Source	This terminator represents an external entity that provides accurate position information. External systems that use GPS, terrestrial trilateration, or driver inputs are potential examples. This terminator contains sensors such as radio position receivers (e.g. GPS) and/or dead reckoning sensors (e.g. odometer, differential odometer, magnetic compass, gyro, etc.). This external implies that some additional functionality associated with developing an absolute position is outside the system and will not be directly modeled by the logical or physical architecture representations of the system.
Map Update Provider	This terminator represents a third-party developer and provider of digitized map databases used to support ITS services. It supports the provision of the databases that are required exclusively for route guidance (navigable_map) as well as those that are used exclusively for display by operators and at traveler information points, e.g. kiosks (display_map).
Media	This terminator represents the information systems that provide traffic reports, travel conditions, and other transportation-related news services to the traveling public through radio, TV, and other media. Traffic and travel advisory information that are collected by ITS are provided to this terminator. It is also a source for traffic flow information, incident and special event information, and other events that may have implications for the transportation system.
Multimodal Crossings	This terminator represents the control equipment that interfaces to a non-road based transportation system at an interference crossing with the roadway. The majority of these crossings are railroad grade crossings that are more specifically addressed by the "Wayside Equipment" terminator. This terminator addresses similar interface requirements, but for other specialized intersections like draw bridges at rivers and canals. Like highway-rail intersections, these other multimodal crossings carry traffic that may take priority over the road traffic at the intersection. The data provided will in its basic form be a simple "stop road traffic" indication. However more complex data flows may be provided that give the time at which right-of-way will be required and the duration of that right-of-way requirement.
Multimodal Transportation Service Provider	This terminator provides the interface through which Transportation Service Providers can exchange data with ITS. They are the operators of non-roadway transportation systems (e.g. airlines, ferry services, passenger carrying heavy rail). This two-way interface enables coordination for efficient movement of people across multiple transportation modes. It also enables the traveler to efficiently plan itineraries which include segments using modes not directly included in the ITS User Services.
Other Archives	This terminator represents distributed archived data systems or centers whose data can be accessed and shared with a local archive. The interface between the Other Archives Terminator and the Archived Data Management Subsystem allows data from multiple archives to be accessed on demand or imported and consolidated into a single repository.
Other CVAS	This terminator is intended to provide a source and destination for ITS data flows between peer (e.g. inter-regional) commercial vehicle administration functions. It enables commercial vehicle administration activities to be coordinated across different jurisdictional areas. In the Physical Architecture, this terminator is a reciprocal Commercial Vehicle Administration Subsystem (CVAS).
Other Data Sources	This terminator represents the myriad systems and databases containing data not generated from subsystems and terminators represented in the National ITS Architecture that can provide predefined data sets to the ITS archive. The terminator can provide economic, cost, demographic, land use, law enforcement, and other data that is not collected by ITS systems and would otherwise be unavailable within an ITS data archive.

Entity Name	Entity Description
Other EM	Representing other Emergency Management centers, systems or subsystems, this terminator provides a source and destination for ITS data flows between various communications centers operated by public safety agencies as well as centers operated by other allied agencies and private companies that participate in coordinated management of highway-related incidents. The interface represented by this terminator enables emergency management activities to be coordinated across jurisdictional boundaries and between functional areas. In the Physical Architecture this terminator is a reciprocal Emergency Management Subsystem (EM) implying the requirements for general networks connecting many allied agencies. The interface between this terminator and the EM supports coordination of incident management information between many different centers providing Public Safety Answering Point (both public or private sector implementations), Public Safety Dispatch, Emergency Operations, and other functions that participate in the detection, verification, response, and clearance of highway incidents. This terminator also supports interface to other allied agencies like utility companies that also participate in the coordinated response to selected highway-related incidents.
Other ISP	Representing other distinct Information Service Providers, this terminator is intended to provide a source and destination for ITS data flows between peer information and service provider functions. It enables cooperative information sharing between providers as conditions warrant. In the Physical Architecture this terminator is a reciprocal Information Service Provider (ISP) Subsystem.
Other Parking	Representing another parking facility, system or subsystem, this terminator provides a source and destination for information that may be exchanged between peer parking systems. This terminator enables parking management activities to be coordinated between different parking operators or systems in a region. In the Physical Architecture this terminator is a reciprocal Parking Management Subsystem.
Other TM	Representing another Traffic Management center, system or subsystem, this terminator is intended to provide a source and destination for ITS data flows between peer (e.g. inter-regional) traffic management functions. It enables traffic management activities to be coordinated across different jurisdictional areas. In the Physical Architecture this terminator is a reciprocal Traffic Management Subsystem (TMS).
Other TRM	Representing another Transit Management center, system or subsystem, this terminator is intended to provide a source and destination for ITS data flows between peer (e.g. inter-regional) transit management functions. It enables traffic management activities to be coordinated across geographic boundaries or different jurisdictional areas. In the Physical Architecture this terminator represents a reciprocal Transit Management Subsystem (TRMS).
Other Vehicle	This terminator represents a vehicle (of any 4 vehicle types) that is neighboring the Basic Vehicle, where the Basic Vehicle is equipped to support vehicle-to-vehicle communication and coordination. These features are associated with advanced vehicle safety User Service implementations. These high-end vehicle control services may involve vehicles coordinating their activities.
Parking Operator	This terminator is the human entity that may be physically present at the parking lot facility to monitor the operational status of the facility.
Payment Instrument	This terminator represents the entity that enables the actual transfer of funds from the user of a service to the provider of the service. This terminator can be as abstract as an account number in the Logical Architecture, or as real as the electronic tag in the Physical architecture.
Pedestrians	This terminator provides input (e.g. a request for right of way at an intersection) from a specialized form of the Traveler, who is not using any type of vehicle (including bicycles) as a form of transport. Pedestrians may comprise those on foot and those in wheelchairs.
Potential Obstacles	Any object that possesses the potential of being sensed and struck and thus also possesses physical attributes. Potential Obstacles include roadside obstructions, other vehicles, pedestrians, infrastructure elements or any other element which is in a potential path of the vehicle. This external represents the physical obstacles that possess properties which enable detection using sensory functions included as part of the ITS architecture. These physical attributes are represented as a data input to the system.

Entity Name	Entity Description
Rail Operations	This is roughly the railroad equivalent to a highway Traffic Management Center. It is (usually) a centralized control point for a substantial segment of a railroad's operations. It is the source and destination of information that can be used to coordinate rail and highway traffic management. This terminator would also represent a railroad's management information system, if that system is the source or destination for this information. The use of a single terminator for multiple sources and destination for information exchange with the railroad entity is meant to imply the need for a single, consistent interface between a given railroad's operations and ITS traffic management. In any given implementation of ITS there may be multiple instantiations of this interface. For example, a city like Chicago may have interfaces to 5 or more Rail Operations Centers (e.g. BNSF, CSX, NS, UP. CR, etc.)
Roadway	This terminator represents the physical conditions and geometry of the surface on which vehicles travel from an origin to a destination. Roadways can vary in type, such as surface streets, arterials, multi-lane highways, 2-lane rural roads, expressways, tollways, freeways, or any other vehicle travel surface. The condition of the roadway must be monitored by the architecture to enable corrective action and information dissemination regarding roadway conditions which may adversely affect travel. Roadways can also depict travel networks, such as surface street networks, arterial networks, or freeway networks. The roadway interface to the system carries the physical condition and geometry attributes that must be sensed, interpreted, and processed by functions internal to the system to achieve ITS User Service functionality.
Roadway Environment	This terminator represents the physical conditions surrounding the roadway itself. These may include emissions, fog, ice, snow, rain, etc. which will influence the way in which a vehicle can be safely operated on the roadway.
Secure Area Environment	This terminator comprises public access areas that transit users frequent during trips. Areas include bus stops, park and ride (PAR) facilities, at kiosks, and other transit transfer locations. These environments are monitored as part of the ITS Architecture functions to promote transit safety.
Toll Administrator	The Toll Administrator is the human entity that manages the back office payment administration systems for a electronic toll system. This terminator monitors the systems that support the electronic transfer of authenticated funds from the customer to the system operator. The terminator monitors customer enrollment and supports the establishment of escrow accounts depending on the clearinghouse scheme and the type of payments involved. The terminator also establishes and administers the pricing structures and policies.
Toll Operator	The Toll Operator is the human entity that may be physically present at the toll plaza to monitor the operational status of the plaza.
Traffic	The Traffic terminator represents the collective body of vehicles that travel on surface streets, arterials, highways, expressways, tollways, freeways, or any other vehicle travel surface. Traffic depicts the vehicle population from which traffic flow surveillance information is collected (average occupancy, average speed, total volume, average delay, etc.), and to which traffic control indicators are applied (intersection signals, stop signs, ramp meters, lane control barriers, variable speed limit indicators, etc.). All sensory and control elements that interface to this vehicle population are internal to ITS.
Traffic Operations Personnel	This terminator represents the human entity that directly interfaces with vehicle traffic operations. These personnel interact with traffic control systems, traffic surveillance systems, incident management systems, work zone management systems, and travel demand management systems to accomplish ITS services. They provide operator data and command inputs to direct systems' operations to varying degrees depending on the type of system and the deployment scenario. All functionality associated with these services that might be automated in the course of ITS deployment is modeled as internal to the architecture.

Entity Name	Entity Description
Transit Driver	This terminator represents the human entity that is a special form of the Driver terminator that receives and provides additional information that is specific to Transit (including demand responsive transit) operations. This information will not be received by other types of Driver. The Transit Driver terminator operates the Transit Vehicle terminator and represents random route drivers, flexible fixed route drivers and fixed route drivers. The fixed route drivers require minimal information such as run times and passenger loading. The flexible, fixed, and random route drivers require additional information such as dynamically changing routes.
Transit Fleet Manager	This terminator represents the human entity that is responsible for planning the operation of transit fleets, including monitoring and controlling the transit fleet route schedules and the transit fleet maintenance schedules. This comprises planning routes and schedules for either daily use or for special occasions as distinct from making day to day variations to schedules and routes.
Transit Maintenance Personnel	The terminator represents the human entity that is actively responsible for monitoring, controlling, and planning the schedules for the maintenance of transit fleets.
Transit System Operators	This terminator represents the human entities that are responsible for all aspects of the Transit subsystem operation including planning and management. They actively monitor, control, and modify the transit fleet routes and schedules on a day to day basis. The modifications will be to take account of abnormal situations such as vehicle breakdown, vehicle delay, etc. These personnel may also be responsible for demand responsive transit operation and for managing emergency situations within the transit network.
Transit User	This terminator represents the human entities using Public Transit vehicles. They may be in the act of embarking or debarking the vehicles and are thus sensed for the purpose of determining passenger loading and fares, or on the vehicles and able to request and receive information.
Transit Vehicle	This terminator represents a specialized form of the Basic Vehicle used by transit service providers. It supports equipment to collect fares, monitor activities, request priority at signals, and provide information to travelers. It may be a bus, LRT vehicle, or other vehicle specially designed for the carriage of passengers, such as those used by demand responsive transit operators. The monitoring of the Transit Vehicle mechanical condition and mileage provides the major inputs for transit vehicle maintenance scheduling.
Traveler	This terminator represents any individual (human) who uses transportation services. At the time that data is passed to or from the terminator the individual is neither a driver, pedestrian, or transit user. This means that the data provided is that for pre-trip planning or multimodal personal guidance and includes their requests for assistance in an emergency. Subsequent to receipt of pre-trip information, a Traveler may become a vehicle driver, passenger, transit user, or pedestrian.
Vehicle Characteristics	This terminator represents the external view of an individual vehicle. It includes vehicle characteristics such as height, width, length, weight, and other properties (e.g., magnetic properties, number of axles) that allow an individual vehicle to be detected and measured or classified. This external view of an individual vehicle is also used as a source of visible data that supports individual vehicle imaging requirements in the architecture. ITS subsystems at the roadside sense these characteristics and generate ITS data flows. These individual vehicle characteristics are important for toll collection, parking management, and other applications that identify and measure individual vehicles. See also the related "Traffic" terminator which represents physical characteristics of many vehicles in the aggregate that is measured for general traffic applications.
Wayside Equipment	This terminator represents train interface equipment (usually) maintained and operated by the railroad and (usually) physically located at or near a grade crossing. This terminator is the source and destination for HRI information for, or about, approaching trains and their crews (e.g. the time at which the train will arrive and the time it will take to clear a crossing, crossing status or warnings, etc.). Generally one wayside equipment interface would be associated with one highway rail intersection. However, multiple crossings may be controlled using information based on data from one wayside equipment interface.

Entity Name	Entity Description
Weather Service	This terminator provides weather, hydrologic, and climate information and warnings of hazardous weather including thunderstorms, flooding, hurricanes, tornadoes, winter weather, tsunamis, and climate events. It provides current and forecast weather data that is collected and derived by the National Weather Service, private sector providers, and various research organizations. The interface provides formatted weather data products suitable for on-line processing and integration with other ITS data products as well as Doppler radar images, satellite images, severe storm warnings, and other products that are formatted for presentation to various ITS users.
Yellow Pages Service Providers	This terminator represents the individual organizations that provide any service oriented towards the Traveler. Example services that could be included are gas, food, lodging, vehicle repair, points of interest, and recreation areas. The Service Providers may pay a fee to have their services advertised to travelers. The interface with the Service Provider is necessary so that accurate, up-to-date service information can be provided to the traveler and to support electronic reservation capabilities included in the ITS User Services.

1.4. Graphical Data Flow Model

1.4.1. Introduction

This section contains a complete set of Data Flow Diagrams (DFDs) for the ITS Logical Architecture. They are taken from the Logical Architecture model produced by the CASE tool (Teamwork) used by the Architecture Development Team.

1.4.2. Data Flow Diagrams

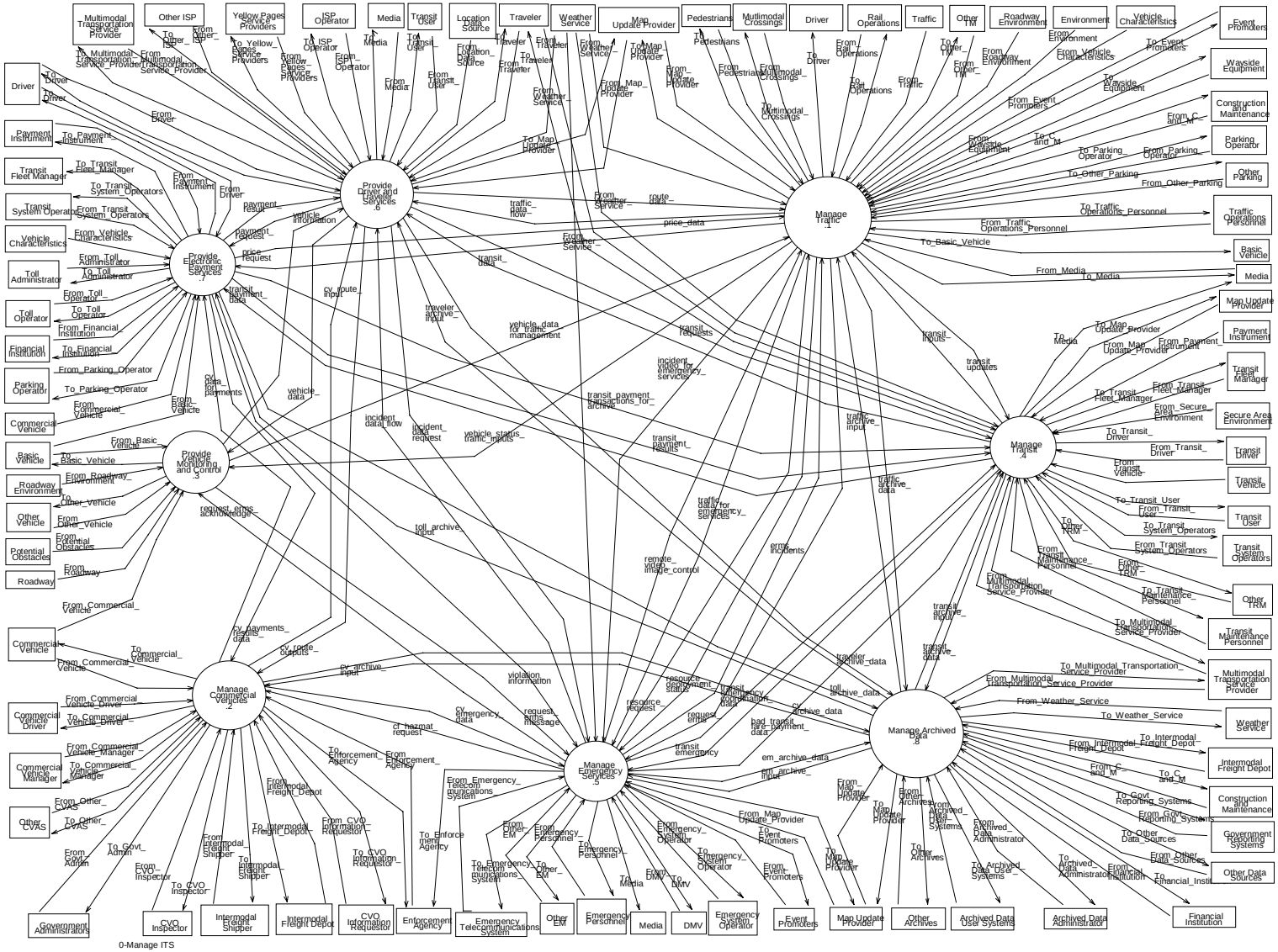


Figure 5. Manage ITS (DFD 0)

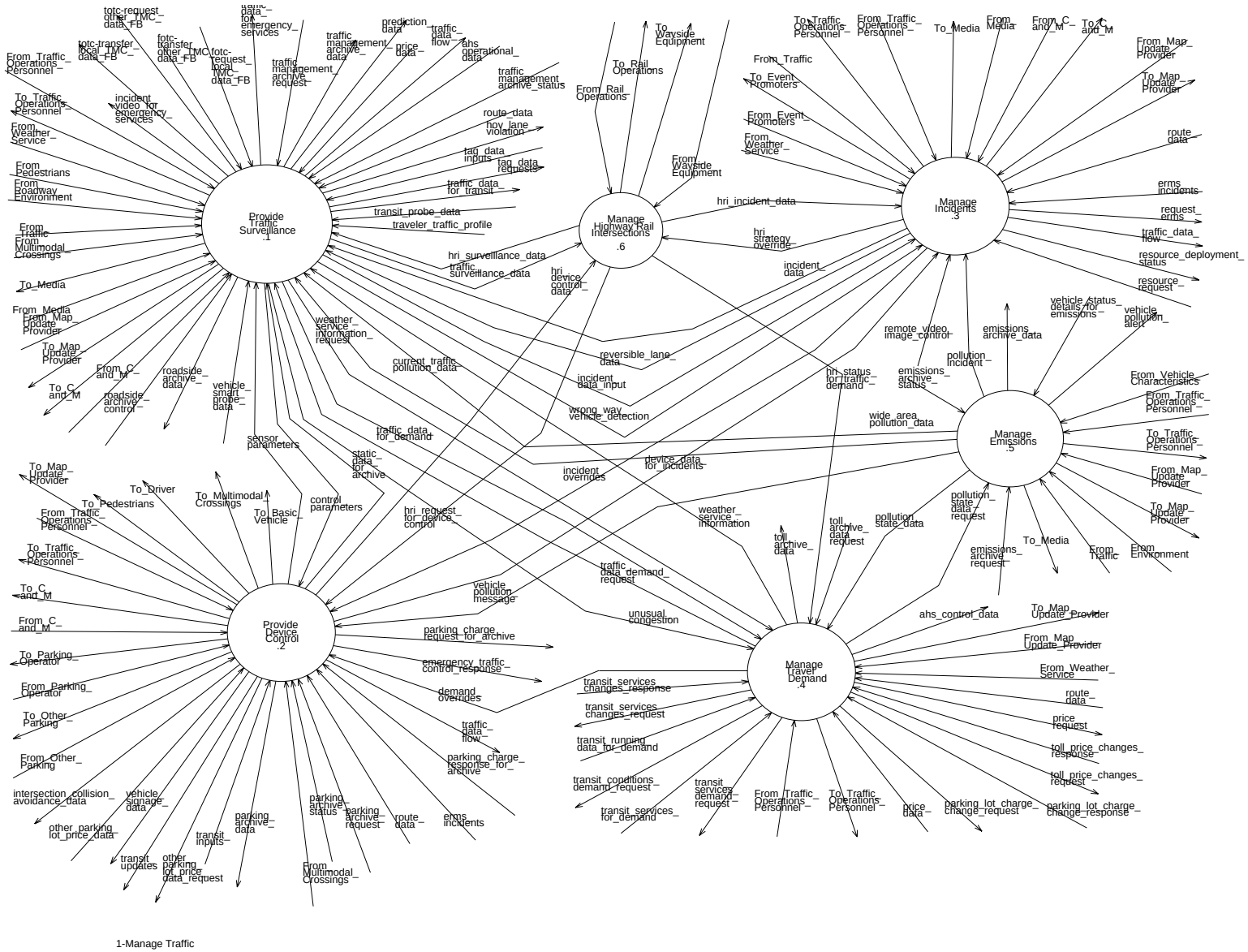


Figure 6. Manage Traffic (DFD 1)

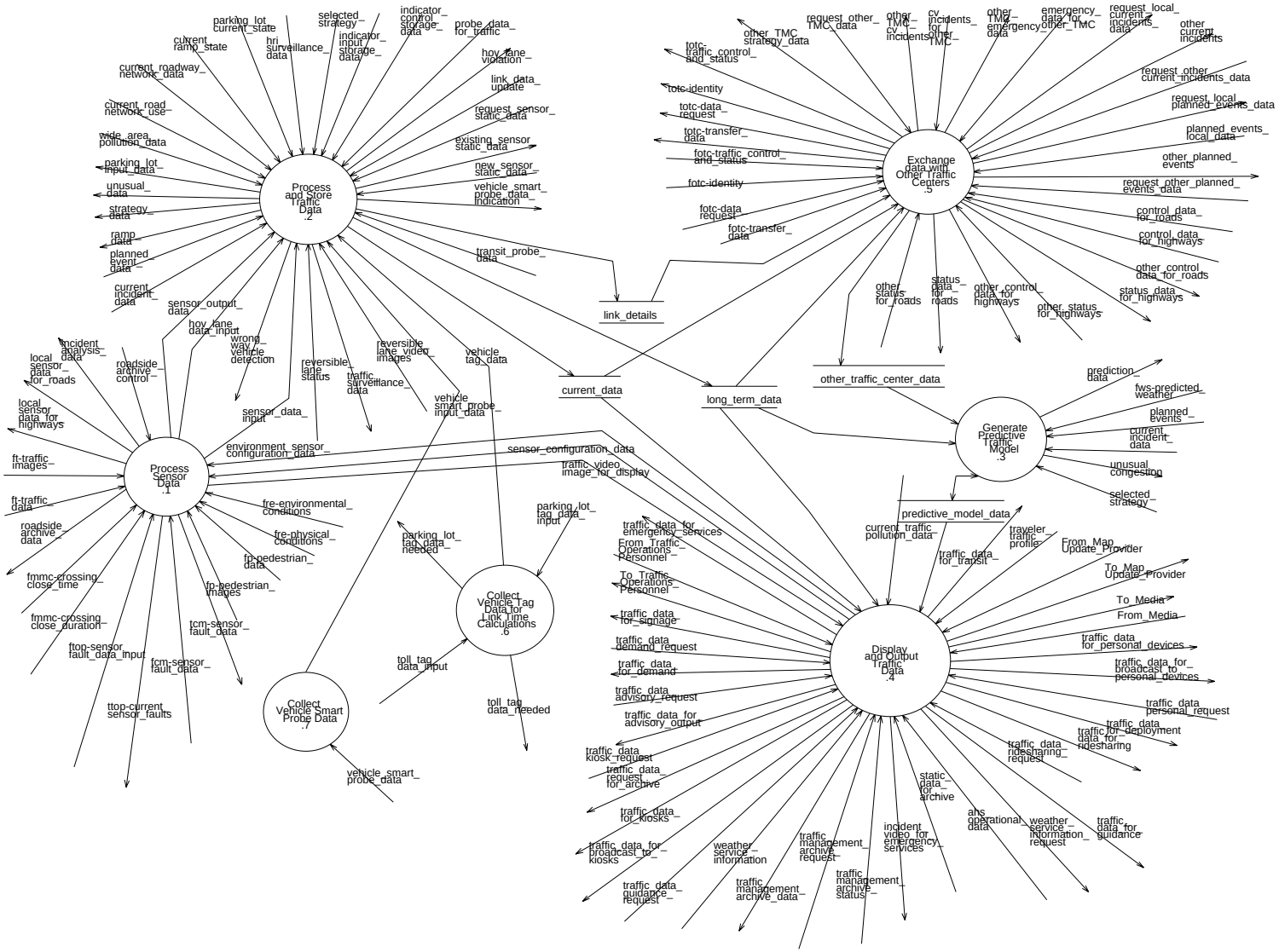
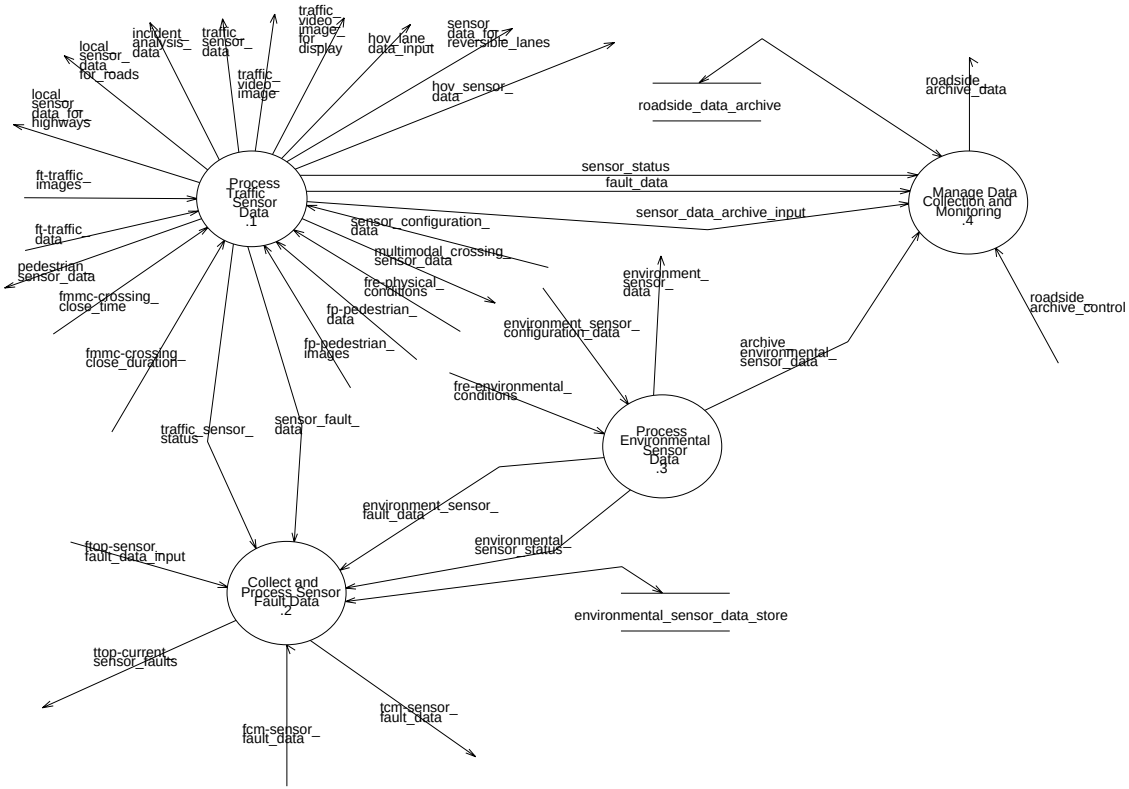
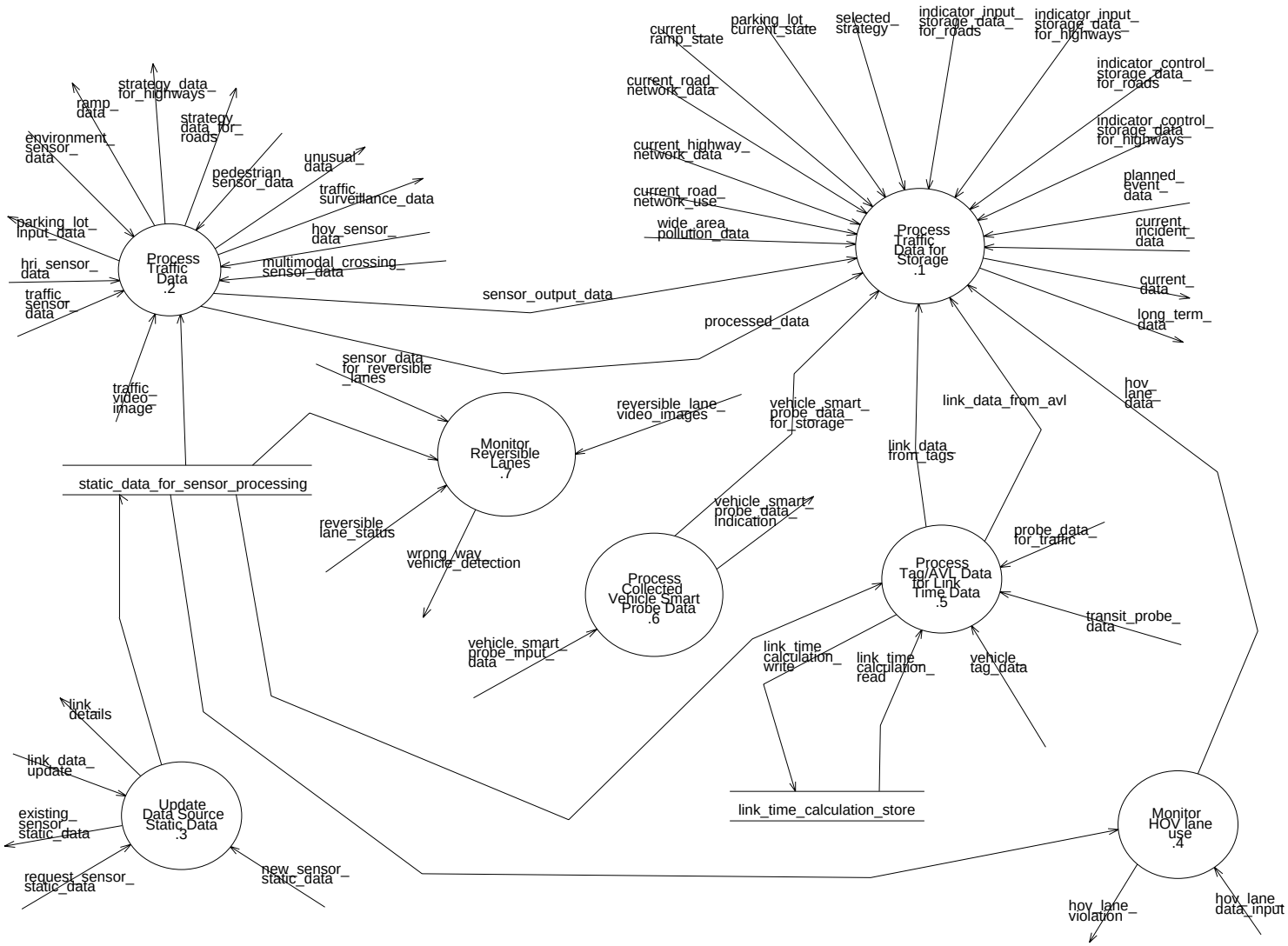


Figure 7. Provide Traffic Surveillance (DFD 1.1)



1.1.1-Process Sensor Data

Figure 8. Process Sensor Data (DFD 1.1.1)



1.1.2-Process and Store Traffic Data

Figure 9. Process and Store Traffic Data (DFD 1.1.2)

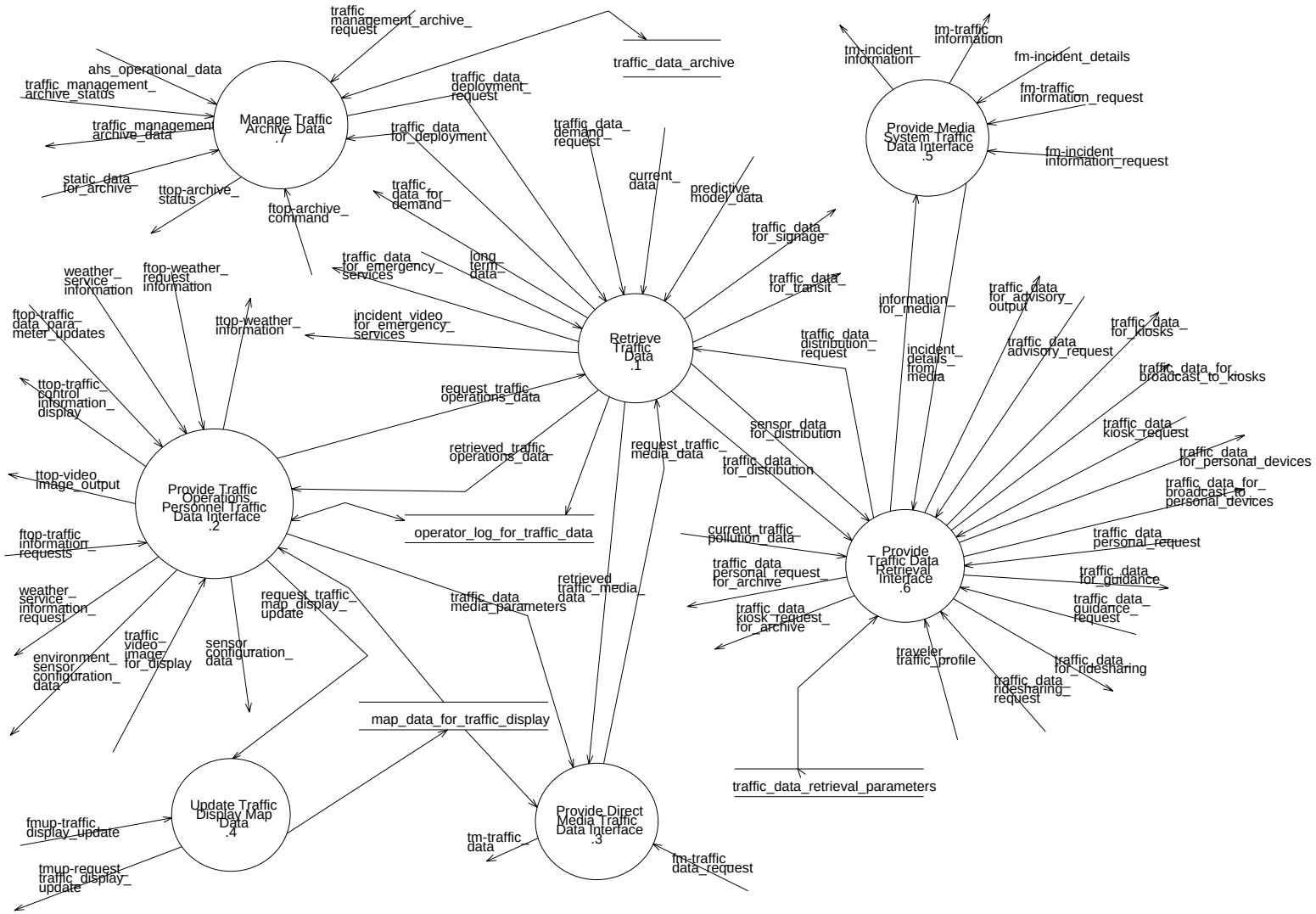
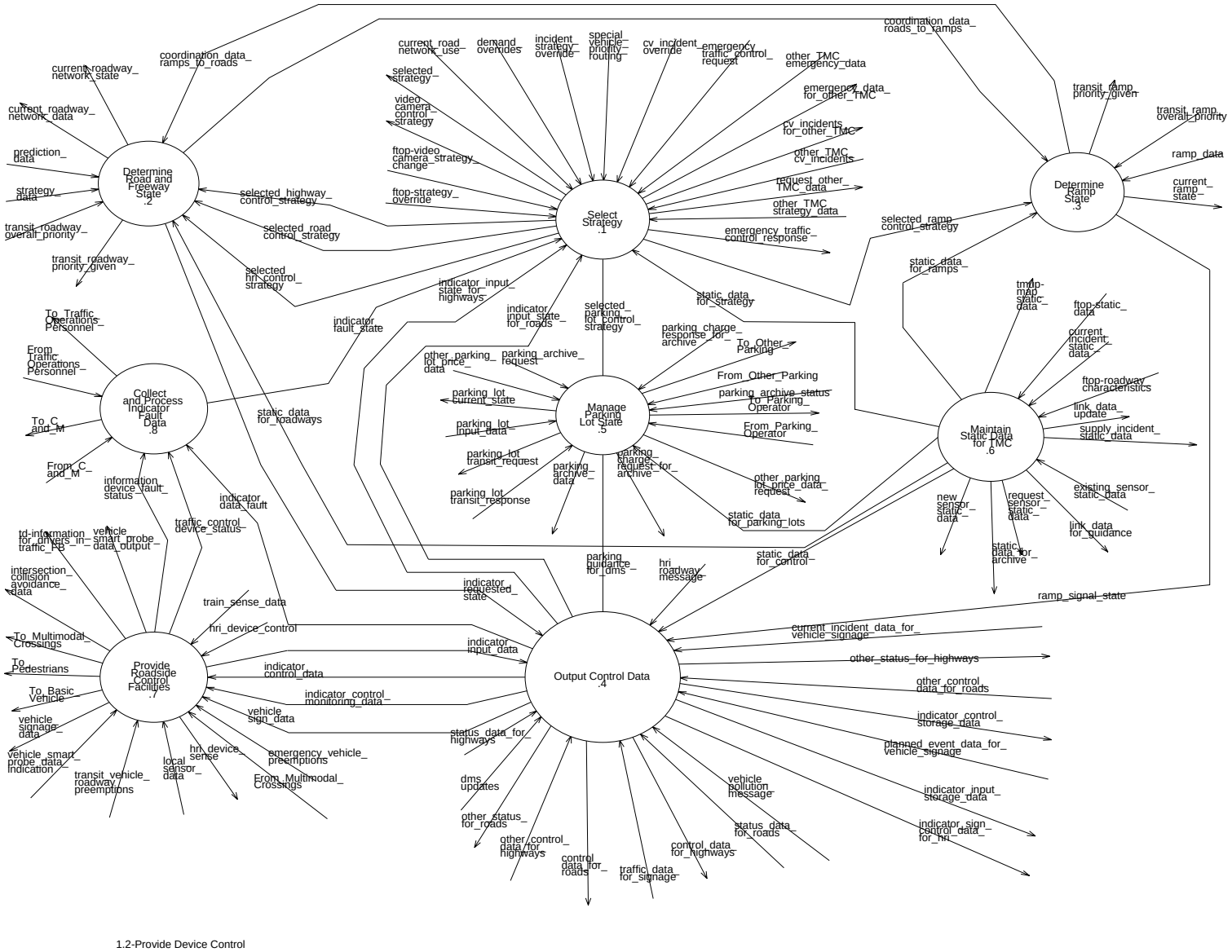
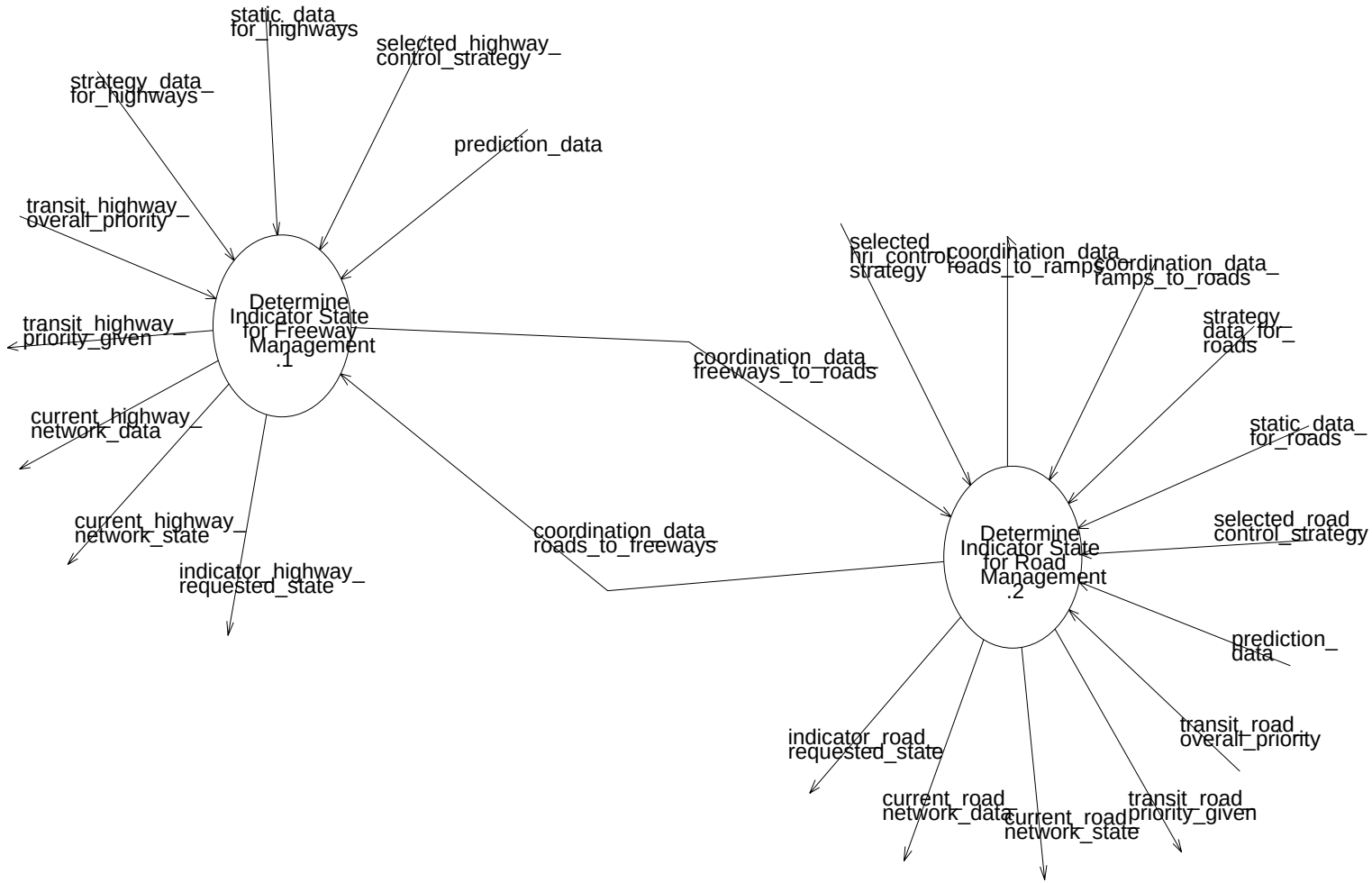


Figure 10. Display and Output Traffic Data (DFD 1.1.4)



1.2-Provide Device Control

Figure 11. Provide Device Control (DFD 1.2)



1.2.2-Determine Road and Freeway State

Figure 12. Determine Road and Freeway State (DFD 1.2.2)

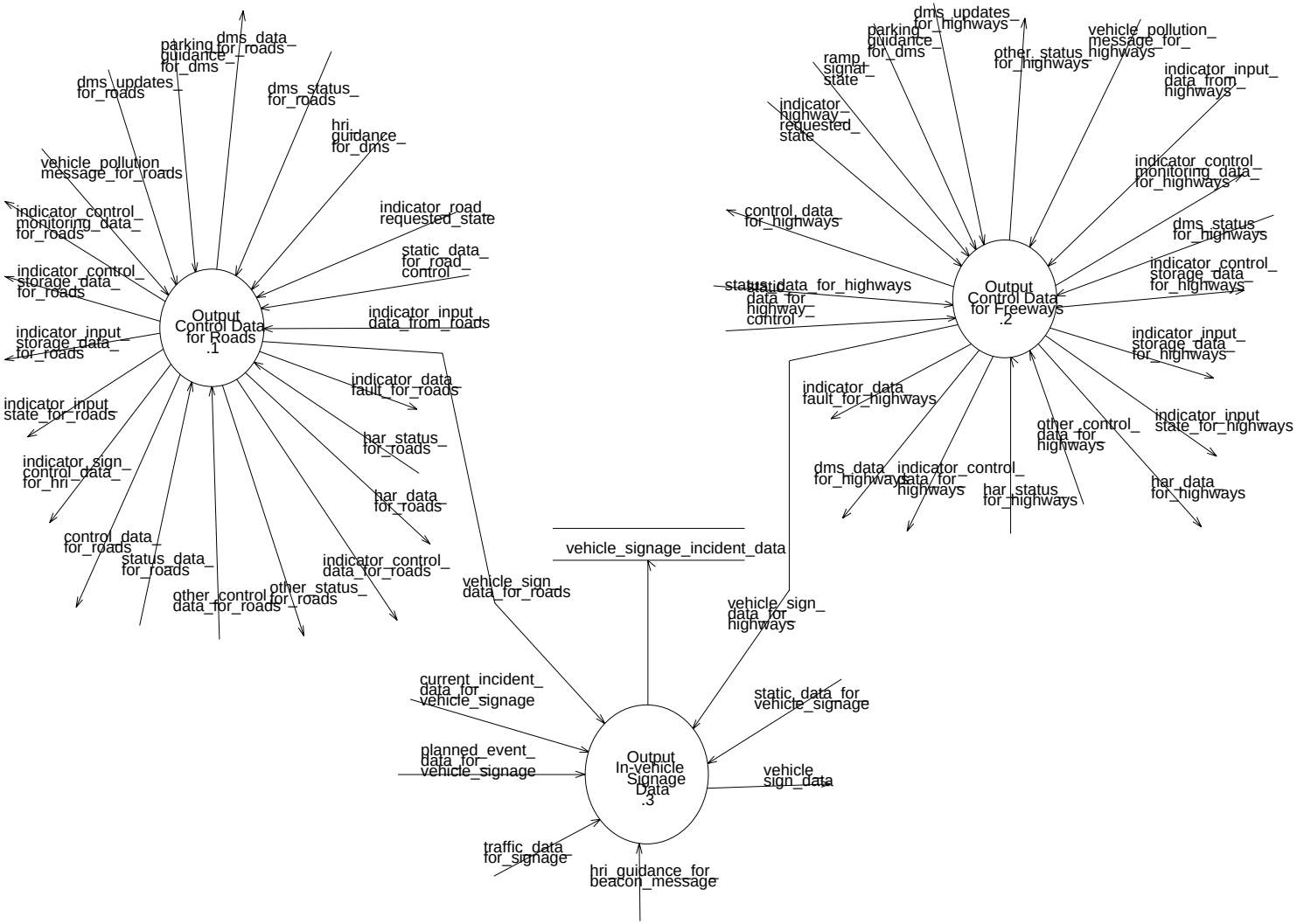


Figure 13. Output Control Data (DFD 1.2.4)

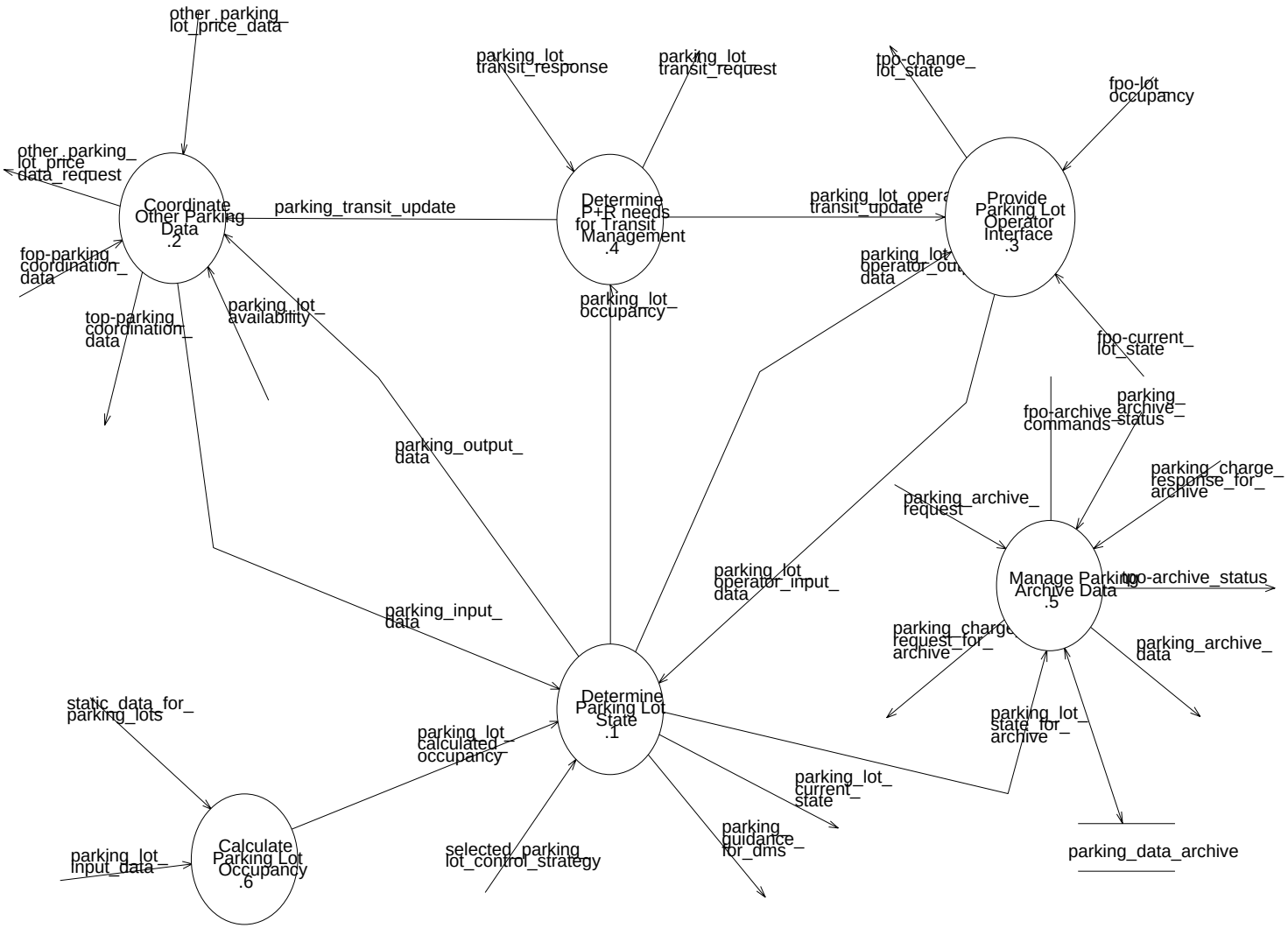
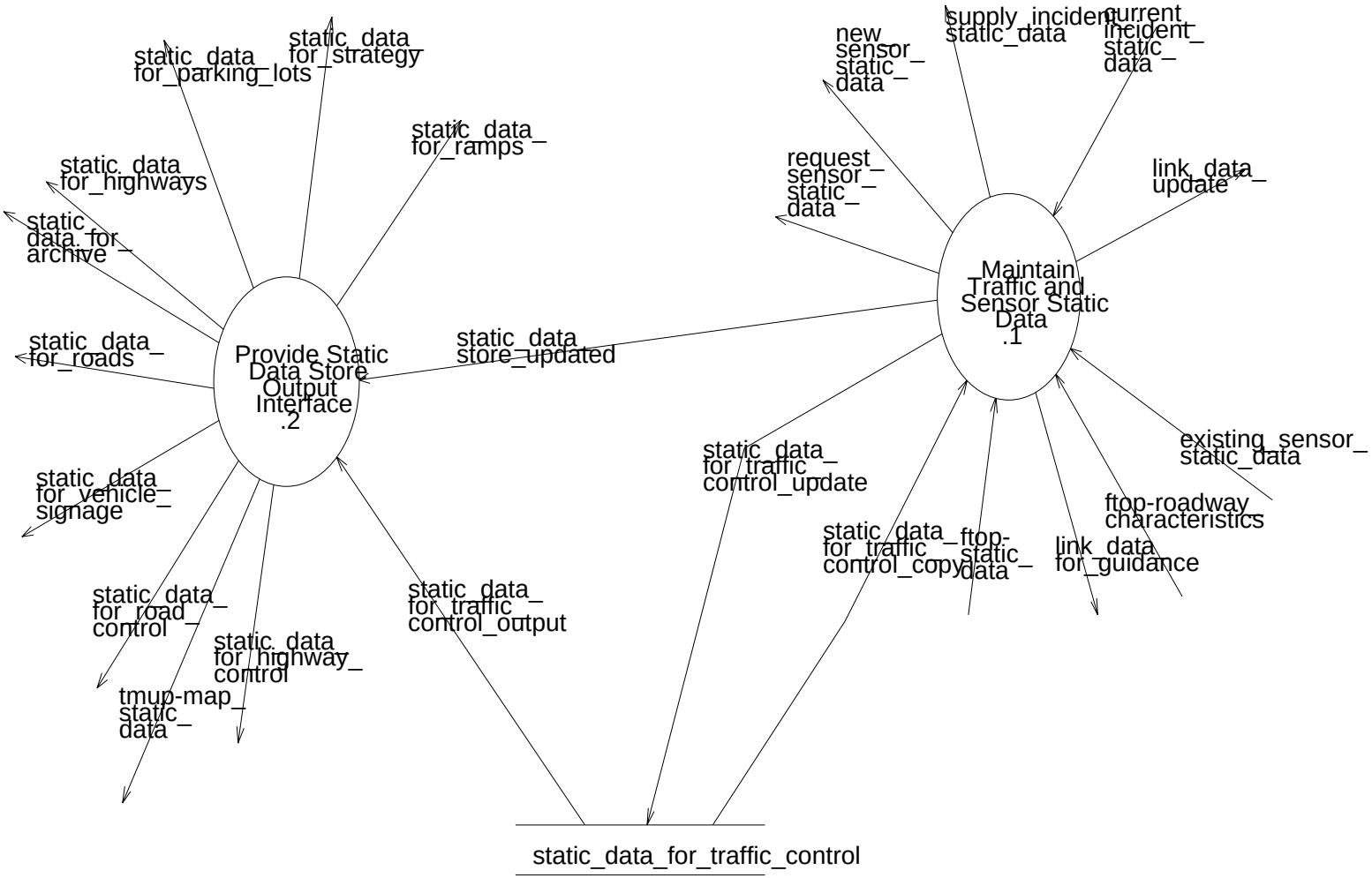
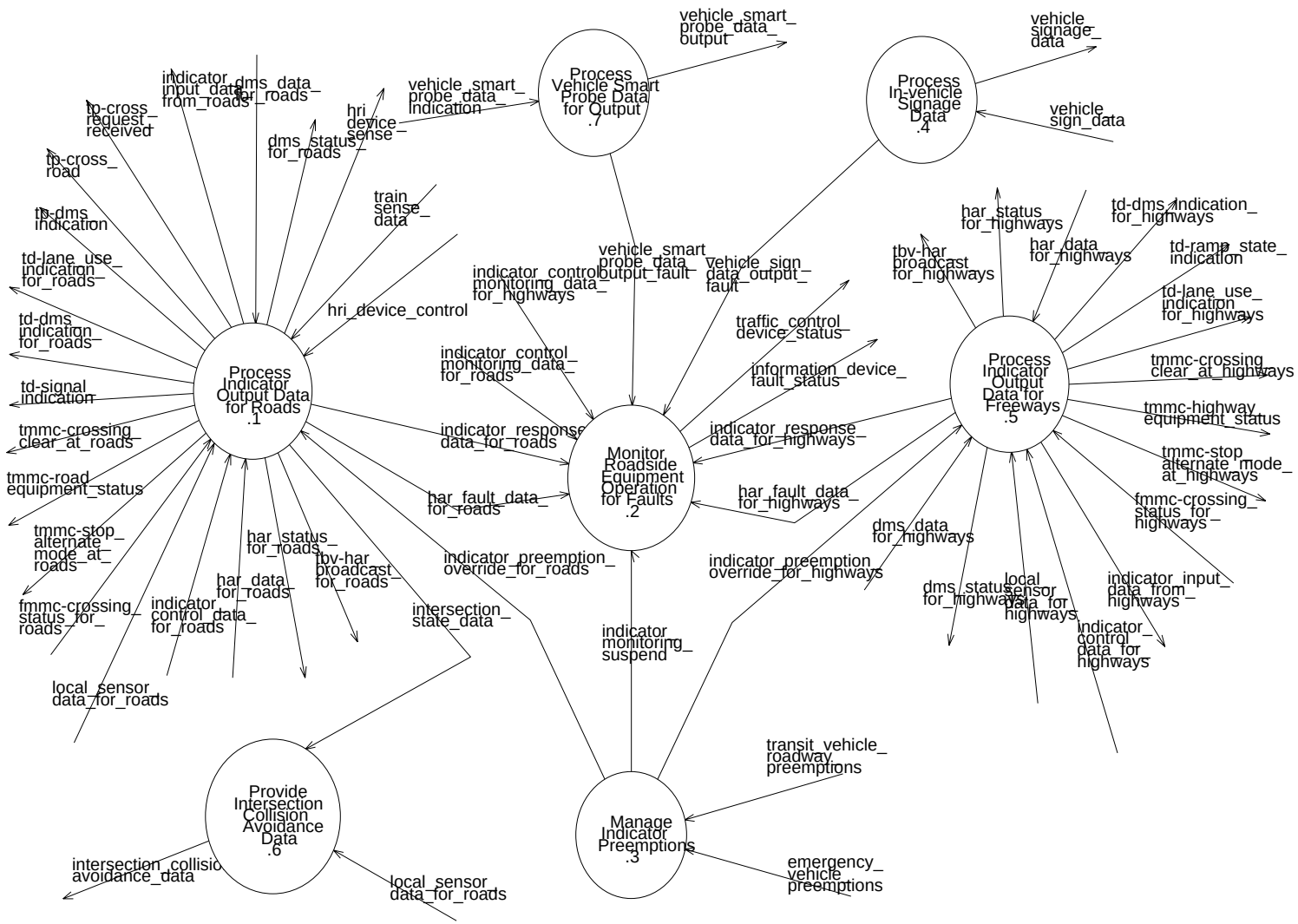


Figure 14. Manage Parking Lot State (DFD 1.2.5)



1.2.6-Maintain Static Data for TMC

Figure 15. Maintain Static Data for TMC (DFD 1.2.6)



1.2.7-Provide Roadside Control Facilities

Figure 16. Provide Roadside Control Facilities (DFD 1.2.7)

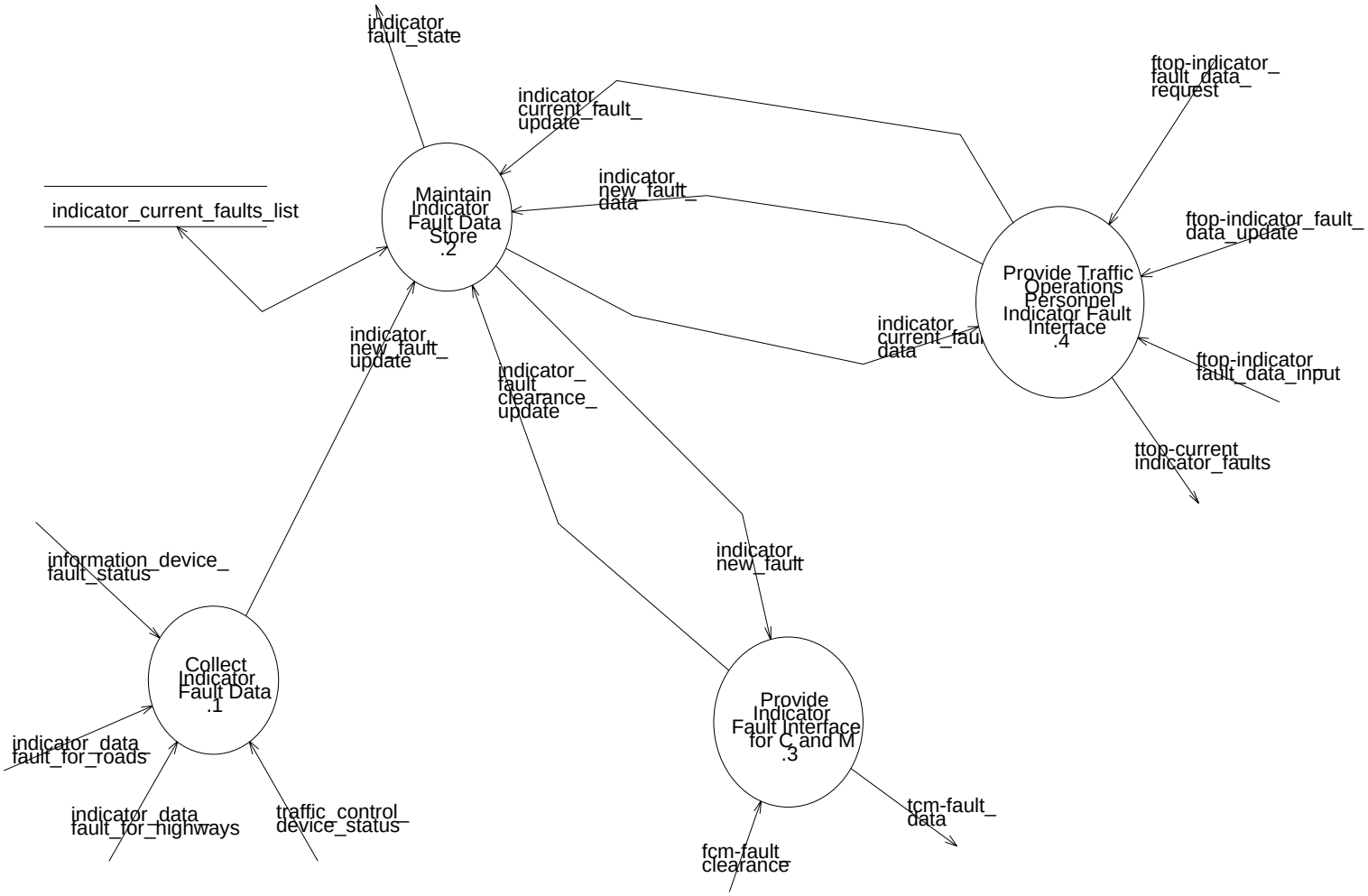
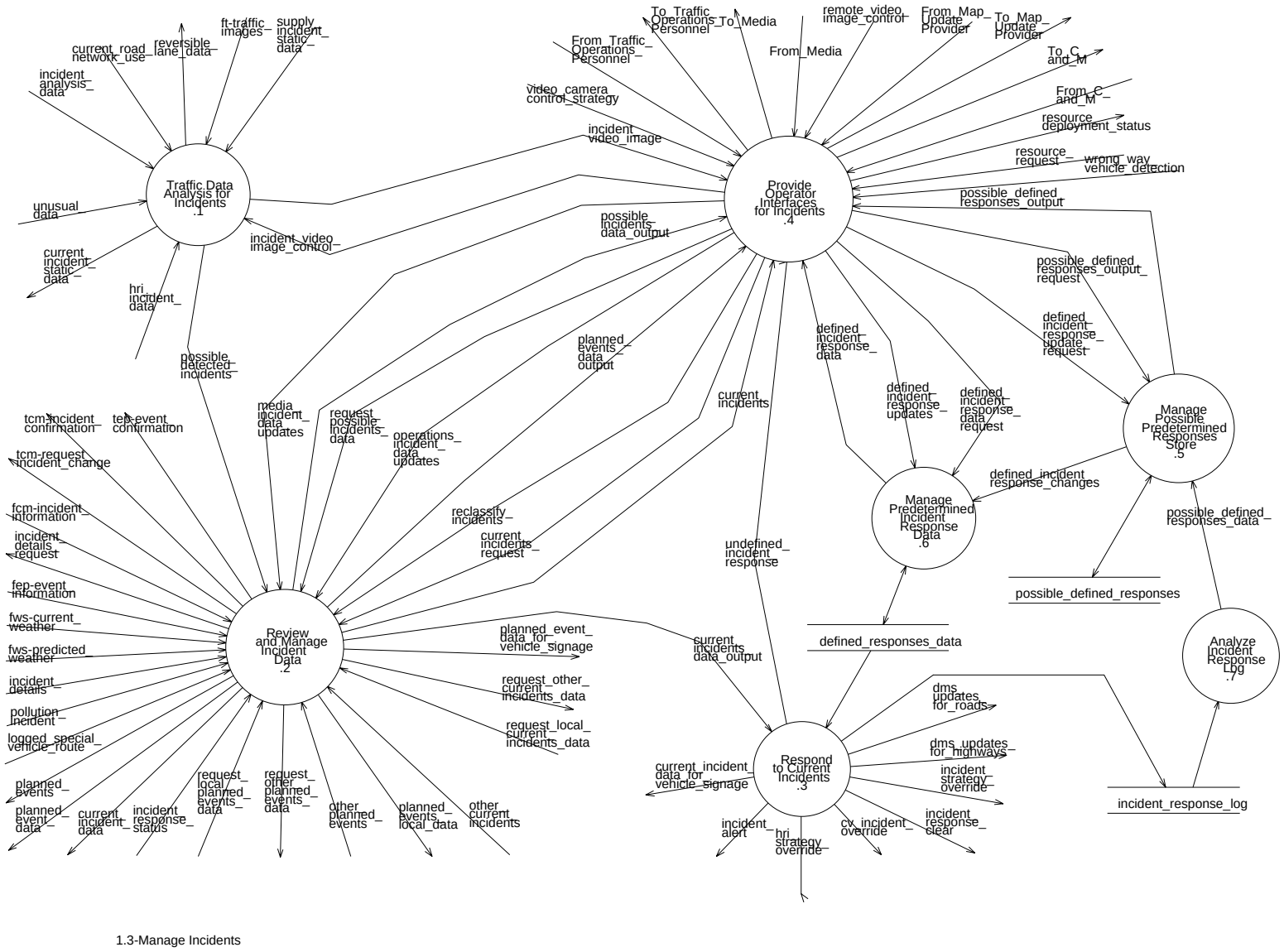


Figure 17. Collect and Process Indicator Fault Data (DFD 1.2.8)



1.3-Manage Incidents

Figure 18. Manage Incidents (DFD 1.3)

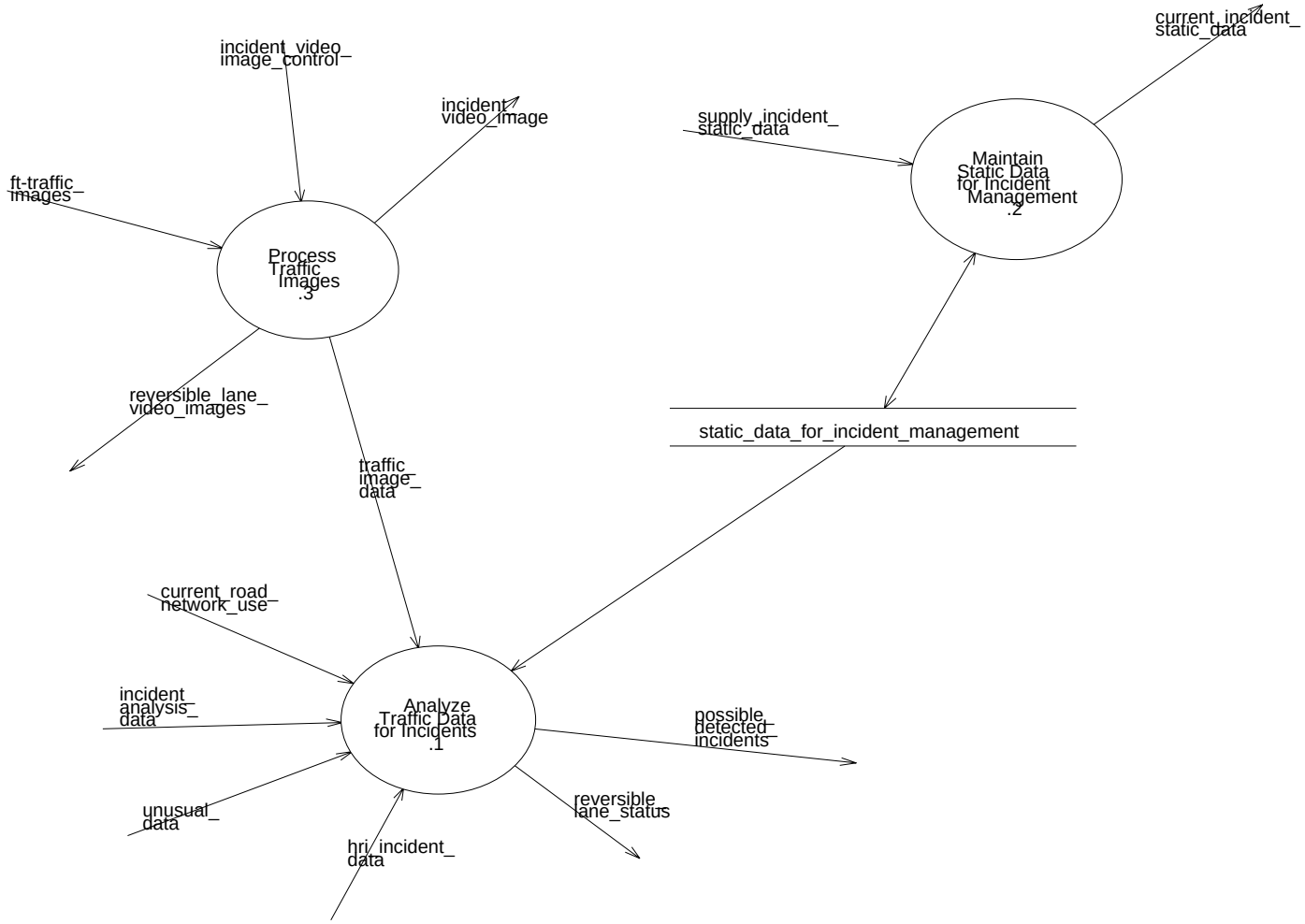


Figure 19. Traffic Data Analysis for Incidents (DFD 1.3.1)

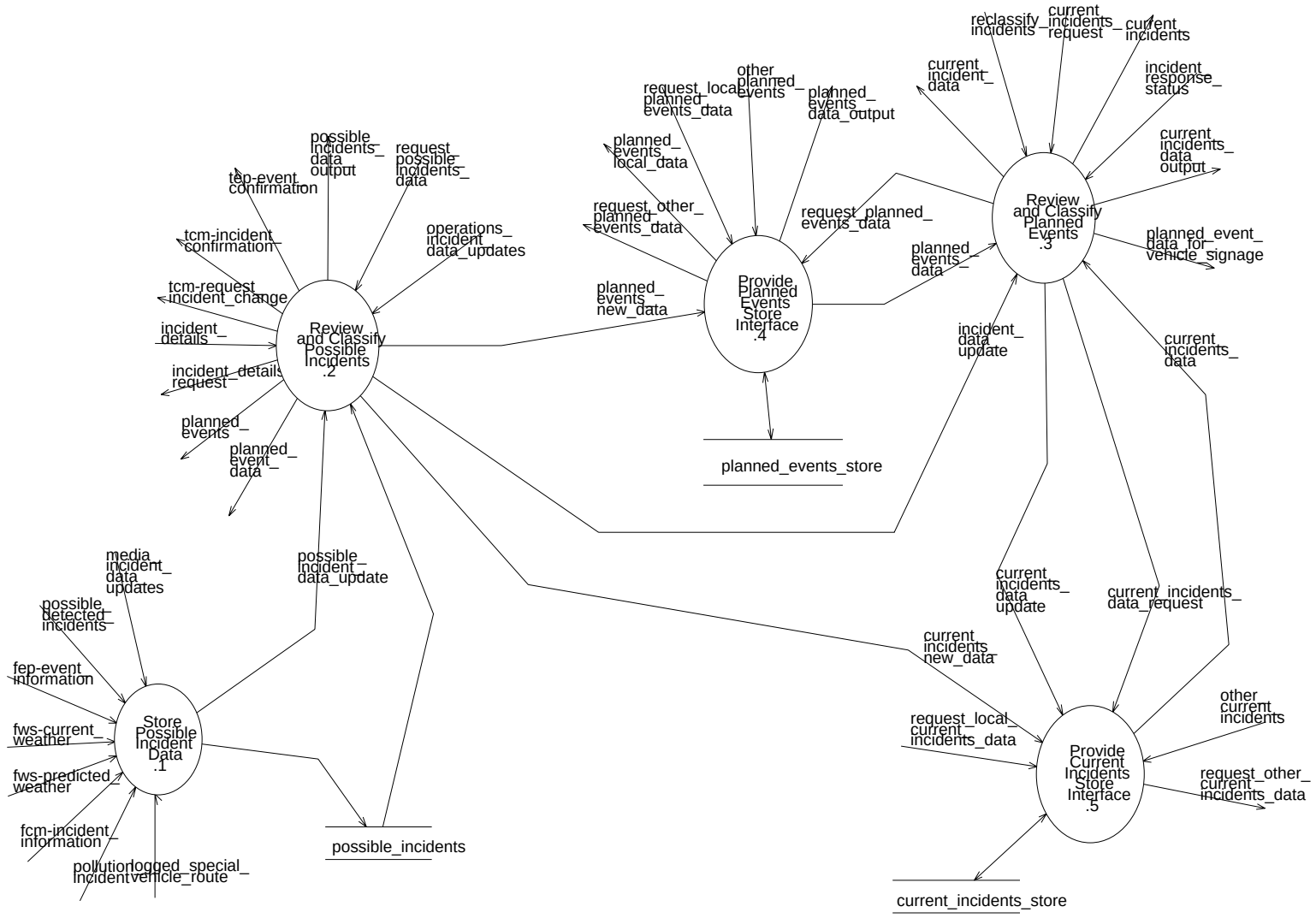


Figure 20. Review and Manage Incident Data (DFD 1.3.2)

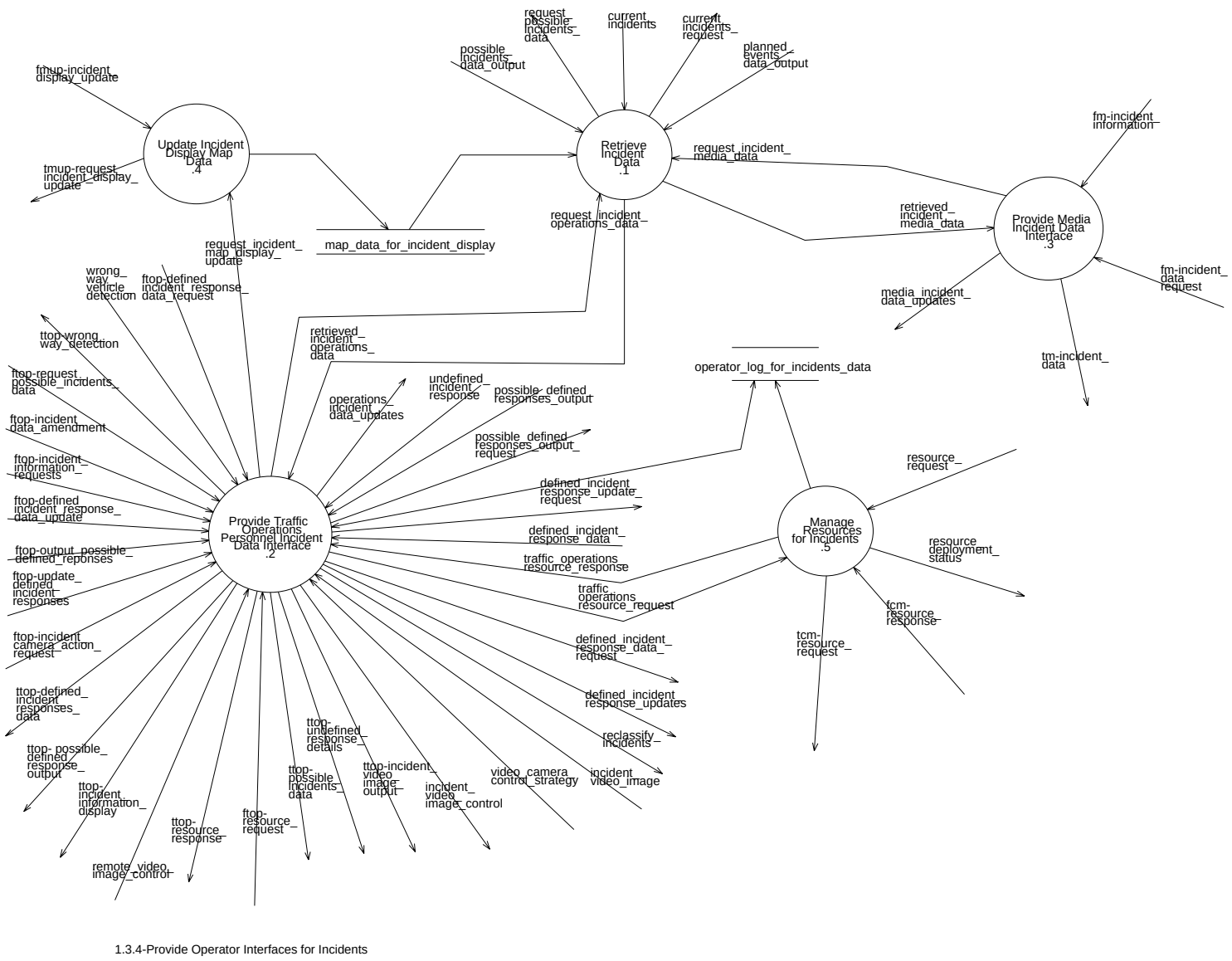
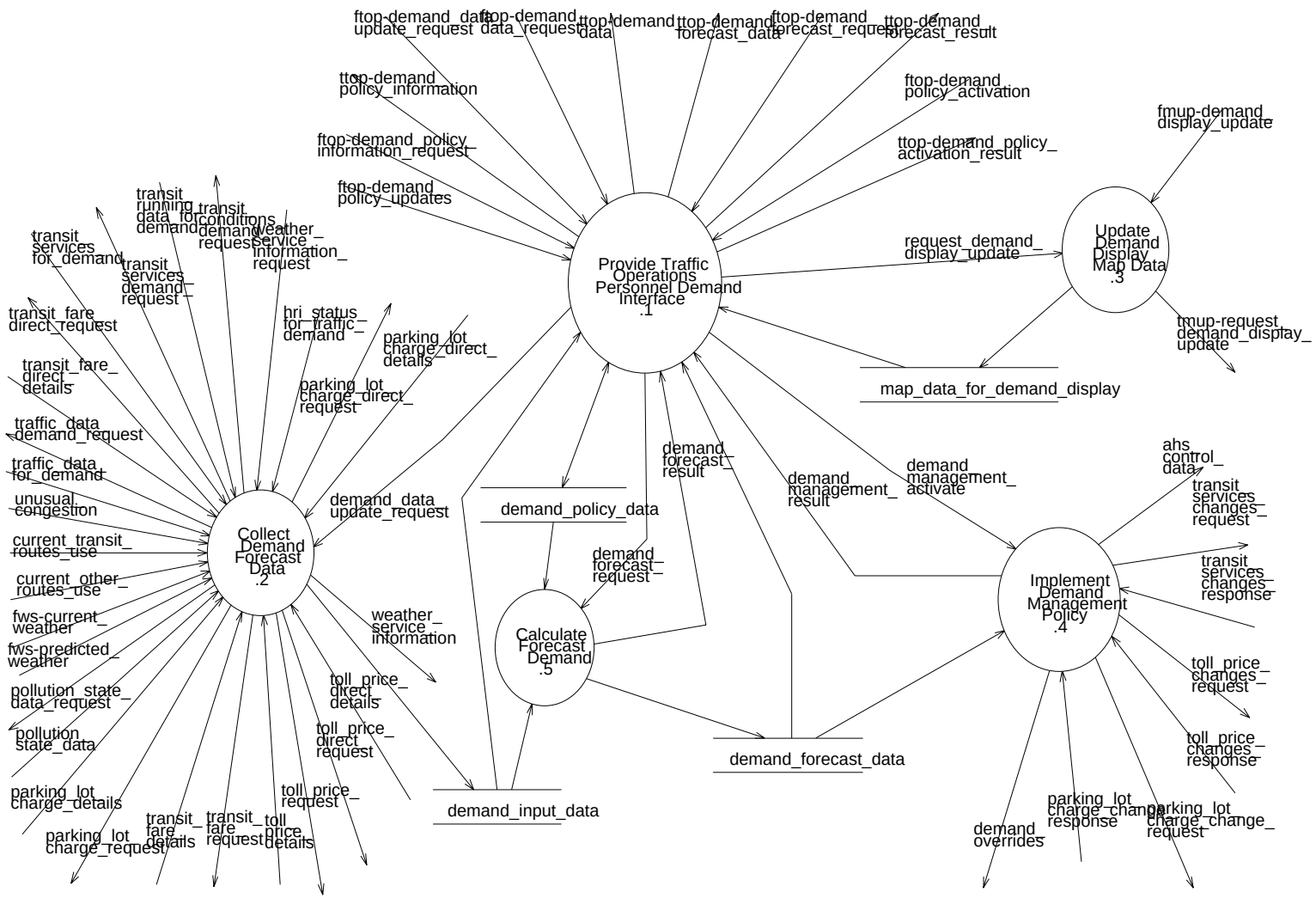


Figure 21. Provide Operator Interfaces for Incidents (DFD 1.3.4)



1.4-Manage Travel Demand

Figure 22. Manage Travel Demand (DFD 1.4)

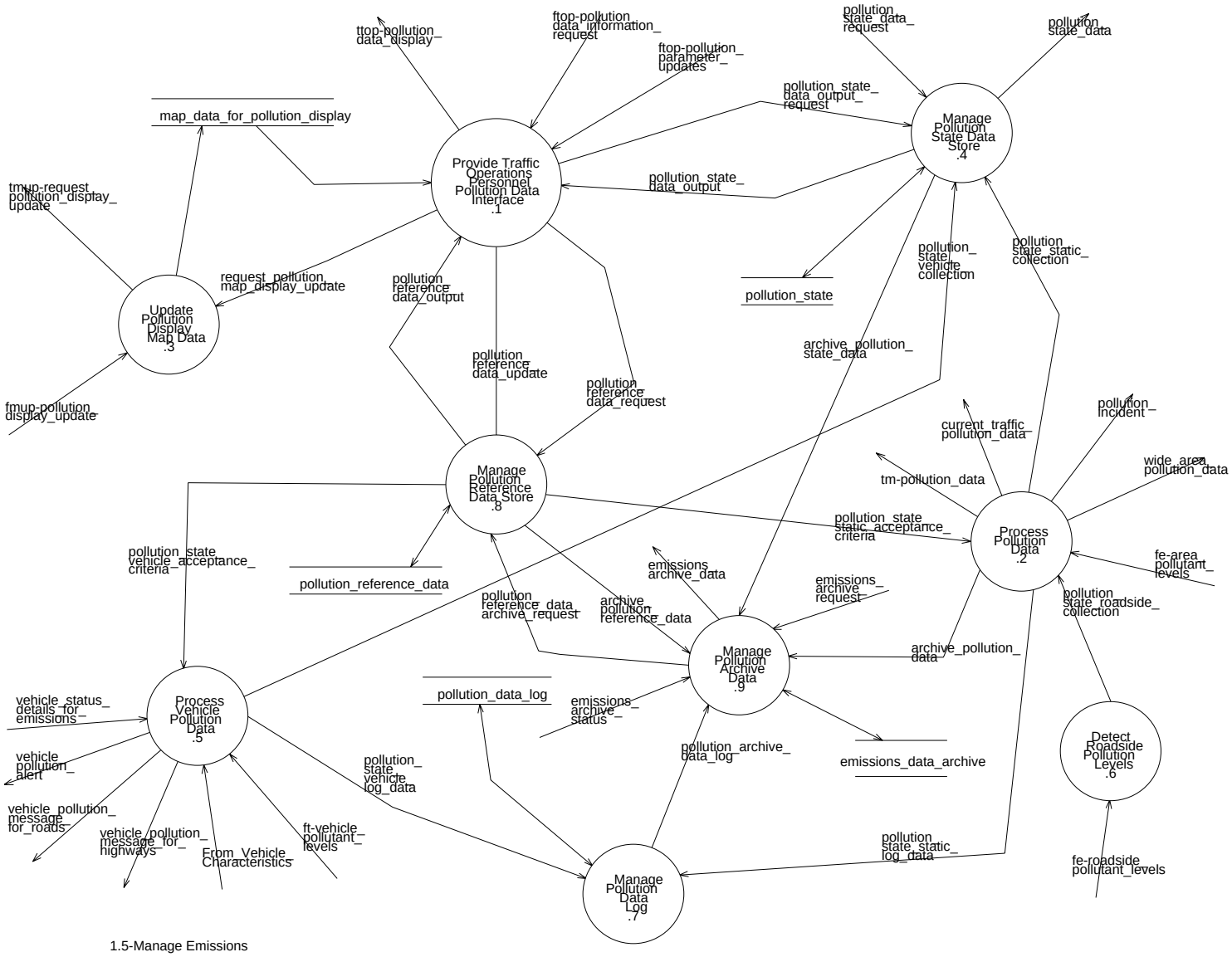
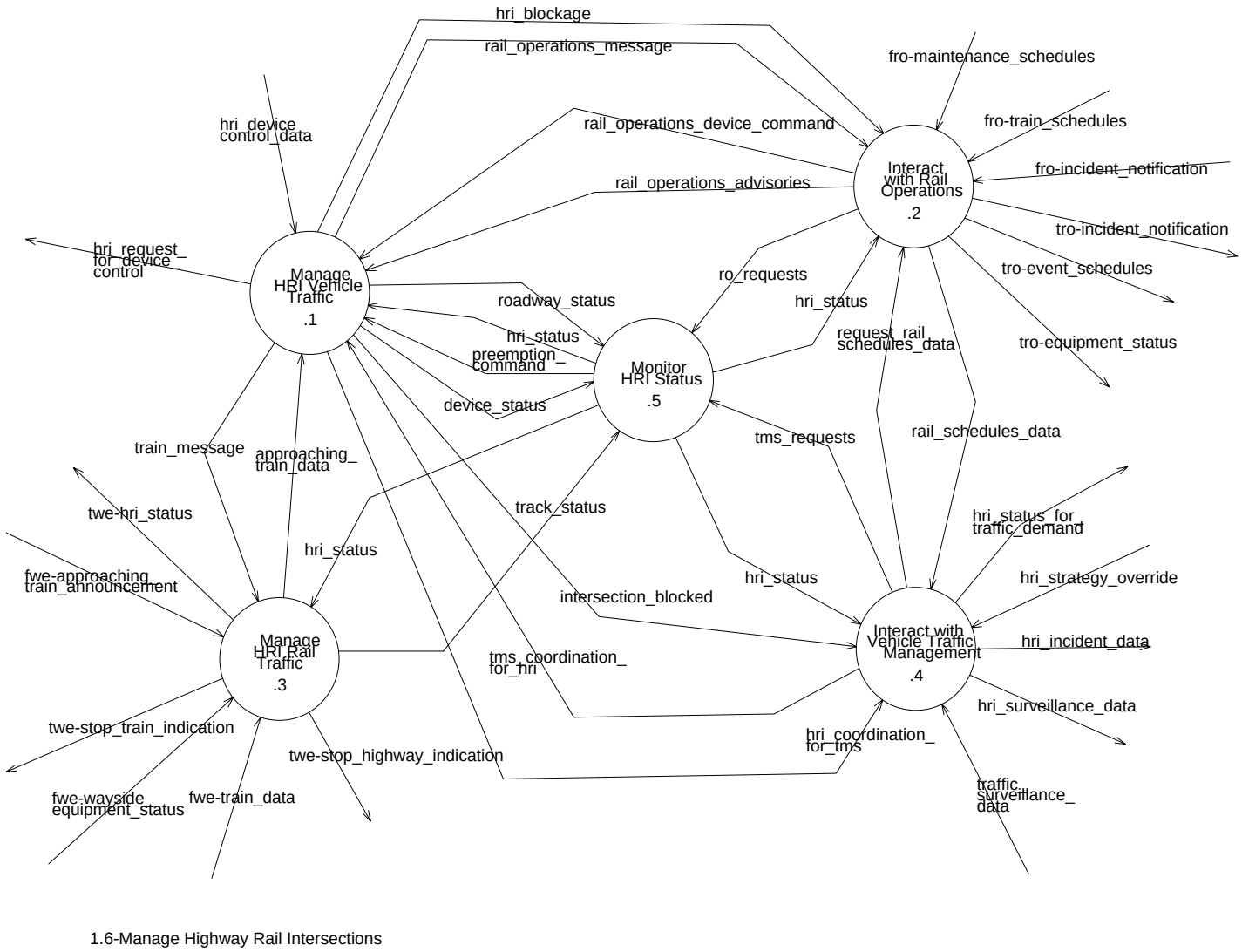
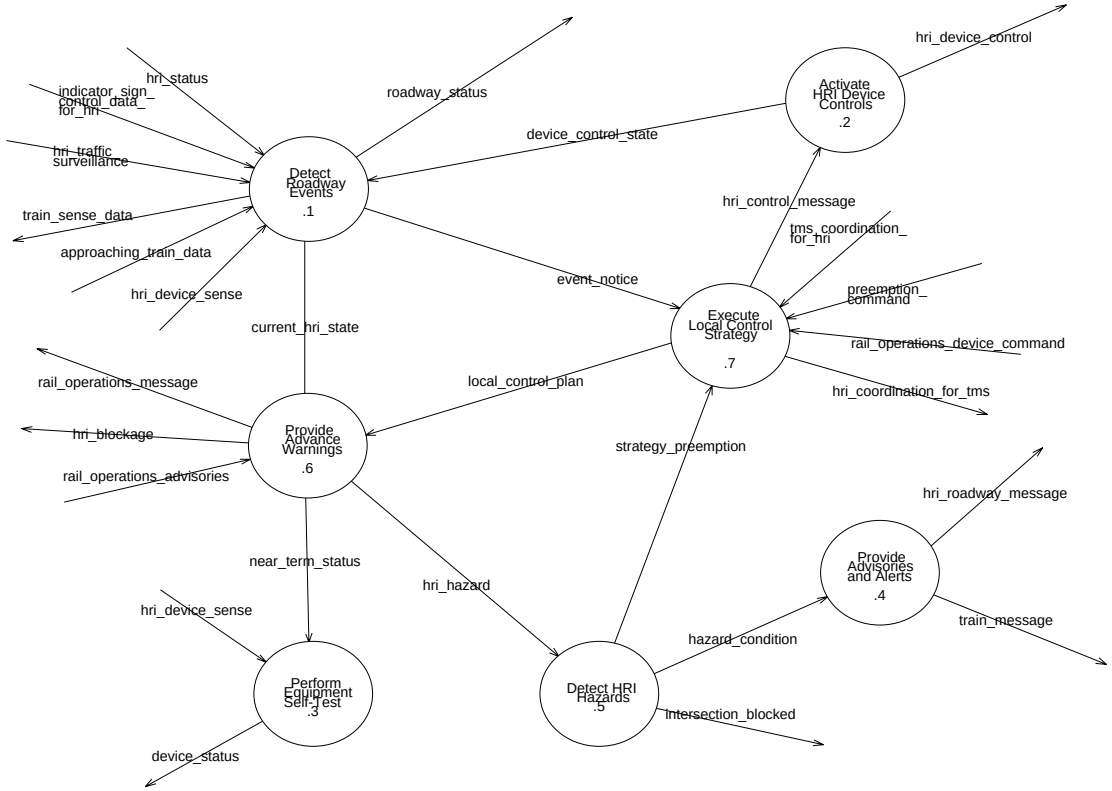


Figure 23. Manage Emissions (DFD 1.5)



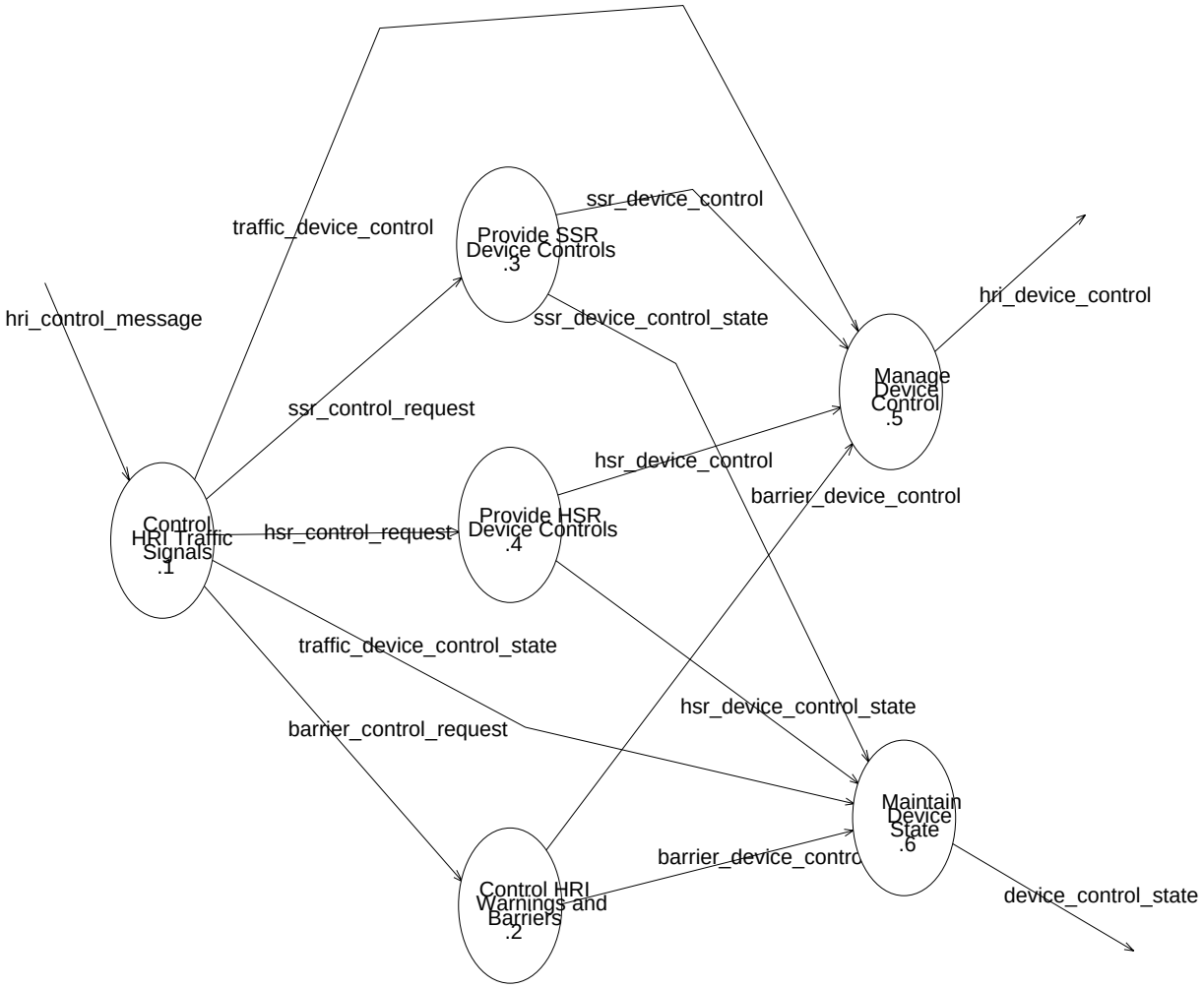
1.6-Manage Highway Rail Intersections

Figure 24. Manage Highway Rail Intersections (DFD 1.6)



1.6.1-Manage HRI Vehicle Traffic

Figure 25. Manage HRI Vehicle Traffic (DFD 1.6.1)



1.6.1.2-Activate HRI Device Controls

Figure 26. Activate HRI Control Devices (DFD 1.6.1.2)

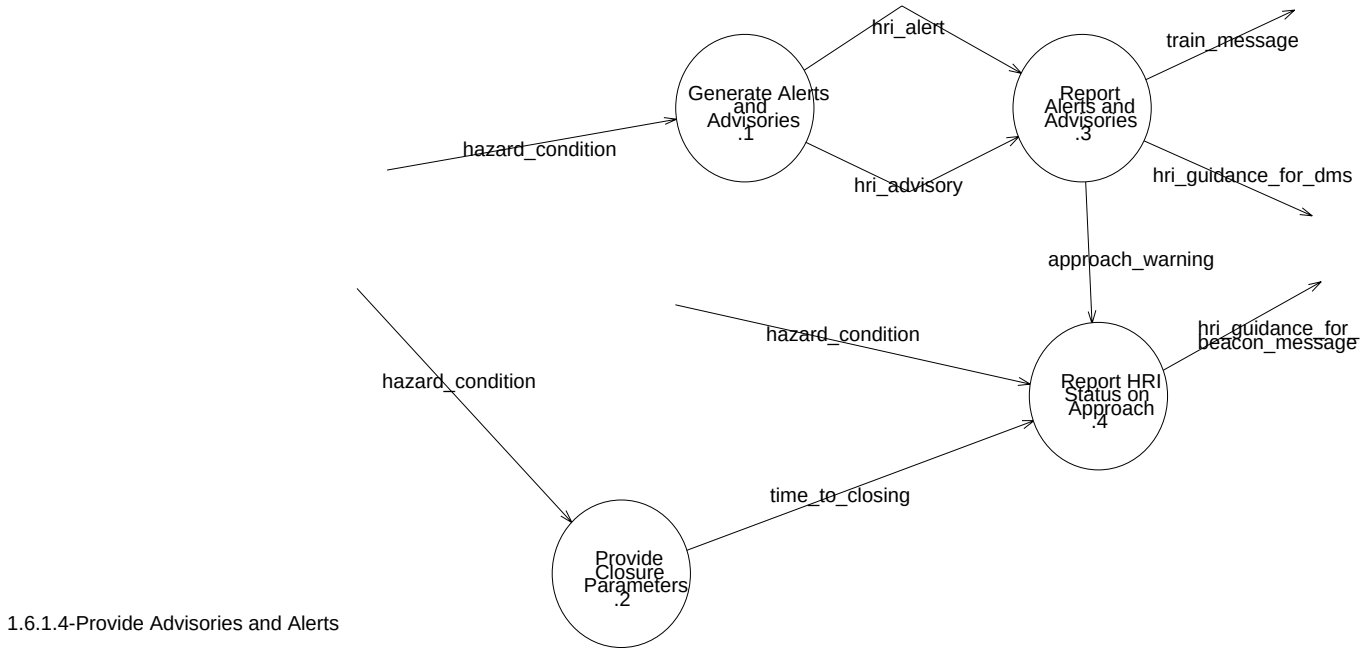
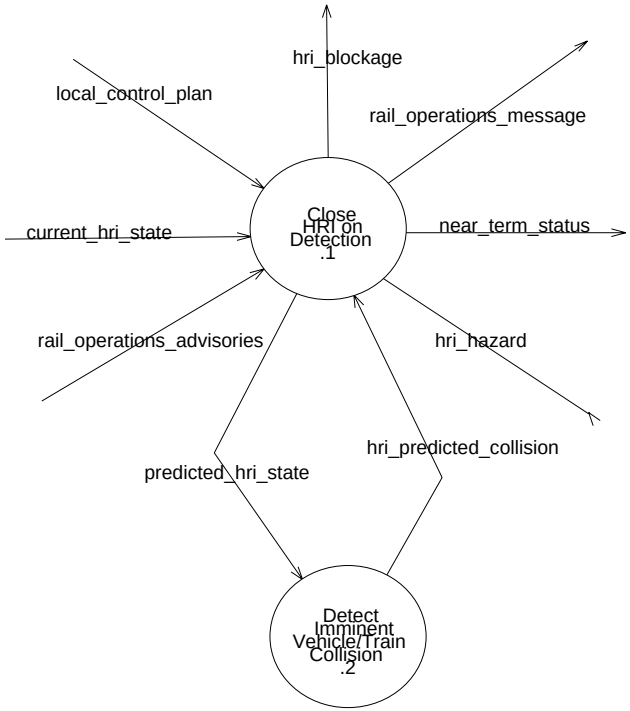
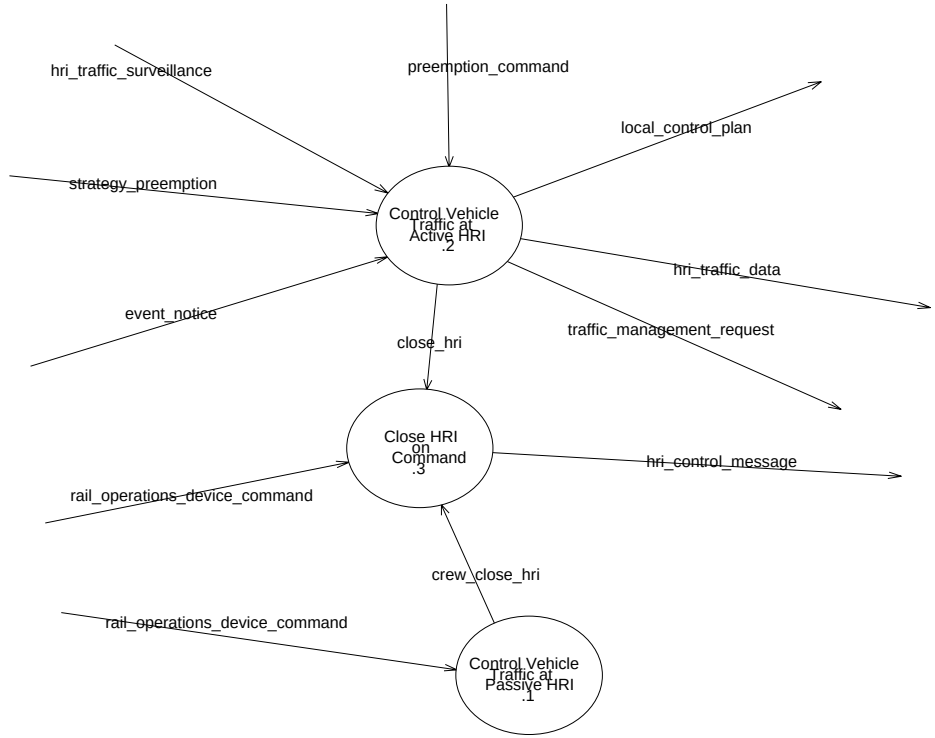


Figure 27. Provide Advisories and Alerts (DFD 1.6.1.4)



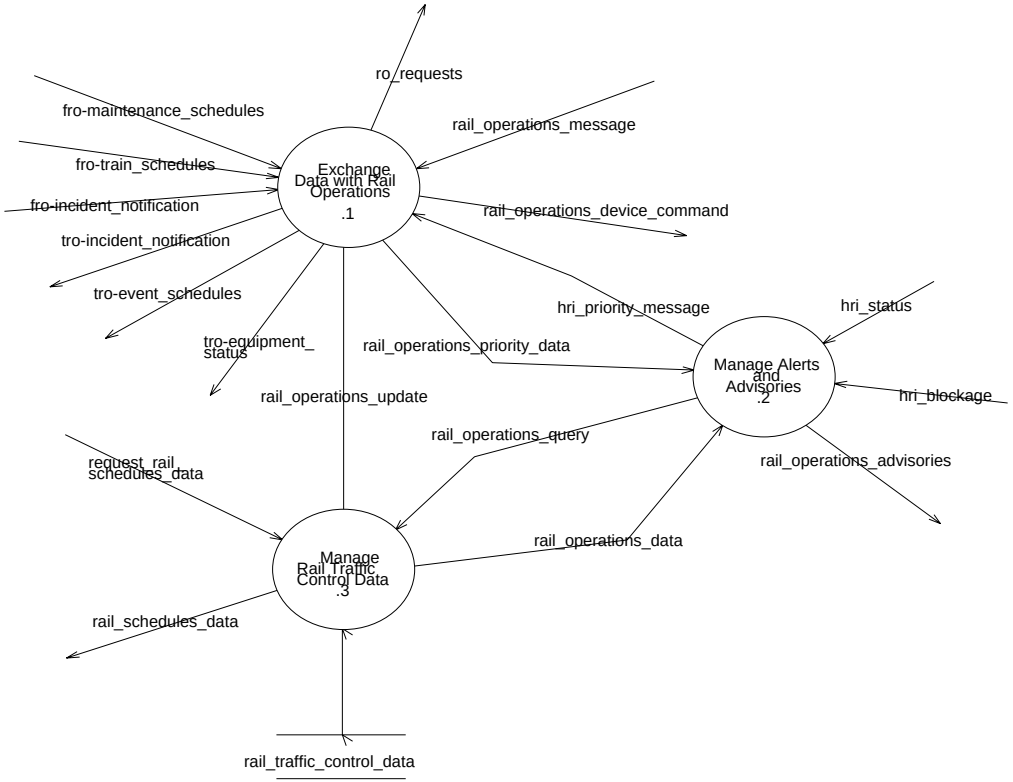
1.6.1.6-Provide Advance Warnings

Figure 28. Provide Advance Warnings (DFD 1.6.1.6)



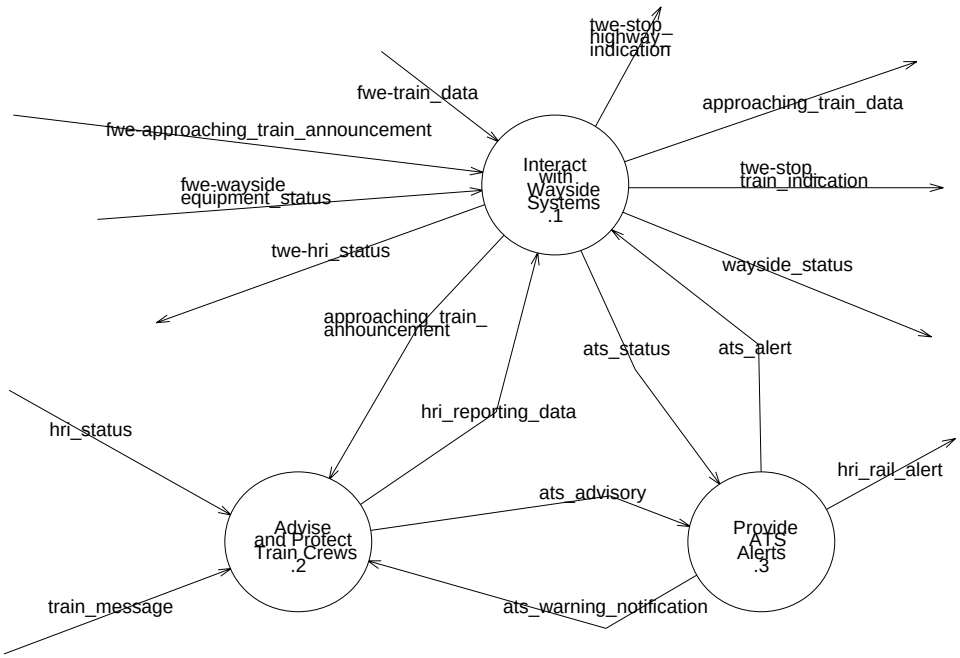
1.6.1.7-Execute Local Control Strategy

Figure 29. Execute Local Control Strategy (DFD 1.6.1.7)



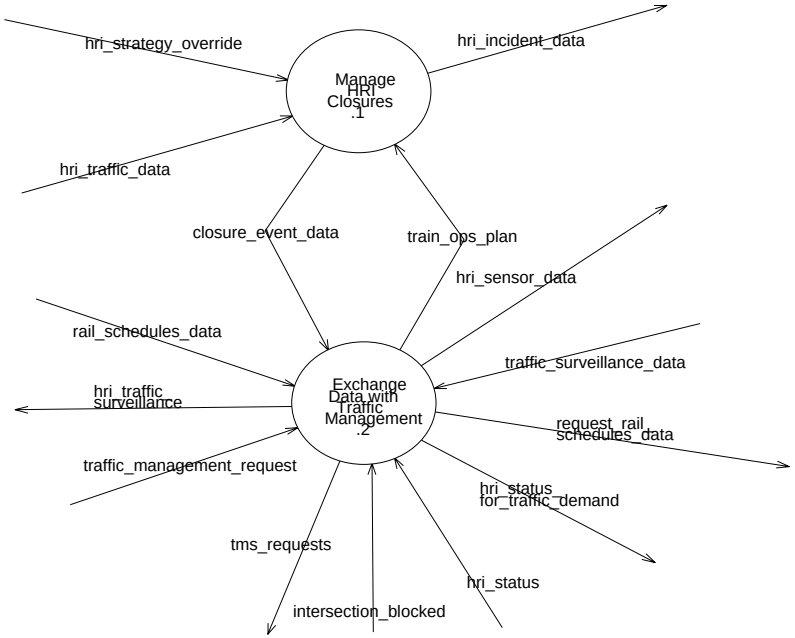
1.6.2-Interact with Rail Operations

Figure 30. Interact with Rail Operations (DFD 1.6.2)



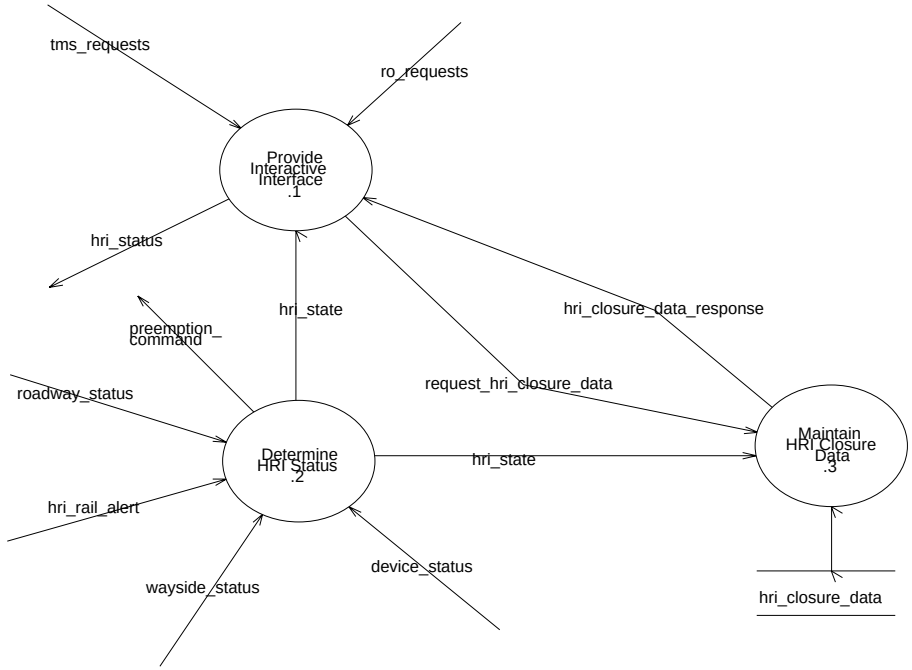
1.6.3-Manage HRI Rail Traffic

Figure 31. Manage HRI Rail Traffic (DFD 1.6.3)



1.6.4-Interact with Vehicle Traffic Management

Figure 32. Interact with Vehicle Traffic Management (DFD 1.6.4)



1.6.5-Monitor HRI Status

Figure 33. Monitor HRI Status (DFD 1.6.5)

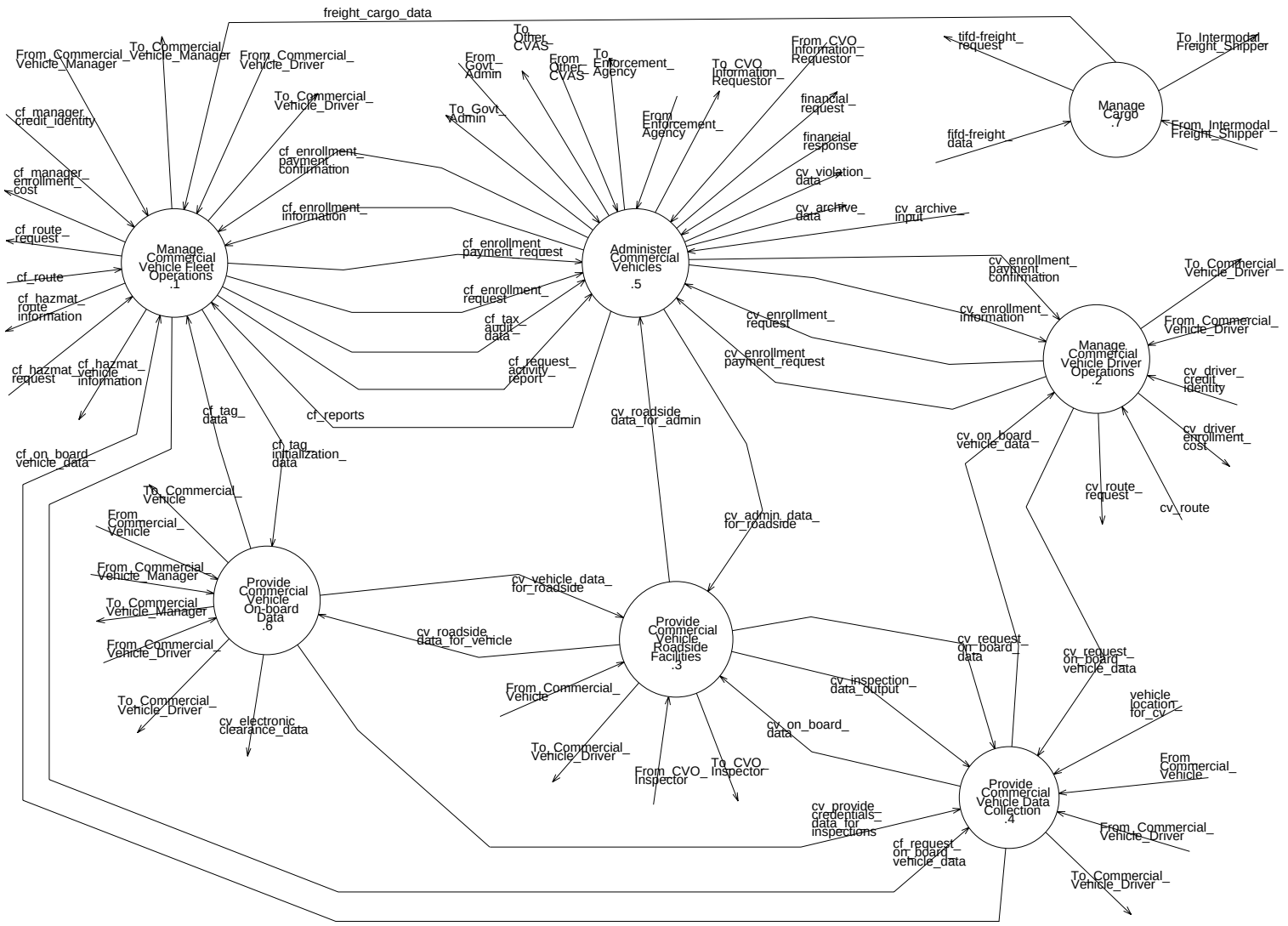


Figure 34. Manage Commercial Vehicles (DFD 2)

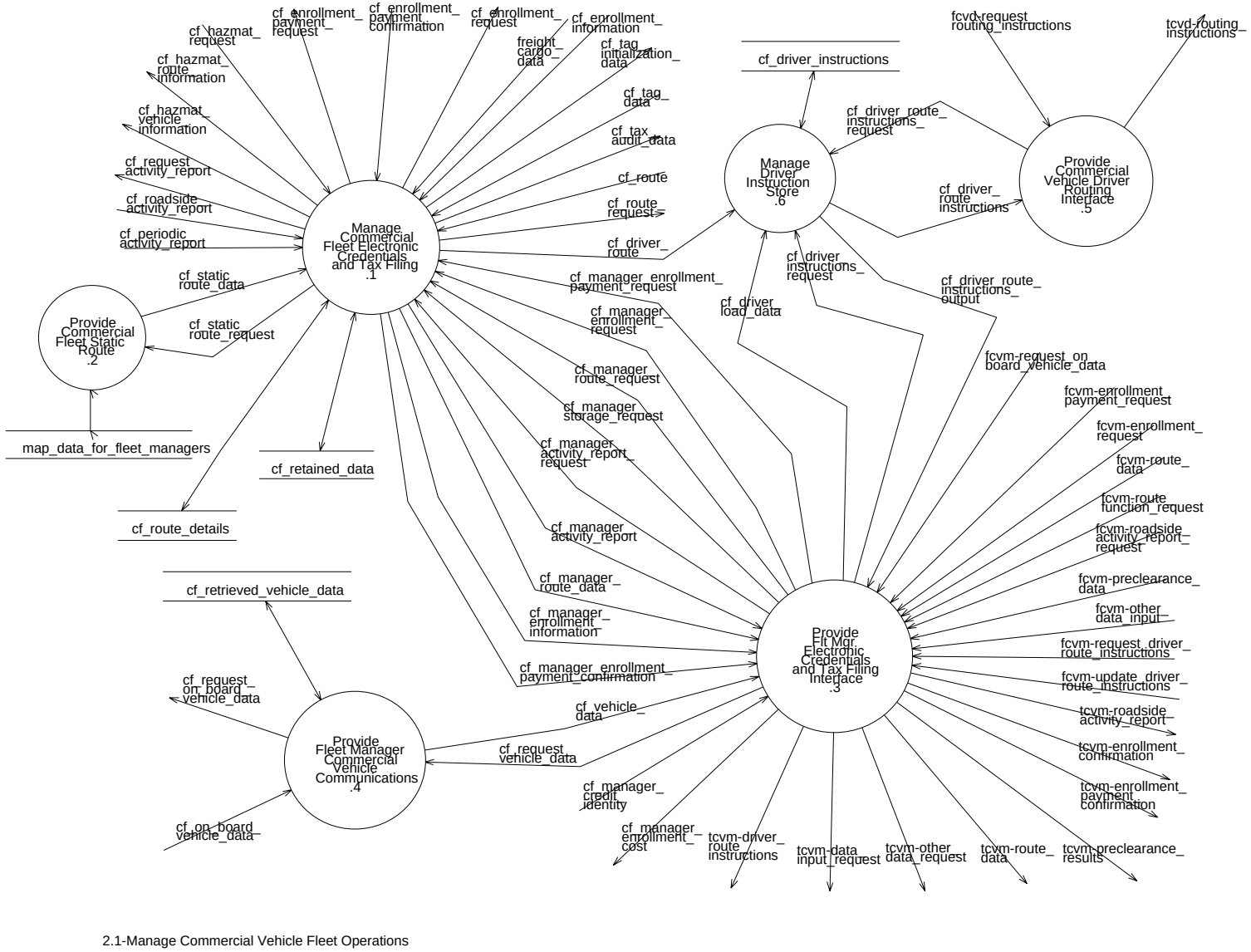


Figure 35. Manage Commercial Vehicle Fleet Operations (DFD 2.1)

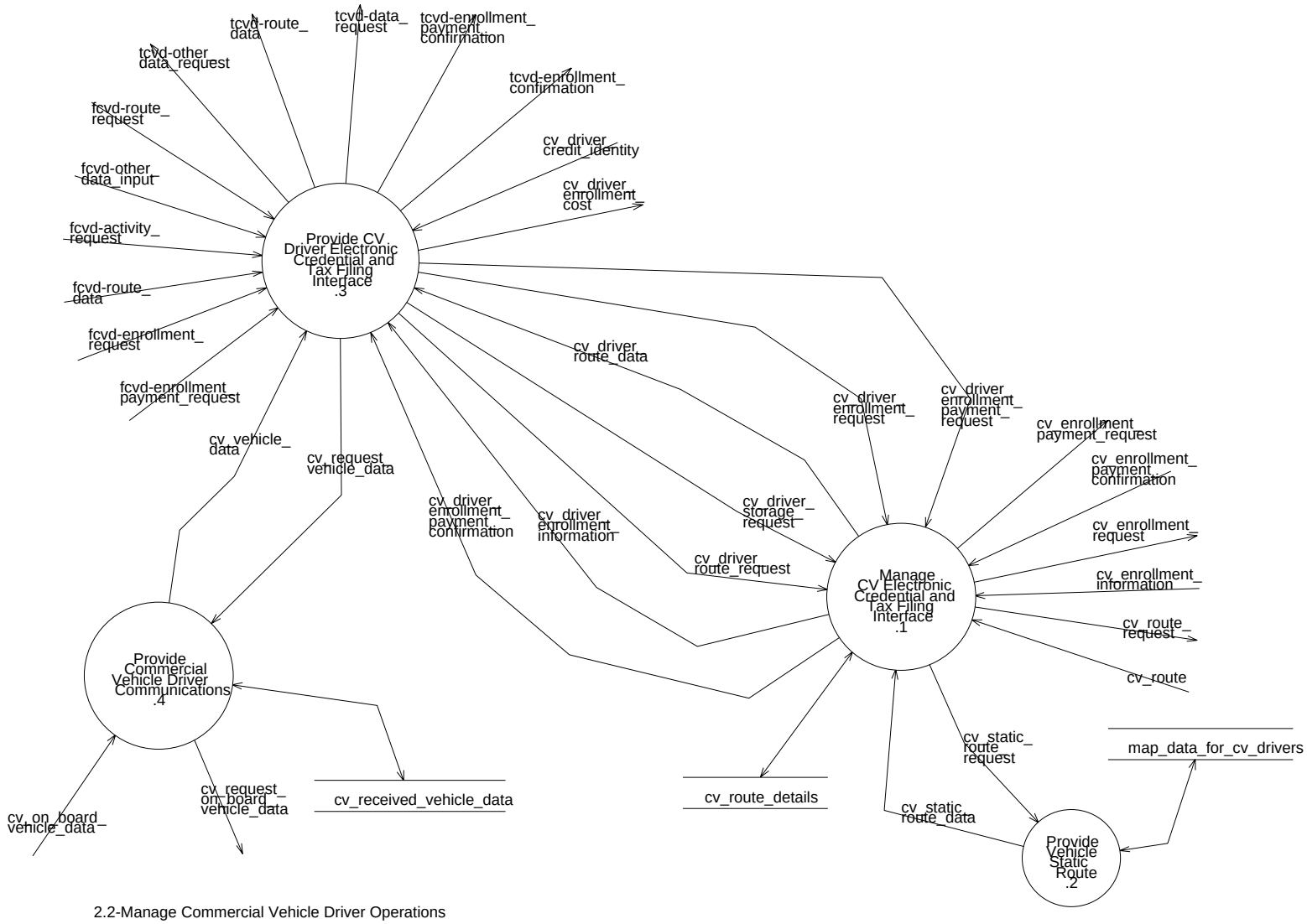


Figure 36. Manage Commercial Vehicle Driver Operations (DFD 2.2)

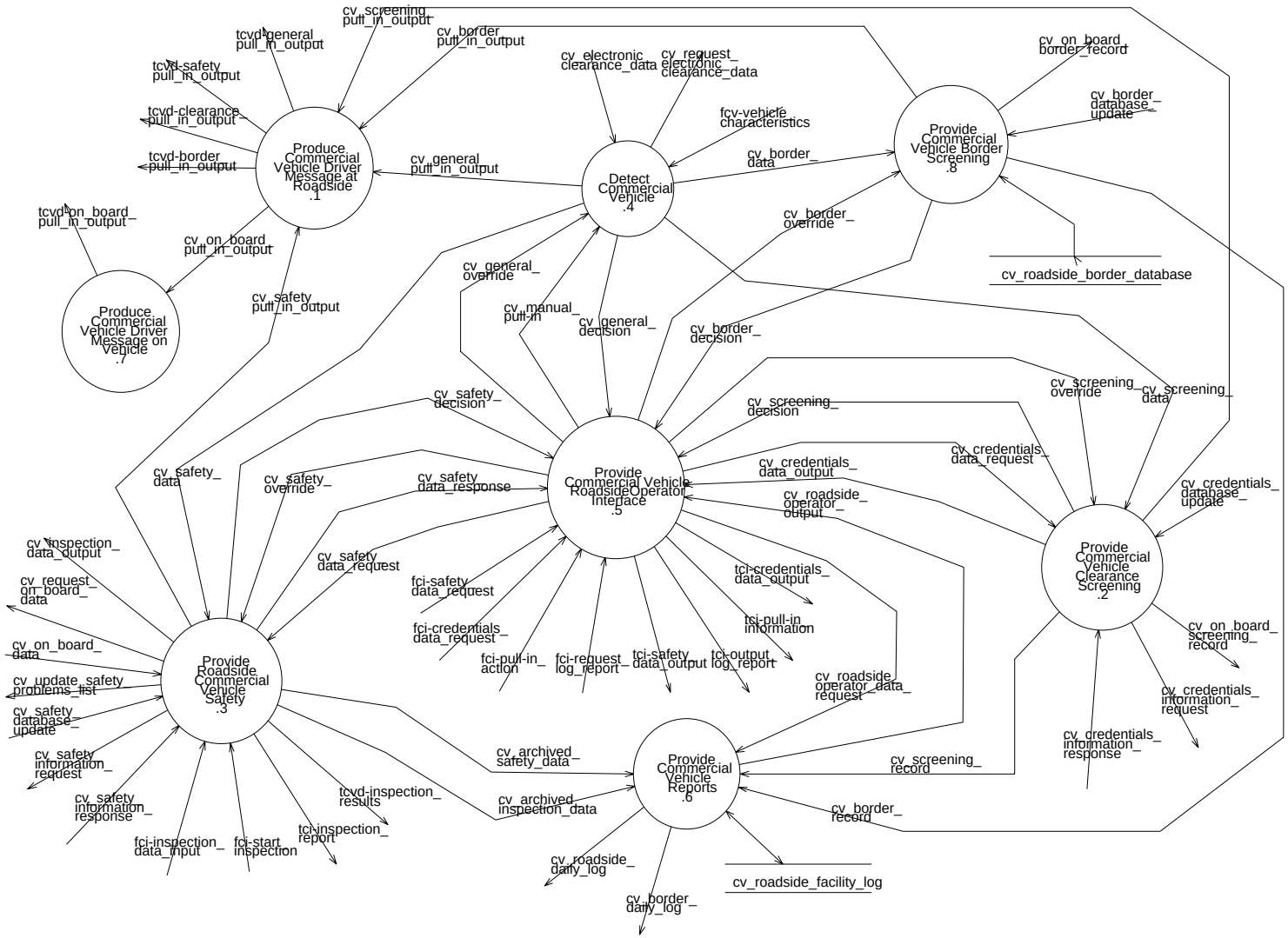


Figure 37. Provide Commercial Vehicle Roadside Facilities (DFD 2.3)

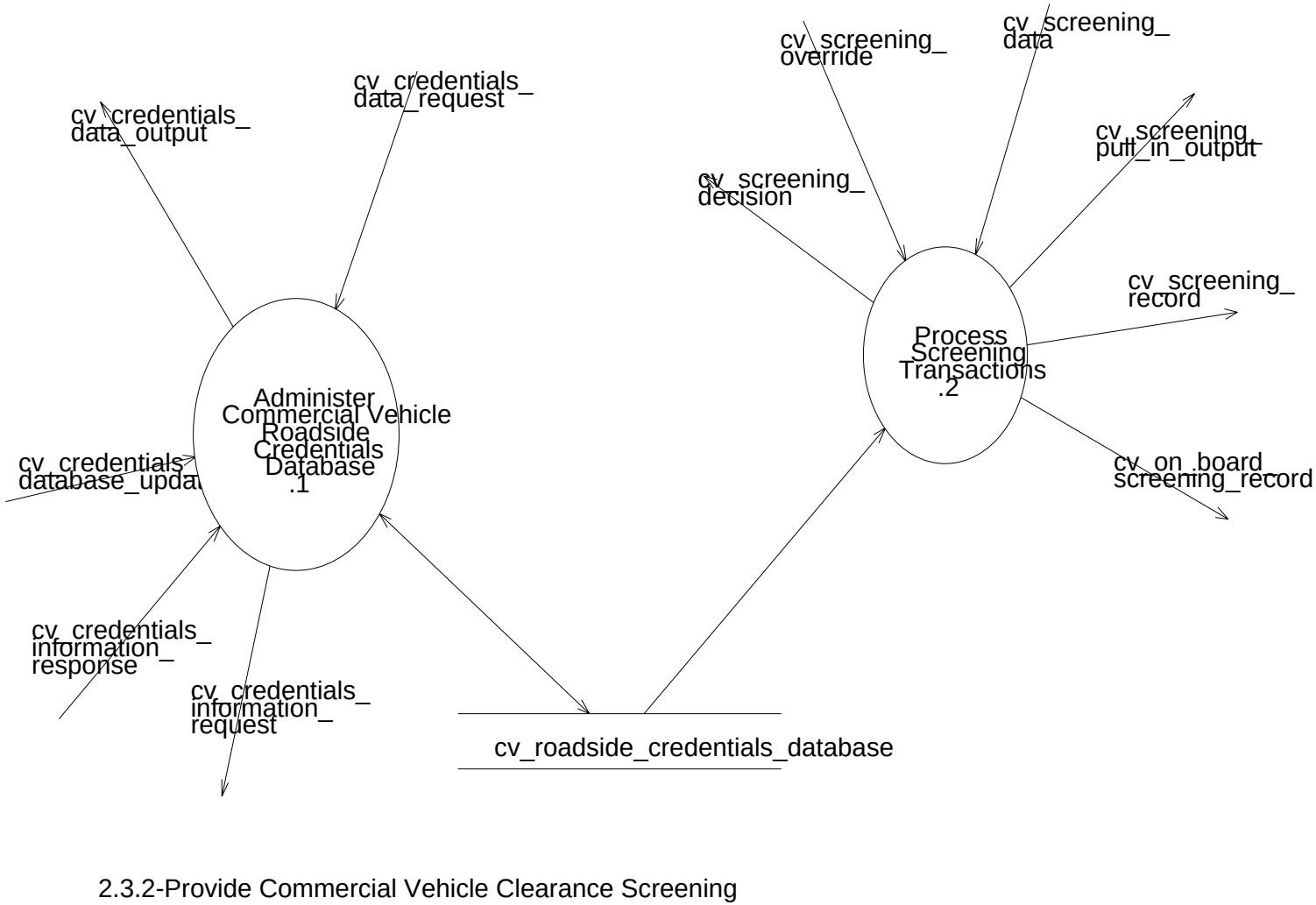


Figure 38. Provide Commercial Vehicle Clearance Screening (DFD 2.3.2)

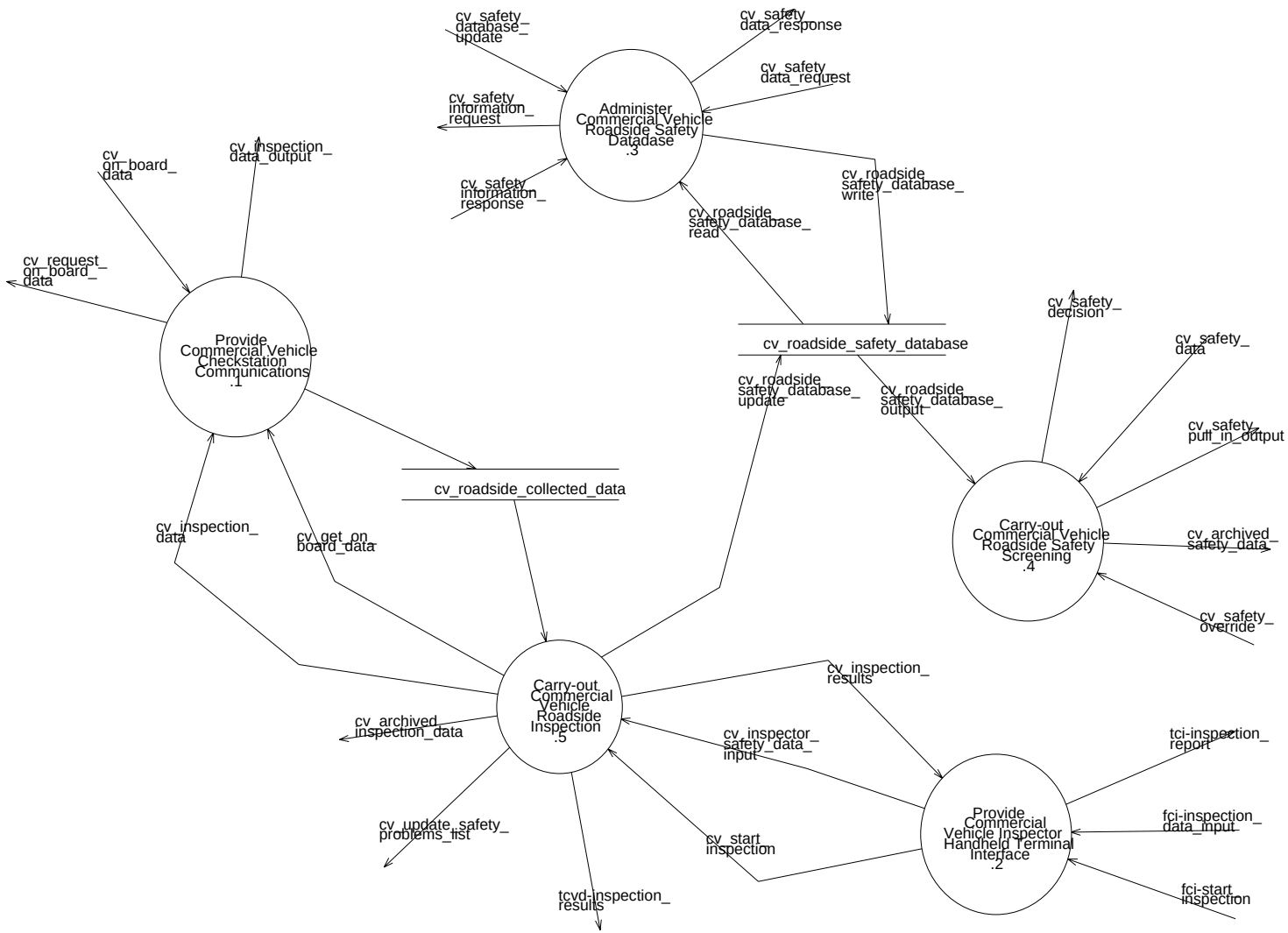


Figure 39. Provide Roadside Commercial Vehicle Safety (DFD 2.3.3)

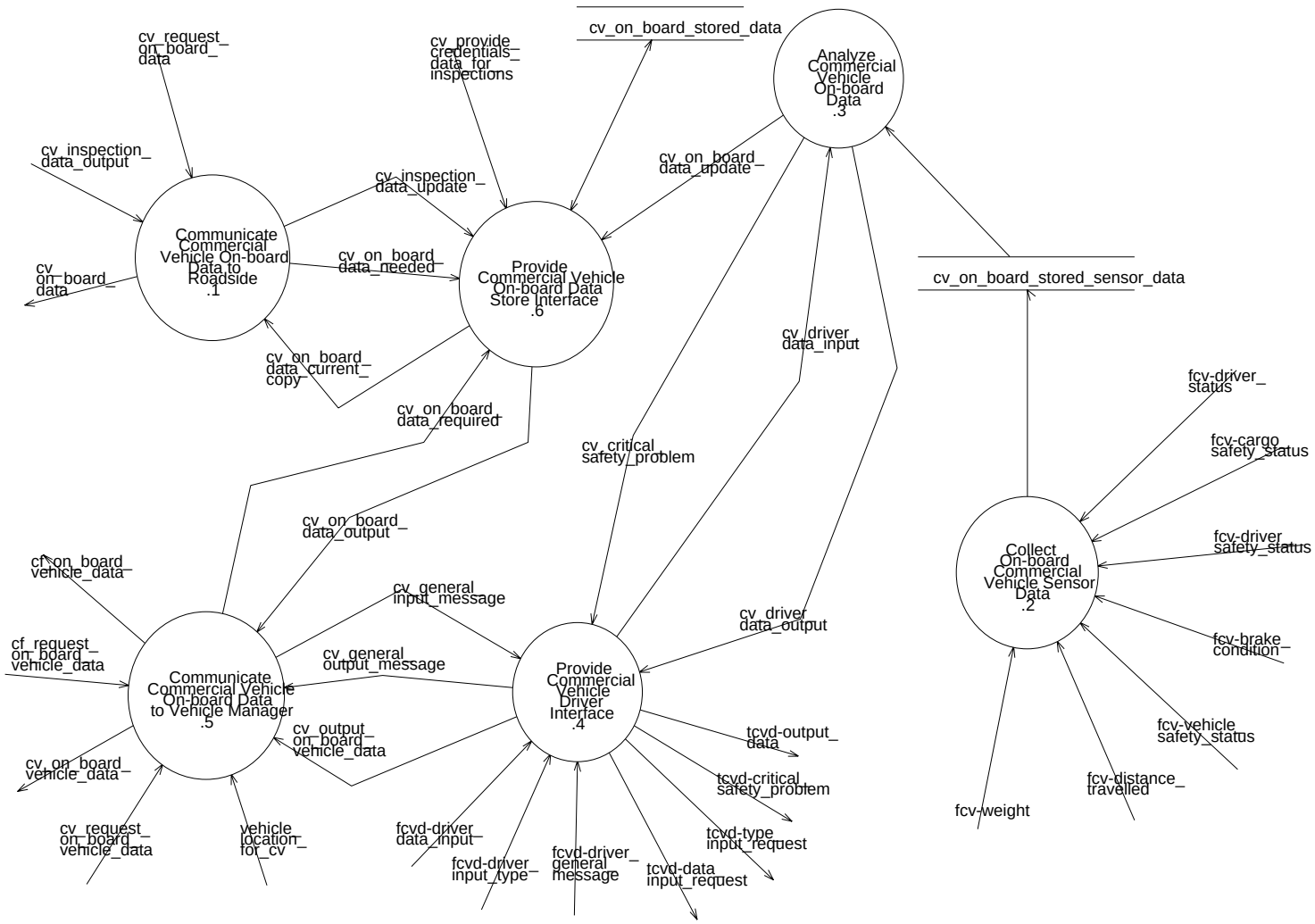


Figure 40. Provide Commercial Vehicle Data Collection (DFD 2.4)

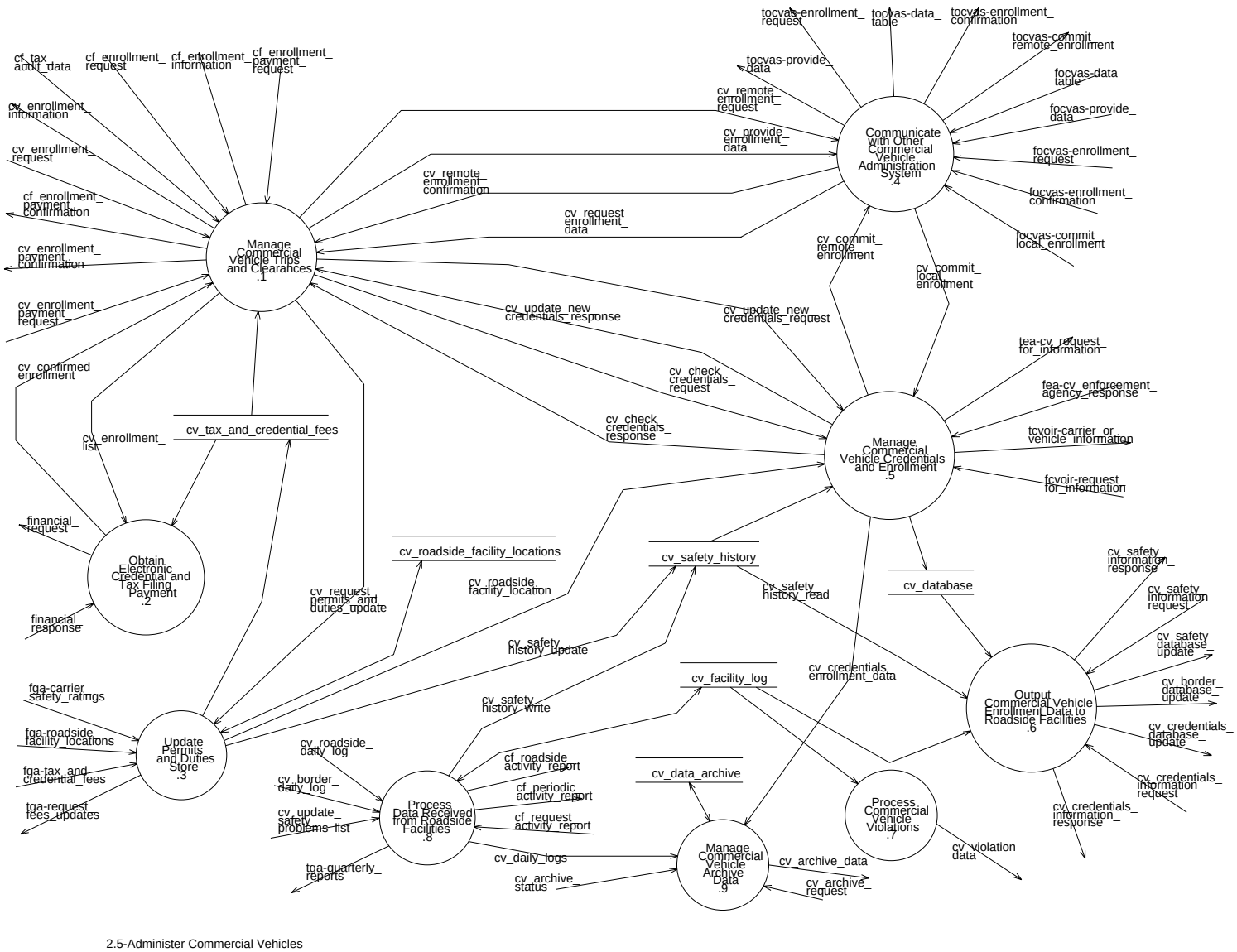


Figure 41. Administer Commercial Vehicles (DFD 2.5)

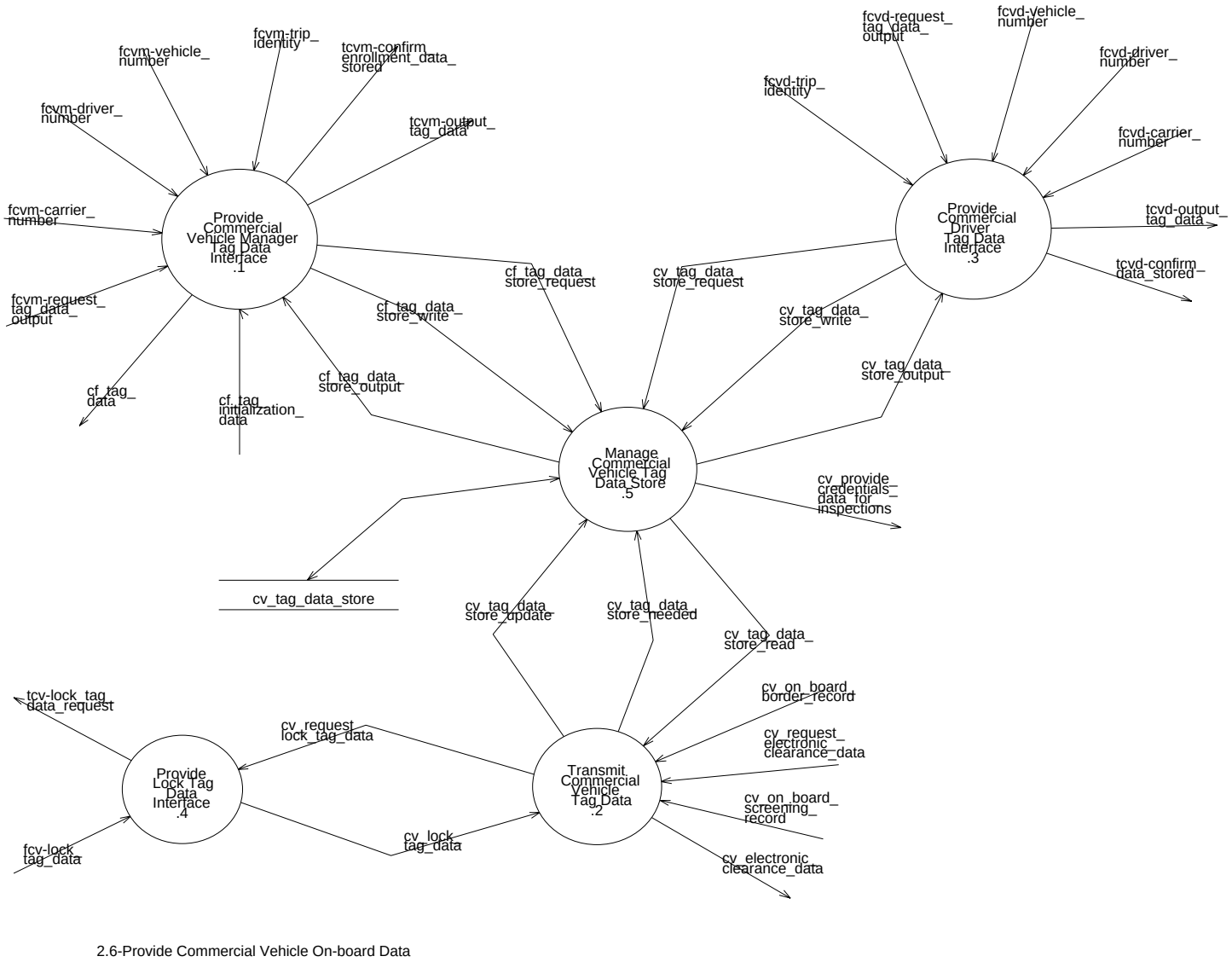


Figure 42. Provide Commercial Vehicle On-board Data (DFD 2.6)

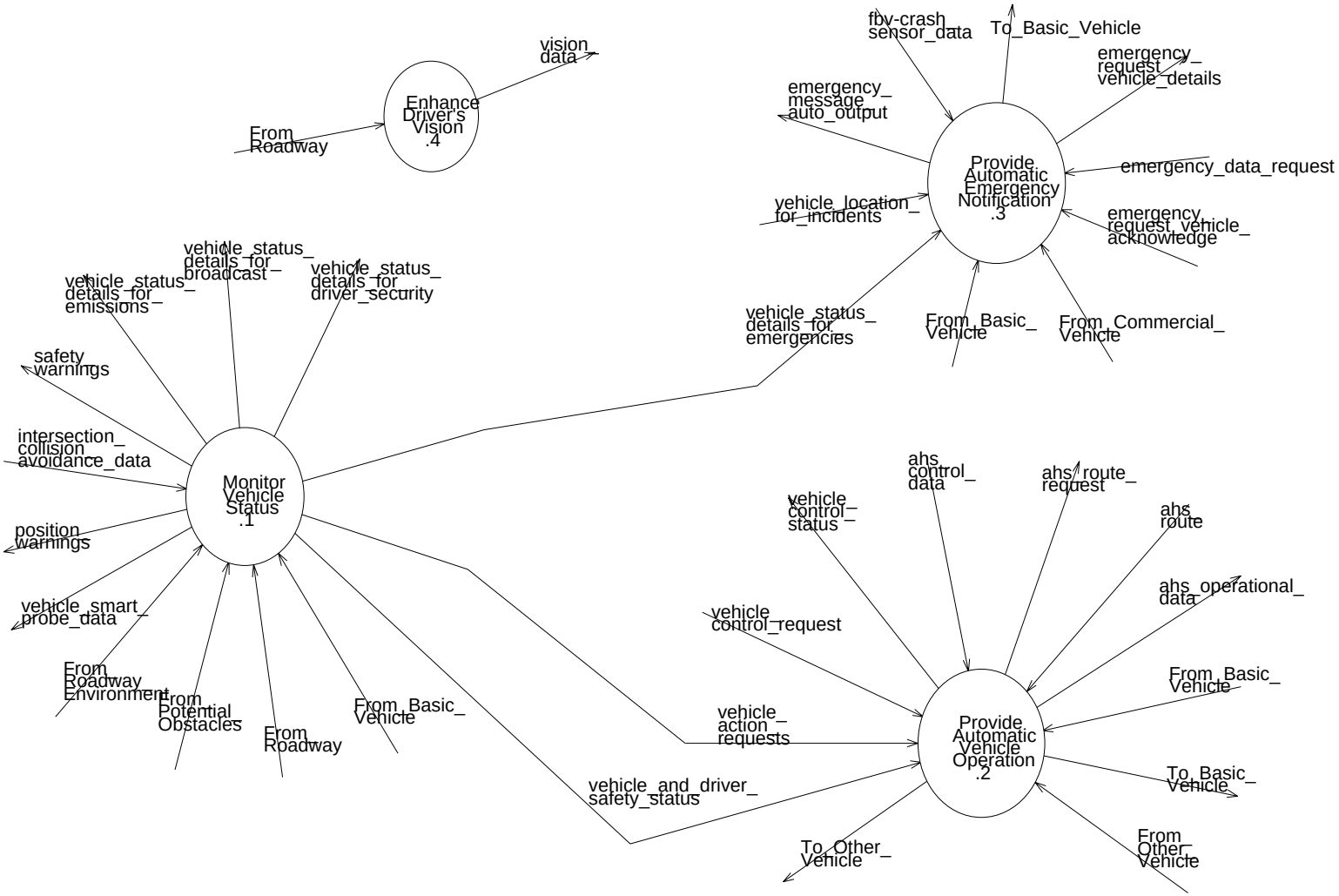


Figure 43. Provide Vehicle Monitoring and Control (DFD 3)

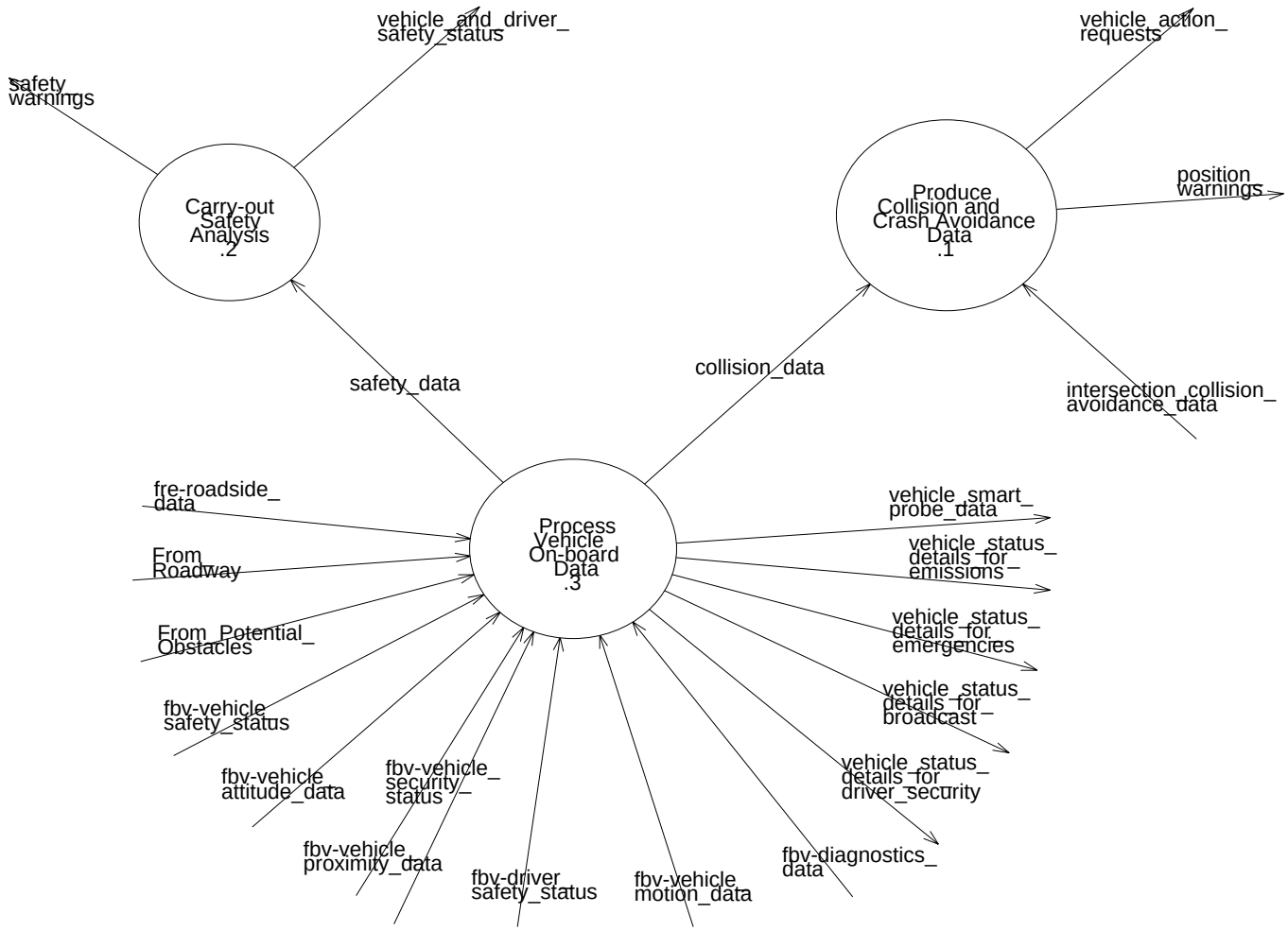


Figure 44. Monitor Vehicle Status (DFD 3.1)

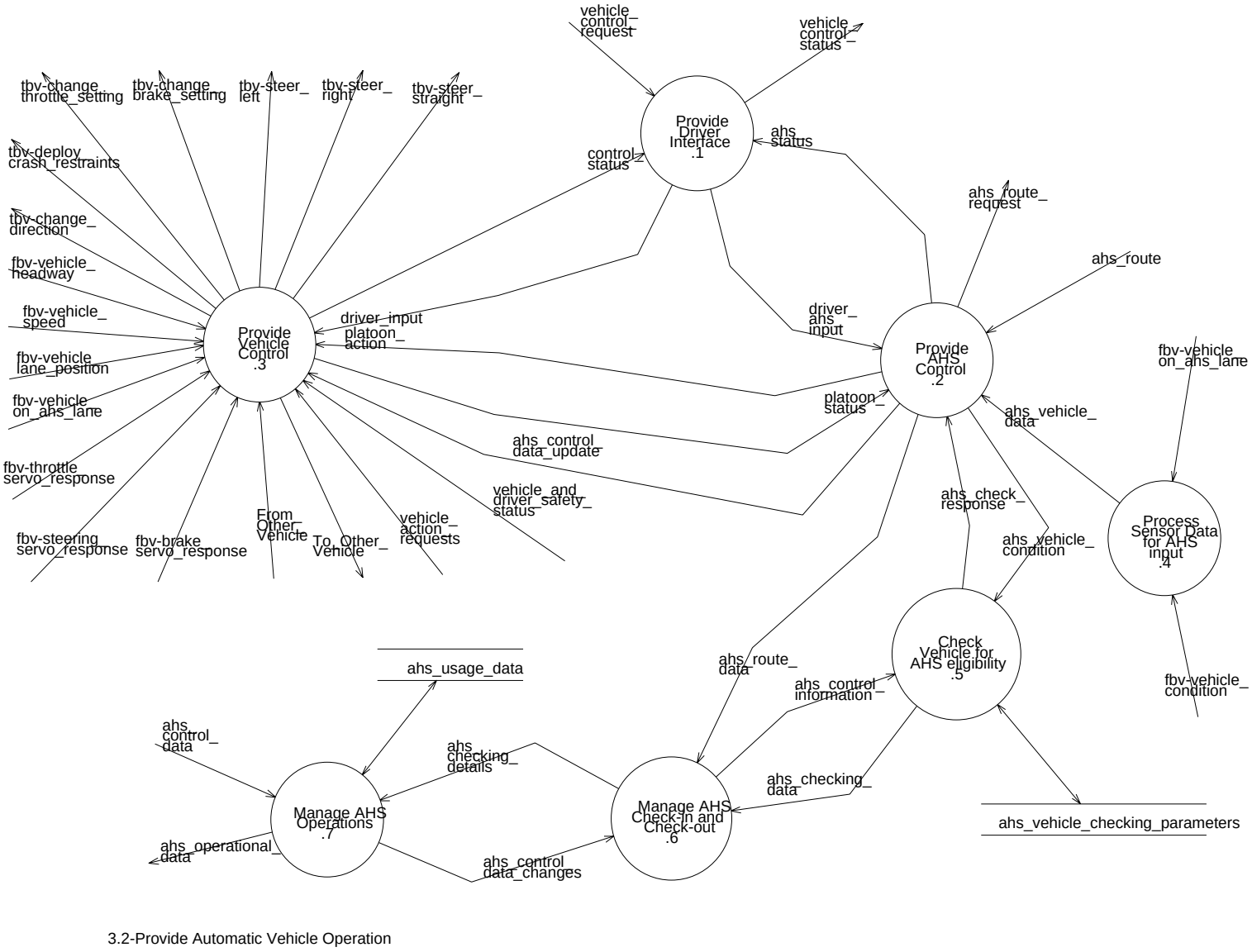


Figure 45. Provide Automatic Vehicle Operation (DFD 3.2)

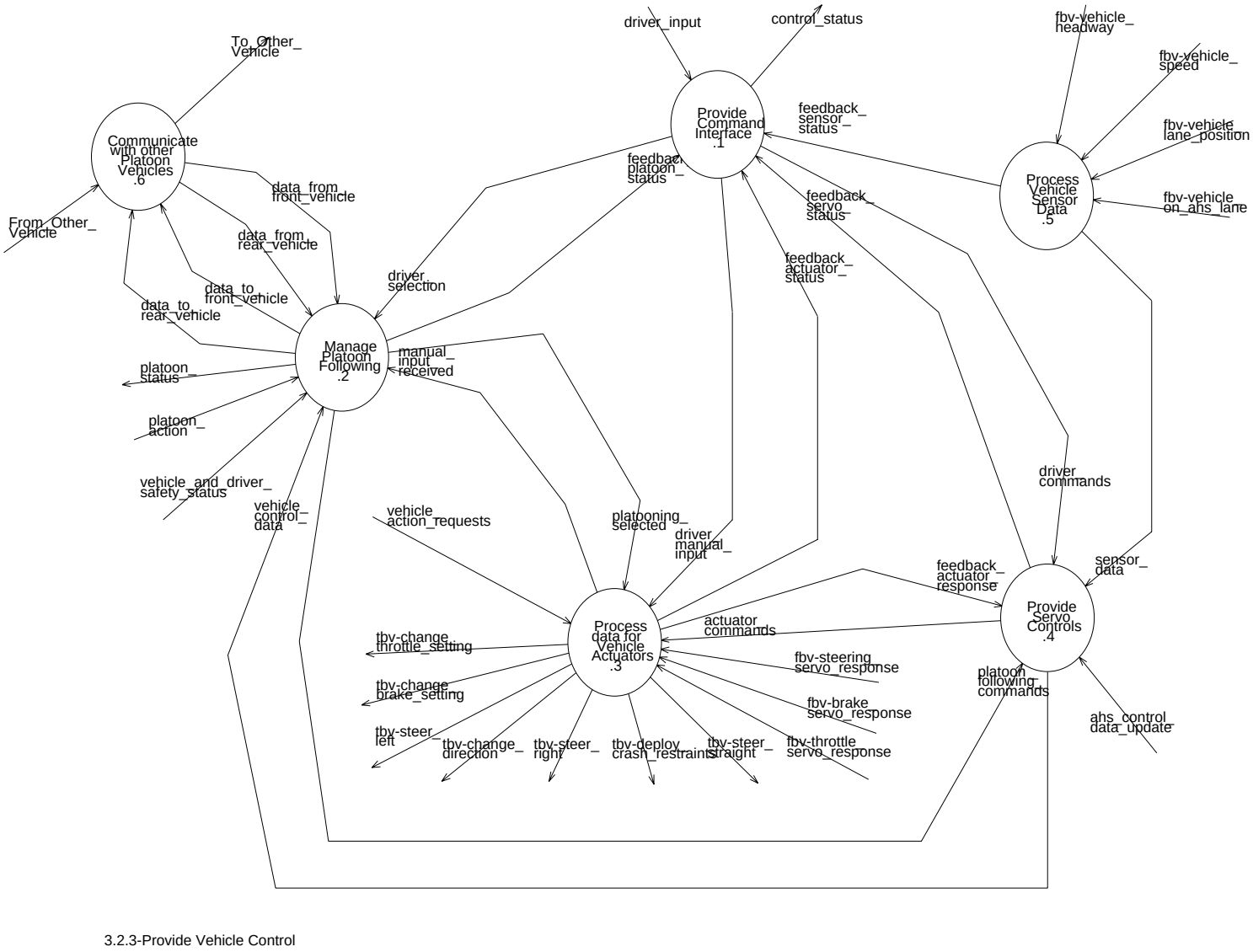


Figure 46. Provide Vehicle Control (DFD 3.2.3)

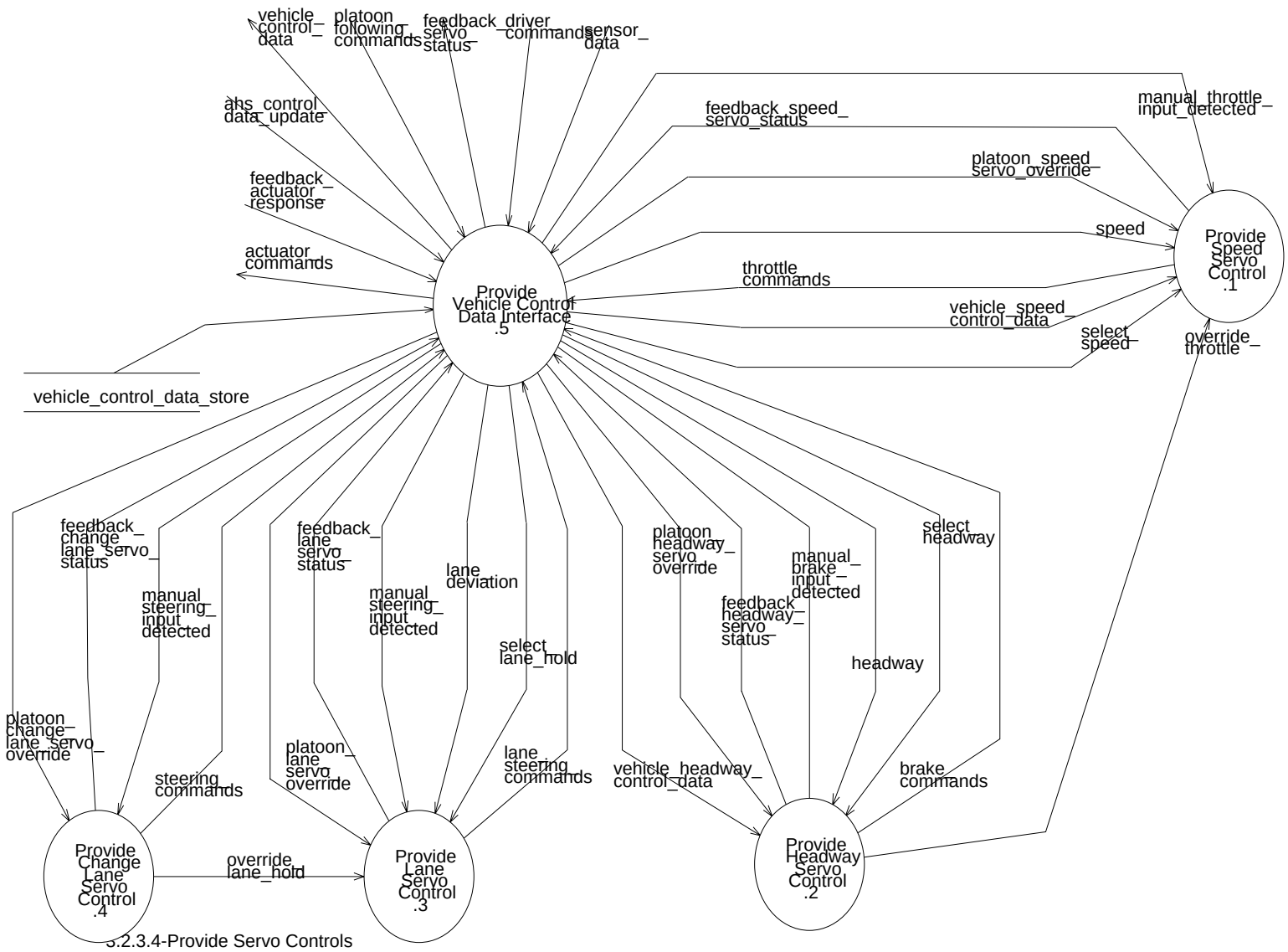


Figure 47. Provide Servo Control (DFD 3.2.3.4)

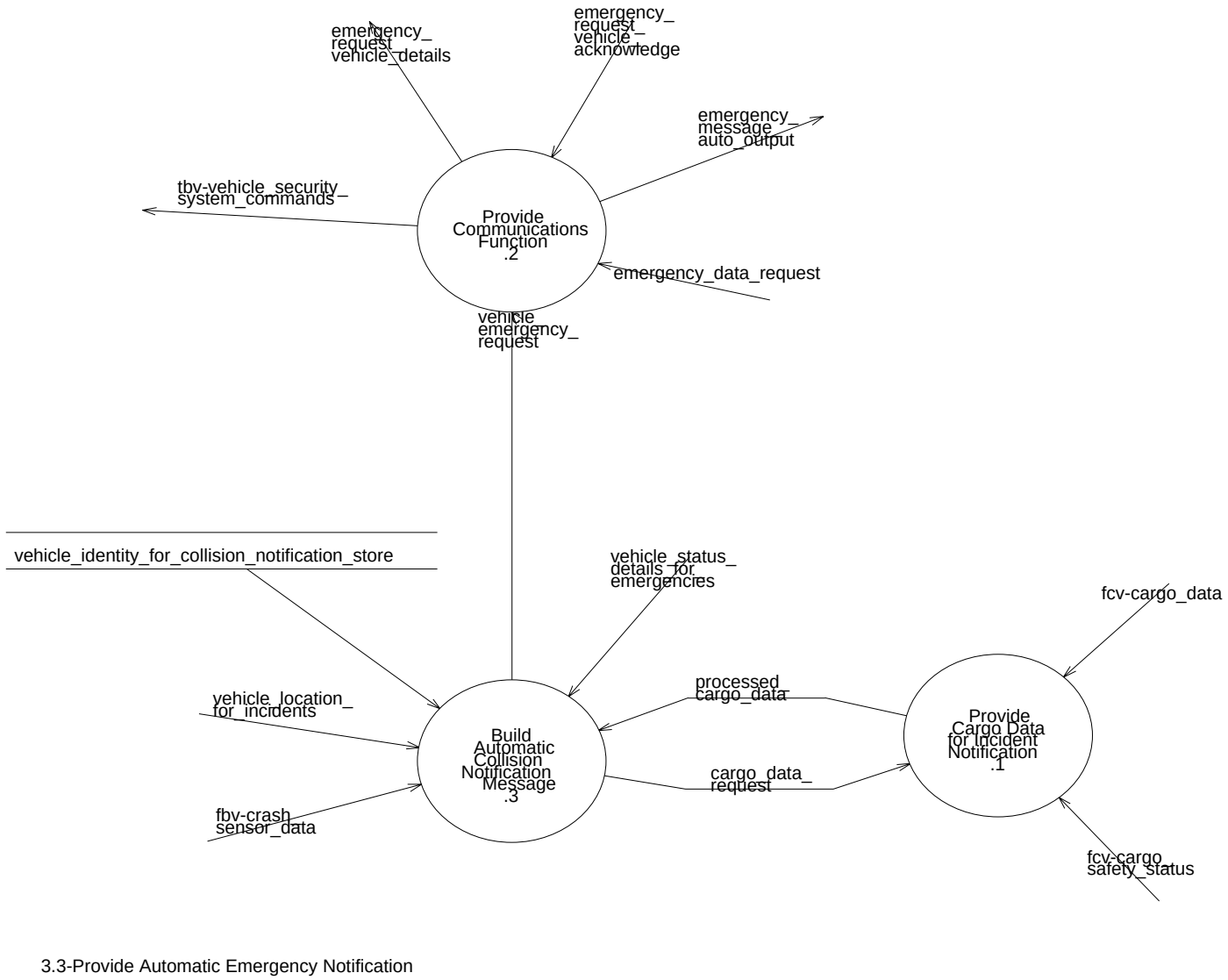


Figure 48. Provide Automatic Emergency Notification (DFD 3.3)

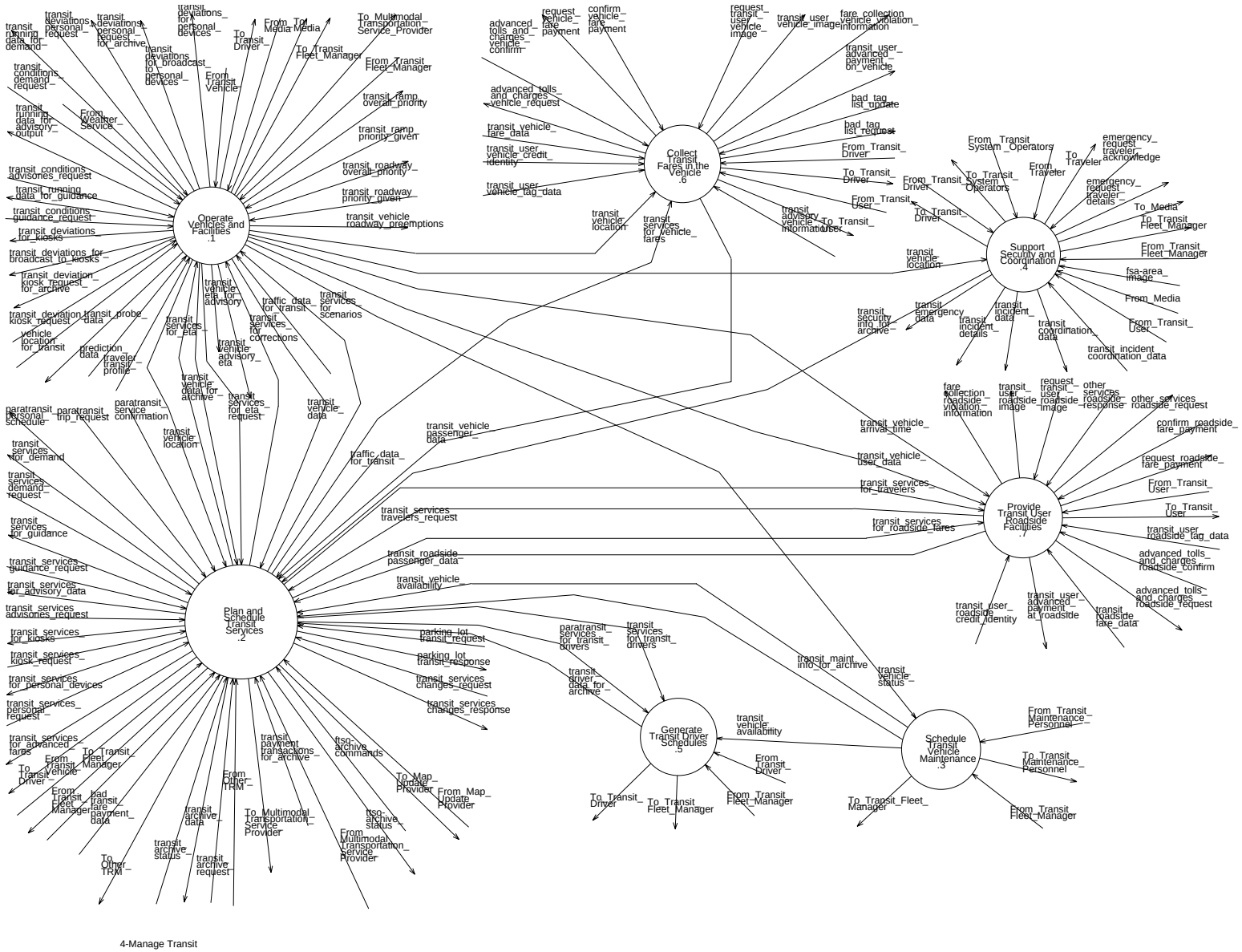


Figure 49. Manage Transit (DFD 4)

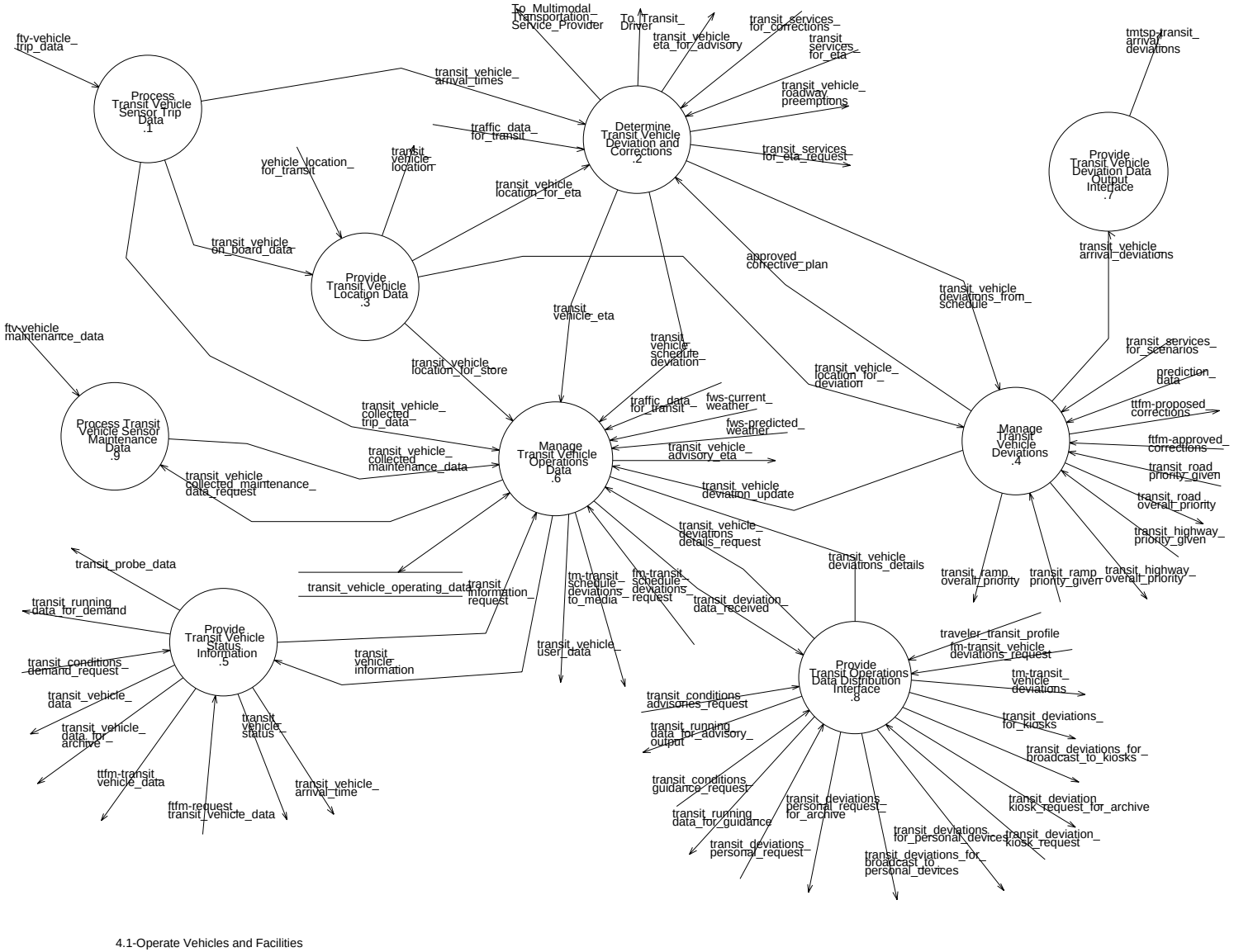


Figure 50. Operate Vehicles and Facilities (DFD 4.1)

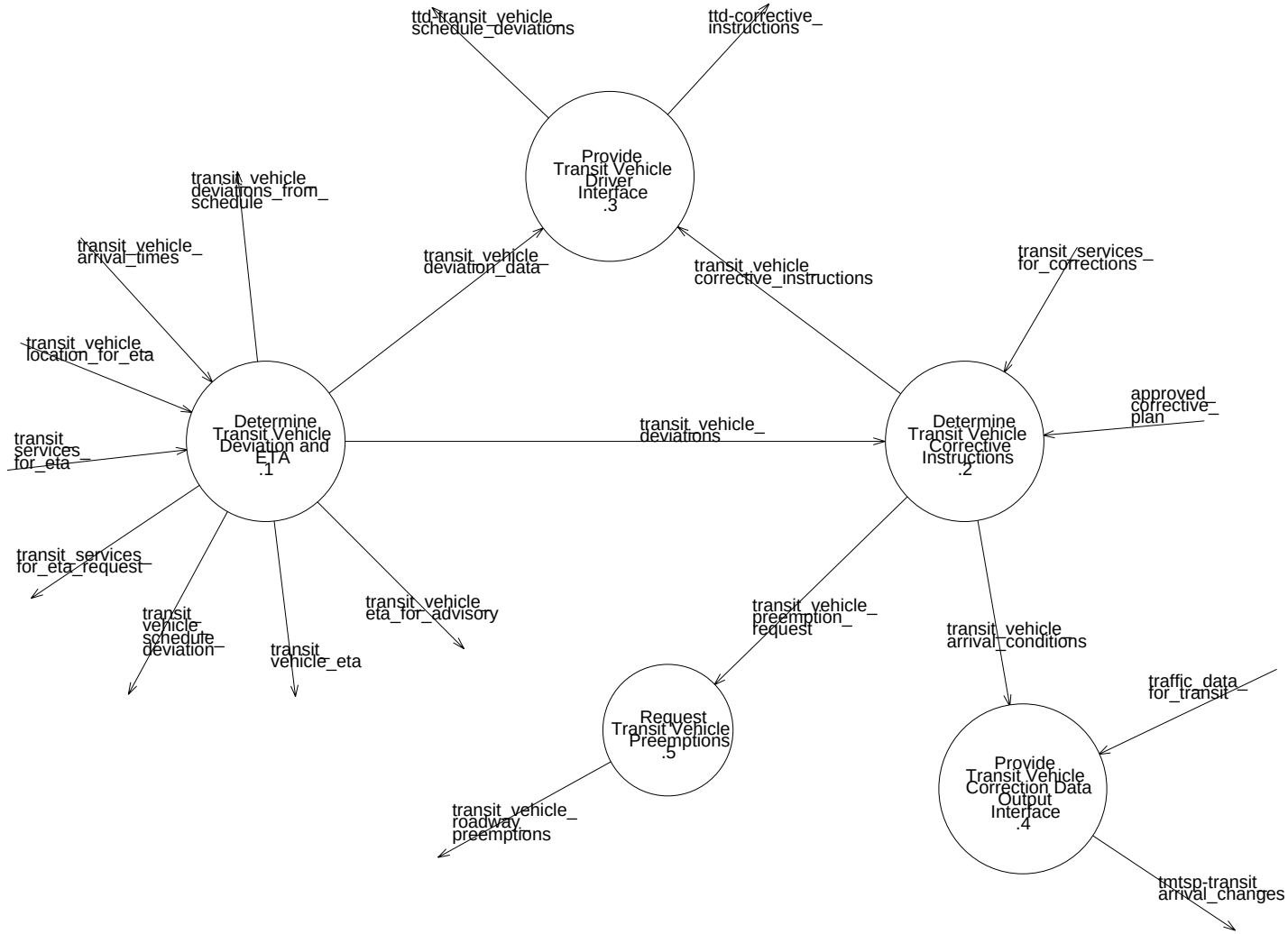


Figure 51. Determine Transit Vehicle Deviation and Corrections (DFD 4.1.2)

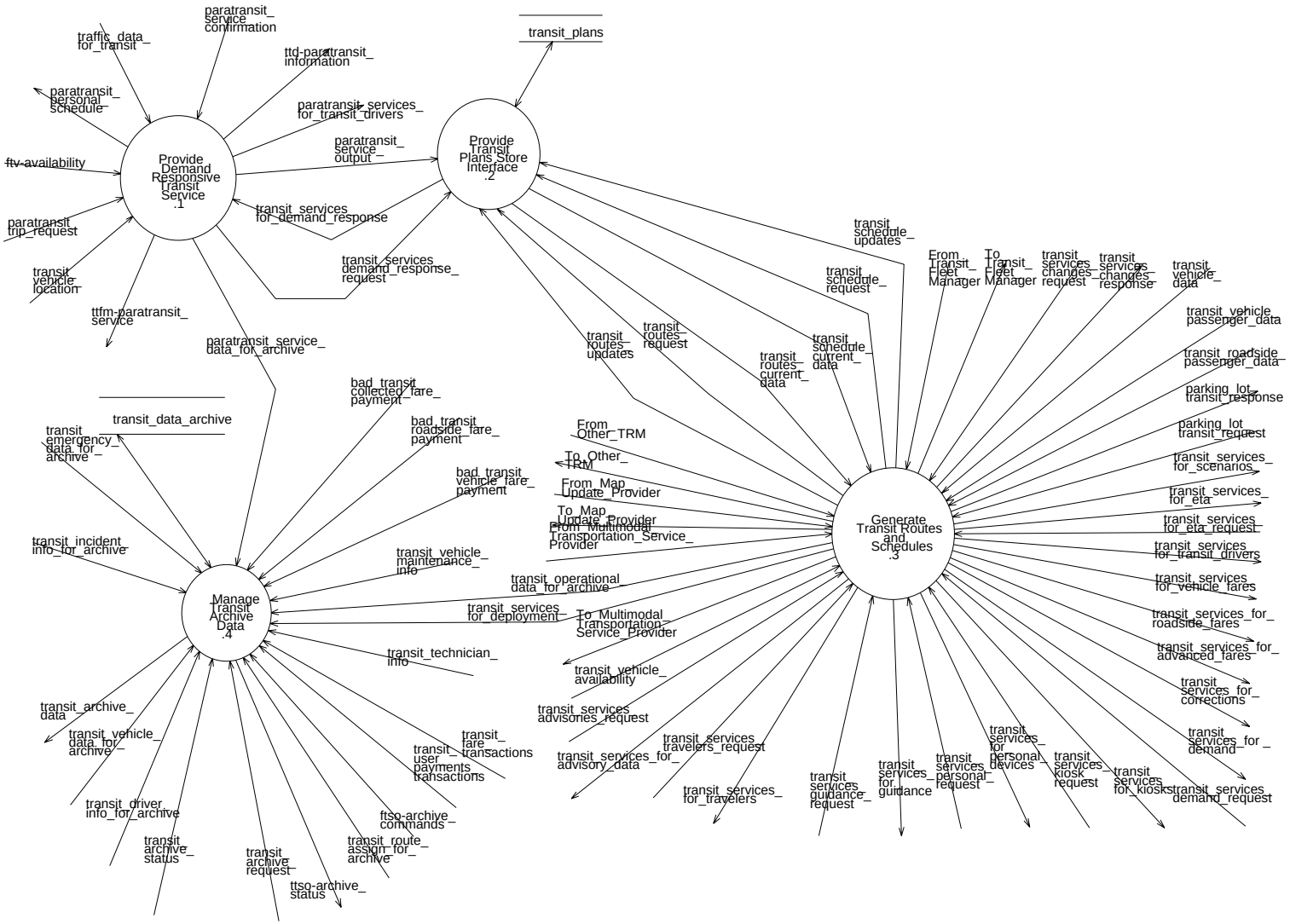


Figure 52. Plan and Schedule Transit Services (DFD 4.2)

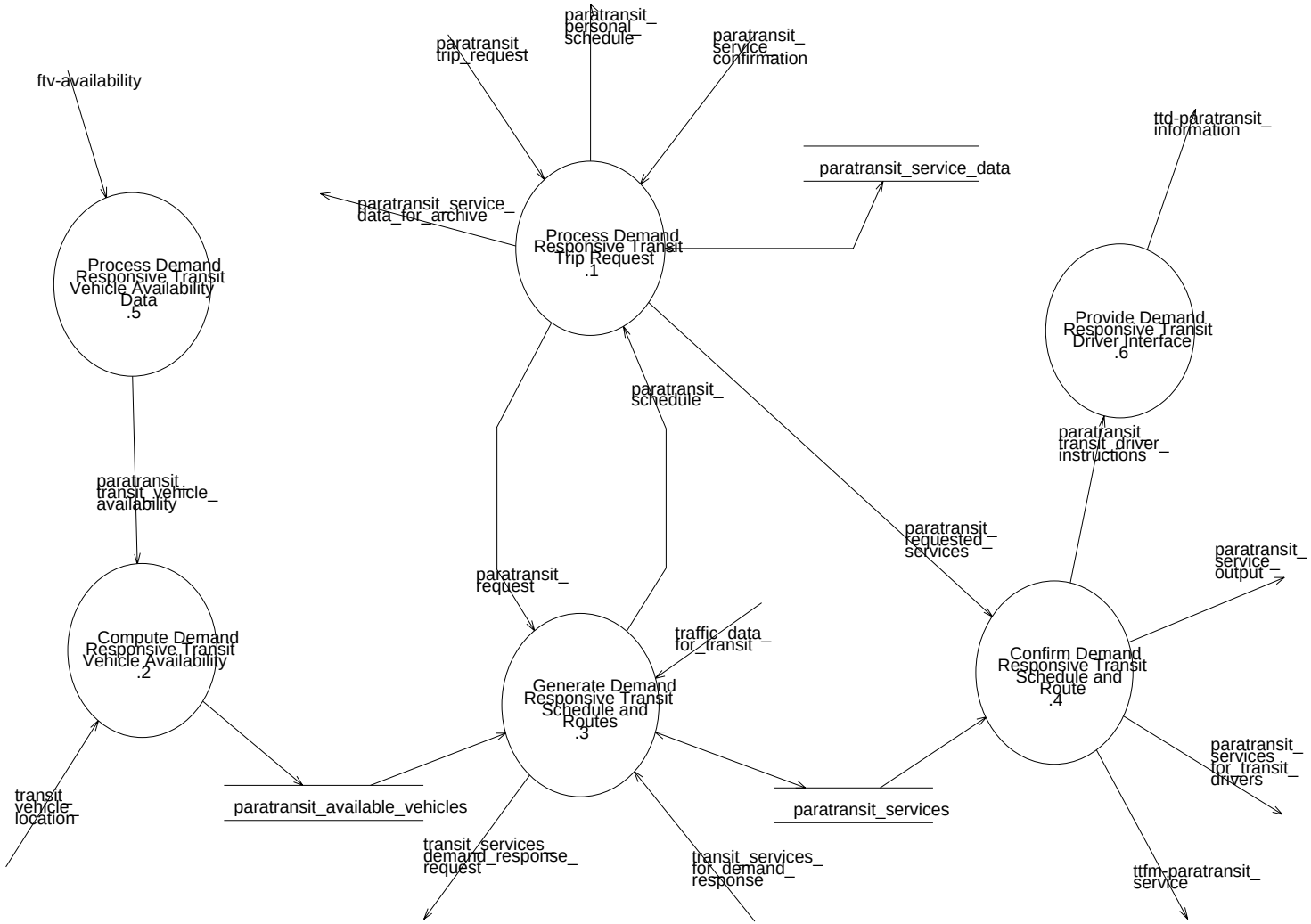


Figure 53. Provider Demand Responsive Transit Services (DFD 4.2.1)

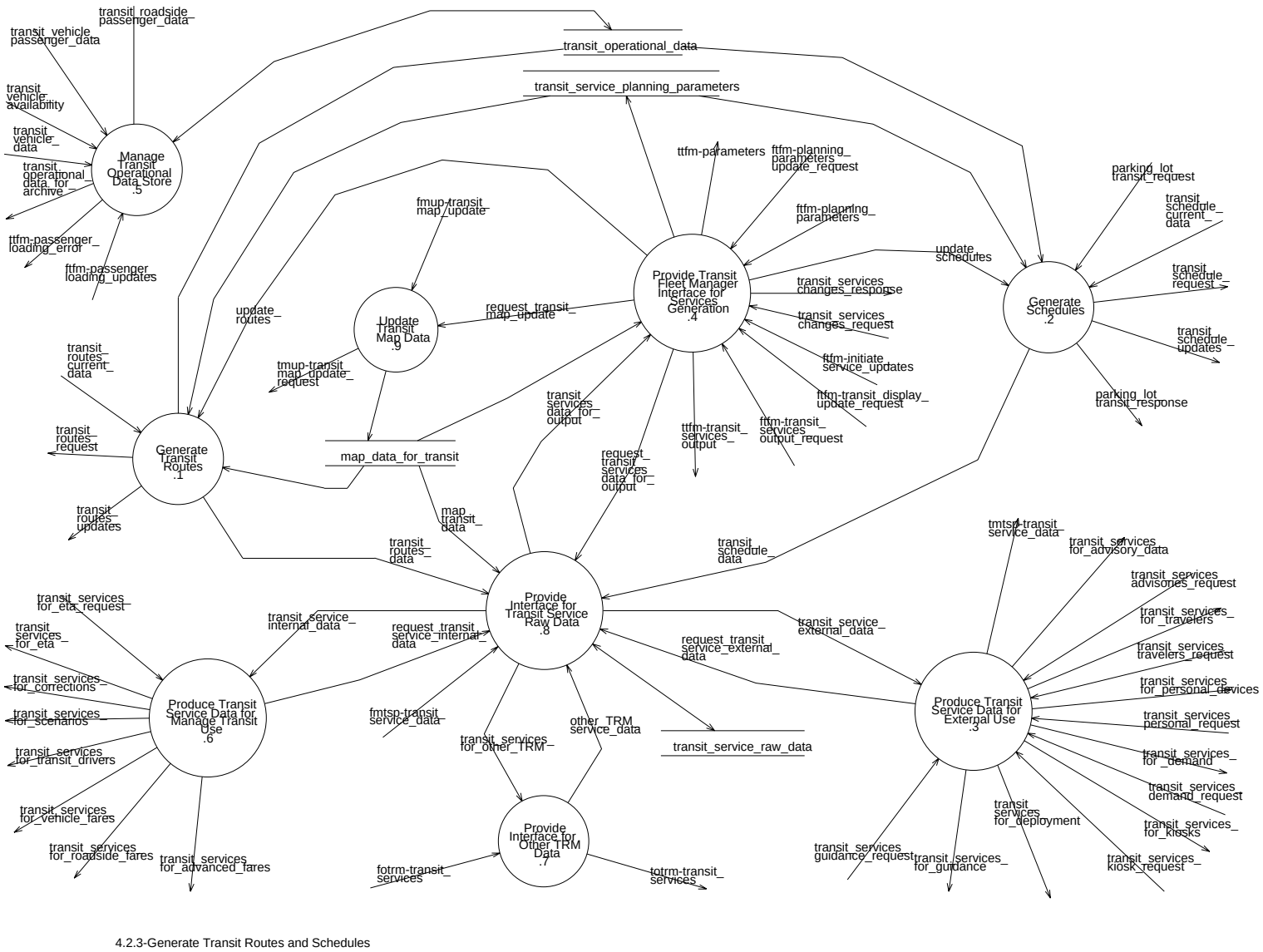


Figure 54. Generate Transit Routes and Schedules (DFD 4.2.3)

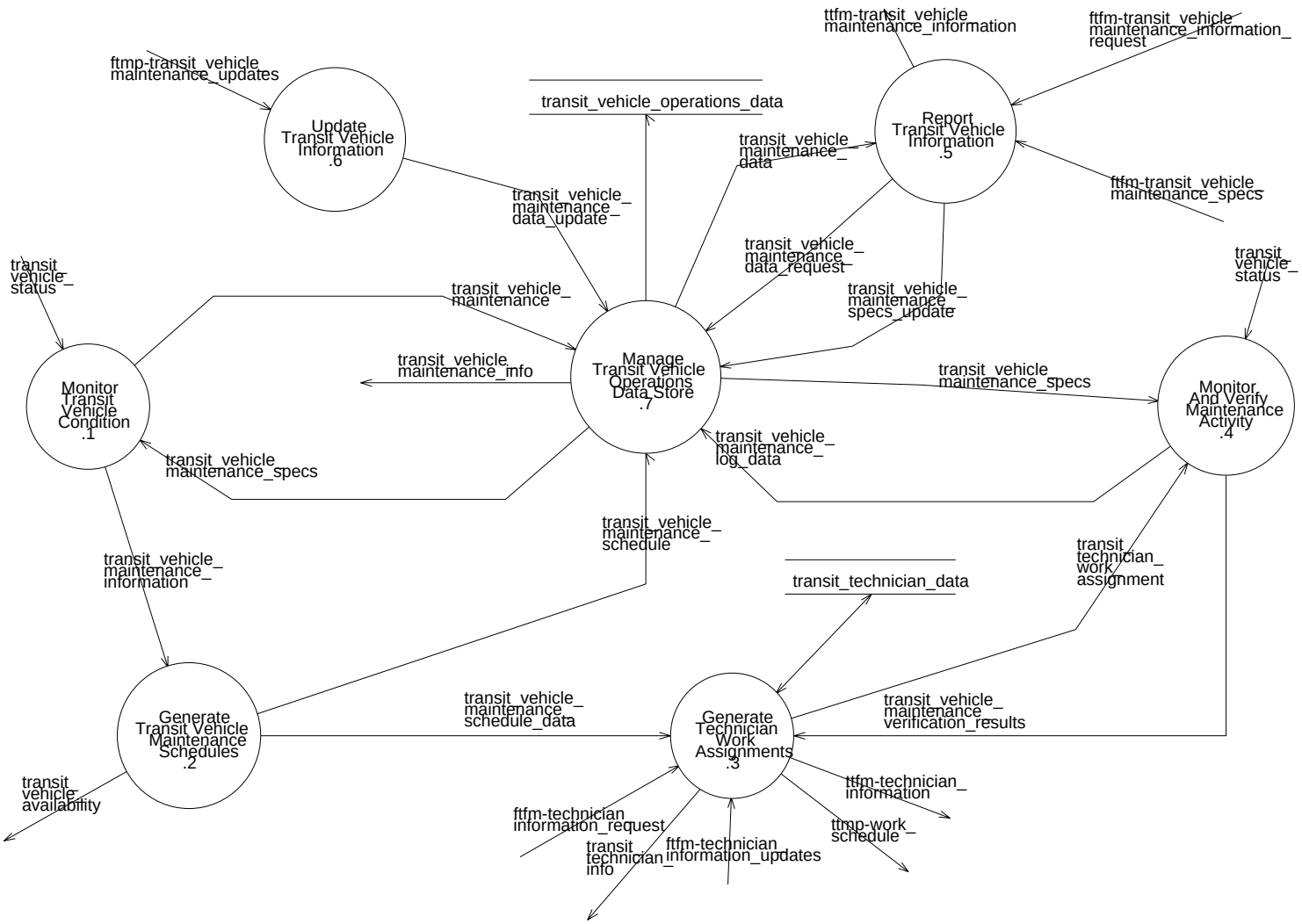


Figure 55. Schedule Transit Vehicle Maintenance (DFD 4.3)

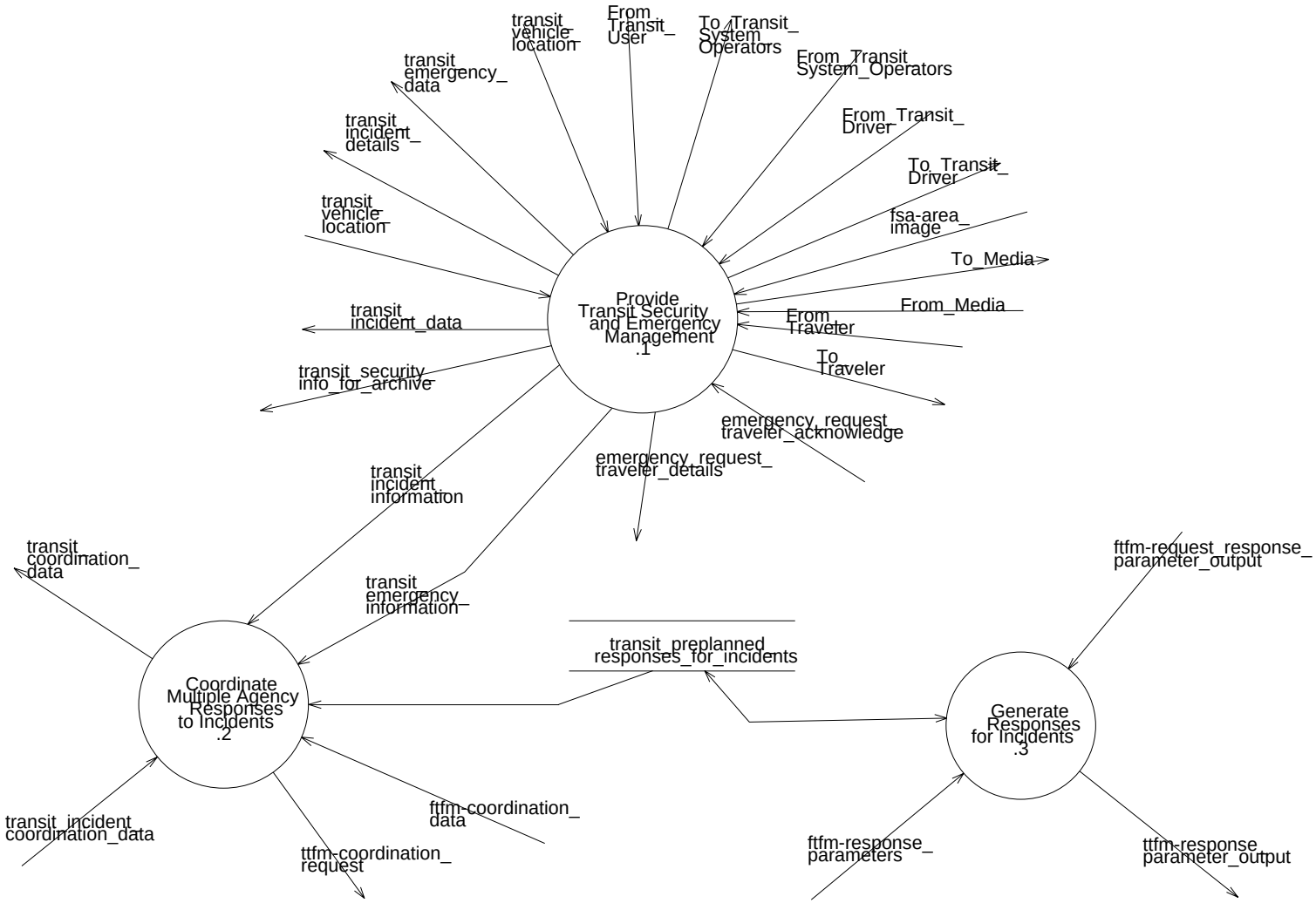


Figure 56. Support Security and Coordination (DFD 4.4)

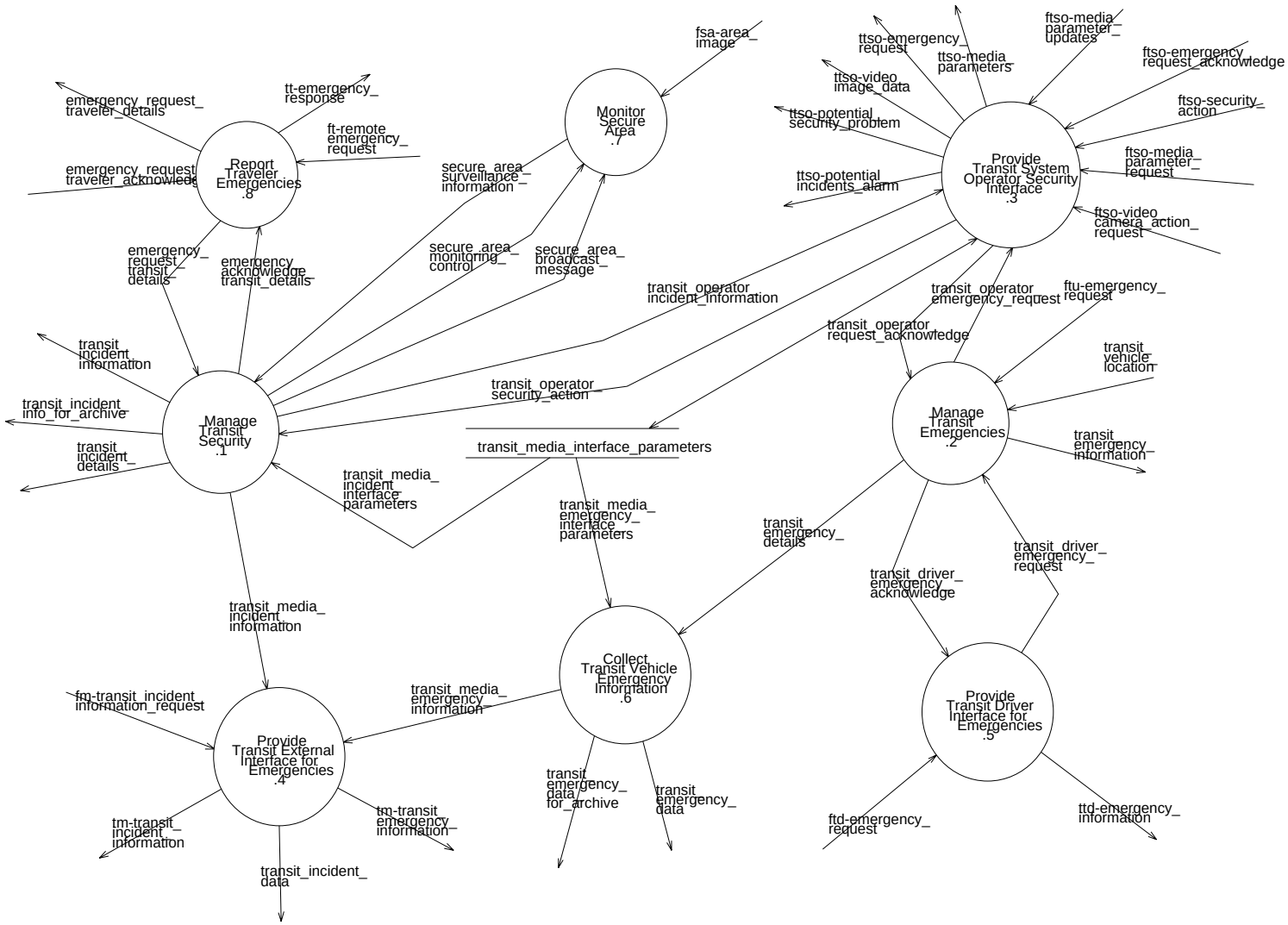


Figure 57. Provide Transit Security and Emergency Management (DFD 4.4.1)

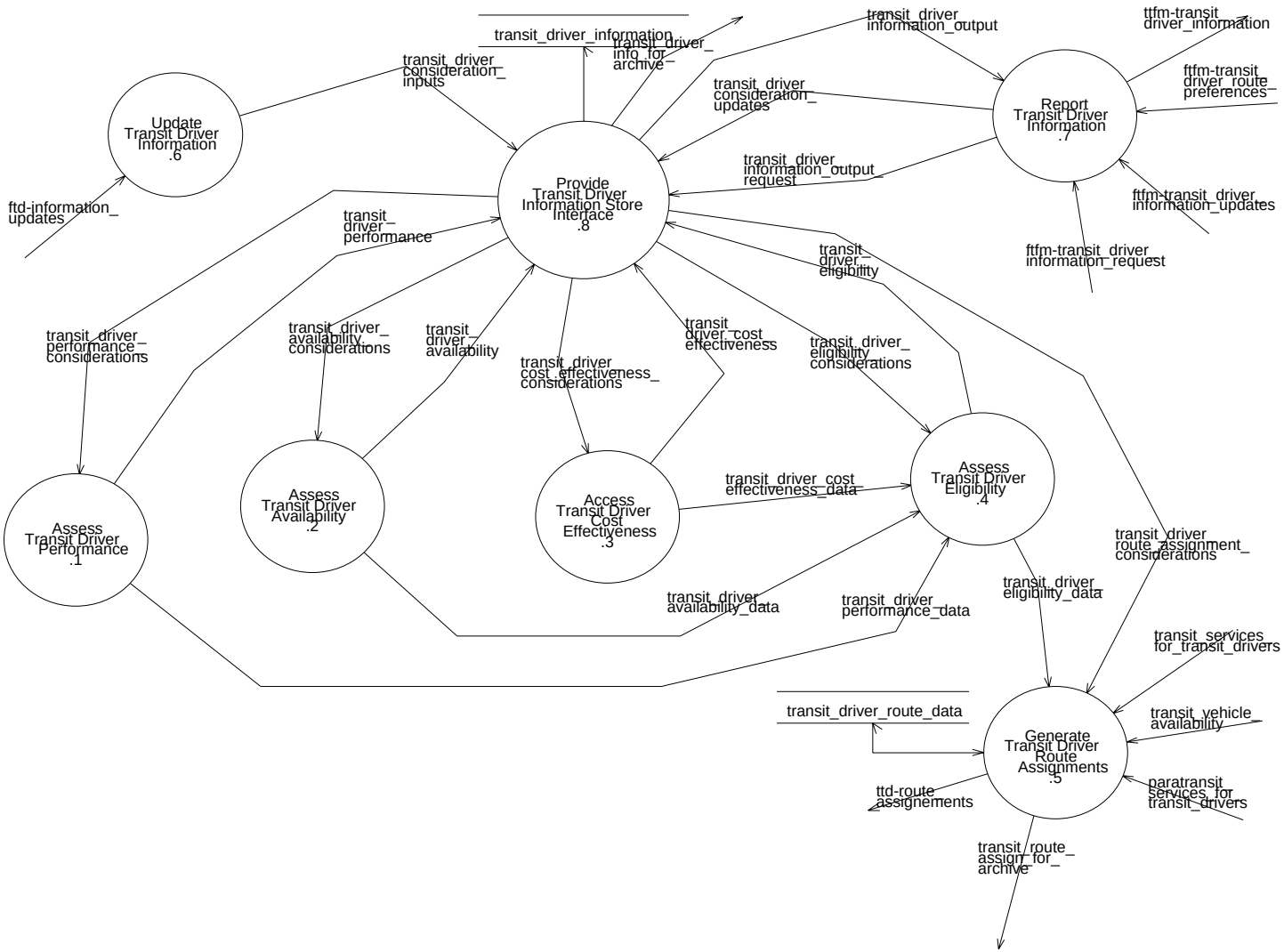


Figure 58. Generate Transit Driver Schedules (DFD 4.5)

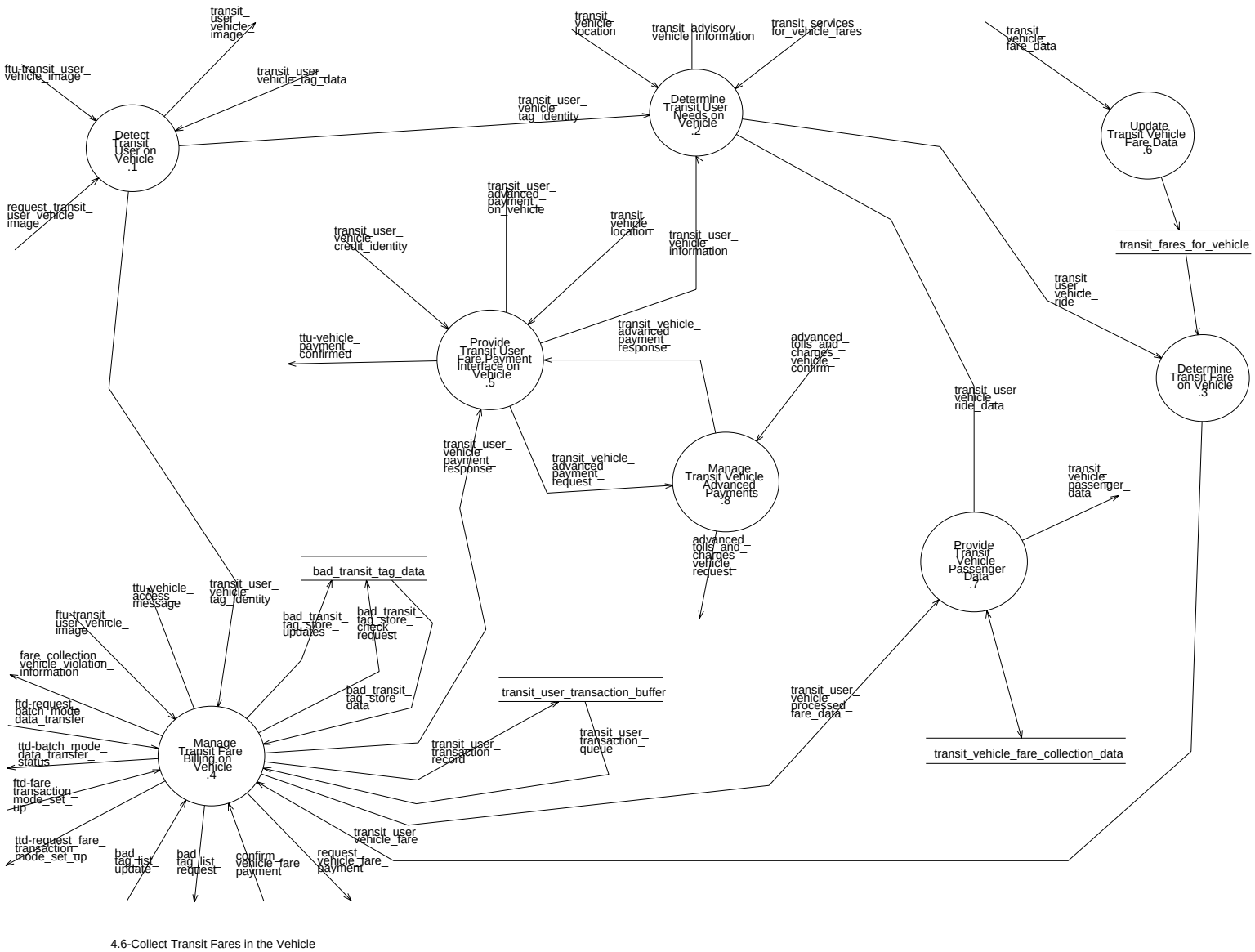
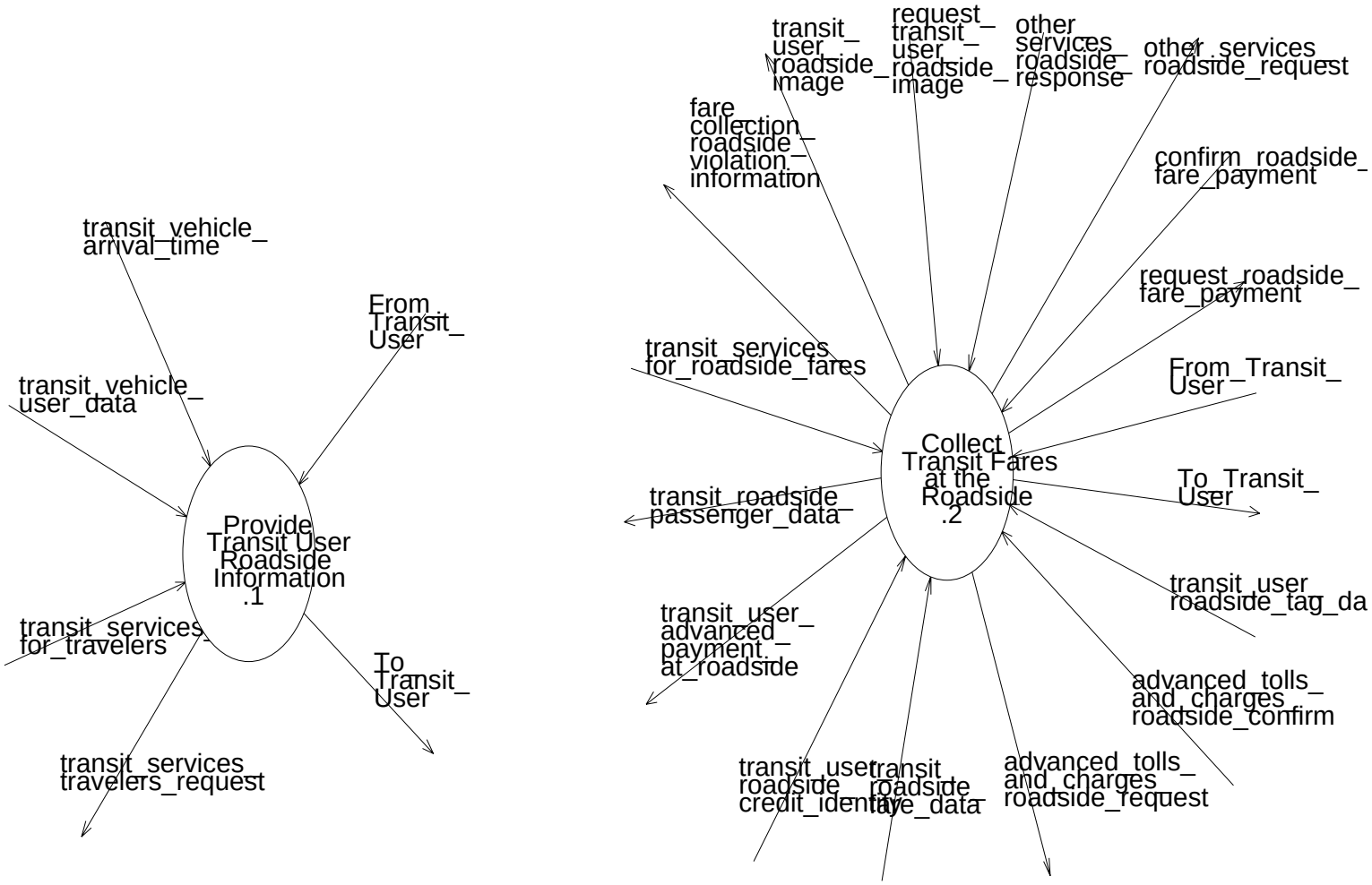


Figure 59. Collect Transit Fares in the Vehicle (DFD 4.6)



4.7-Provide Transit User Roadside Facilities

Figure 60. Provide Transit User Roadside Facilities (DFD 4.7)

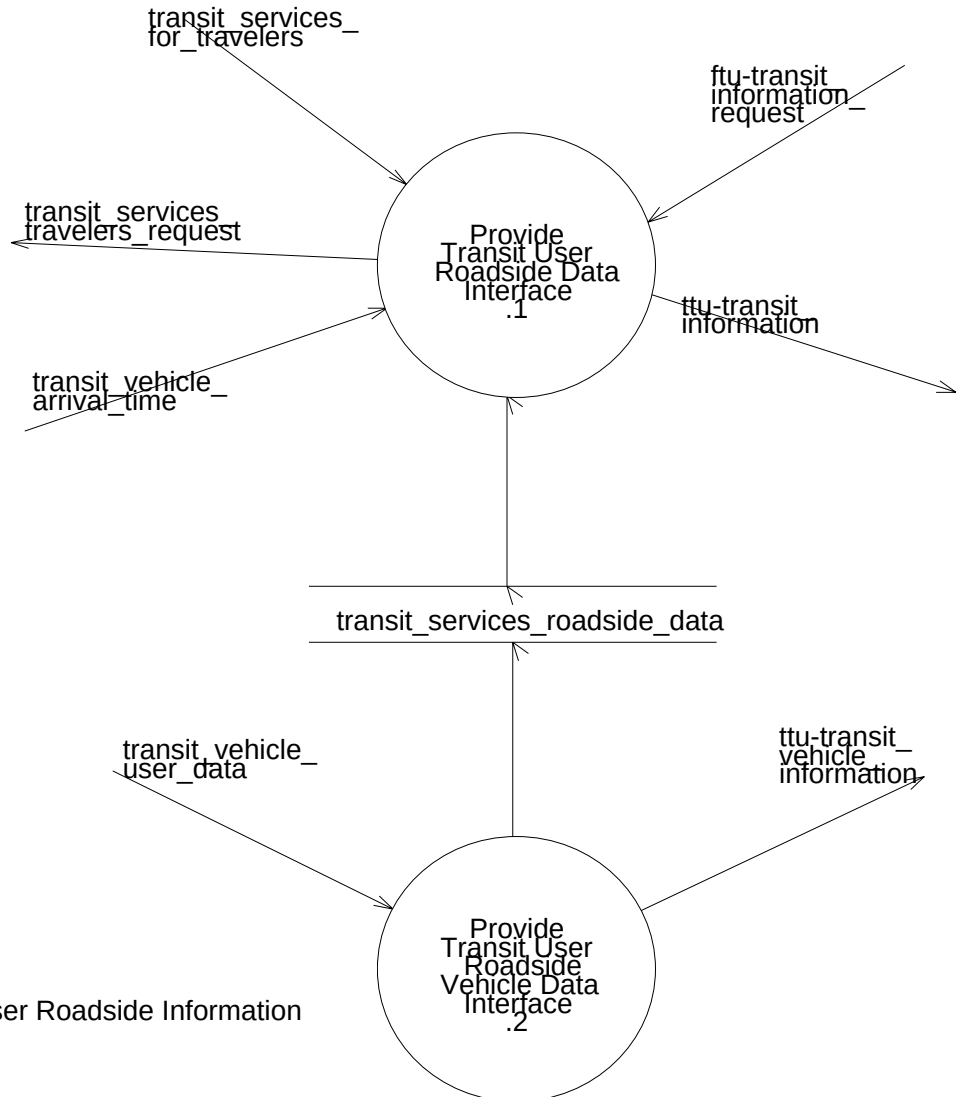


Figure 61. Provide Transit User Roadside Information (DFD 4.7.1)

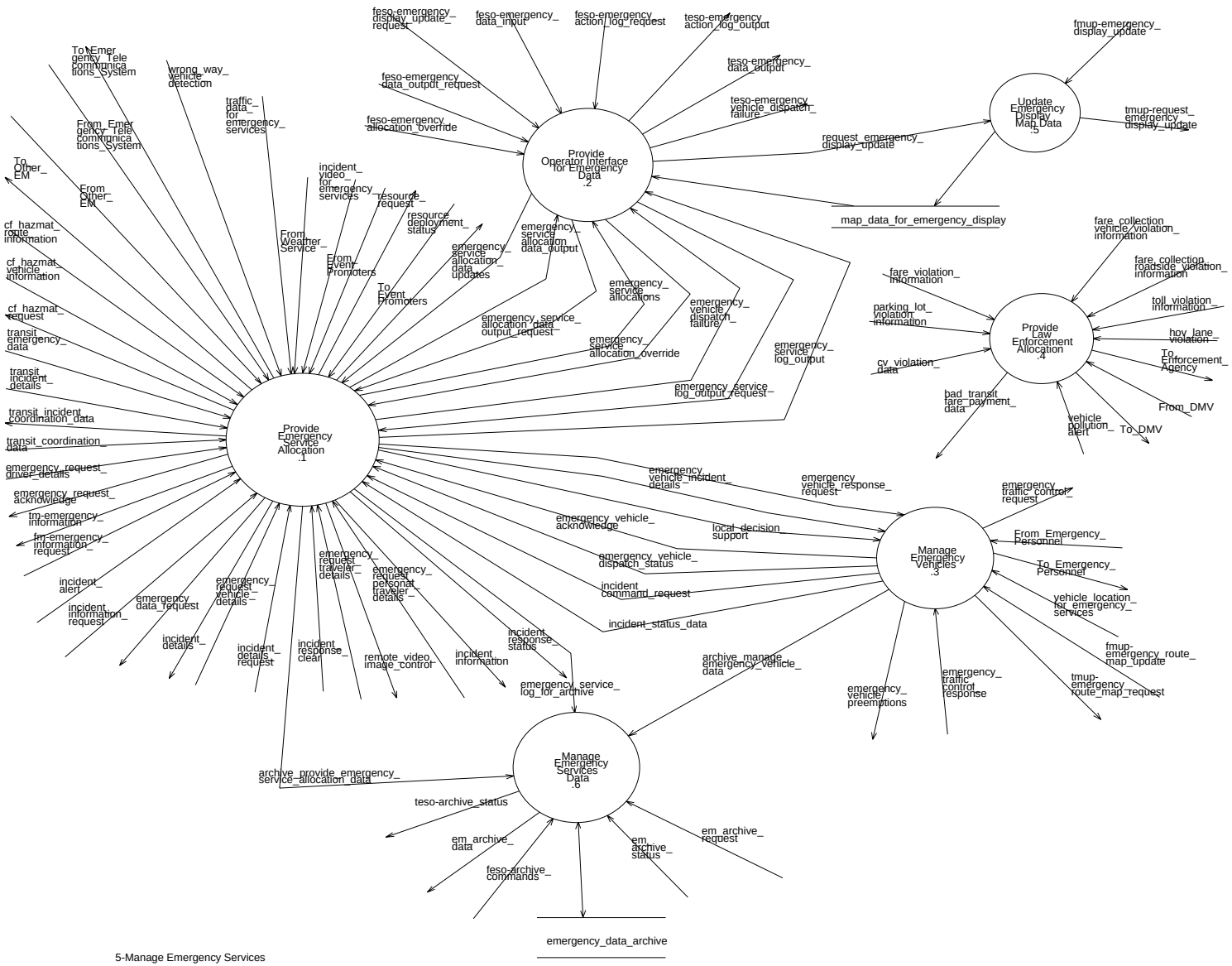


Figure 62. Collect Transit Fares at the Roadside (DFD 4.7.2)

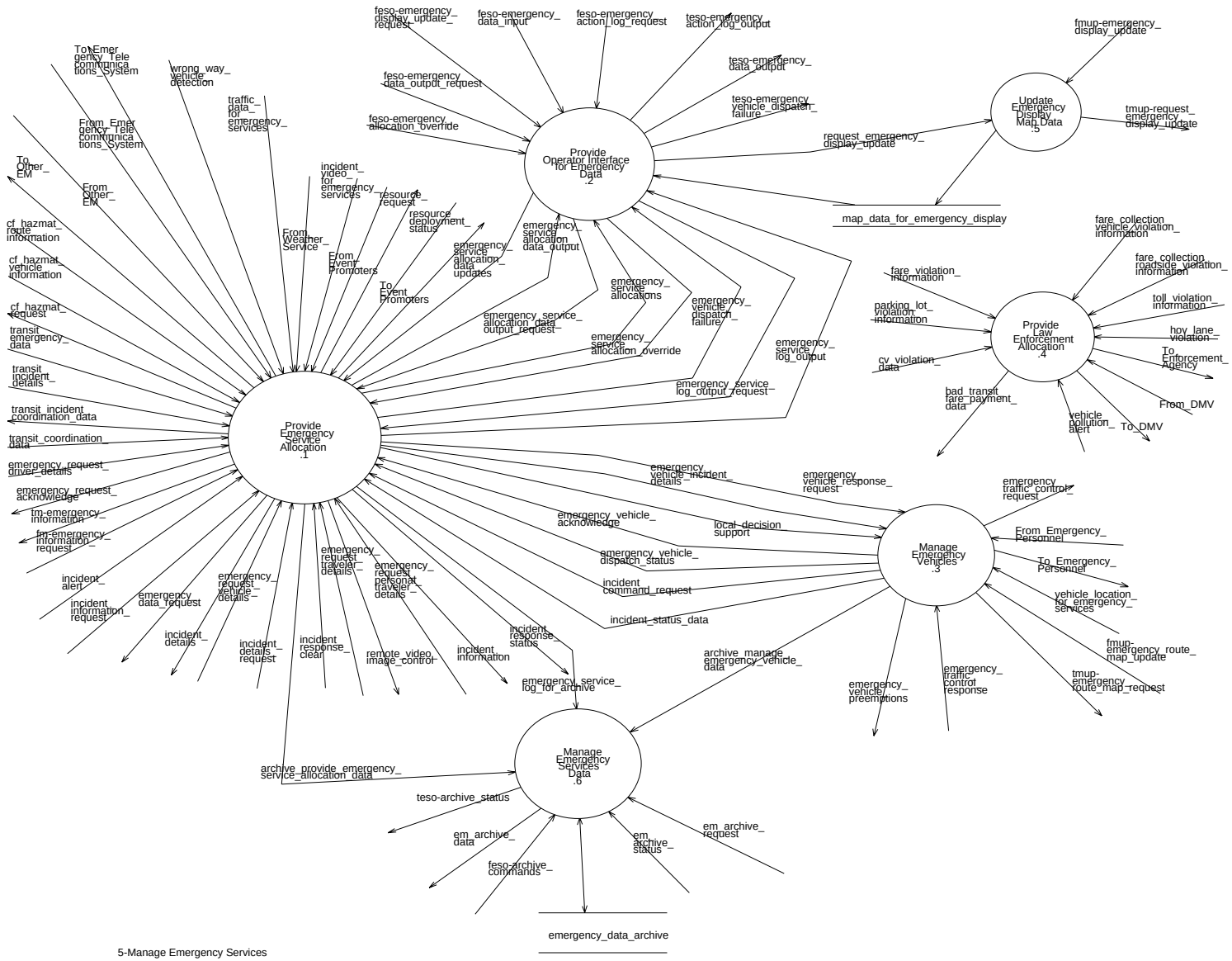


Figure 63. Manage Emergency Services (DFD 5)

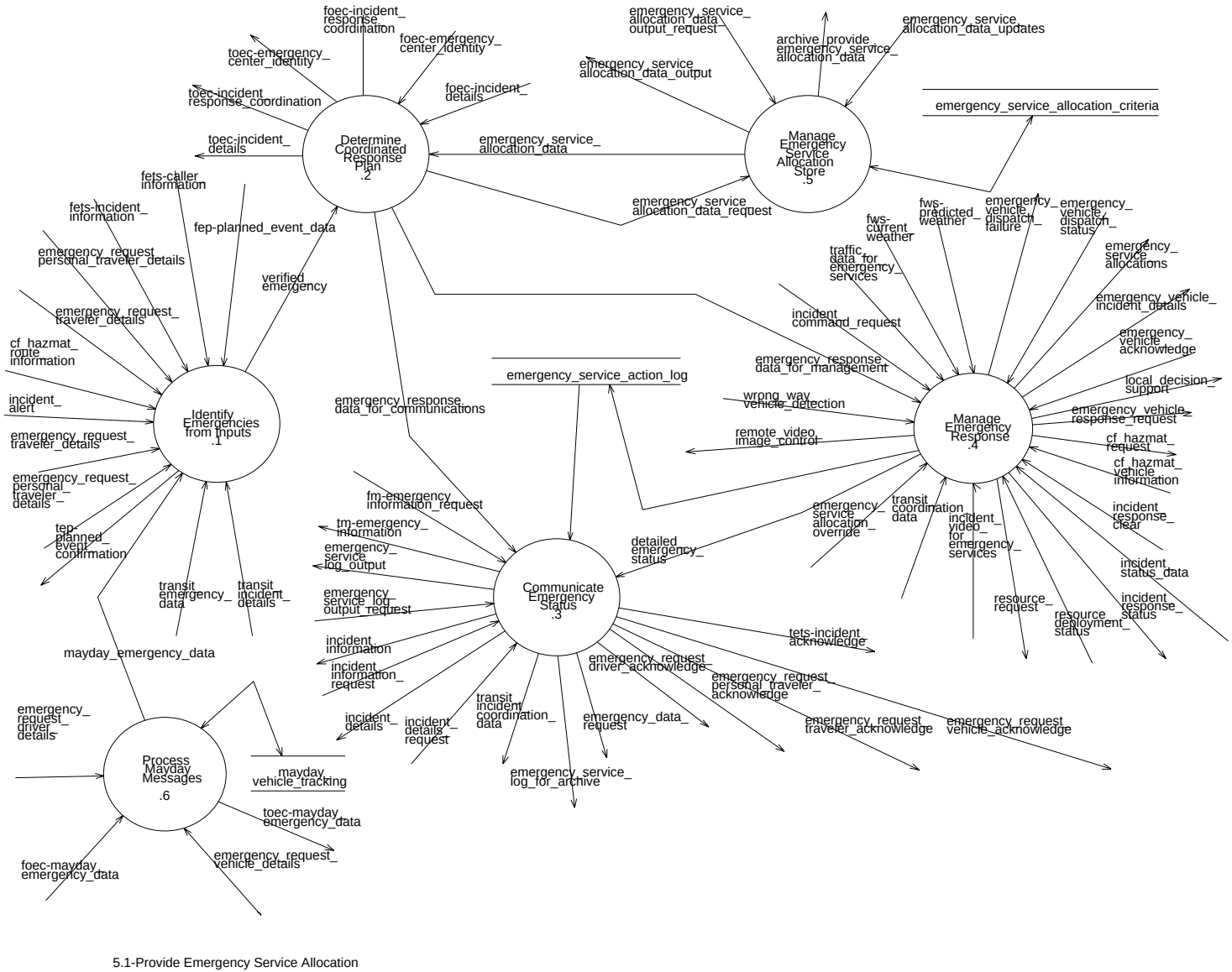


Figure 64. Provide Emergency Services Allocation (DFD 5.1)

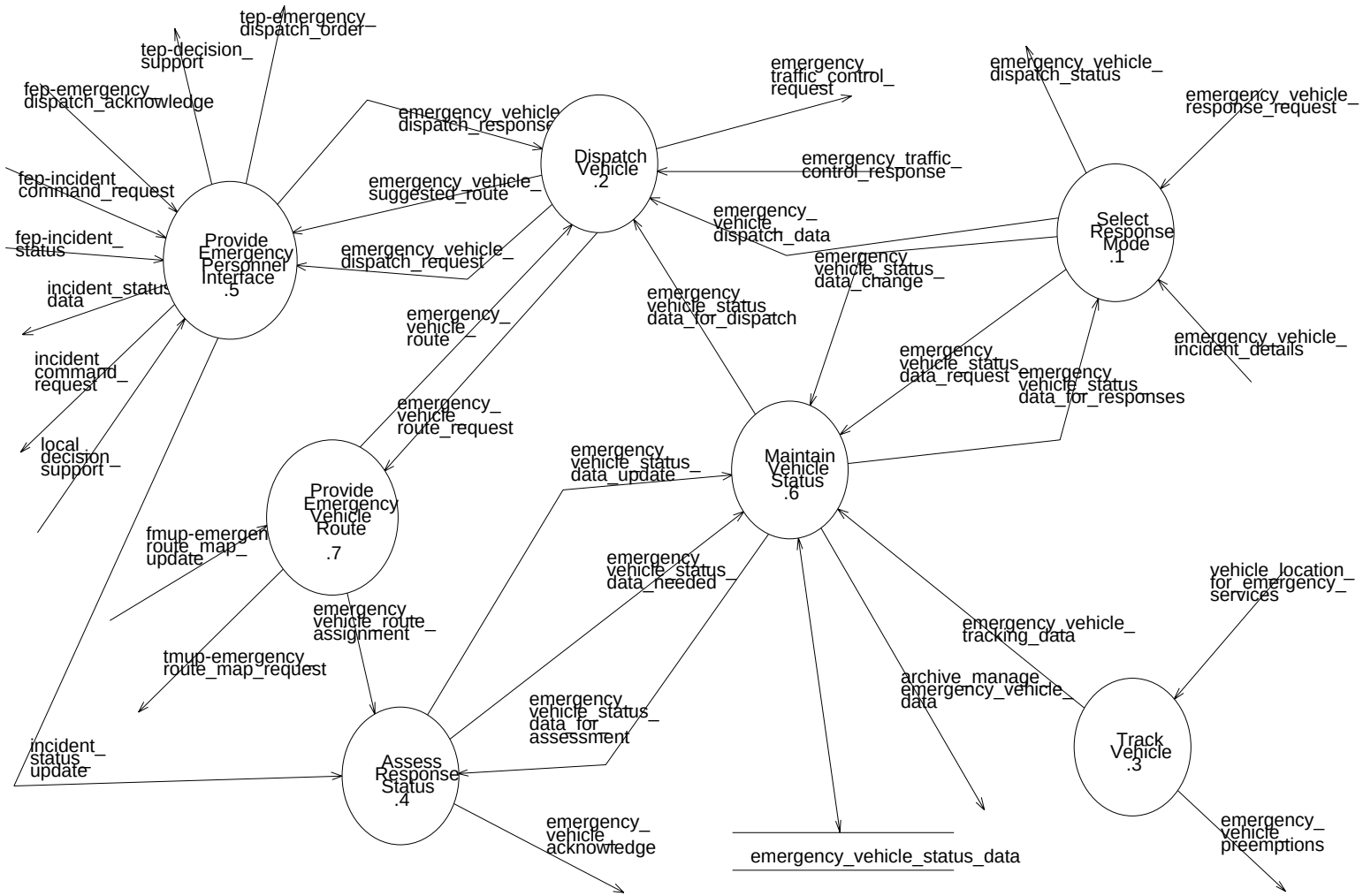


Figure 65. Manage Emergency Vehicles (DFD 5.3)

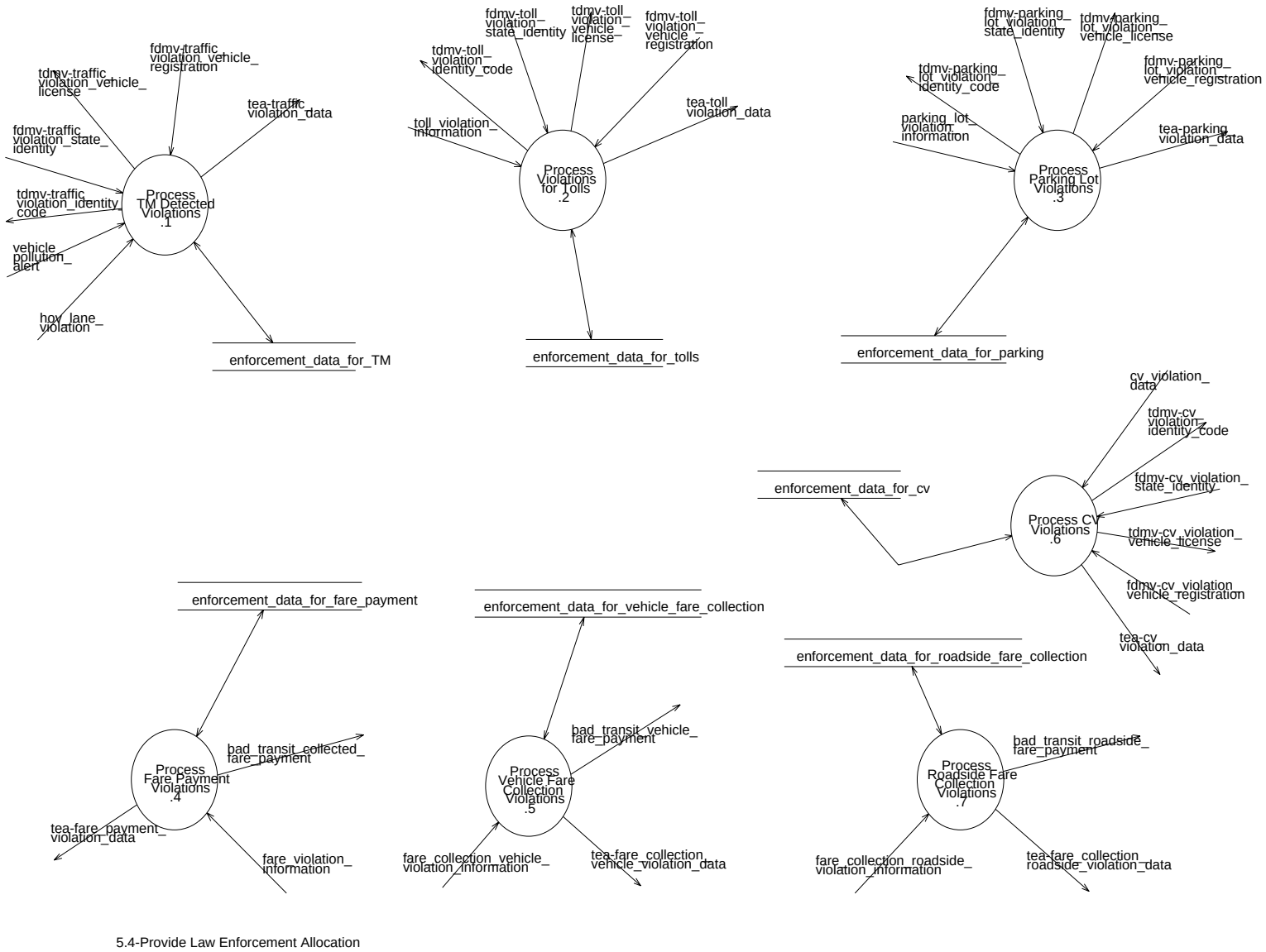


Figure 66. Provide Law Enforcement Allocation (DFD 5.4)

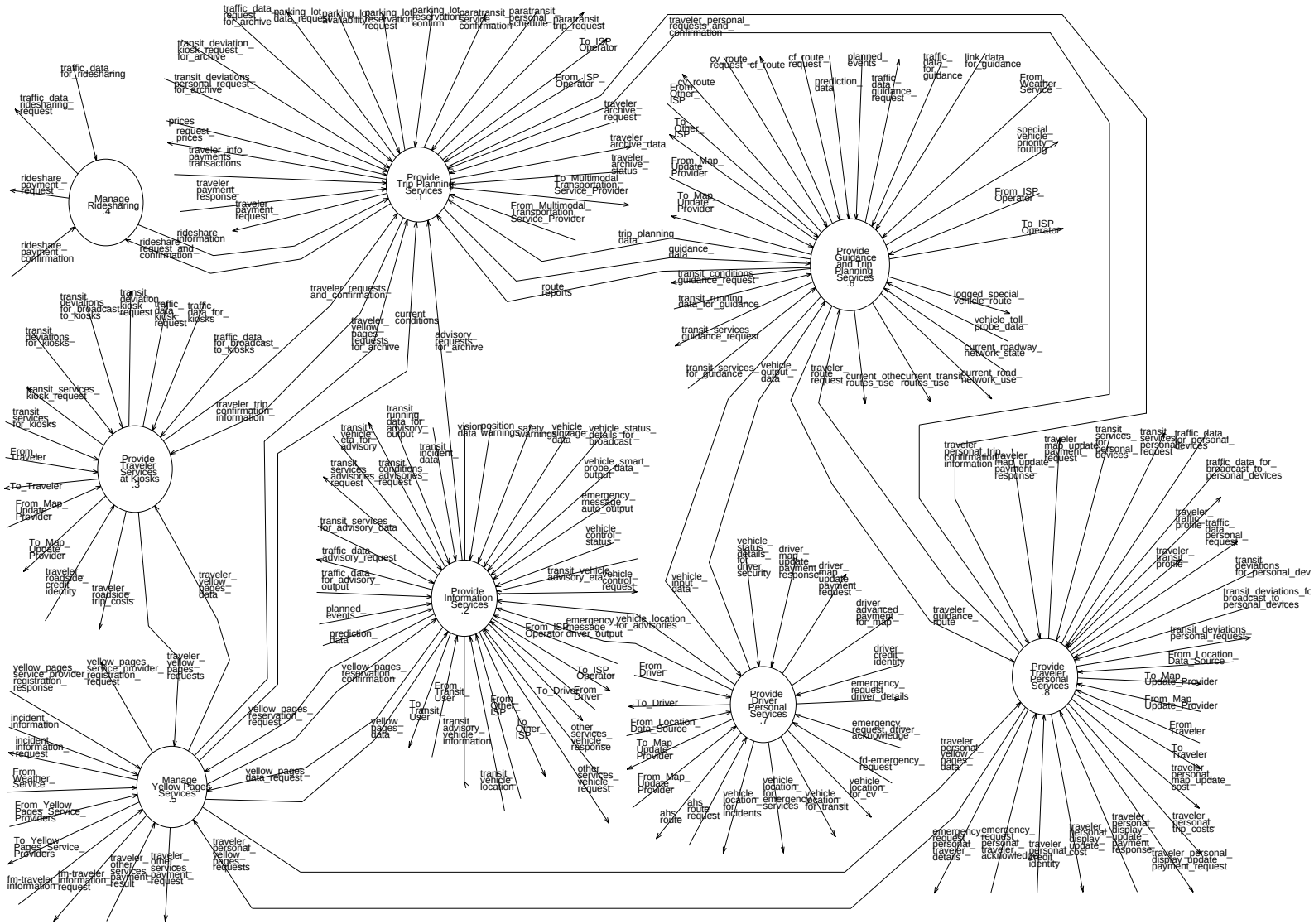


Figure 67. Provide Driver and Traveler Services (DFD 6)

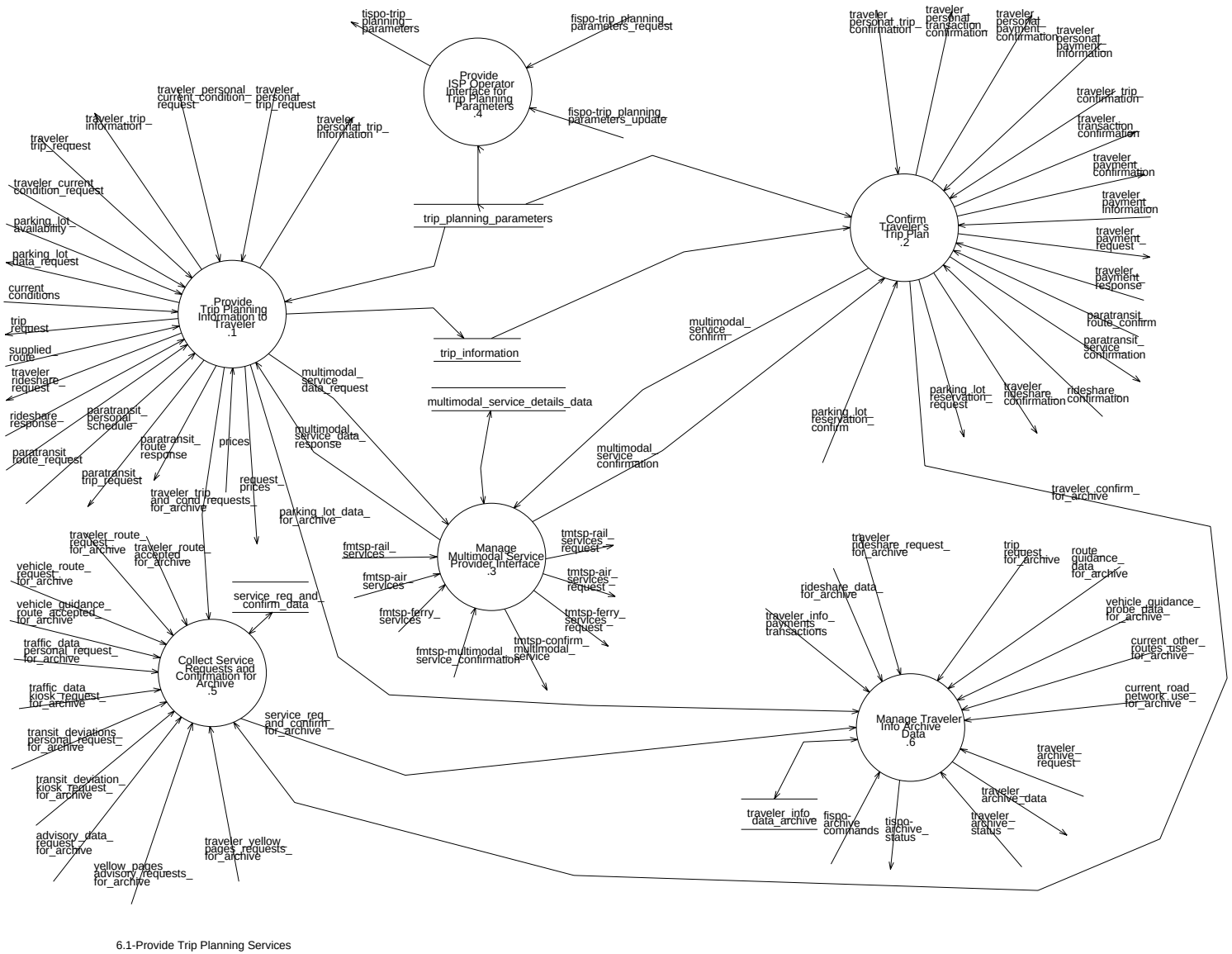


Figure 68. Provide Trip Planning Services (DFD 6.1)

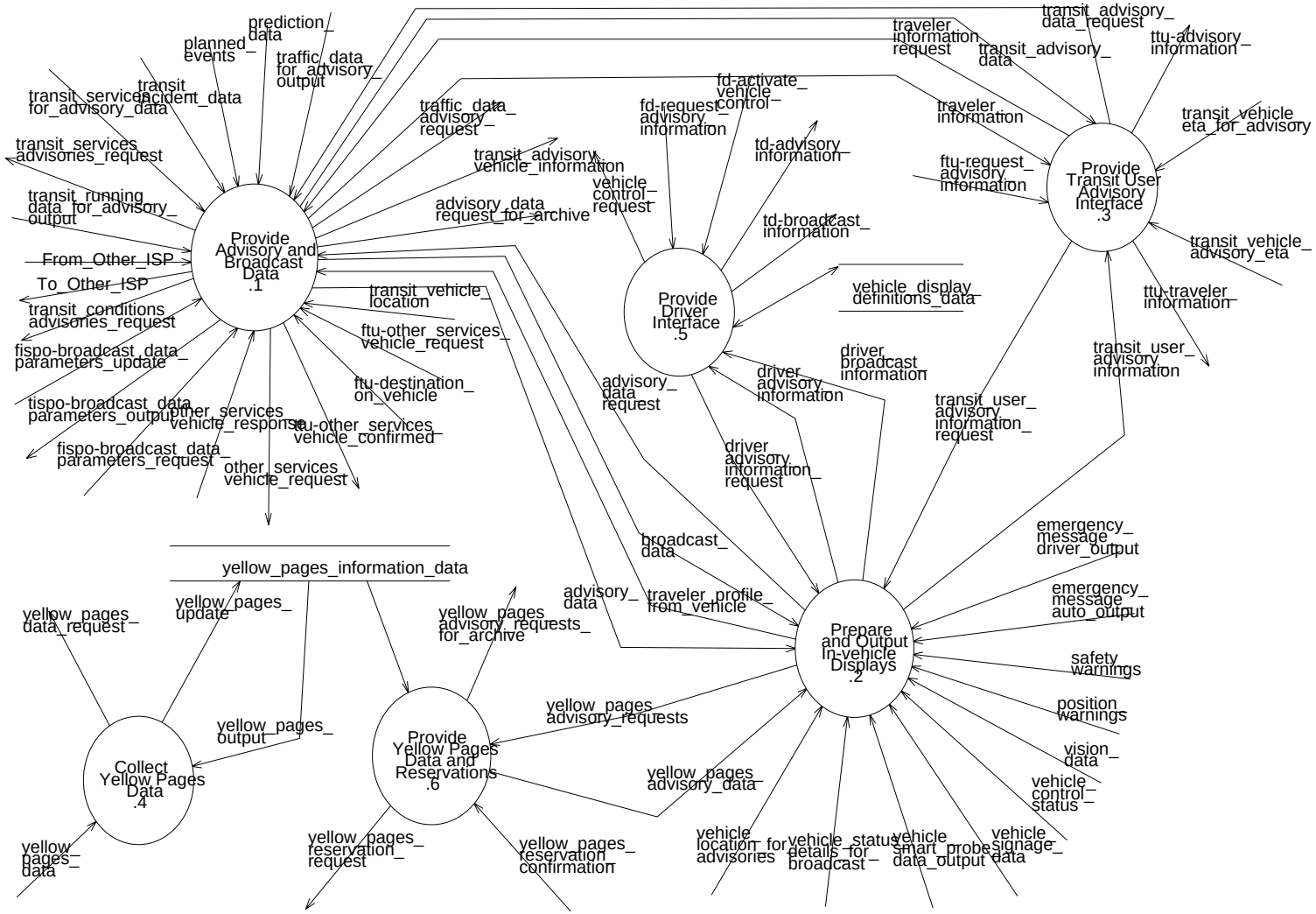


Figure 69. Provide Information Services (DFD 6.2)

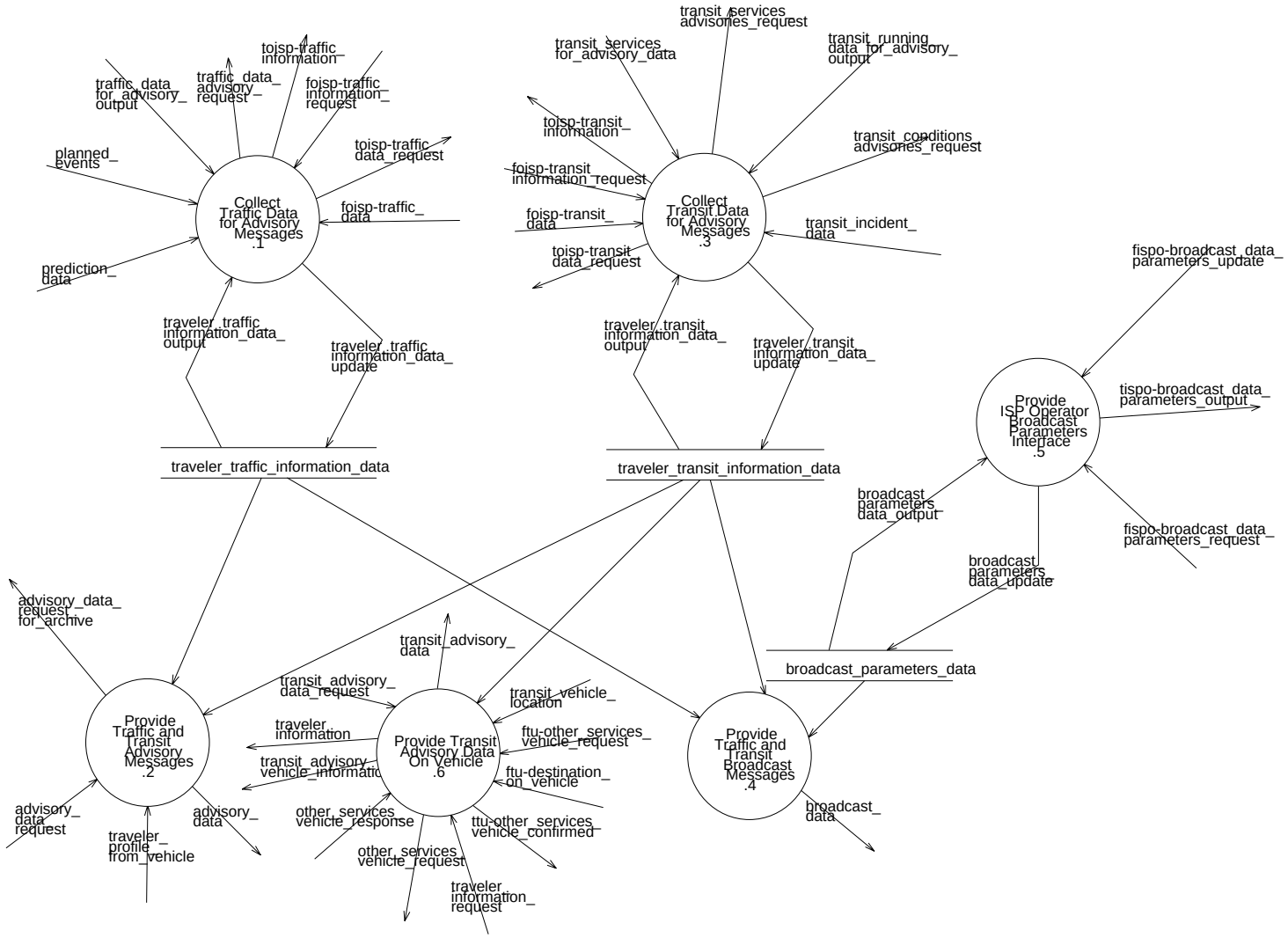


Figure 70. Provide Advisory and Broadcast Data (DFD 6.2.1)

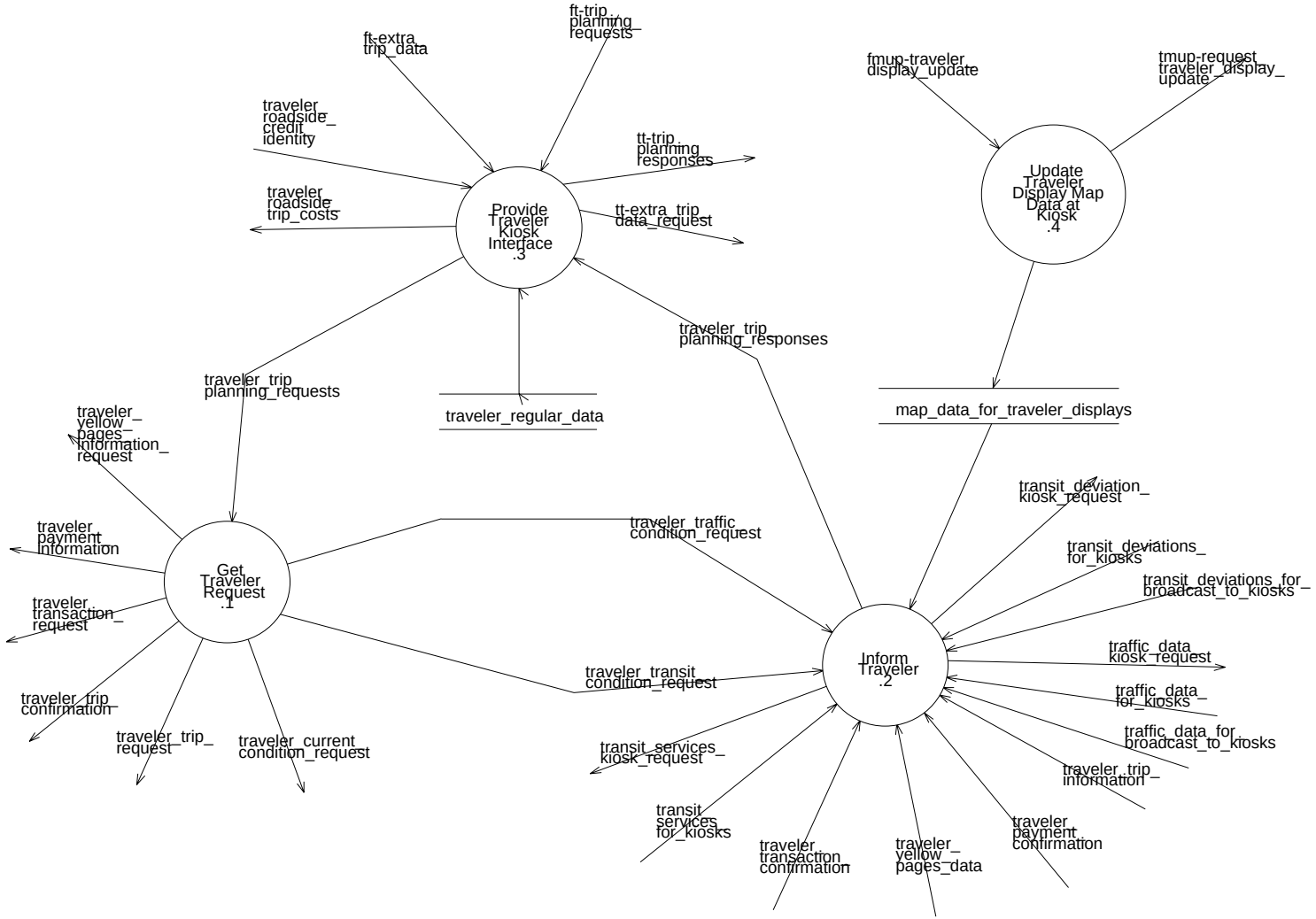


Figure 71. Provide Traveler Services at Kiosks (DFD 6.3)

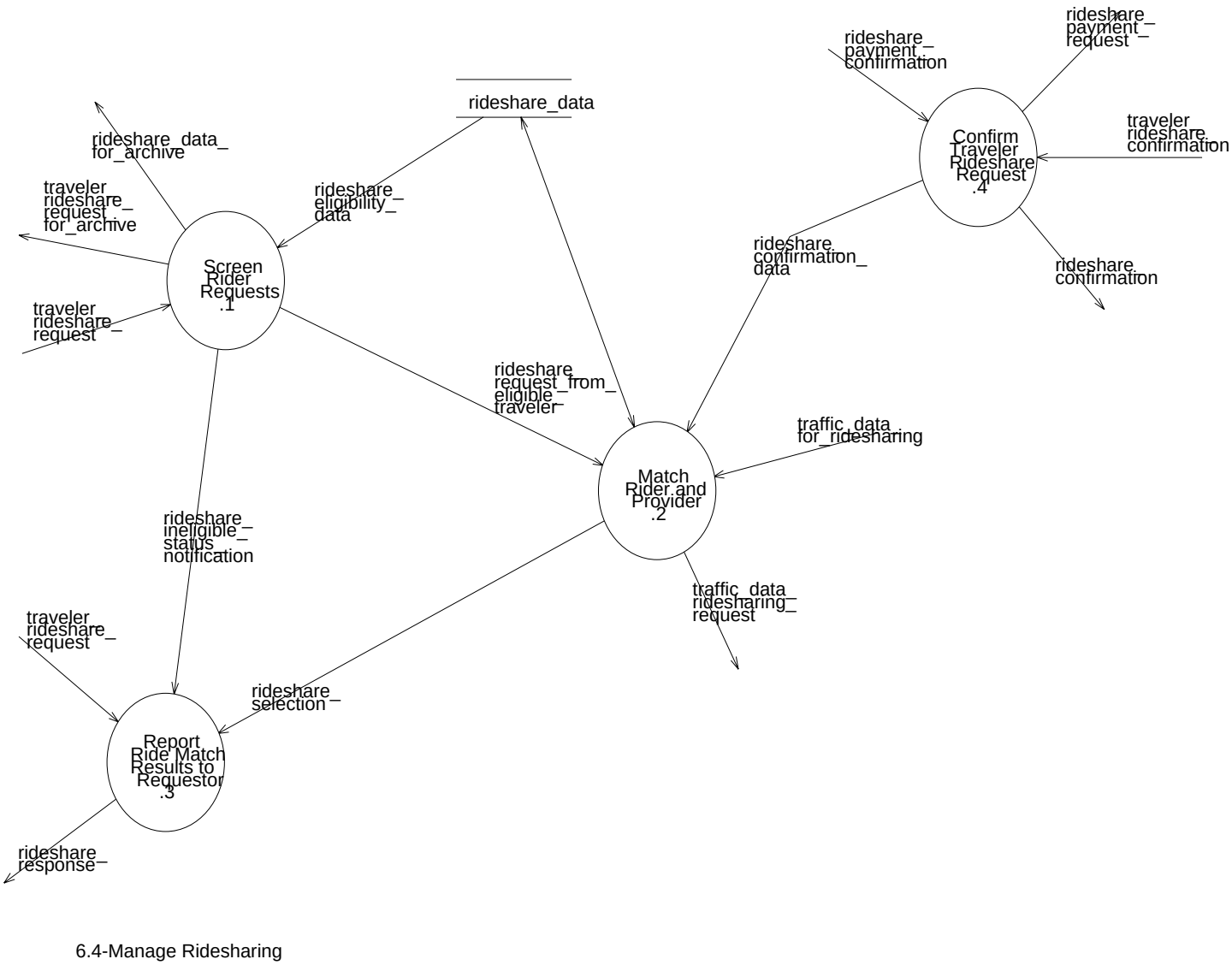


Figure 72. Manage Ridesharing (DFD 6.4)

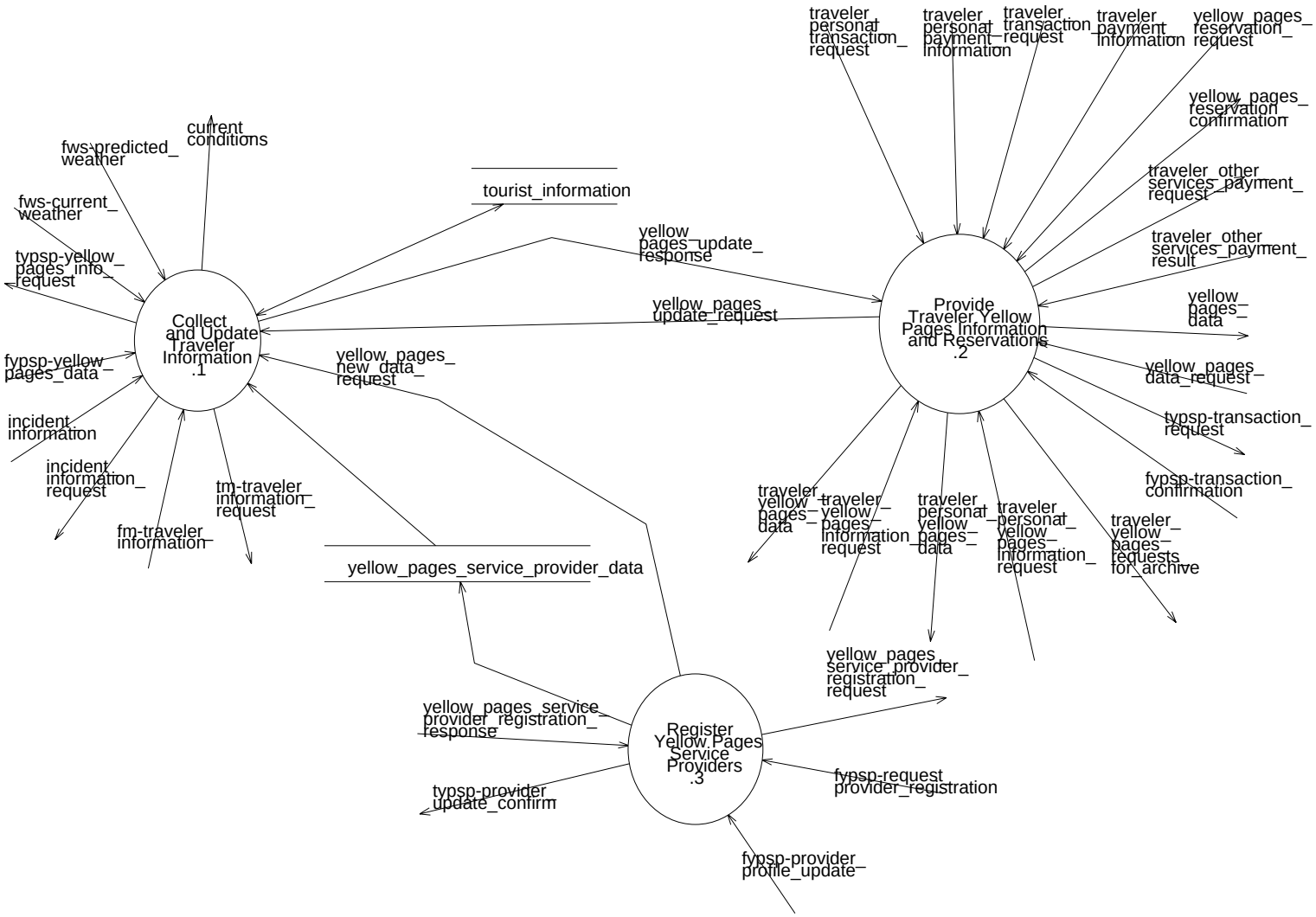


Figure 73. Manage Yellow Pages Services (DFD 6.5)

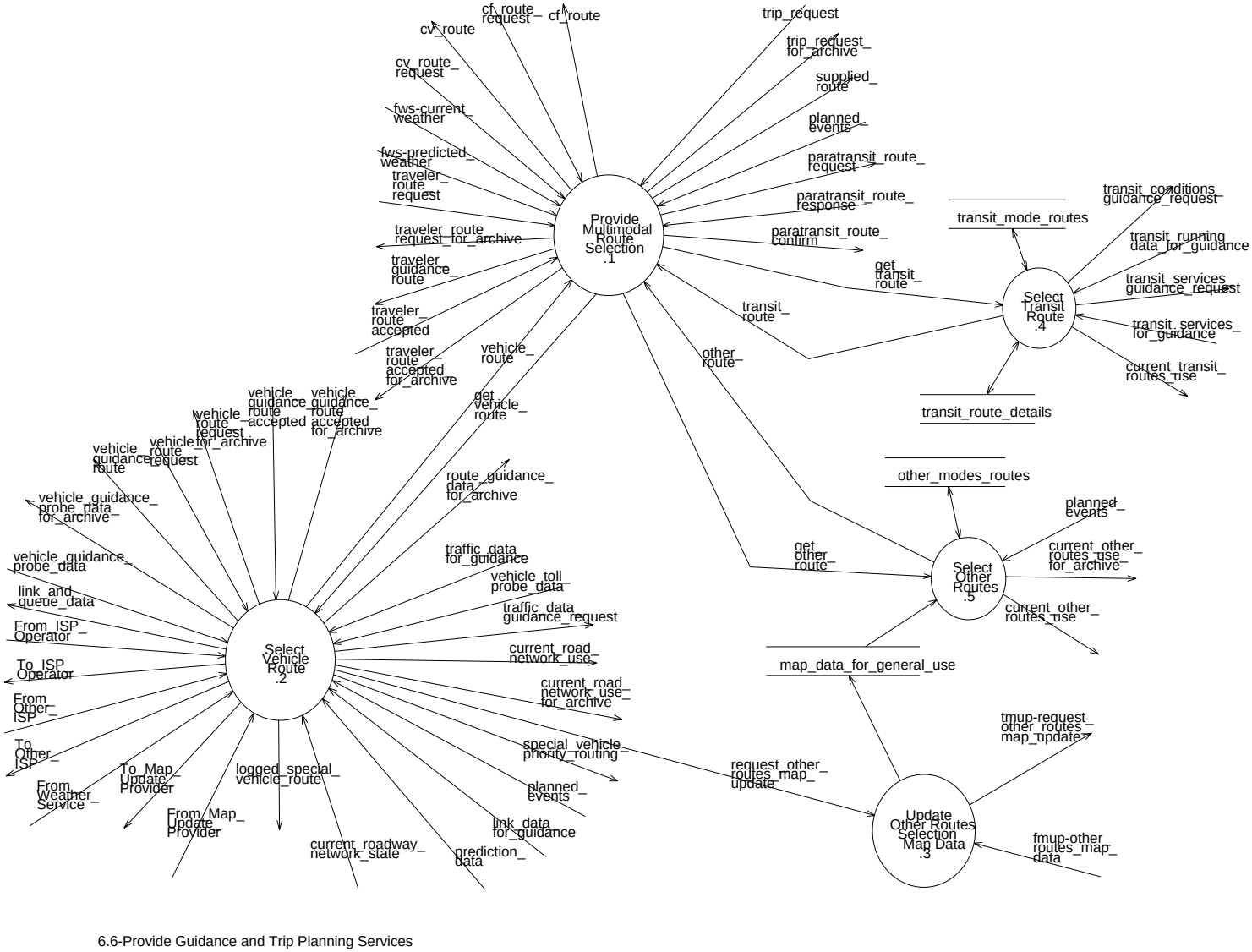


Figure 74. Provide Guidance and Trip Planning Services (DFD 6.6)

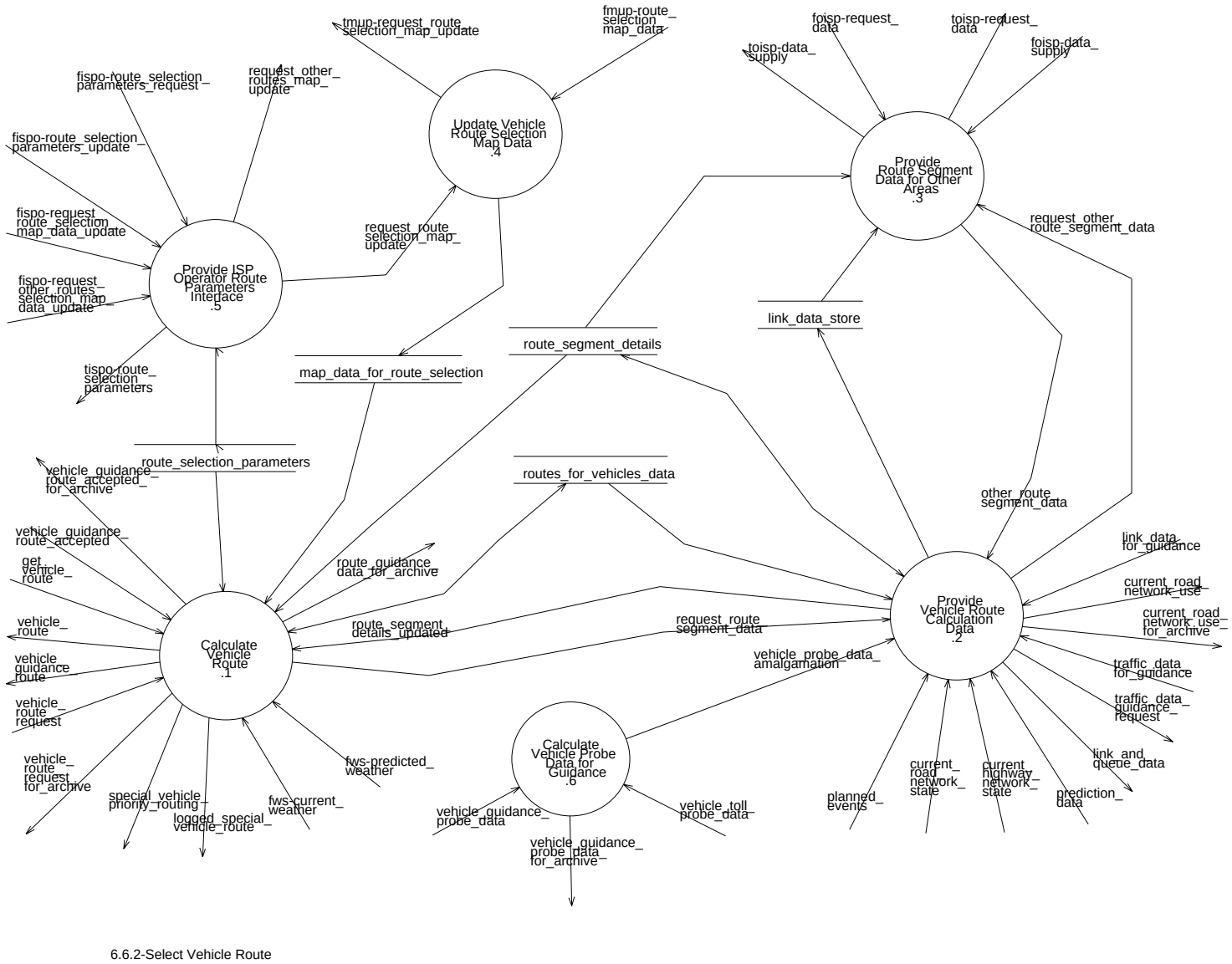


Figure 75. Select Vehicle Route (DFD 6.6.2)

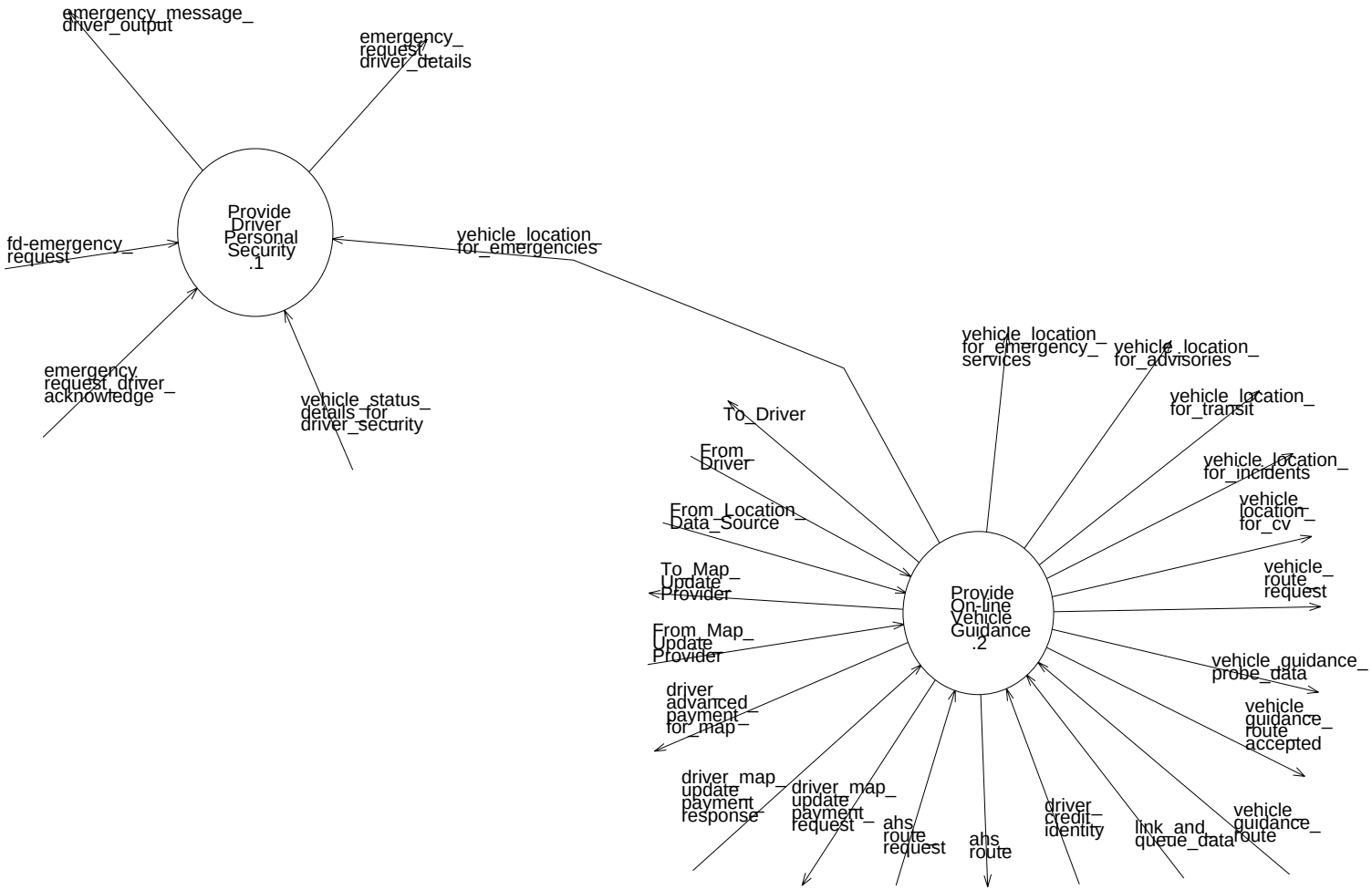


Figure 76. Provide Driver Personal Services (DFD 6.7)

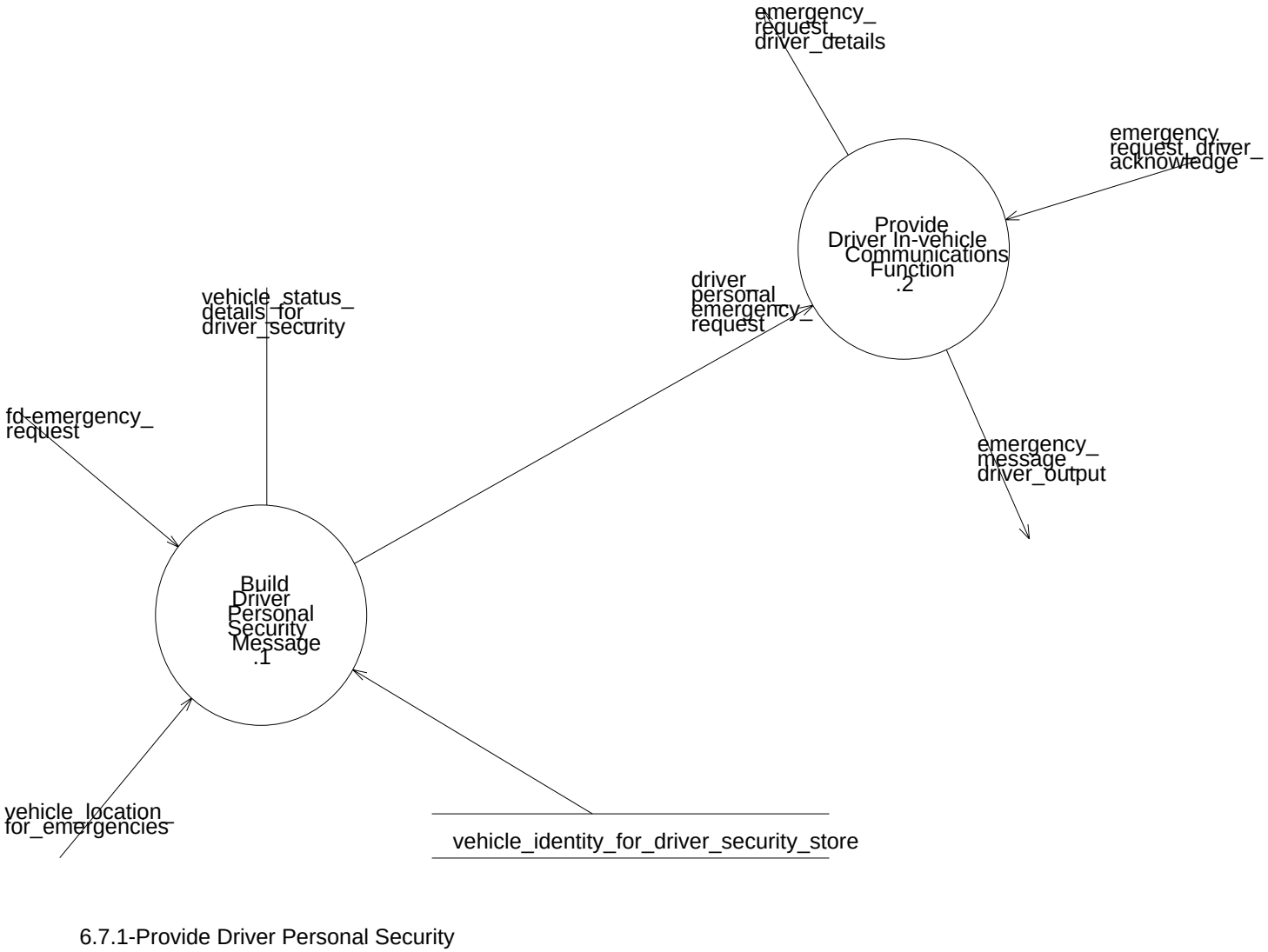


Figure 77. Provide Driver Personal Security (DFD 6.7.1)

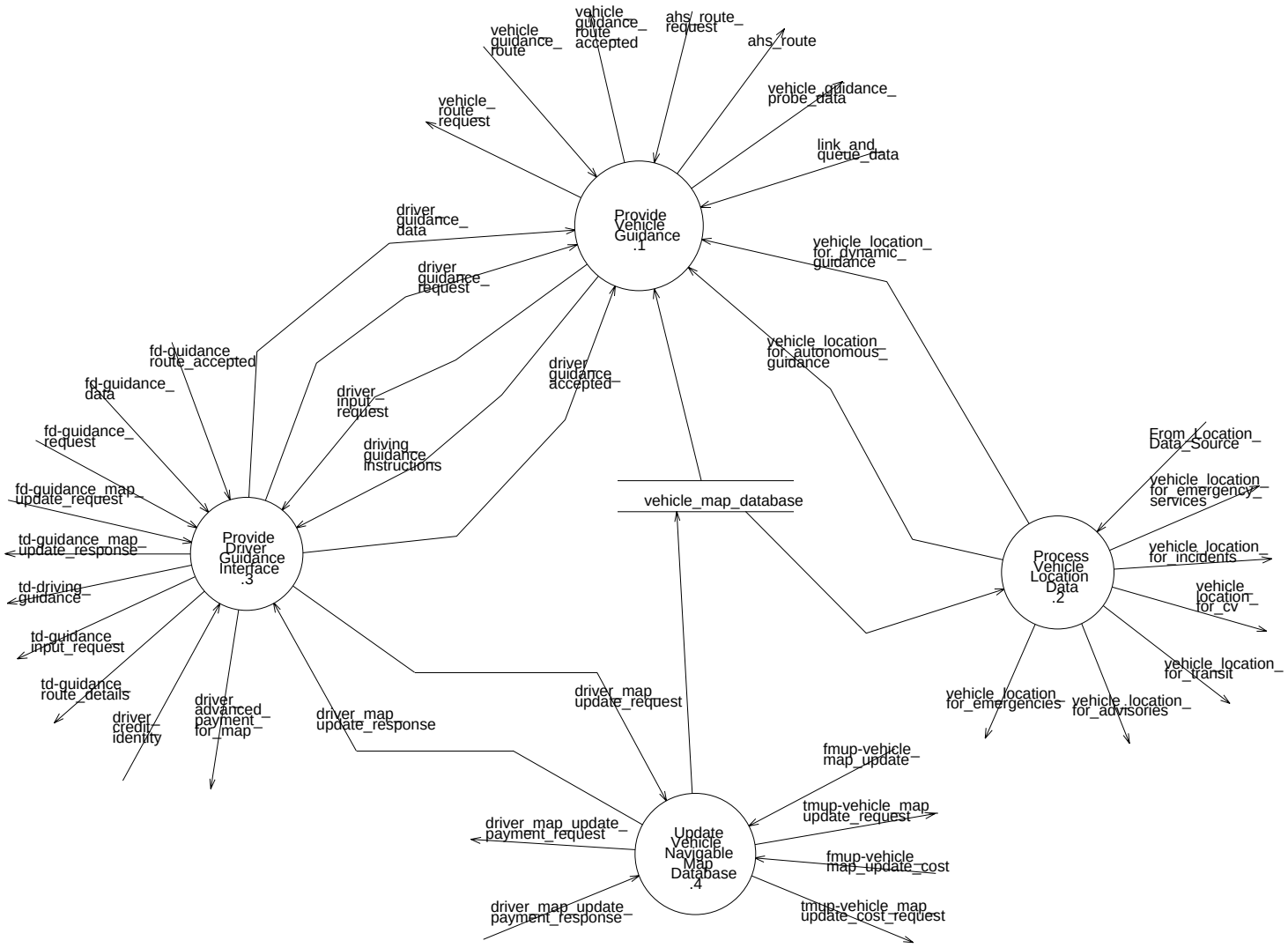


Figure 78. Provide On-Line Vehicle Guidance (DFD 6.7.2)

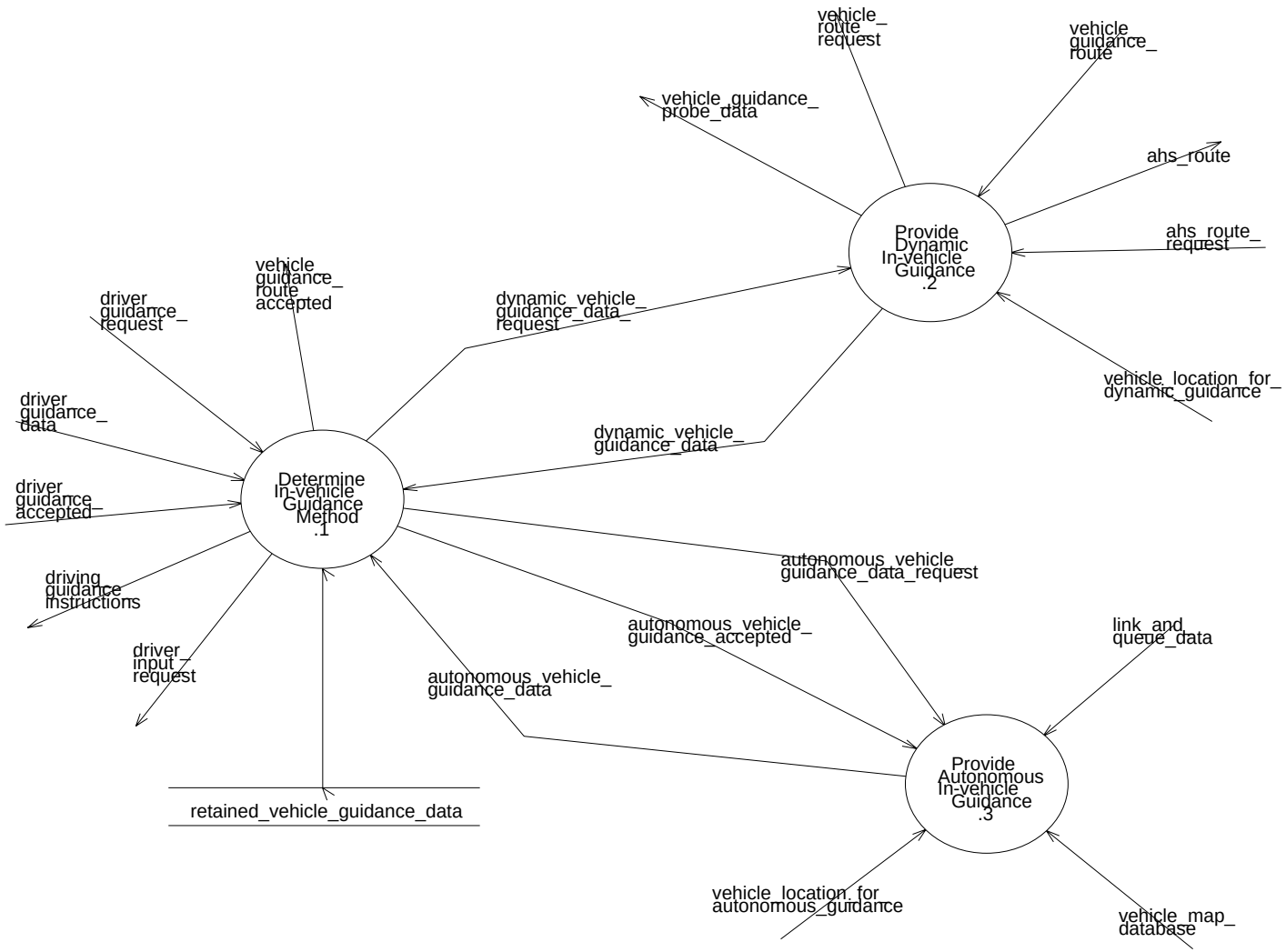


Figure 79. Provide Vehicle Guidance (DFD 6.7.2.1)

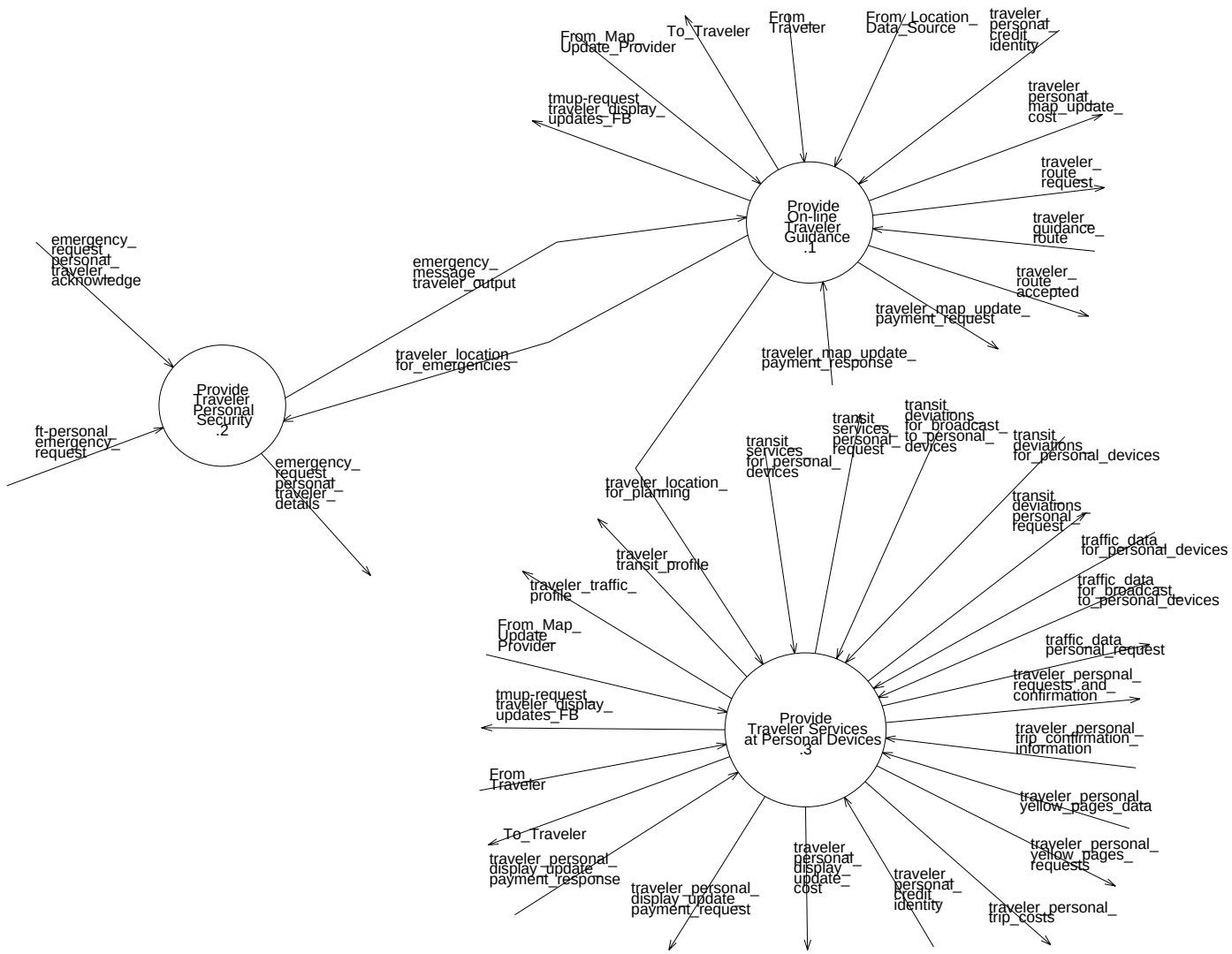


Figure 80. Provide Traveler Personal Services (DFD 6.8)

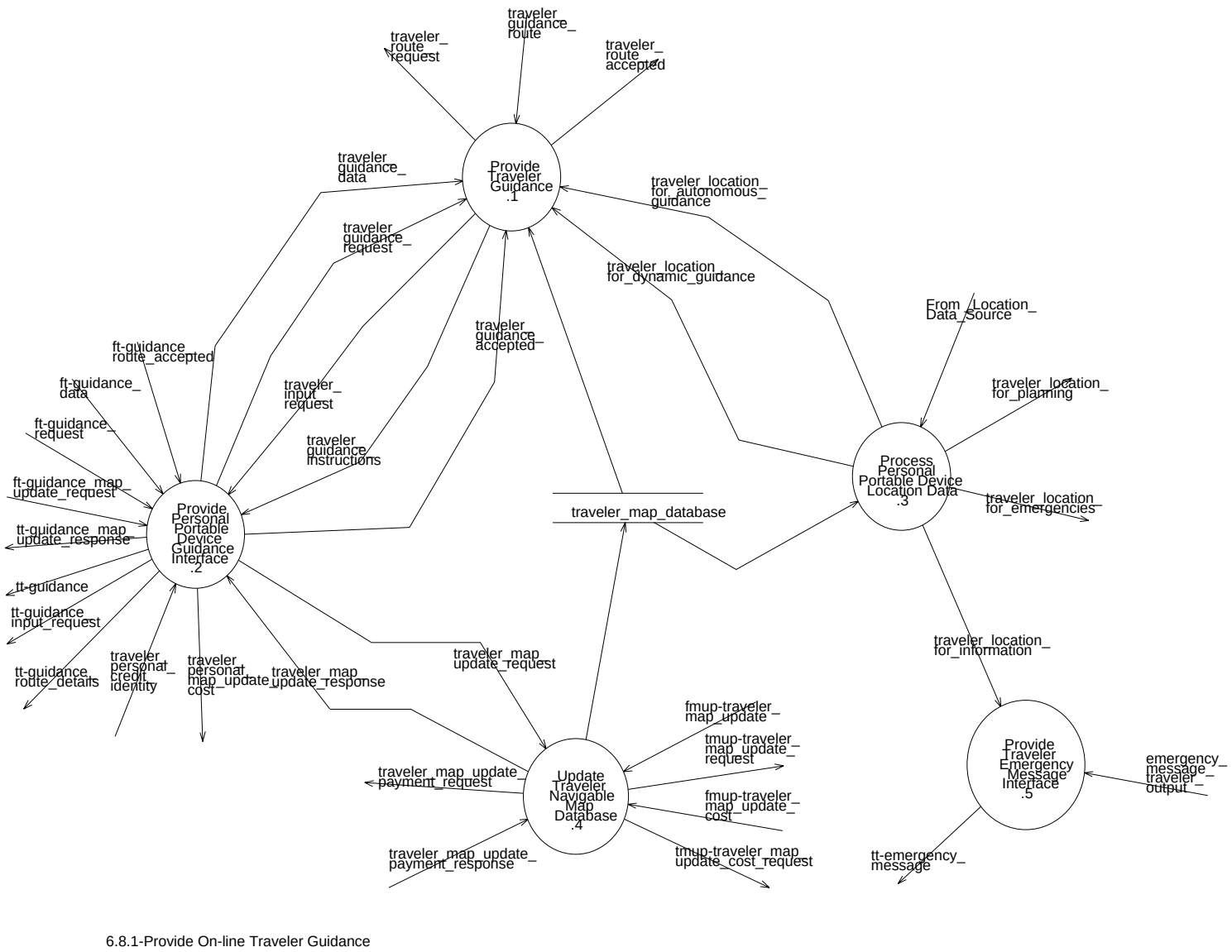
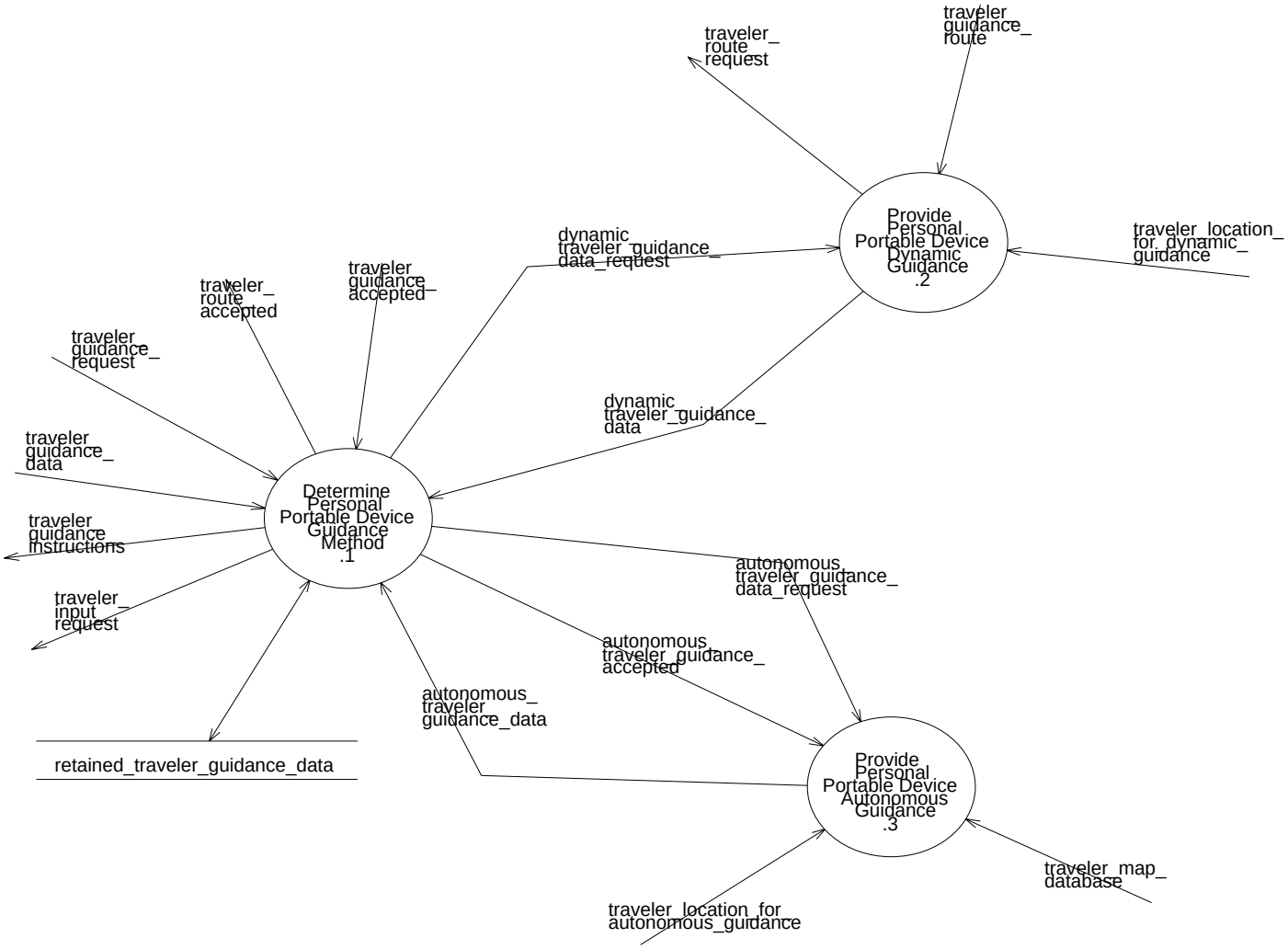


Figure 81. Provide On-Line Traveler Guidance (DFD 6.8.1)



6.8.1.1-Provide Traveler Guidance

Figure 82. Provide Traveler Guidance (DFD 6.8.1.1)

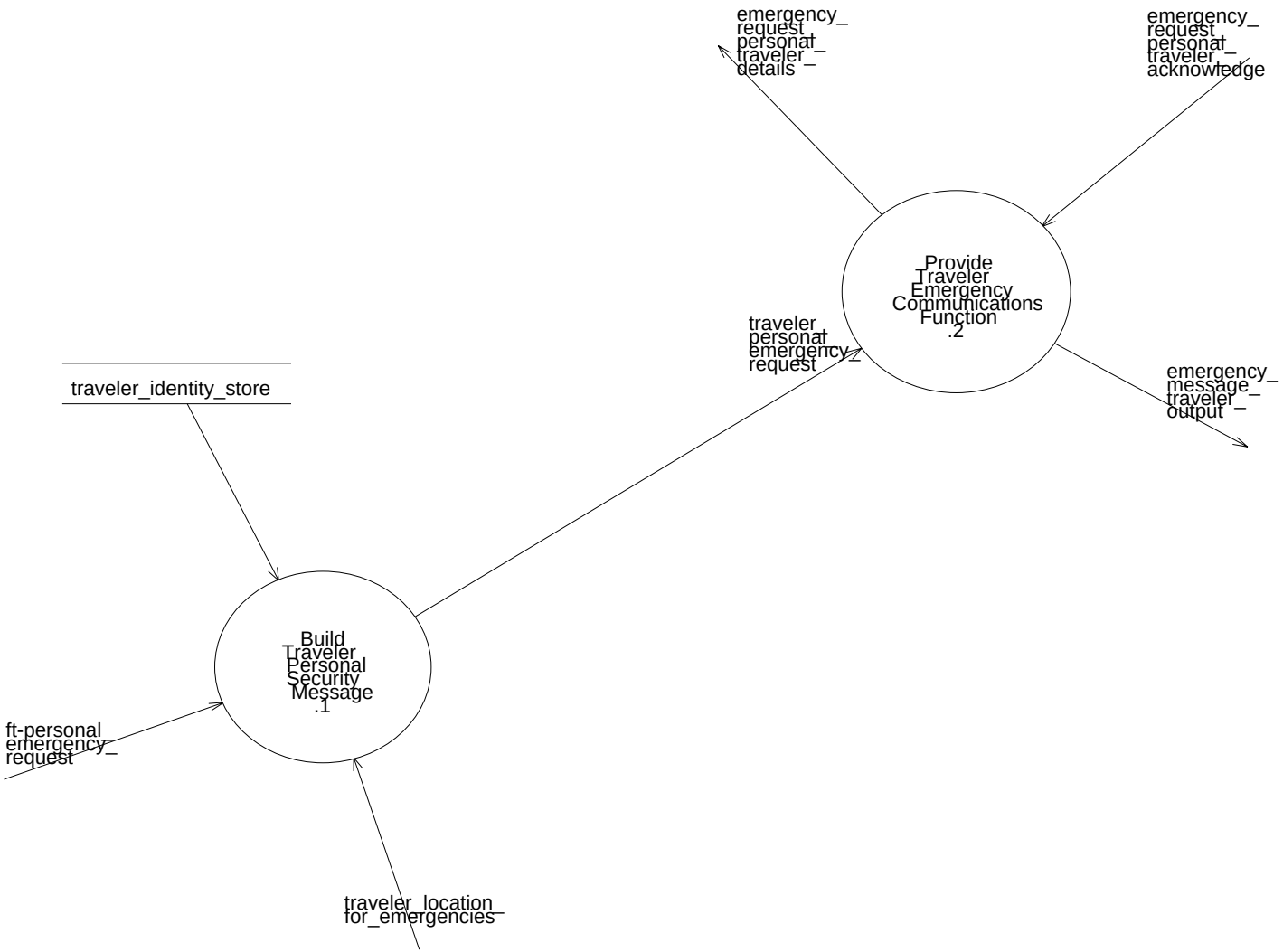


Figure 83. Provide Traveler Personal Security (DFD 6.8.2)

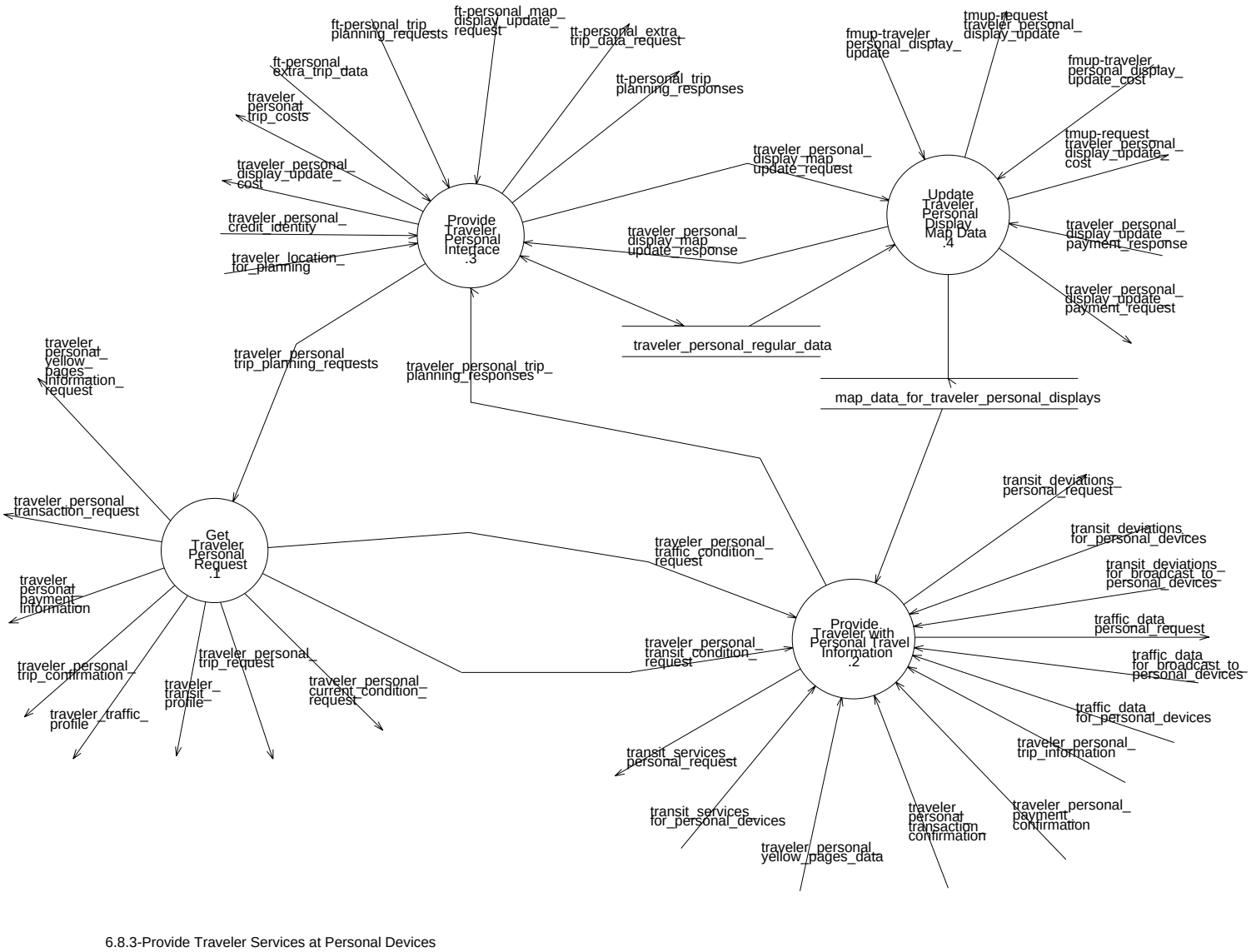


Figure 84. Provide Traveler Services at Personal Devices (DFD 6.8.3)

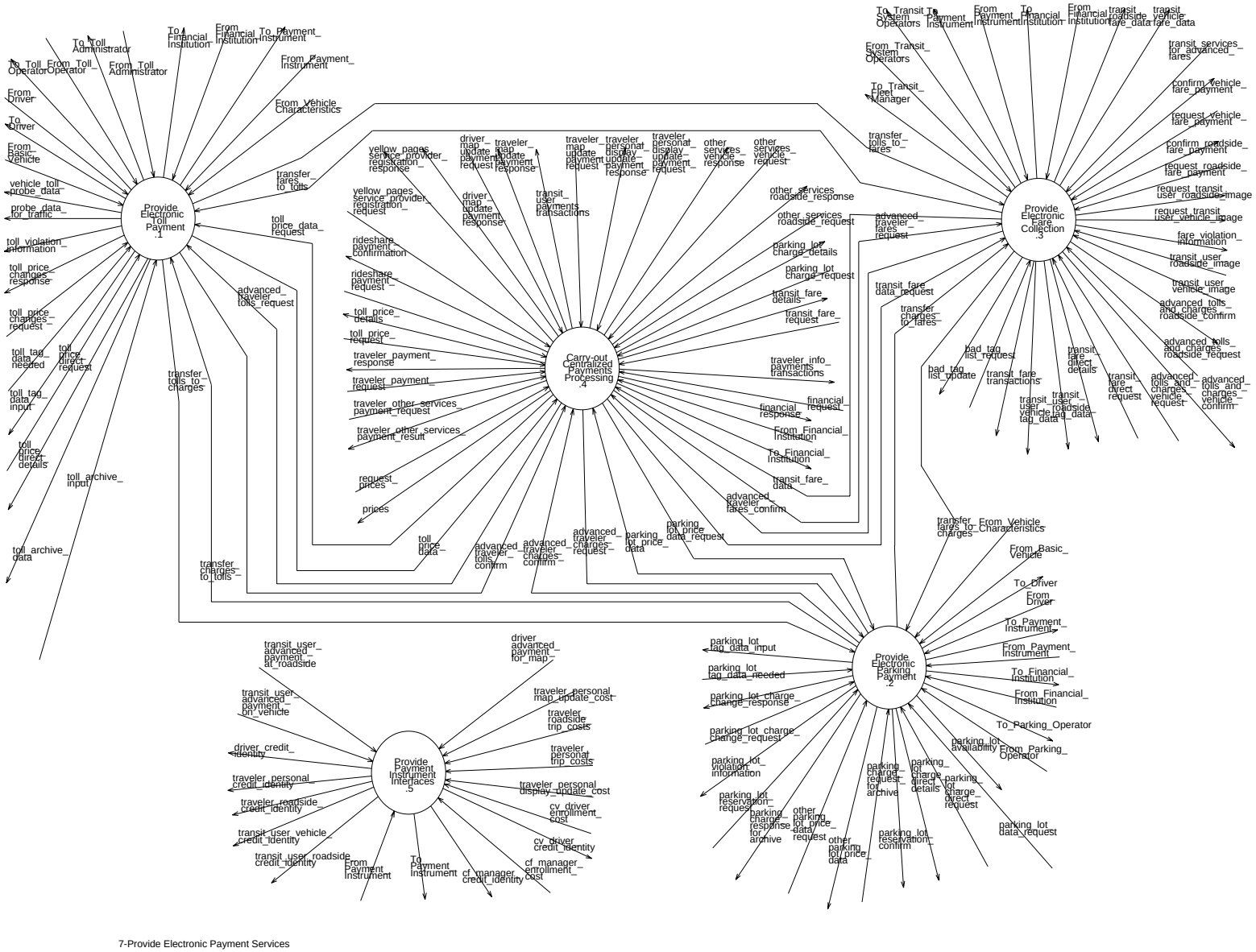
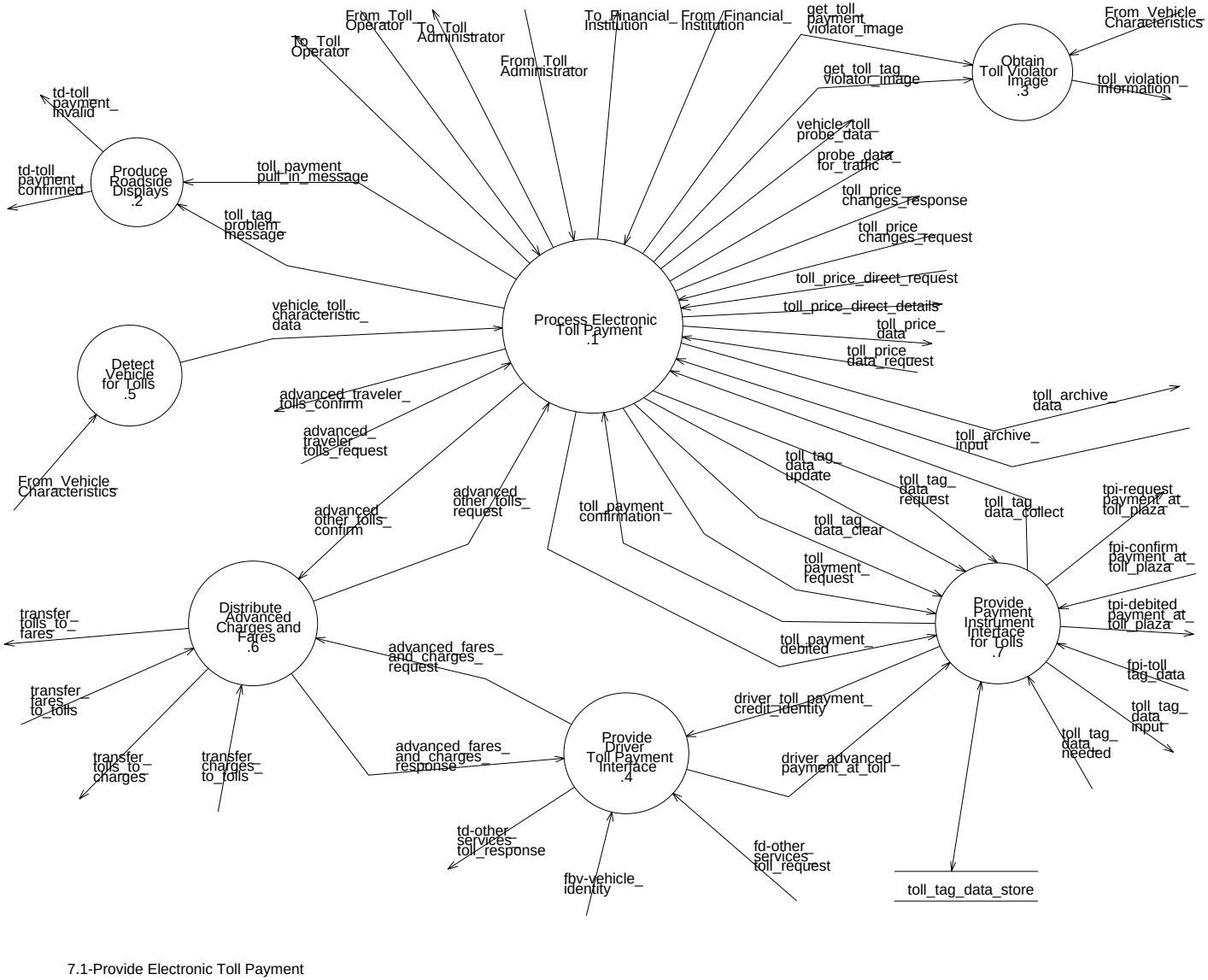


Figure 85. Provide Electronic Payment Services (DFD 7)



7.1-Provide Electronic Toll Payment

Figure 86. Provide Electronic Toll Payment (DFD 7.1)

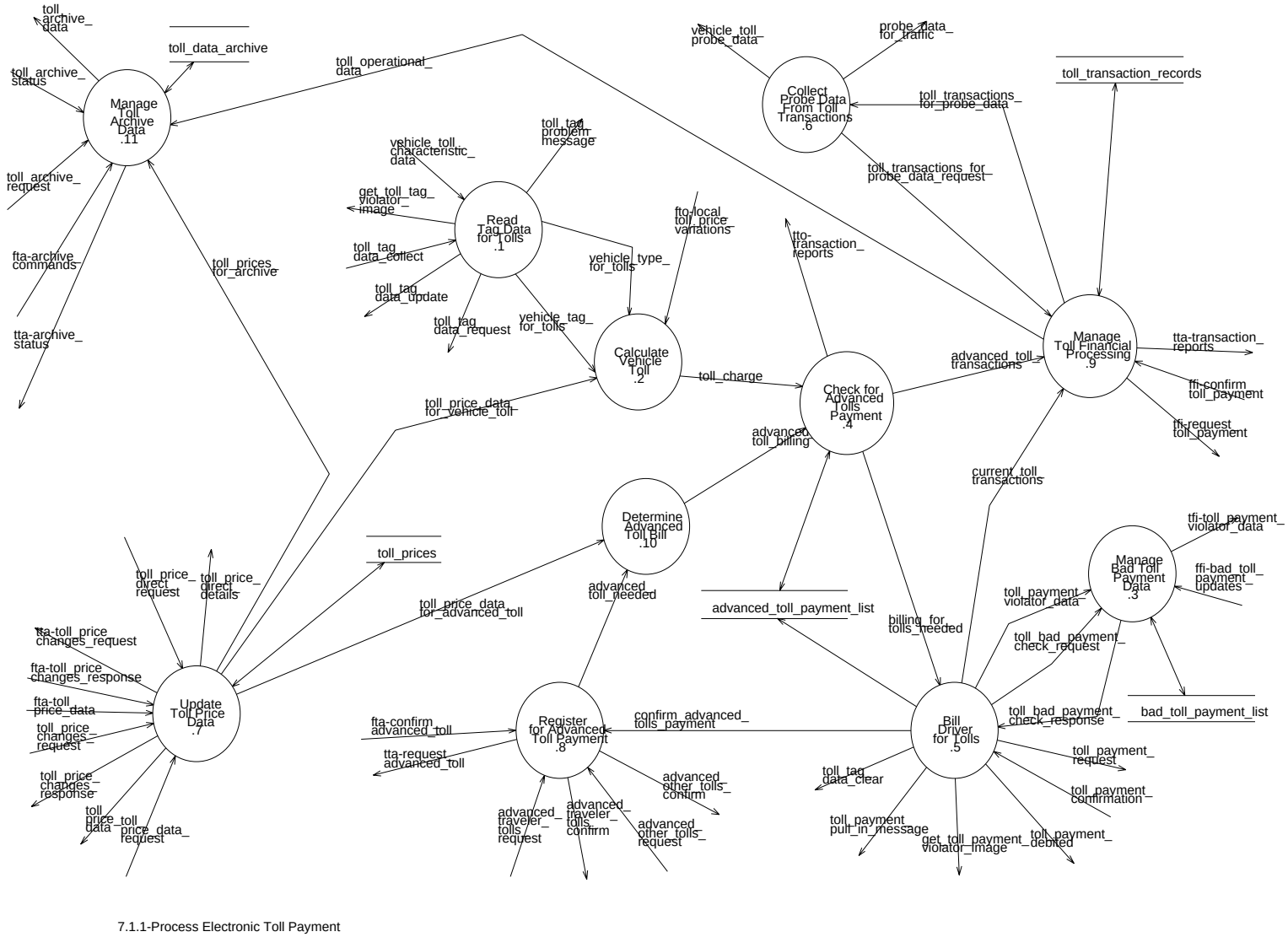
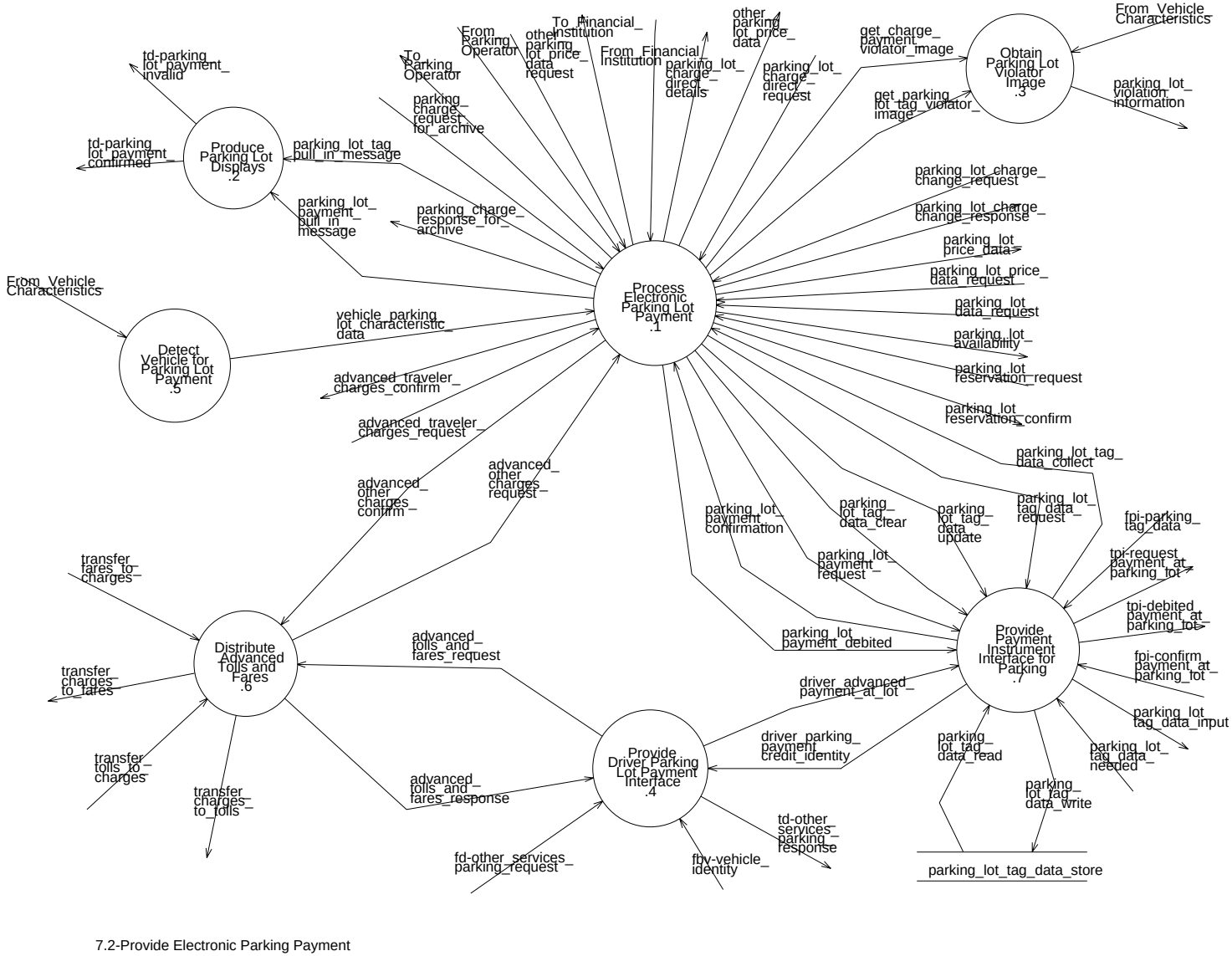


Figure 87. Process Electronic Toll Payment (DFD 7.1.1)



7.2-Provide Electronic Parking Payment

Figure 88. Provide Electronic Parking Payment (DFD 7.2)

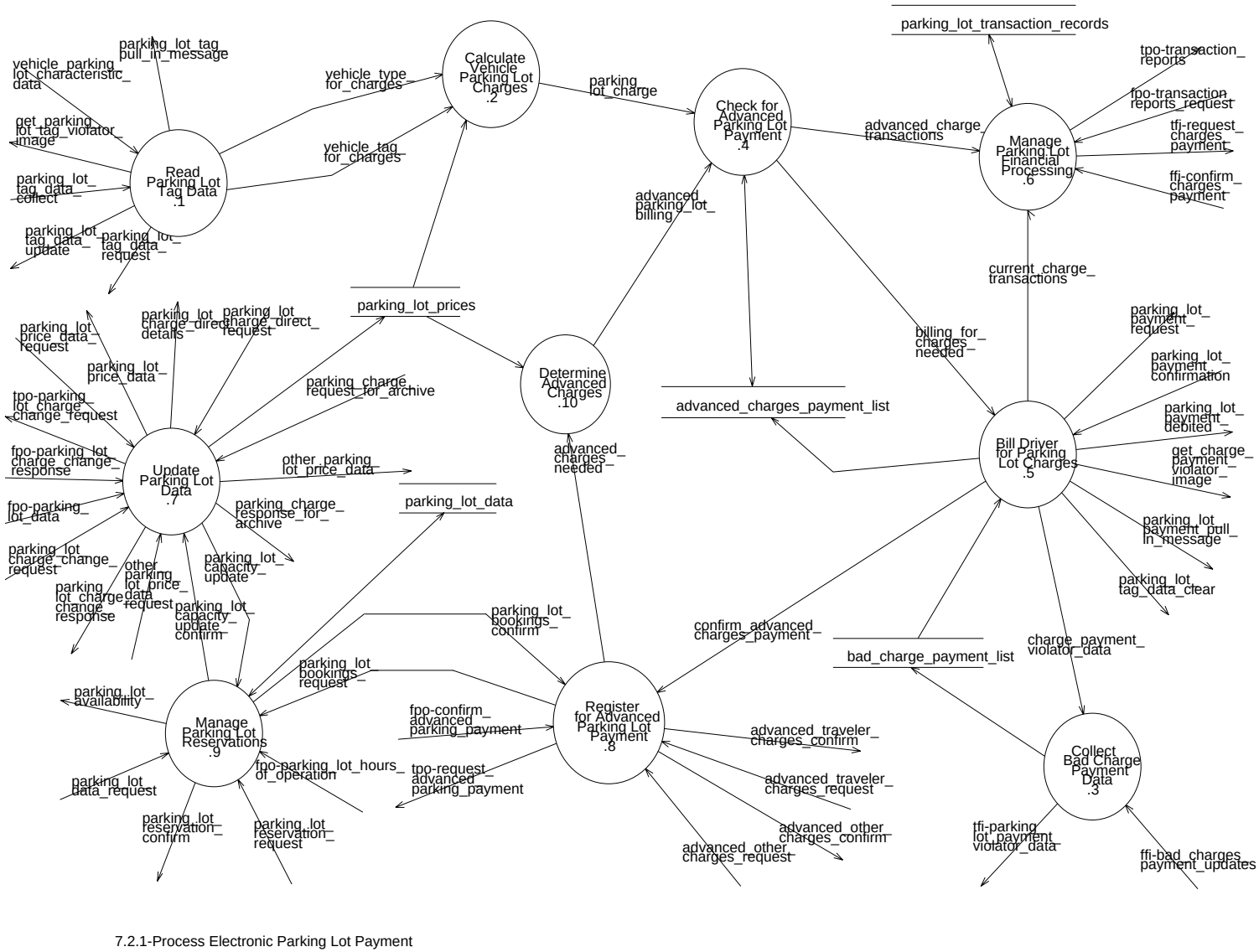


Figure 89. Process Electronic Parking Lot Payment (DFD 7.2.1)

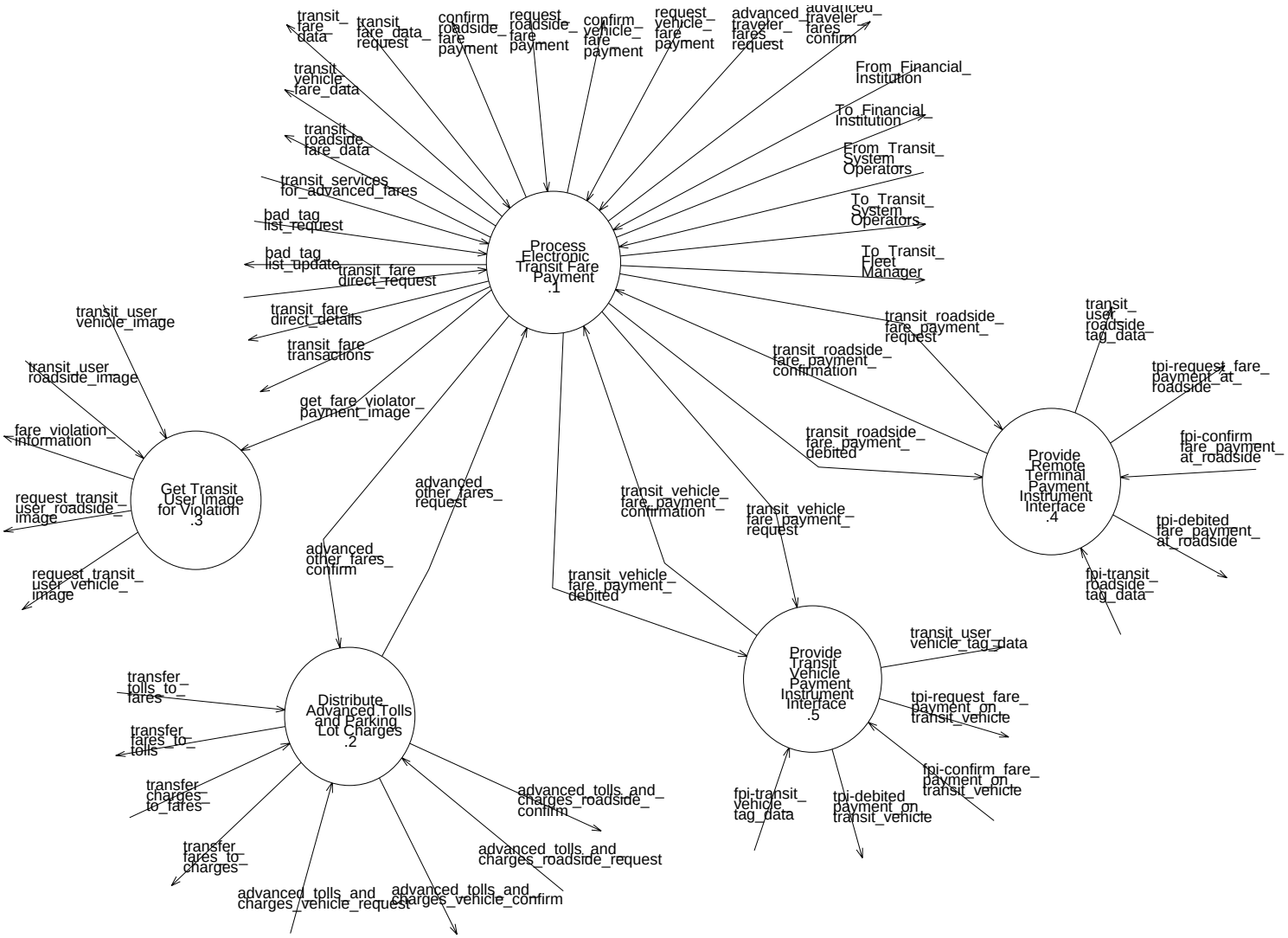


Figure 90. Provide Electronic Fare Collection (DFD 7.3)

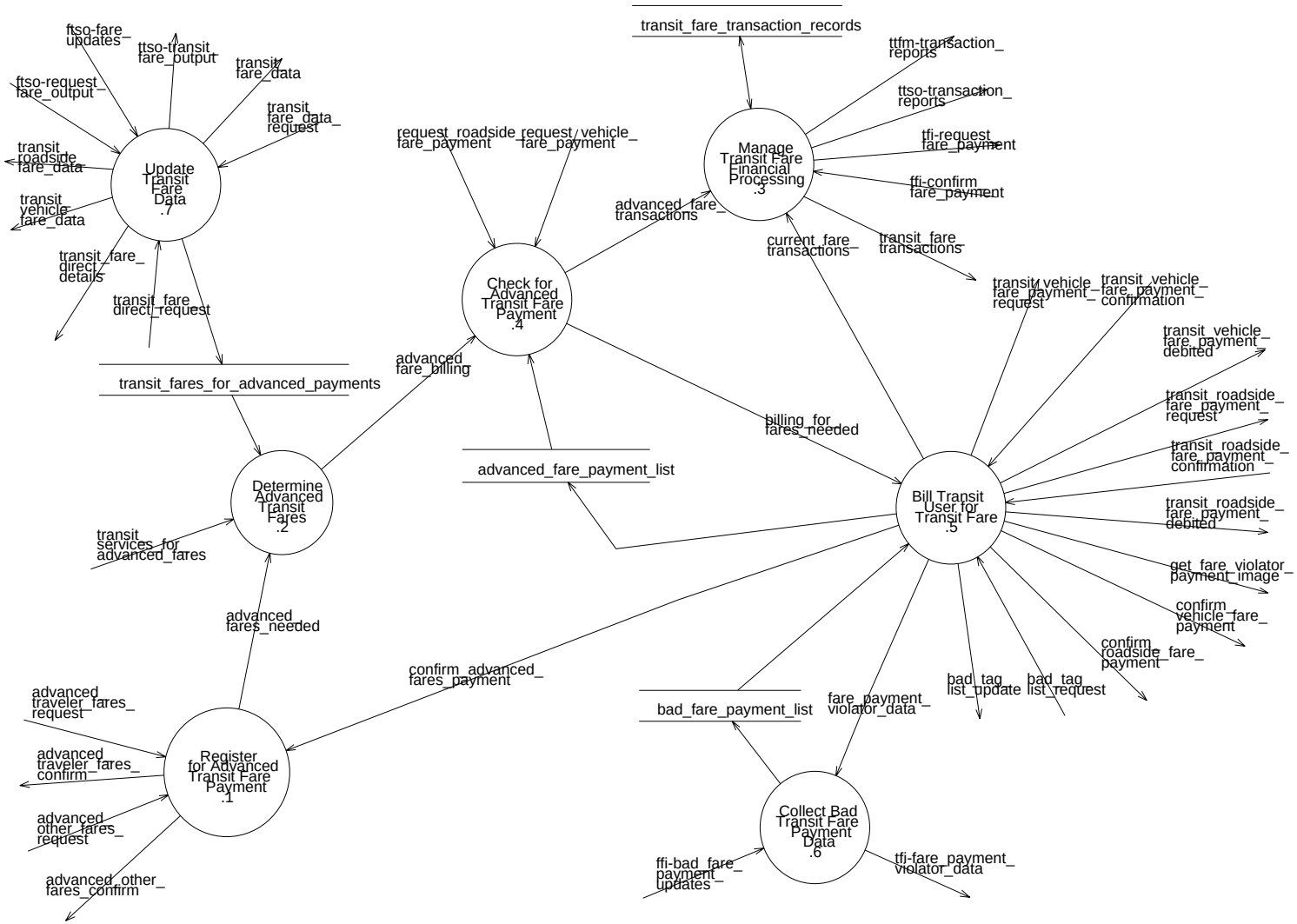


Figure 91. Process Electronic Transit Fare Payment (DFD 7.3.1)

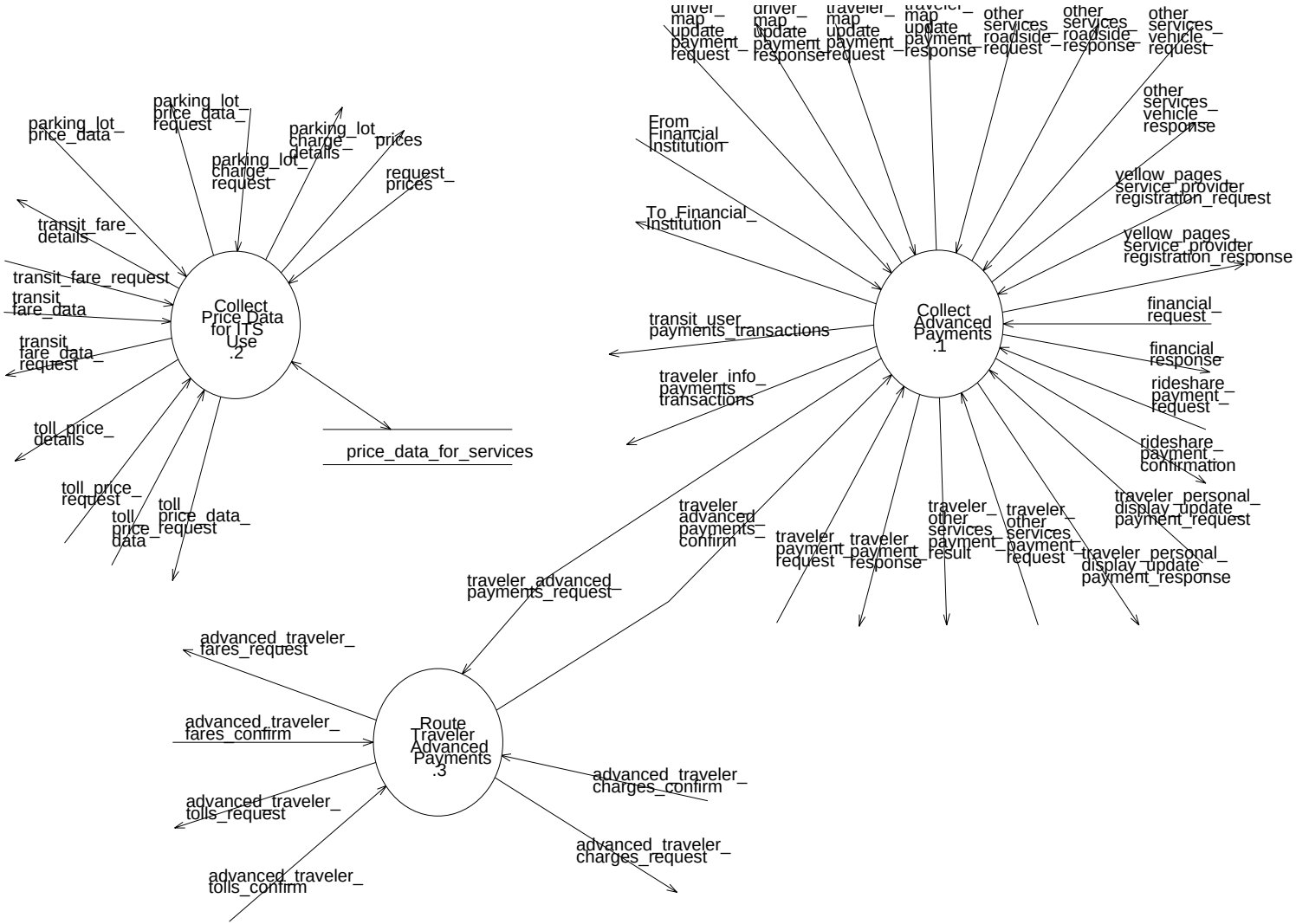
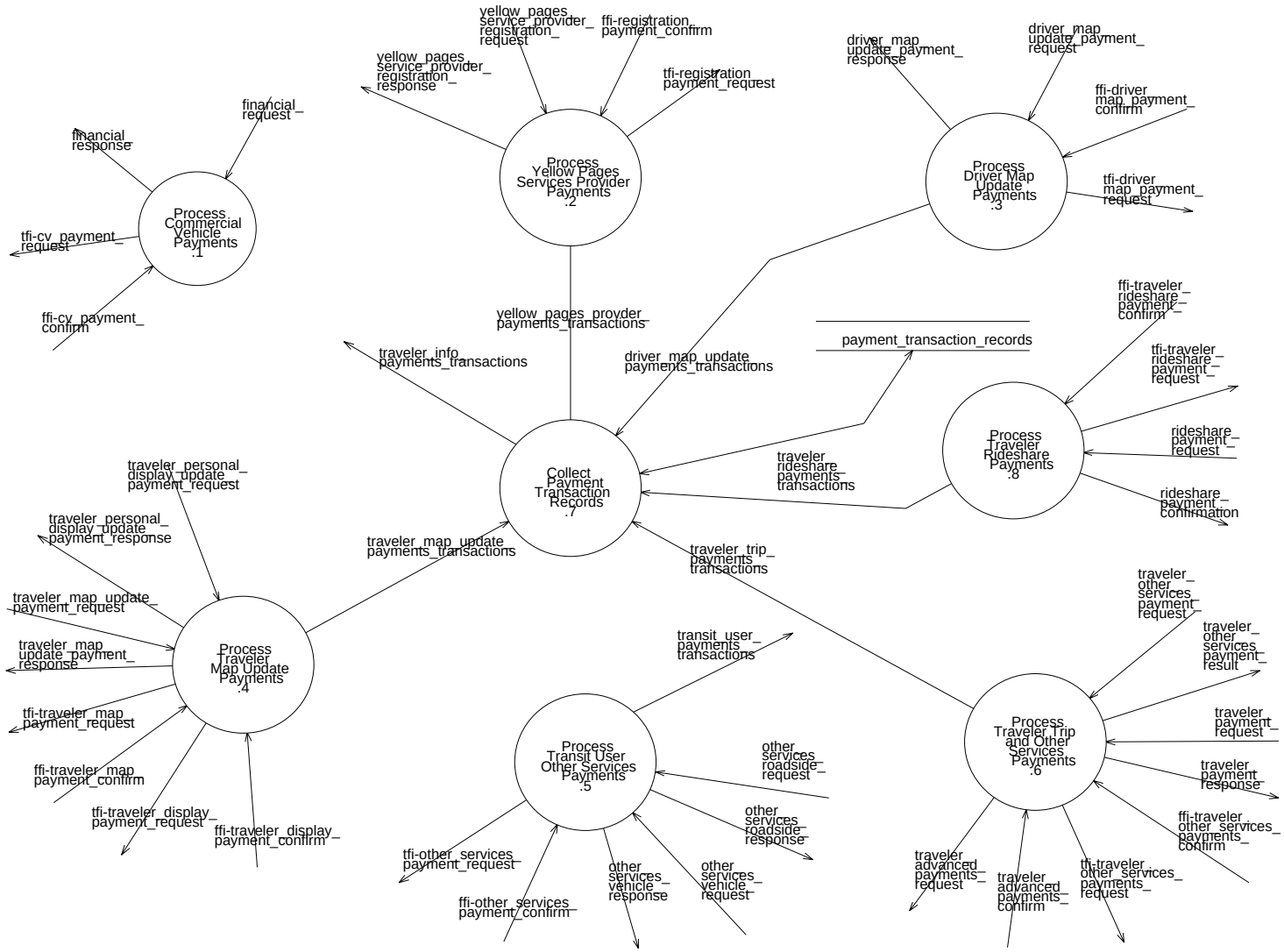


Figure 92. Carry-Out Centralized Payments Processing (DFD 7.4)



7.4.1-Collect Advanced Payments

Figure 93. Collect Advanced Payments (DFD 7.4.1)

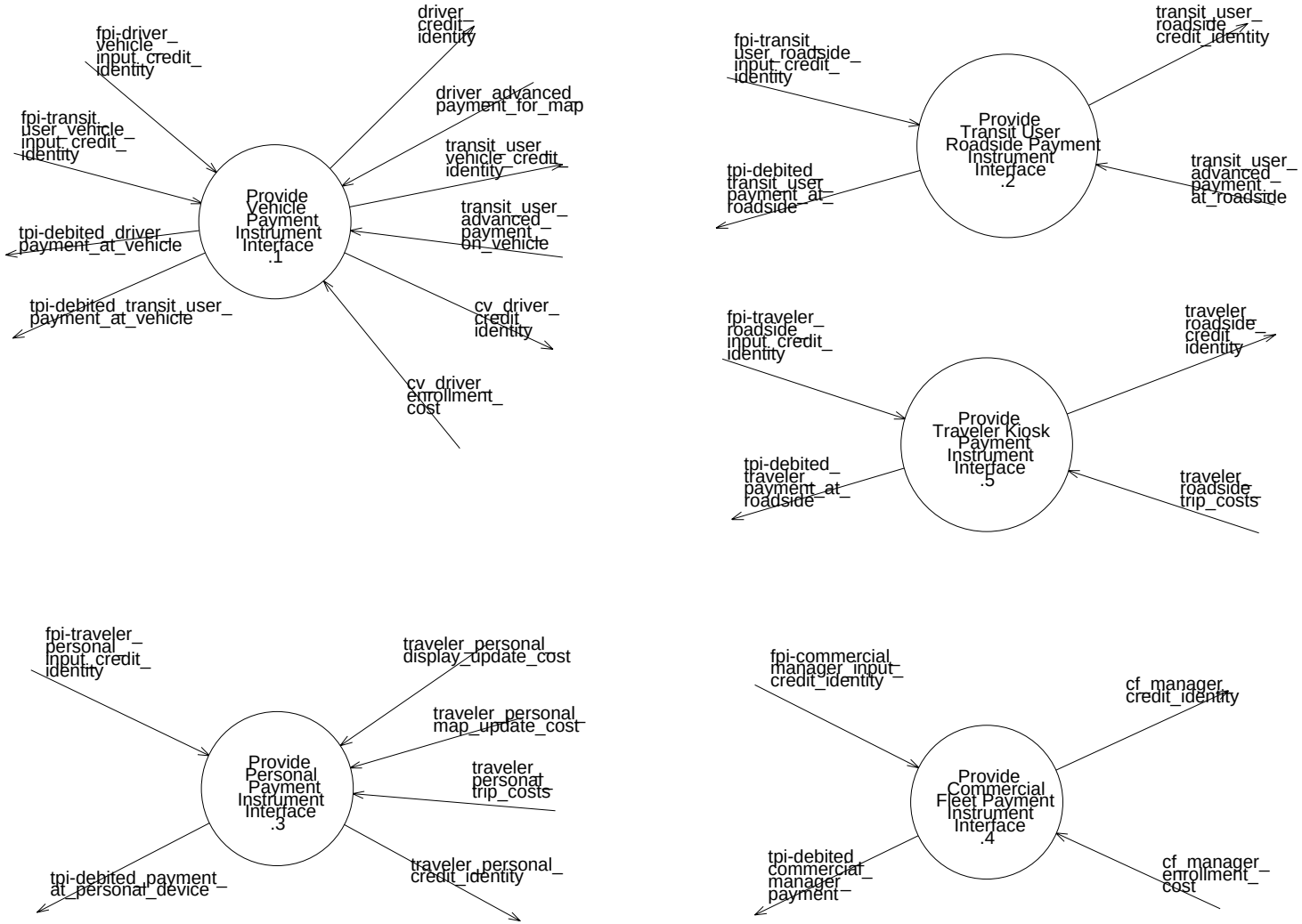


Figure 94. Provide Payment Instrument Interfaces (DFD 7.5)

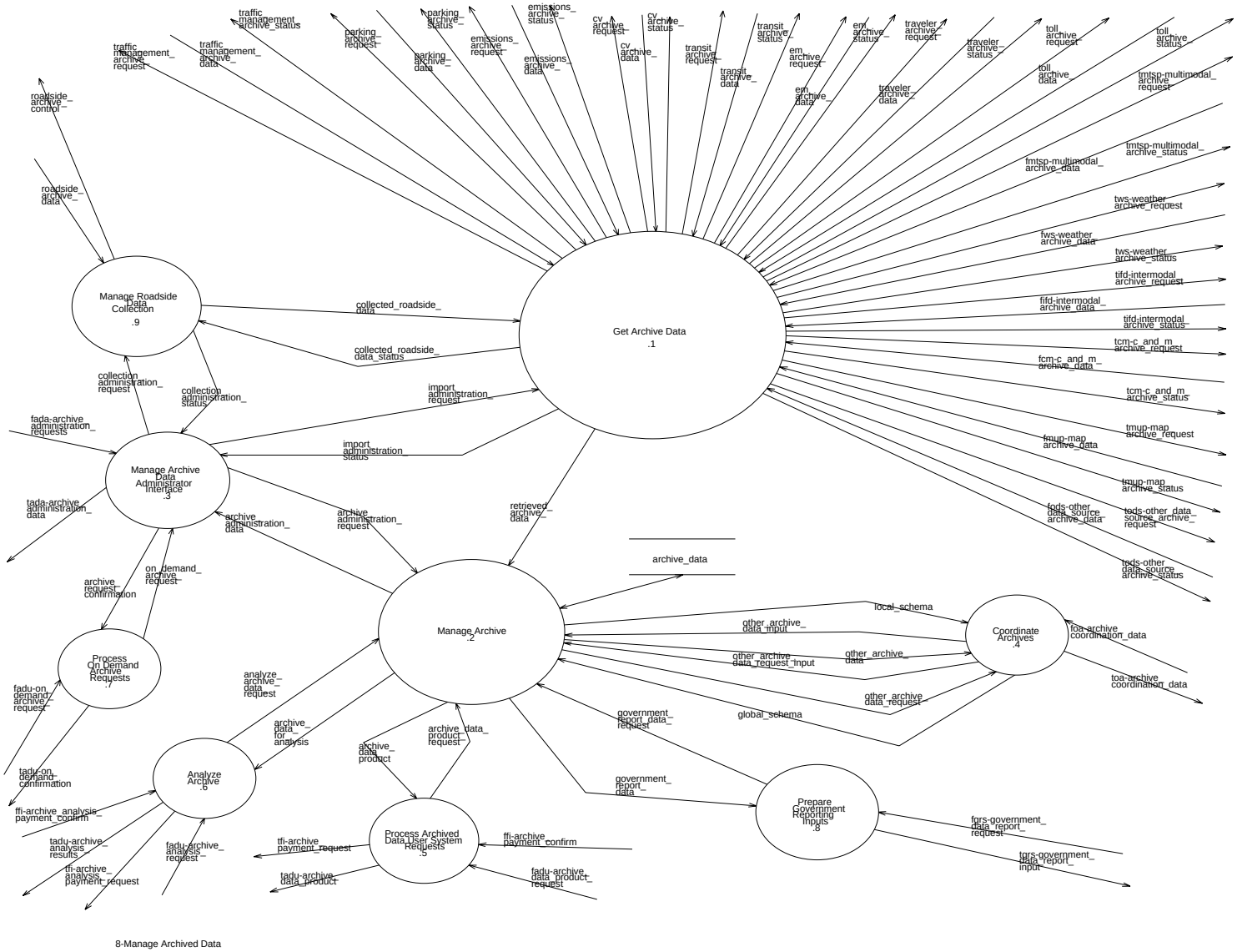


Figure 95. Manage Archived Data (DFD 8)

1.5. Data Driven Control Concepts

The notion of control flow in the ITS Logical Architecture is captured directly in the structured English of the Process Specifications (P-Specs). This is a natural implementation when the system is strongly oriented towards data-triggered control. In the Architecture, P-Specs are connected by data flows which will generally be implemented with discreet messages or datagrams (also known as data packets). The arrival of a message at a P-Spec captures not only the notion of a data flow, but also the notion of a possible control-event. Thus P-Specs that issue data messages as a result of processing can be effectively issuing control flows simultaneously, and P-Specs that wait for a data message (or set of data messages) and then begin processing are effectively activated by a data/control flow (or a set of flows). This notion of data-triggered control is used throughout the Architectural design. Control is essential to the design and explicitly appears in this form throughout the P-Specs.

1.6. Functional Specification

The Functional Specification is expressed in two ways. First, in graphical form as Data Flow Diagrams (DFDs), and second, in more detailed textual form as Process Specifications (P-Specs) and data flow descriptions.

In general, the DFDs provide a convenient "road map" of the structure of the requirements and are shown by the Figures in section 1.4.2 of this document. They consist of lines showing data flows and "bubbles" that represent either a P-Spec, or a lower level DFD. In section 1.6.1 that follows, descriptions are provided for the DFDs starting from the highest level, DFD 0. This DFD shows the highest (least detailed) level of functionality needed to meet the User Service Requirements. Each of its eight "bubbles" is itself a DFD which provides a first level decomposition of the high level functionality. The "bubbles" in these eight DFDs will themselves decompose into further lower level DFDs, or are P-Specs. They form a hierarchical structure that is shown in tabular form by an Appendix to this document. Each of the descriptions in section 1.6.1 highlights the main features of each DFD and provides a brief overview of the function in each of its "bubbles" regardless of whether it is a P-Spec or DFD.

The P-specs provide the essence of the requirements in that they describe how data that flows into the Logical Architecture is transformed either for use elsewhere, or for output from the Architecture. The P-specs stand alone in that they completely and rigorously capture the functional requirements of the Architecture. As noted above, section 1.6.1 provides an overview of the functionality of each P-Spec. A full textual description of the functionality provided by each P-Spec, including a list of User Service Requirements that they serve, is provided separately as a reference volume to this document - see Volume 2.

The descriptions of the data flows are contained in the Data Dictionary Entries (DDEs), which like the DFDs and P-specs, form a hierarchical structure. In this instance, the hierarchical structure enables one data flow to be comprised of several other data flows, each of which may decompose into other data flows until the primitive or lowest level data flows are reached. Due to their number and overall size, the DDEs describing each data flow, its components (if any), and size, are also provided separately as a second reference volume to this document - see Volume 3.

1.6.1. Data Flow Diagram (DFD) Descriptions

Narrative descriptions are provided in the following pages for all of the Data Flow Diagrams (DFDs) shown by the diagrams in section 1.4.2 of this document. It should be noted that these descriptions provide an executive summary of the functionality and facilities provided in each DFD and are for convenience only. The essence of the architecture is found in the Process Specifications (P-specs) and the descriptions of the data flows themselves - see previous section.

1.6.1.1. Manage ITS (DFD 0)

This DFD shows the eight functional process trees that make up the high level decomposition of the ITS Logical Architecture to fulfill the User Service Requirements (USRs). The key points about the functions they perform are as follows:

* - the processes provided are designed to satisfy all of the User Services Requirements,

* - a modular approach has been adopted for all groups of processes to enable partial or full deployment of functions depending on technological developments, and the needs of the implementers and stakeholders (jurisdictional authorities and private organizations);

* - the modular approach also allows the inclusion of other later architecture developments without needing major changes.

The eight functional process trees in DFD0 are designed to provide a complete response to the User Service Requirements, and in some cases provide more functionality than is required. The function performed by each tree of processes is described below.

(a) **Manage Traffic** (1) - this functional process tree includes all the functionality needed for the management of the traffic in the road and highway network. Included are traffic surveillance, traffic control, incident management, demand management and emissions management functions, management of highway rail intersections, and all associated capabilities. The traffic surveillance and traffic control functions include facilities for the management of highway rail intersections, access to parking lots, i.e., directing vehicles to those that currently have spaces, and the notification of faults with roadside equipment. The traffic surveillance, traffic control and incident management facilities work closely together to both detect incidents from traffic data (and highway rail intersections) and minimize their impact on the flow of traffic in the network. A link is provided to the Manage Emergency Services function so that detected incidents can be reported for action by the appropriate emergency service. The User Services Requirements included in this functional tree are:

1.6 Traffic Control

1.7 Incident Management

1.8 Travel Demand Management

1.9 Emission Testing and Mitigation

1.10 Highway Rail Intersections

(b) **Manage Commercial Vehicles** (2) - this functional process tree performs the management functions which are concerned with the efficient management of Commercial Vehicles, e.g., electronic credentials, tax filing and safety checking and the movement of freight. Although the movement of vehicles is confined to the surface transportation system, interfaces are provided to enable freight to be moved by this and any other means, e.g., specialist carries using air or sea transport. Interactions with other functions are provided to convey information to the Commercial Vehicle Driver in support of the User Services Requirements. Those that are included in this functional process tree are:

4.1 Commercial Vehicle Electronic Preclearance

4.2 Automated Roadside Safety Inspection

4.3 On-Board Safety Monitoring

4.4 Commercial Vehicle Administrative Process

4.5 Hazardous material Incident Response

4.6 Commercial Fleet Management

(c) **Provide Vehicle Monitoring and Control** (3) - this functional process tree performs all of the functionality associated with monitoring and control of the vehicle subsystems, including automatic

emergency notification when sensors detect that the vehicle has been involved in an accident. All vehicle types (private, transit and commercial) are handled by these processes so that the functions that are identified are independent of vehicle type. Interaction with the driver is through the Provide Driver and Traveler Services function - see below. An interface with the Manage Traffic function is also provided to support high-end automated freeway system services. The User Services Requirements that are included in this functional process tree are:

5.1 Emergency Notifications and Personal Security

6.1 Longitudinal Collision Avoidance

6.2 Lateral Collision Avoidance

6.3 Intersection Collision Avoidance

6.4 Vision Enhancement for Crash Avoidance

6.5 Safety Readiness

6.6 Pre-Crash Restraint Deployment

6.7 Automated Vehicle Operation

(d) **Manage Transit** (4) - this functional process tree performs the management functions which apply to fixed routed transit services, plus the provision of the flexibly routed transit service (demand responsive transit). Information is provided to the Transit Driver and Transit User directly through this function, but that for the traveler trip planning and guidance is provided through the Provide Driver and Traveler Services function - see below. Interactions with the Manage Traffic function is provided to support priority at signalized intersections and freeway ramps, and also to reflect the overall coordination between transit and traffic management services(including provision for transit vehicle location data to be passed to traffic management as probe information. Interaction is also provided with the Provide Electronic Payment Services function to enable the advanced payment of transit fares and other services. The User Services Requirements that are included in this functional process tree are:

2.1 Public Transportation Management

2.2 En-Route Transit Information

2.3 Personalized Public Transit

2.4 Public Travel Security

(e) **Manage Emergency Services** (5) - this functional process tree performs the management functions needed for dispatch and control of emergency services responding to incidents and the activation of law enforcement agencies to pursue payment and pollution violators. It therefore has interaction with the Manage Traffic, Provide Vehicle Monitoring and Control, Manage Transit and Provide Driver and Traveler Services functions for the detection and deployment of emergency services and law enforcement agencies. An interface is also provided to the Manage Traffic function for the coordination of incident management functions (including resource coordination between traffic management and emergency management) and to provide priority for emergency vehicles at signalized roadway intersections and freeway ramps. The processes also perform coordination of the incident between incident commanders in the field, emergency services, and allied emergency management agencies. The User Services Requirement that is included in this functional process tree is

5.2 Emergency Vehicle Management

(f) **Provide Driver and Traveler Services** (6) - this functional process tree provides the multimodal trip planning, route guidance and advisory functions for all types of travelers and drivers. It also enables then to confirm and pay for yellow pages services and provides personal emergency notification functions. The driver interface to the Provide Vehicle Monitoring and Control functions is provided, as is that to other functions, to enable advisory information to be output to both drivers and travelers. The multimodal trip planning function enables trips to include private car and regular transit

modes, plus ridesharing, demand responsive transit and other modes such as walking, cycling, etc. Links are also provided to multimodal transportation service providers to that travelers may use modes such as heavy rail and airlines as part of their trips. Both centralized dynamic and autonomous modes of on-line guidance are provided for drivers and travelers, with drivers also being able to use current link journey times as part of the autonomous vehicle guidance. The User Services Requirements that are included in this functional process tree are:

1.1 Pre-Trip Travel Information

1.2 En-Route Driver Information

1.3 Route Guidance

1.4 Ride Matching and Reservation

1.5 Traveler Services Information

5.1 Emergency Notifications and Personal Security

(g) **Provide Electronic Payment Services** (7) - this functional process tree is responsible for the collection and management of tolls and parking lot charges, in both real time and as advanced charges. It also collects charges for yellow pages services and has an interface to the Manage Transit function for the management of fare collection plus advanced payment of fares and other services. The User Services Requirement that is included in this functional process tree is

3.1 Electronic Payment Services

(h) **Manage Archived Data** (8) - this functional process tree manages the flow of operational data into an archive of ITS and non-ITS data. Functions include the import of data, cleansing and formatting the data for the archive format, and attaching the appropriate sets of meta-data to the incoming archive data. The Manage Archived Data function coordinates data sharing between archives. The function that interfaces to the administrator contains the settings on the data acquisition process, security of the archive, formatting of the data, and produces the necessary administration reports. Archived data users systems interface with the archive to either access data for retrieval or to analyze the data using data mining, fusion, or aggregation functions. This function can also produce reports that can be formatted for input to a government reporting system. The User Services Requirements that are included in this functional process tree are:

7.1 Archived Data Function

Centralizing the route guidance function makes it possible to globally optimize the routes being provided and used by ITS users, as well as provide custom advisory information to users. In consequence, many of the data flows between the above groups of processes carry requests for routes, the data on the resulting computed routes, or the data used in the route selection process. Where necessary, data used in trip planning and route guidance can be obtained from processes outside the general area controlled by a particular group. This enables the service provided for trip planning and route guidance to apply across wide areas of the nation, without the need for the traveler or driver to be aware of the communication processes being employed in these services.

1.6.1.2. Manage Traffic (DFD 1)

This DFD shows the processes that provide the Manage Traffic function. This function is responsible for providing facilities to manage traffic flowing in the area it serves so that the most efficient use is made of the surface street and freeway network. The key points about the function are as follows:

* - collection of traffic data and traffic management provided for the surface street and freeway network;
* - collected data can be used by other ITS functions, operations personnel and the media;
* - incident management available based on pre-defined responses;
* - details of incidents available to the media;

* - demand management available based on pre-defined policies and operational data;

* - pollution monitoring available both on a wide area and individual vehicle basis;

* - highway rail intersection is monitored and controlled;

* - intersection collision avoidance data provided to vehicles;

* - smart probe data collected from and provided to vehicles plus other ITS functions;

* - data can be exchanged with similar functions serving other geographic or jurisdictional areas.

There are six processes in this DFD all of which are themselves DFDs. They divide the overall functionality of the DFD between themselves in the following ways.

(a) Provide Traffic Surveillance (1.1) - these processes provide traffic surveillance, data storage, predictive modeling and communication with other TMCs. Traffic surveillance is provided through devices that obtain data about vehicles and pedestrians on the surface street and freeway network served by the function from devices that are driven by equipment outside of ITS, such as multimodal crossings. All data, plus that provided by the control processes - see (b) below, is stored as current data (applies to the last five minutes) and long term data. The long term data shows hourly values for the current day and a rolling period of at least two weeks. Both current and long term data are provided to other TMCs and act as input to the predictive modeling process, together with other inputs such as traffic data from other TMCs and forecast weather. The current, long term and predictive model data are also available for dissemination to other ITS functions, the media, travelers and transit users on request.

(b) Provide Device Control (1.2) - these processes enable traffic control through devices that output information to vehicle drivers and pedestrians on the surface street and freeway network served by the function. The devices comprise different types of indicators, such as intersection and pedestrian controllers, dynamic message signs (DMS), multimodal crossings, freeway ramp meter controllers, in-vehicle signage data broadcasting equipment, etc. Various types of traffic management strategy, including the management of car park occupancy are supported by the processes, as is the ability for the traffic operations personnel to override a selected strategy. The data for all these activities is provided by the traffic surveillance processes described in (a) above. Facilities are also provided for the detection of equipment faults and their notification to the construction and maintenance organization for repair.

(c) Manage Incidents (1.3) - these processes are responsible for incident management. They provide for the detection, recording and managing of both current incidents and planned events, as well as generating the responses to incidents as they become current. The responses are generated automatically from a library set up from data obtained from previous incident occurrences. Facilities are provided for the traffic operations personnel to monitor and if necessary override the operation of these processes, particularly for incidents that do not have a pre-defined response.

(d) Manage Travel Demand (1.4) - these processes are responsible for the management of travel demand within the surface street and freeway network served by the function. The objective of the management process is to enable the network to provide transportation in the most efficient way, which is to minimize the impact on the environment. This will be achieved by monitoring, controlling and influencing the operation of the traffic control, route guidance, public transport and payment functions. The operation of the demand management processes can be monitored and controlled by traffic operations personnel.

(e) Manage Emissions (1.5) - these processes are responsible for the collection, storage and dissemination of data on atmospheric emissions. The data is collected from sensors that can measure atmospheric pollution in general or that produced by individual vehicles. Data from atmospheric pollution measurements is dissemination to other parts of the Manage Traffic function. Details of the identification of individual vehicles that are violating the pollution limits are displayed to the vehicles and sent to the law enforcement facility in the Manage Emergency Services function for further action which may eventually lead to prosecution of the offender.

(f) Manage Highway Rail Intersections (1.6) - the processes in this function have coupling with other facilities and functions within ITS such as route guidance, trip planning, transit management, electronic payments processing and plan system deployment. This enables them to be both provided with data and assisted in their work. An example of the assistance is that the traffic control facility will activate special routes for emergency vehicles as 'green-waves' once they have been produced by the route guidance facility. Where these routes go outside the area controlled by the local Manage Traffic function, the data about the route is passed on to the relevant remote Manage Traffic function for implementation. Similarly details of routes originating outside the local area are received and implemented by this Manage Traffic function.

Each of the traffic control, manage incidents and manage emissions facilities could be implemented independently without any of the others. In this form the traffic control process would be able to provide some improvement to the overall traffic flow within the surface street and freeway network, whereas the incident management and manage emissions facilities would do little more than provide data recording services. There would be little or no point in implementing the manage travel demand facility without any of the other facilities that provide the data on which the demand forecasting is based.

Provide Traffic Surveillance (DFD 1.1)

This DFD shows the processes that make up the Provide Traffic Surveillance facility within the Manage Traffic function. These processes collect and store traffic data collected by sensors for use in traffic management, and by the media and other ITS functions. They are also responsible for using the data to generate a predictive model of network operation and for the exchange of data with Manage Traffic functions serving other areas. The key points about the facility are as follows:

* - data collected about the passage of vehicles and pedestrians through the surface street and freeway network;

* - collected data is stored as either current data (five minutes old) or long term (historic) data;

* - collected data used by the Provide Device Control facility to control vehicles and pedestrians;

* - predictive model produced using long term data and data from other traffic management centers;

* - predictive model data used by the Manage Travel Demand and Route Selection facilities;

* - many ITS functions use the current, long term and predictive data stores as a source of traffic data;

* - traffic operations personnel can display current, long term and predicted data;

* - media operator can also display data and send some for output by the media system;

* - smart probe data collected from vehicles and provided both for storage and for output;

* - collected data and incident data is exchanged with other traffic management centers.

There are four processes and two DFDs in this DFD, and they divide its overall functionality between themselves in the following ways.

(a) Process Sensor Data (1.1.1) - the processes in this DFD are responsible for collecting all of the data obtained from sensors including sensor data for vehicles, pedestrians (travelers using other modes of transport) and multimodal crossings. The data obtained from the sensors can receive both passive (e.g. presence) and active (e.g. tag) data from vehicles. Where any of the data is provided in analog form, the data in the processes are responsible for converting it into digital form. The converted data is sent to other processes for distribution, further analysis and storage. The processes will also control interface the video cameras that may be used to provide traffic surveillance data.

(b) Process and Store Traffic Data (1.1.2) - the processes in this DFD load the processed sensor data produced by the process in (a) into the current and long term data stores, and distribute it to other processes in the Provide Device Control and Manage Incidents facilities. The data is also used to monitor the traffic flowing along high occupancy vehicle (HOV) lanes and to calculate link journey times

from vehicle probe data. Indicator control and response data, parking lot data and current strategy data is sent from processes in the Provide Device Control facility to this DFD for loading into the current and long term data stores.

(c) Generate Predictive Traffic Model (1.1.3) - this process will be responsible for continually producing and updating a predictive model of the traffic flow conditions in the road or freeway network served by the Manage Traffic function that an instance of this process is allocated to. The prediction will be based on current surveillance, historic traffic data and surveillance, current incidents and planned events, current traffic control strategy, data received from other Traffic Management Subsystems (TMS's) serving other geographic and/or jurisdictional areas, and current and predicted weather conditions. The predictive model of traffic flow produced by this process will be used by processes in the Manage Traffic function and other ITS functions.

(d) Display and Output Traffic Data (1.1.4) - the processes in this DFD provide interfaces through which current, long term and predicted traffic data can be made available to others. Processes are provided to enable traffic operations personnel and the media operators to request displays of data, using a background of digitized map data if desired. Data may also be requested by other ITS functions. When unusual levels occur in some items of data, e.g. congestion, output can be sent directly to media systems such as highway advisory radio.

(e) Exchange data with Other Traffic Centers (1.1.5) - this process will exchange data with similar processes in other Traffic Management Subsystems (TMSs). The other TMS can be adjacent geographically, under control of a different jurisdiction, or part of a more complex hierarchy. The exchange of data will be triggered by either a request from a remote TMS for data from the TMS to which the Manage Traffic function belongs, or because data needs to be sent from the local TMS to a remote TMS. This data will include emergency vehicle preemption ('green waves') or special commercial vehicle routes which pass through the local network but have a destination in an area served by a remote TMS, or include data about an incident that has an impact on the traffic conditions in the network served by a remote TMS. The data received from remote TMSs will be used either to vary the current traffic control strategy to give signal preemption to emergency vehicles or enable the passage of commercial vehicles with unusual loads, or as input to the local traffic predictive model estimation process.

(f) Collect Vehicle Tag Data for Link Time Calculations (1.1.6) - this process will collect data from toll and parking tags on passing vehicles. This will be achieved by transmitting a tag data request message and collecting any tag reply data that is received. This reply data will be translated by the process into a unique but anonymous ID that does not store or transmit the identity of the tag in any way that is traceable to the tag owner, e.g. credit identity or stored credit value. This ID is then passed on to another process for further link travel time calculation analysis.

(g) Collect Vehicle Smart Probe Data (1.1.7) - this process will collect data from vehicle smart probes. This data will include information about conditions in the vicinity of the vehicle operating as a smart probe. It will receive this data from passing vehicles and will add its own identity and location before sending the data on to the process which outputs the data.

All data about vehicles and pedestrians passing through the surface street and freeway network is collected by processes (a) and (f). It is then sent to processes in (b) which distribute it to other facilities and load it into the current and long term data stores. The data in these stores plus weather and incident data is used by process (c) to produce a predictive model of future traffic conditions. The results of this process and the data stored by processes in (b) are available for display by the traffic operations personnel and the media operator through the processes in (d). The long term data is also exchanged with other traffic centers, the data from which is also used as input to the predictive model by process (c).

Although all of these processes, except (a), (f) and (g), depend on others in the group for data, they will each operate continuously and independently. This enables traffic data to be processed, stored and accumulated in a timely fashion. Process (a) could be deployed on its own with some of the control processes in the Roadside Control facility - see DFD 1.2.7, to provide a roadside based traffic control facility with no links to any central system for coordination, fault reporting, etc.

Processes in (a) also controls the video cameras used for traffic surveillance. This enables them to be set up to collect traffic data from different "views", where a "view" is a particular video image of part of the surface street and freeway network. The "view" being provided by a camera may be changed by either the traffic operations personnel or automatically as part of a traffic control strategy through a process in the Provide Device Control facility - see DFD 1.2. This enables the same camera to be used to gather different traffic data at different times of the day, days of the week, etc. One example is the data needed to monitor traffic flows in the morning and evening peak traffic periods may need to be obtained from different "views".

Process Sensor Data (DFD 1.1.1)

This DFD shows the processes that make up the Process Sensor Data facility within the Manage Traffic function. These processes analyze, collect, store, and distribute sensor data to other facilities. The key points about the facility are as follows:

* - processed sensor data to other processes within the Manage Traffic function;

* - sensors are monitored to detect and report any sensor faults,

* - collected sensor data is stored within a sensor data store.

There are three processes in this DFD and they divide its overall functionality between themselves in the following way.

(a) Process Traffic Sensor Data (1.1.1.1) - this process will be responsible for collecting surveillance obtained from the roadside, vehicles, pedestrians (travelers using other modes of transport), railroad grade and multimodal crossings. The process will be able to receive both passive (e.g. presence) and active (e.g. tag) data from vehicles. Where any of the data is provided in analog form, the process will be responsible for converting it into digital form and calibrating. The converted data will be sent to other processes for distribution, further analysis and storage.

(b) Collect and Process Sensor Fault Data (1.1.1.2) - this process will be responsible for collecting sensor status, identifying faults, and logging faults that have been detected by processes in other parts of the Manage Traffic function. It will be possible for the faults to have been detected locally at the sensors, or centrally through communications links with the sensors. The process will pass on new fault data to another processes for communication to the Construction and Maintenance terminator and will receive fault clearances from the same terminator. It will also maintain a store of the current fault state of all sensors. The process will provide facilities that enable traffic operations personnel to review and update the current fault status of all sensors. Details of faulty and fixed equipment will be passed by the process to the traffic control strategy selection process so that it can adjust its strategy to take account of the fault(s).

(c) Process Environmental Sensor Data (1.1.1.3) - this process will be responsible for collecting data obtained from environmental sensors. Where any of the data is provided in analog form, the process will be responsible for converting it into digital form and calibrating. The converted data will be sent to other processes for distribution, further analysis and storage.

(d) Manage Data Collection and Monitoring (1.1.1.4) - This process collects and monitors sensor data from the roadside. The process collects the sensor data including sensor status and sensor faults from roadside equipment and distributes it to the Manage Archive Data function. The process runs when a request fordata is received from an external source.

The collected data is received by process (b). The actual sensor data from the roadside is received by processes (a) and (b). The data is then collected and sent to process (b) to detect and store faults in the sensors. Process (b) then sends messages to the responsible terminator to correct the fault. These processes distribute the sensor data to other facilities in the Manage Traffic function.

Process and Store Traffic Data (DFD 1.1.2)

This DFD shows the processes that make up the Process Traffic Data for Storage facility within the Manage Traffic function. These processes analyze collected data, distribute it to other facilities in the function and store the data, together with that provided by other facilities. The key points about the facility are as follows:

* - processed sensor data to other processes within the Manage Traffic function;

* - high occupancy vehicle (HOV) lane operation monitored and violators reported;

* - data from on-board vehicle tags processed to determine journey times;

* - vehicle smart probe data processed to determine roadway hazards ready for storage and output.

There are six processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Process Traffic Data for Storage (1.1.2.1) - this process will receive data from other processes and store the data into the long term and current data stores. The data will comprise of sensor data (both smoothed and unsmoothed) processed sensor surveillance data, data sent to control indicators. Other data items include parking lot management data and other street equipment, the status data received from the indicators, plus current traffic conditions, planned events, current incidents, parking lot states, freeway ramp states, link travel times, roadway conditions provided by vehicle probes, and selected traffic control strategy. The data stored by the process in the current data store will be the values collected over a relatively short period of time. The data stored in the long term data store will be retained for a longer period. The data retained in the long term data store may be aggregated so as to reduce the storage requirements for long historical records, the amount of aggregation to be an implementation decision.

(b) Process Traffic Data (1.1.2.2) - this process will receive and process data from sensors (both traffic and environmental) at the roadway. The process distributes data to Provide Device Control processes that are responsible for freeway, highway rail intersections, parking lot, surface street and freeway management. It also sends the data to another Provide Traffic Surveillance process for loading into the stores of current and long term data.

(c) Update Data Source Static Data (1.1.2.3) - this process will be responsible for the maintenance of the store of static data used in the processing of sensor data. This sensor data will be used to provide traffic surveillance information for use by other processes within the Manage Traffic function. The store will contain data showing the relationship between sensors and the surface street and freeway network. It will also hold information about the ownership of each link (that is, the agency or entity responsible for collecting and storing surveillance of the link) in the network that will be used by processes involved in exchanging surveillance information (and optionally control) with other Traffic Management Subsystems (TMSs).

(d) Monitor HOV lane use (1.1.2.4) - this process will be responsible for monitoring the use of High Occupancy Vehicle (HOV) lanes and detecting vehicles that do not have the required number of occupants. The process also provides data on HOV lane usage for storage in the stores of current and long term data.

(e) Process Tag/AVL Data for Link Time Data (1.1.2.5) - this process will be responsible for processing tag and AVL data collected from roadside readers or obtained from an analysis of toll transaction records. The process will receive the processed tag and AVL data from the data collection process and will calculate the travel time for the links under tag surveillance that have been traveled by the vehicles carrying the tags. This will be achieved by noting the successive times at which the tag data is received and calculating the travel time from the difference. The data obtained from the toll tag transaction record analysis and/or tag reader locations will not need any further processing as it will contain the average travel times between successive toll collection plazas and tag reading locations. The process will maintain a data store which contains the average travel time for each link in the surface street

and freeway network under tag surveillance calculated from the previously described data. Calculation of the actual average values will employ some type of aggregation processing and be stored for differing time categories in periodic increments. The current delay time for a link will be the difference between current travel time value and the aggregate processed value for that time category.

(f) Process Collected Vehicle Smart Probe Data (1.1.2.6) - this process will be responsible for the processing of vehicle smart probe data. The process receives data from vehicle subsystems and processes the data to estimate type and level of roadway conditions and hazards. The process will send the road condition and hazard estimates to the Provide Device Control facility for output to future passing vehicles. It will send this data, together with the fixed unit identity and fixed location to the traffic data storage process for loading into the current and long term data stores.

(g) Monitor Reversible Lanes (1.1.2.7) - this process will be responsible for monitoring the use of reversible lanes and detecting wrong-way vehicles in reversible lanes. The process will monitor sensor data and video images from the reversible lanes, and use this information along with the lane status (which direction it is currently operating) to identify when a vehicle is traveling in the wrong direction on the reversible lane.

The collected data is received by process (b). This distributes it to other facilities in the Manage Traffic function using the data in the store of static data to decide which processes should actually receive the data. The data is also sent by process (a) to process (a) for loading into the current and long term data stores. This process also receives and loads into the stores indicator control and response data, implemented strategies, freeway ramp and parking lot data received from the Provide Device Control facility. Process (d) provides its link journey time data direct to process (a) again for loading into the stores. Data from vehicle smart probes analyzed by process (e). This process then sends it for storage and for to the Provide Roadside Control Facilities facility - see DFD 1.2.7, for output to passing vehicles.

Overwriting of the data stored in the current data store will remove the data for the previous five minute period. The exception to this is the video image data which is overwritten as soon as it is received. The data in the long term data store will not be overwritten as new data is accumulated and, it will be possible to display the data so far accumulated in the current hour. The life of this data will depend on the size of the data store in each implementation and the availability of store archiving and back-up facilities.

Although all of these processes depend on others in the group for data, they will each operate continuously and independently so that traffic data can be processed, stored and accumulated in a timely fashion. The last two processes may be omitted from specific implementations if no HOV lanes are present, or there is no roadside equipment to interrogate on-board vehicle tags for data.

Display and Output Traffic Data (DFD 1.1.4)

This DFD shows the processes that make up the Display and Output Traffic Data facility within the Manage Traffic function. These processes provide the interfaces through which stored traffic data can be provided to other ITS functions and the media. The key points about the facility are as follows:

* - access to current, historic and predictive model data provided for traffic operations personnel;
* - media operator and media system can access data under the control of traffic operations personnel;
* - other ITS functions and Manage Traffic facilities provided with access to the data on request;
* - output can be presented against the background of digitized map data.

There are six processes in this DFD and they divide up its overall functionality between themselves in the following ways.

(a) Retrieve Traffic Data (1.1.4.1) - this process will on request retrieve traffic data from the data stores managed by other processes in the Provide Traffic Surveillance facility of the Manage Traffic function. It will be possible for requests to originate from traffic operations personnel, the media operator, the Manage Demand facility within the Manage Traffic function, and the Provide Driver and Traveler Services function. With the exception of those from the Manage Demand facility, all requests

will be provided by interface processes. The process will also generate traffic data for output by other processes to in-vehicle signage functions.

(b) Provide Traffic Operations Personnel Traffic Data Interface (1.1.4.2) - this process will provide the interface through which traffic operations personnel can obtain access to the data stored by other processes in the Provide Traffic Surveillance facility of the Manage Traffic function, and set up the parameters that govern the data that is available to non-traffic operations people via a separate process to the media operator. This stored data will comprise current and long term (historic) data on traffic conditions, weather conditions and roadside equipment activity, plus prediction estimates of traffic conditions. The data will apply to some or all of the surface street and freeway network served by the specific instance of the Manage Traffic function. Where appropriate and/or requested by the traffic operations personnel, the process will provide the data output in the form of an overlay onto a map of the relevant part(s) of the surface street and freeway network served by the instance of the function. The process will obtain the map from a local data store, which it will enable the traffic operations personnel to update as and when required.

(c) Provide Direct Media Traffic Data Interface (1.1.4.3) - this process will be responsible for providing the interface between the media and the process responsible for obtaining data from the stores of traffic data maintained by other processes within the Provide Traffic Surveillance facility of the Manage Traffic function. The process will enable the media to request and be provided with current, long term (historic) and predicted traffic data. The data may be provided in one or more formats: as a data stream, as processed and displayed to Traffic Operations, or as a display with data included on a map of relevant part(s) of the road and freeway served by the Manage Traffic function. The media will only be able to request and see displayed that data that the traffic operations personnel have made available, through the use of the definition in the traffic data media parameters.

(d) Update Traffic Display Map Data (1.1.4.4) - this process will provide updates to a store of digitized map data when a request is received from traffic operations personnel via their interface process. The map data will be for use as the background for displays of traffic data requested by traffic operations personnel and media operators through their respective interface processes. This process will obtain the new map data from either a specialized data supplier or some other appropriate data source.

(e) Provide Media System Traffic Data Interface (1.1.4.5) - This process will provide the interface through which traffic and incident data can be output to the Media. The output will comprise traffic and incident data that is suitable for output to the Media System as determined by traffic managers. This interface is only for the output of data that has been requested by the Media.

(f) Provide Traffic Data Retrieval Interface (1.1.4.6) - this process will provide customized sets of traffic data for broadcast, advisories, and personalized data to travelers and the media. This process will use the parameters in the data store traffic_data_retreival_parameters to define exactly what data will be retrieved as a result of each request. The process will select the appropriate subset of traffic data which will be sent to each ITS function which is requesting data. The process will accept traveler profiles for use in determining what personalized data to send to the traveler.

(g) Manage Traffic Archive Data (1.1.4.7) - This process collects traffic data and ahs operational data to distribute to the Manage Archive Data function. The process runs when a request for data is received from an external source, or when fresh data is received.

Process (a) is responsible for retrieving the requested data from the stores of current, long term (historic) and predictive model data. It receives requests from either process (b) which provides the traffic operations personnel interface, or from process (f). This process acts as the interface between processes (c) and (a). It enables the traffic operations personnel to control the access that the media and other ITS functions have to the stored data. It also controls the output of data to process (e) which is the output interface to the media systems, e.g. highway advisory radio (HAR), dynamic message signs (DMS), or flashing lights that direct drivers to tune their radios to a particular frequency to receive traffic information.

The processes (b), (c) and (e) depend on the processes (a) and (f) for data and can only function as a group. It is possible for the outputs provided by the processes (b) and (c) to appear without the digitized map data produced by the fourth process. For process (b) an example might be video image data provided by traffic surveillance cameras.

Provide Device Control (DFD 1.2)

This DFD shows the processes that make up the Provide Device Control facility within the Manage Traffic function. These processes provide the mechanism through which traffic management strategies can be implemented on the road and highway network served by the function. The key points about this facility are as follows:

* - traffic management provided through coordination of roadside equipment (indicators);
* - traffic management strategy depends current traffic conditions and default strategy;
* - traffic management strategy can be overridden by Manage Incident and Manage Demand facilities;
* - traffic management strategy can also be overridden by traffic operations personnel;
* - indicators can be intersection, ramp or pedestrian controllers, or dynamic message signs (DMS);
* - coordination of controller outputs can be based on a range of algorithms using real time data;
* - controllers can operate using local data with no coordination;
* - override strategies available to give emergency, high occupancy (HOV), and transit vehicle priority;
* - DMS can be used to guide drivers away from congestion;
* - DMS can also be used to guide drivers towards parking lots with spaces currently available;
* - output of data to in-vehicle signage equipment provided through roadside units;
* - output of smart probe data collected from vehicles provided through roadside units;
* - incorrect operation of indicators reported as faults to the construction and maintenance organization.

There are two processes and six DFDs in this DFD and they divide its functionality between themselves in the following ways.

(a) Select Strategy (1.2.1) - this process will select the appropriate traffic control strategy to be implemented over a road and/or freeway section served by the specific instance of the Manage Traffic function. The strategy will be selected by the process from a number that are available, e.g. adaptive control, fixed time control, local operations. The selected strategy will be passed by the process to the actual control processes for implementation according to the part of the network to which it is to be applied, i.e. surface roads, freeways, ramps and/or parking lots. The definition of strategy can be extended to include a strategy for the operations of sensors such as video cameras used to provide traffic surveillance data. The process will make it possible for the current strategy selection to be modified to accommodate the effects of such things as incidents, emergency vehicle preemption, the passage of commercial vehicles with unusual loads, equipment faults and overrides from the traffic operations personnel. The strategy for control of freeways and parking lots is through use of DMS signs and lane indicators. The strategy for control of ramps is through the timing plans for ramp meters. The selected strategy will be sent to the process within the Provide Traffic Surveillance facility responsible for maintaining the store of long term data.

(b) Determine Road and Freeway State (1.2.2) - the processes in this DFD are responsible for implementing the selected traffic control strategies on some or all of the surface street and freeway network served by the Manage Traffic function. They create data which is sent to other processes in DFD 1.2 for output as control data to the indicators (intersection and pedestrian controllers, dynamic message signs (DMS), etc.) that are located within the network. The indicators are used as the mechanism by

which instructions and advisory messages can be sent to drivers and pedestrians to enable the selected traffic control strategies to be implemented.

(c) Determine Ramp State (1.2.3) - this process will implement the selected control strategies on some or all of the freeway entry ramps in the freeway network served by the Manage Traffic function. It will implement the strategies only using the ramps that are specified in the implementation request and will coordinate its actions with those of the process that controls the road network. The process will base its ramp metering decisions on the data from sensors and ramp meters monitoring traffic conditions upstream and downstream of the ramps. Data from sensors on the ramp used to detect flow past the meter, extent of queues on the ramp, and the presence of vehicles will also be used as the basis for the ramp metering decisions. The decision making process will use an algorithm to determine the ramp's state based on the ramp control strategy and the sensor input data received. The process will coordinate its activities with the process responsible for controlling the road (surface street) network.

(d) Output Control Data (1.2.4) - the processes in this DFD are responsible for the output of control data generated by other processes in DFD 1.2 to equipment within the surface street and freeway network served by the Manage Traffic function. This equipment comprises the various indicators, i.e. intersection and pedestrian controllers, dynamic message signs (DMS), etc., plus units that can output the same data in a form that can be used by in-vehicle signage units. The processes also monitor data received from the indicators showing the way in which they are responding to the data that they are being sent. Any incorrect responses or actual fault indications will be passed to the processes responsible for fault management - see DFD 1.2.8 below. All data output to and received from the roadside equipment will also be sent to another process in the Manage Traffic function to be loaded into the store of long term data.

(e) Manage Parking Lot State (1.2.5) - the processes in this DFD determine the current conditions at parking lots based on either data from the Parking Service Provider, or from traffic counting detectors sited at entrances and exits to the lots, or from direct input by Parking Lot Operators at the lots. The parking lot conditions are produced as a “state”, which may be ’FULL’, ’ALMOST FULL’, ’SPACES’, etc., and/or an actual occupancy value, shown as the number of unused spaces. The occupancy data requires input from the counting detectors, which may not always be present at a parking lot entry and exits. When it is present, the “states” can be calculated from the occupancy data, so that no inputs are needed from the Parking Service Provider or Lot Operator. Requests for transit services are automatically sent to the Manage Traffic function, based on the numbers of vehicles arriving at the lots so that an efficient and demand driven park and ride (P+R) service can be provided.

(f) Maintain Static Data for TMC (1.2.6) - the processes in this DFD maintain the stores of static and link data used as a source of this type of data by the other processes both within this DFD and other parts of the Manage Traffic function. The processes can also provide a copy of the current static data on request from the Manage Archived Data function.

(g) Provide Roadside Control Facilities (1.2.7) - the processes in this DFD produce the actual indications that drivers and pedestrians see and is the means by which they receive instructions and advice about what they must (or should) do. The indications may be provided through roadside equipment or through broadcast to in-vehicle signage units. Data received by the processes in this DFD is the direct result of the implementation by other processes of the selected traffic control strategy - see DFDs 1.2.2 through 1.2.5. The operation of the processes is monitored so that any failure to respond to the output data can be notified as a fault. Data about vehicles for which a collision potential exists at an intersection is passed to other processes in the Provide Vehicle Monitoring and Control function for action.

(h) Collect and Process Indicator Fault Data (1.2.8) - the processes in this DFD are responsible for collecting data about indicator faults and forwarding it to the Construction and Maintenance organization. The processes maintain a record of all faults, provide facilities for the Traffic Operations Personnel to update the fault data or enter faults themselves, and pass on fault clearances.

Process (a) provides the interface through which strategies can be applied to controllers (intersection and pedestrian), ramp metering equipment and parking lots. The strategy selected will always be that with the highest status, based on the principle that emergency vehicle priority comes first, followed by other overrides, and the background strategy comes last. It will be possible to apply different strategies to various parts of the network, thus for example enabling areas that are geographically separate to be controlled in different ways. Equipment that has been reported as faulty will be excluded from strategies and only restored to the current strategy when notification is received of its successful repair.

The store of static data is used to provide these processes with a "model" of the controlled road network and the devices which are used for its control, plus the background traffic control strategy. The latter is a set of strategies which are used to change the method of traffic control either by time of day (to the nearest minute), or by day of the week (i.e. Monday through Sunday), or for special days of the year, e.g. particular public holidays such as Thanksgiving and New Years Day. The "model" of the road network will define which road segments link to others and provide details about each segment, e.g. number of lanes, standard journey time, etc. The device data held in the static data store will enable the processes to decide how each roadside indicator will perform, and monitor the actual performance against what is expected, so that any errors can be reported as soon as they occur for prompt maintenance action. These errors may be anything from lack of response to control commands, to the failure of a single lamp bulb.

Although some of these processes depend on others in the group for data, they will each operate continuously and independently so that traffic control can be implemented in a timely fashion. Note that the processes in (g) receive data from the process (a) in the Provide Traffic Surveillance facility - see DFD 1.1, so that they can continue to function using local data if control data is not received from the processes in (d).

Determine Road and Freeway State (1.2.2)

This DFD shows the processes that make up the Determine Road and Freeway State facility within the Manage Traffic function. These processes implement selected traffic management strategies for the road and highway network served by the function. The key points about the facility are as follows:

* - adaptive, fixed time and local control strategies supported for indicators on roads;
* - sequencing control strategies supported for indicators on freeways;
* - strategies may be implemented on one, some or all indicators on roads and freeways;
* - coordination provided between freeway, road and ramp control processes.

There are two processes in this DFD and they split its overall functionality between themselves in the following ways.

(a) Determine Indicator State for Freeway Management (1.2.2.1) - this process will implement selected traffic control strategies and transit vehicle overall priority on some or all of the indicators covering the freeway network served by the Manage Traffic function. It will implement the strategies only using the indicators (e.g. dynamic message signs (DMS)) specified in the implementation request and will coordinate its actions with those of the process that controls the road network. The process will also be capable of monitoring the extra inputs that will arise where tunnels are involved, including the detection of fire and the consequent requirement to re-route traffic.

(b) Determine Indicator State for Road Management (1.2.2.2) - this process will implement selected traffic control strategies and transit priority on some or all of the indicators covering the road (surface street) network served by the Manage Traffic function. It will implement the strategies only using the indicators (intersection and pedestrian controllers, dynamic message signs (DMS), etc.) that are specified in the implementation request and will coordinate its actions with those of the processes that control the freeway network and the ramps that give access to the freeway network.

Control strategies are applied according to data received by the two processes from the strategy selection process in the Provide Device Control facility - see DFD 1.2.2 in previous section. The strategies may be

implemented on one, or some or all of the indicators in the road or freeway networks, so that different strategies may be applied to differing areas of each network. The freeway control strategies supported by process (a) are specified as a series of sign setting rules. These specify the way in which dynamic message signs (DMS) must be set in order that a desired objective can be achieved, e.g. close one lane, set a temporary speed limit, etc. The road control strategies supported by process (b) include real time adaptive control, various types of fixed time plan selection, and local (uncoordinated) control. The use of DMS to create diversionary routes, and vehicle priority routes are also supported. The latter are known as "green waves" because they give the vehicle(s) a green (or go) indication at each traffic intersection as they move along their route(s).

These processes can be implemented singly, or as a pair where traffic management of a mixed system is required. In either case, the coordination flows will be present to provide linkages to the other process controlling the other roadway type.

Output Control Data (1.2.4)

This DFD shows the processes that make up the Output Control Data facility within the Manage Traffic function. The key points about the facility are as follows:

* - non-compliance with control commands by indicators reported as faults;

* - data for in-vehicle signage output to roadside equipment automatically.

There are three processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Output Control Data for Roads (1.2.4.1) - this process will transfer data to processes responsible for controlling equipment located at the roadside within the road (surface street) network served by the Manage Traffic function. This data will contain outputs for use by roadside indicators, such as intersection and pedestrian controllers, dynamic message signs (DMS), highway advisory radio (HAR), etc. Data for use by in-vehicle signage equipment will be sent to another process for output to roadside processes. All data will be sent to this process by processes within the Manage Traffic function. This process will also be responsible for the monitoring of input data showing the way in which the indicators are responding to the data that they are being sent, and the reporting of any errors in their responses as faults to the Collect and Process Indicator Fault Data facility within the Manage Traffic function. All output and input data will be sent by the process to another process in the Manage Traffic function to be loaded into the store of long term data.

(b) Output Control Data for Freeways (1.2.4.2) - this process will transfer data to processes responsible for controlling equipment located at the roadside within the freeway network served by the Manage Traffic function. This data will contain outputs for use by roadside indicators, such as dynamic message signs (DMS), etc. Data for use by in-vehicle signage equipment will be sent to another process for output to roadside processes. All data will have been sent to this process by processes within the Manage Traffic function. This process will also be responsible for the monitoring of input data showing the way in which the indicators are responding to the data that they are being sent, and the reporting of any errors in their responses as faults to the Collect and Process Indicator Fault Data facility within the Manage Traffic function. All output and input data will be sent by the process to another process in the Manage Traffic function to be loaded into the store of long term data.

(c) Output In-vehicle Signage Data (1.2.4.3) - this process will format and output data for use by roadside processes in creating in-vehicle signage. This process supports a full range of functionality for in-vehicle signage (from display of signage to location specific advisory data). The process will be capable of outputting some or all of the following advisory data: link state data, current incidents, planned events, and highway rail intersection status. The process will be capable of outputting some or all of the following signage data: dynamic message sign contents or fixed signage. The data will be structured by this process so that it can be output by each roadside process to vehicles for use by in-vehicle signage equipment.

These processes will use the store of static data to determine the format of the actual control data that is sent to the indicators. The content of the control data is provided by the processes in the Determine Road and Freeway, Ramp and Parking Lot State facilities - see DFD 1.2.2, process 1.2.3 and DFD 1.2.5. The static data will also define the relationship between the dynamic message signs (DMS) and the parking lots, so that the relevant parking information can be shown at each DMS. This will enable vehicles to be guided towards those parking lots with spaces, thus reducing queuing time and the numbers of vehicles taking up valuable road and freeway space searching for parking lots with spaces. Process (c) will provide a copy of the data being output by indicators plus information about incidents and traffic conditions to processes at the roadside so that they can output it to display units in passing vehicles.

These processes can be implemented separately, as two pairs, one for freeways and the other for roads. In the latter case there will be a broadcast output process in each of the pairs, with only one input flow. It would also be possible to implement all three processes as one group for a mixed freeway and road management system.

Manage Parking Lot State (1.2.5)

This DFD shows the processes that make up the Manage Parking Lot State facility within the Manage Traffic function. These processes determine and manage the state of parking lots in the area served by the function. The key points about the facility are as follows:

* - parking lot state can be determined from inputs provided by a variety of sources;
* - the precise input configuration can be set up to suit individual parking lots;
* - Manage Transit function link enables provision of a demand responsive park and ride (P+R) service;
* - parking lot data used to in dynamic message signs (DMS) output to guide vehicles to lots with spaces;
* - parking lot data stored for use by traffic operations personnel and the media operator;
* - parking lot data also used by the Mange Demand facility.

There are five processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Determine Parking Lot State (1.2.5.1) - this process will implement the selected control strategies on some or all of the parking lots in the surface street and freeway network served by the Manage Traffic function. It will use the current parking lot occupancy provided by another process to determine the parking lot state to be used in sign settings implemented by other processes in the function, when this is not subject to a strategy override. The parking lot state will be determined using threshold occupancy values contained in the static data. Fixed thresholds for the states: full, almost full, and available are in the data flow static_data_for_parking_lots.

(b) Coordinate Other Parking Data (1.2.5.2) - This process continuously communicates and exchanges data with parking operators and systems. The exchange of data is triggered by either a request from a remote Parking Management Subsystem for data from the operators or systems the Provide Electronic Payment function belongs, or because data needs to be sent from the local Parking Management Substystem to another remote Parking Management Subsystem. This data includes parking lot state, parking price information, parking availability, etc.

(c) Provide Parking Lot Operator Interface (1.2.5.3) - this process will provide the interface to a local parking lot operator that controls the use of the lot. The operator will provide inputs of occupancy and/or the current lot state to this process. This process will provide the operator with outputs that request a change to the lot state, which the operator will implement by activating local dynamic message signs (DMS) and controlling the use of entry/exit barriers, and data about transit services that provide a park and ride (P+R) operation to be output through local DMS.

(d) Determine P+R needs for Transit Management (1.2.5.4) - this process will be responsible for calculating the need for transit services to provide a park and ride (P+R) operation at a

parking lot. This calculation will be based on the rate of change of the current parking lot occupancy. The results of the calculation will be sent to the Manage Transit function in the form of a request for an additional (or reduced) level of service, depending on demand at the parking lot. The results of the request will also be passed to other processes within the function.

(e) Manage Parking Archive Data (1.2.5.5) - This process obtains parking lot availability and charge data and distributes it to the Manage Archive Data function. The process runs when a request for data is received from an external source.

(f) Calculate Parking Lot Occupancy (1.2.5.6) - this process will calculate the occupancy of a parking lot based on processed traffic sensor data provided by other processes within the Manage Traffic function. The process will use the static data for parking lots to determine the part(s) of the supplied data that apply to its entry and exit lanes, so that the numbers of vehicles entering and leaving can be calculated. These calculated flows will be used by the process to generate the current parking lot occupancy.

Since both parking lot state and (if available) occupancy are provided by process (a), it will be possible for the dynamic message signs to display which ever is best suited to local requirements. The actual output of the data to the relevant dynamic message signs (DMS) is handled by the Output Control Data facility - see DFD 1.2.4. Both state and occupancy data will be made available to other processes in the Manage Traffic function and to other ITS functions. The state will only provide a qualitative assessment of parking lot occupancy which in many cases is sufficient for driver information needs. Occupancy on the other hand provides a quantitative assessment which will be needed for activities such as predictive modeling, demand forecasting and planning future changes to the surface street and freeway network served by ITS.

These processes can be implemented in a variety of sub-sets. The one common process is (a) which determines the parking lot state, some or all of the others need not be present in any individual implementation. A typical implementation would have process (a), plus one out of processes (b), (c), or (f), plus (optionally) process (d).

Maintain Static Data for TMC (1.2.6)

This DFD shows the processes that make up the Maintain Traffic and Sensor Static Data facility within the Manage Traffic function. These processes provide static data for use by facilities within the function. The key points about the facility are as follows:

* - static data maintained by Traffic Operations Personnel;

* - current static data can be retrieved and sent to the Manage Archived Data function.

There are two processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Maintain Traffic and Sensor Static Data (1.2.6.1) - this process will maintain the store of static and link data used by other processes within the Manage Traffic function. Link data will also be sent to the Provide Driver and Traveler Services function to enable it to obtain data about links that are not in the geographic area which it serves.

(b) Provide Static Data Store Output Interface (1.2.6.2) - this process will provide updates of static data to other processes in the Provide Traffic Control facility of the Manage Traffic function. An update of the data will only be provided when this process has been notified by another process that the contents of the store of static data has been changed.

The two processes in this facility must be implemented as a pair. This is because process (b) is driven to provide its outputs by process (a) and relies on that process to provide the data in the store. Process (a) may also receive a request for a copy of the current static data from the Manage Archived Data function. In this case it requests the current data from the processes that serve the stores in the Provide traffic Surveillance and Manage Incidents facilities - see DFDs 1.1 and 1.3, and combines the data that they

provide with that in its own store. This combined set of data is then sent to the Manage Archived Data function.

Provide Roadside Control Facilities (1.2.7)

This DFD shows the processes that make up the Provide Roadside Control Facilities facility within the Manage Traffic function. These processes distribute the data implementing traffic management strategies to roadside equipment served by the function. The key points about the facility are as follows:

* - control data translated into output that will be easily and readily understood by drivers and travelers;

* - indicator faults reported when their operation does not match that specified in their control data;

* - indicators can operate with local sensor data possible if required, or no control data provided;

* - local priority can be given to transit and emergency vehicles;

* - in-vehicle signage data and smart probe data output to passing vehicles;

* - data provided warning vehicles of potential intersection collisions;

There are seven processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Process Indicator Output Data for Roads (1.2.7.1) - this process will implement the indicator output data generated by other processes within the Manage Traffic function for use on the roads (surface streets) served by the function. It will perform the functions needed to provide control at intersections or pedestrian crossings, generate the output for dynamic message signs (dms) and highway advisory radios (HAR), or provide the interface for data to be sent to the units (or systems) that manage multimodal crossings.

(b) Monitor Roadside Equipment Operation for Faults (1.2.7.2) - this process will monitor the operation of the processes that output in-vehicle signage, highway advisory radio, as well as indicator data in the road (surface street) and freeway network. It will report any instances where the indicator response does not match that expected from the contents of the indicator control data it is receiving, the in-vehicle signage process reports a fault, or the HAR processes report a fault.

(c) Manage Indicator Preemptions (1.2.7.3) - this process will receive indicator preemption and priority requests from other functions within ITS. These requests will enable the process to give selected vehicles signal preemption or priority at intersections, pedestrian crossings and multimodal crossings in the surface street and freeway network served by the instance of the Manage Traffic function.

(d) Process In-vehicle Signage Data (1.2.7.4) - this process will output data for use by in-vehicle signage equipment on vehicles traveling along the road (surface street) and freeway network served by the Manage Traffic function. This data will be able to provide information from any of the types of indicators that are supported by the function, e.g. intersection controller, pedestrian controller, dynamic message sign (dms), plus data about incidents and link information such as speed, travel times or roadway conditions. The process will be responsible for its own fault monitoring, which will check that output data is being sent and that it is an accurate representation of the input data. When a fault is detected this process will report it to the process responsible for the monitoring of roadside equipment faults.

(e) Process Indicator Output Data for Freeways (1.2.7.5) - this process will implement the indicator output data generated by other processes within the Manage Traffic function for use on freeways served by the function. It will perform the functions needed to output control data to ramp metering controllers and multimodal crossings, generate the output for dynamic message signs (dms), or generate the output for highway advisory radios(HAR). The dms may be either those that display variable text messages, or those that have fixed format display(s), for such things as vehicle restrictions, or lane open/close.

(f) Provide Intersection Collision Avoidance Data (1.2.7.6) - this process will provide collision avoidance data to vehicles that are approaching intersections served by the Manage Traffic

function. The process will use the data available from traffic sensors to determine any vehicle position conflict(s) that will arise if no action is taken. This process will output data giving the direction from which the potential collision hazard will arise to the vehicle(s) that is(are) likely to receive the impact.

(g) Process Vehicle Smart Probe Data for Output (1.2.7.7) - this process will output data about the conditions on roads and freeways. The process will be provided with this data by other processes in the Manage Traffic function, which have received and processed data output by smart probes in vehicles. The data will be output by the process for reception by those vehicles that are passing the deployed instance of this process (e.g. by dedicated short range communications). The process will perform its own fault detection and report faults that are found to the fault monitoring process.

Although the processes in this facility form a cohesive group, only processes (a) and (e) are essential for the output of indications to drivers and travelers. They receive the data from the output control data process in the Provide Device Control facility - see DFD 1.2. Process (b) provides the facility to monitor the operation of processes (a) and (e) unless this is temporarily suspended by process (c), as well as the operation of processes (d) and (g). Process (d) will enable vehicles to receive a copy of the data that is being output by indicators plus information about incidents and traffic conditions, that are local to the process itself.

All processes apart from (a), (b) and (e) may be regarded as options and need only included when the facility that they provide is required by a particular implementation. Processes (a) or (e) could be provided in conjunction with process (a) in the Provide Traffic Surveillance facility - see DFD 1.1, as a local roadside traffic control unit. This would use locally detected traffic and pedestrian data to determine its control outputs and not be able to provide the benefits of coordination obtained from links other traffic management equipment.

Collect and Process Indicator Fault Data (1.2.8)

This DFD shows the processes that make up the Collect and Process Indicator Fault Data facility within the Manage Traffic function. These processes manage faults detected in roadside equipment served by the function. The key points about the facility are as follows:

* - faults reported to and cleared by, the construction and maintenance organization;
* - fault reporting and clearance monitored by traffic operations personnel;
* - traffic operations personnel can modify fault data and enter faults not detected automatically.

There are four processes in this DFD and they each provide different parts of the overall functionality in the following ways.

(a) Collect Indicator Fault Data (1.2.8.1) - this process will collect data about faults in the operation of indicators that have been detected by processes in other parts of the Manage Traffic function. It will be possible for the faults to be detected locally at the indicators, or centrally through communications links with the indicators.

(b) Maintain Indicator Fault Data Store (1.2.8.2) - this process will collect data about indicator faults that have been detected by processes in other parts of the Manage Traffic function. It will be possible for the faults to have been detected locally at the indicators, or centrally through communications links with the indicators. The process will pass on new fault data to another process for communication to the Construction and Maintenance terminator and will receive fault clearances from the same process communicating with that terminator. It will also maintain a store of the current fault state of all indicators. The process will provide facilities that enable traffic operations personnel to review and update the current fault status of all indicators. Details of faulty and fixed equipment will be passed by the process to the traffic control strategy selection process so that it can adjust its strategy to take account of the current fault(s).

(c) Provide Indicator Fault Interface for C and M (1.2.8.3) - this process will provide an interface for the exchange of data with the Construction and Maintenance terminator. The interface will

be used to both send data containing details of new indicator equipment faults, and to receive clearances when the faults are cleared. The details of new equipment faults and the clearances will be received from and sent to another process.

(d) Provide Traffic Operations Personnel Indicator Fault Interface (1.2.8.4) - this process will provide the interface through which traffic operations personnel access data about faults on indicator equipment controlled by the Manage Traffic function. The process will enable the personnel to monitor all indicator equipment faults that have been detected, and if necessary, amend that data. It will also enable the traffic operations personnel to manually input faults in cases where they cannot otherwise be detected.

Fault data is collected by process (a) which passes the data to process (b) for logging in the list of current indicator faults. The data is then sent from process (b) to process (c) for output to the construction and maintenance organization. Process (b) also updates the Select Strategy process (see process (a) in DFD 1.2.2) with the fault state, so that the faulty indicator(s) are not included in any strategy selection, and if necessary some strategies may be revised to take account of indicator faults. Fault clearance data is received from the construction and maintenance organization by process (c) and sent to process (b). This updates the current indicator faults list and outputs the new (cleared) fault status to the Select Strategy process.

The four processes in this facility form a cohesive group, although only the first three are essential to the processing of indicator fault data. The operator interface process can be omitted if the reporting and clearance of indicator faults is to be left as an automatic process.

Manage Incidents (DFD 1.3)

This DFD shows the processes that make up the Manage Incidents facility within the Manage Traffic function. These processes manage the classification of incidents and implement responses when they actually occur. The key points about the facility are as follows:

* - incident inputs available from many sources, e.g. emergency services, event promoters, etc.;
* - data from traffic sensors analyzed for indications of possible incidents;
* - traffic operations personnel can update incident data with other inputs, e.g. telephone reports;
* - incident inputs from construction and maintenance organization must be confirmed;
* - when an incident occurs predefined mitigation strategy is automatically implemented;
* - predefined incident strategies can be set up in advance by the traffic operations personnel;
* - incident status provided as input to the predictive traffic model and to vehicle route selection criteria;
* - information on incidents is available to the media.

There are four processes and three DFDs in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Traffic Data Analysis for Incidents (1.3.1) - the three process in this DFD analyze and look for anomalies in the data continuously received from traffic and from vehicle probes. Vehicle probes are required by the guidance process to frequently report their current position, providing data on route segment journey times and queue delays. Data from part of the static data is used to identify the location of the sensors that are providing the traffic data in which an anomaly has been found.

(b) Review and Manage Incident Data (1.3.2) - the five processes in this DFD receive data on incidents from process (a) and from a variety of other sources. They classify each incident by type and assign a confidence level depending on a number of factors including such things as the source of the incident report. If the data shows that the incident has yet to take place it is classified as a planned event, otherwise it is classified as a current incident. The processes manage the stores of both planned events and current incidents into which the received data is loaded once it has been processed.

(c) Respond to Current Incidents (1.3.3) - this process is responsible for providing the responses to incidents that become current, i.e. active. The response to each type of incident is defined for the process in the store of defined responses data. If the process cannot find a defined response for a particular incident, it will send the details to the traffic operations personnel so that they can provide an update to the store of defined responses. The process output the defined responses to an incident when it receives notification from another process in the Manage Incidents facility that a new current incident has occurred. At the same time it will also output the incident data to the process responsible for providing broadcast data to roadside processes. The other process in the Manage Incidents facility will also provide details of incidents that have ceased to be current (terminated) so that this process can send out data to clear the actions requested and roadside broadcast information output in response to its occurrence.

(d) Provide Operator Interfaces for Incidents (1.3.4) - the five processes in this DFD provide an interface through which the traffic operations personnel can review and update data about incidents, data defining the responses to each type of incident and the response suggested by the process in (c) when a predefined one does not already exist. The processes also provide facilities that enable a "sanitized" output of data on current and planned events to be produced for use by the media in its dissemination of traffic related information.

(e) Manage Possible Predetermined Responses Store (1.3.5) - this process will manage the data store containing possible predetermined responses to incidents used within the Manage Incidents facility. These responses will be those that another process within the facility has found to be worth including in the store of predetermined responses from an analysis of the incident response log. This process will enable retrieval of the data from the store for presentation to traffic operations personnel and its possible transfer to the process that manages the store of predetermined incident responses that are actually used by other processes in the Manage Incidents facility.

(f) Manage Predetermined Incident Response Data (1.3.6) - this process will manage data held in the store of predetermined incident responses that are used by processes within the Manage Incidents facility of the Manage Traffic function. The process will provide details of the current predetermined responses in response to requests from traffic operations personnel, and will also update the store with new responses received from the process that manages the store of possible predetermined responses.

(g) Analyze Incident Response Log (1.3.7) - this process will analyze the data in the log of incident responses within the Manage Incidents facility of the Manage Traffic functions. The process will analyze the log so that possible standard predetermined incident responses can be identified from the data in the incident_response_log data store. Any such possible standard predetermined responses that are identified will be passed by this process to the process that manages the store of possible predetermined responses.

The processes in this DFD and its constituent DFDs divide incidents up into three types comprising, possible, predicted and current data. Those in the possible category need further analysis work to establish their status as actual incidents. They may then be either planned events, which are those that have yet to happen, or current incidents, which are those that are actually happening currently. Examples of planned events are, special events, sports events and road construction activities, while current incidents can be any event when it actually occurs, traffic accidents and incidents caused by the effects of the weather.

Facilities are provided to enable the traffic operations personnel to oversee the management of incidents through the processes in (d). Thus planned events notified by event promoters and the construction and maintenance organization through processes in (b) are subject to confirmation by the traffic operations personnel. This enables these types of incident to be scheduled away from peak travel times. Traffic operations personnel can also amend incident data, and are responsible for the setting up of the defined responses that are implemented when an incident becomes current.

The defined responses used for current incidents can be based on policy data provided by the jurisdictional authorities, or on the responses to previous incidents of the same type. The latter are

produced by process (g) which analysis the previous responses to incidents. This creates a store of possible responses which could be added to the library of pre-defined responses. The transfer to this category is carried out by processes (e) and (f) under the direction of the traffic operations personnel. If a defined response is not available for a particular type of current incident, the traffic operations personnel will be notified and expected to provide one, before any further action is taken.

Although the processes in this DFD and its constituents feed each other data they will operate continuously and independently in order that incidents are detected and acted upon in a timely manner. As a minimum, the current incidents processes in (b) and the process in (c) are needed to provide a very basic incident management system, with no automatic detection, or differentiation between current incidents and planned events.

Traffic Data Analysis for Incidents (1.3.1)

This DFD shows the processes that make up the Traffic Data Analysis for Incidents facility within the Manage Traffic function. These processes analyze traffic data to look for indications of possible incidents. The key points about the facility are as follows:

* - video image and other sensor data analyzed for indications of possible incidents;

* - location of possible incidents fixed by location of data source.

There are three processes in this DFD and they each provide different parts of its overall functionality in the following ways.

(a) Analyze Traffic Data for Incidents (1.3.1.1) - this process will analyze traffic sensor data, vehicle probe data, or video images for anomalies that could indicate occurrence of an incident. The data may be collected from roads (surface street) and/or highways served by the Manage Traffic function. The process will pass on any anomalies that it detects to another process in the Manage Incidents facility as possible detected incidents.

(b) Maintain Static Data for Incident Management (1.3.1.2) - this process will maintain the store of static data (data about the location and features of the road or highway links in the transportation network). This data store is used by another process within the Manage Incidents facility to identify and locate incidents. The static data will be input to this process from another process within the function, and it will be possible for that process to request a copy of the current static data.

(c) Process Traffic Images (1.3.1.3) - this process will process raw traffic image data received from sensors located on the road (surface street) and freeway network served by the Manage Traffic function. The process will transform the raw data into images that can be sent to another process within the Manage Incidents facility. It will also act as the control interface through which the images of traffic conditions which are analyzed for incidents can be changed by the traffic operations personnel, who will also be supplied with images for viewing.

Process (a) provides data about possible incidents. It takes data from traffic sensors provided by processes in the Provide Traffic Surveillance facility - see DFD 1.1.1 plus video image data provided by process (c), and analyzes it for anomalies that may indicate the presence of a possible incident. When a possible incident is detected, the process sends the data to the Review and Manage Incidents facility - see DFD 1.3.2. Process (c) acts as the video image processor. It can also change the video image being used for incident analysis and provide the actual video images at the request of the traffic operations personnel through processes in the Provide Operator Interface for Incidents facility - see DFD 1.3.4.

The three processes should be implemented as a group of three. However there may be some implementations without process (c) which provides analysis of video images.

Review and Manage Incident Data (1.3.2)

This DFD shows the processes that make up the Review and Manage Incident Data facility within the Manage Traffic function. These processes manage the classification of incidents into the categories of possible, current, and planned events. The key points about the facility are as follows:

* - possible incidents data reviewed for transfer to predicted category if confidence level high enough;

* - planned events data reviewed for transfer to current category when start time occurs;

* - traffic operations personnel can review and amend incident data;

* - current incidents automatically cleared when duration has expired.

There are five processes in this DFD and they each provide different parts of its overall functionality in the following ways.

(a) Store Possible Incident Data (1.3.2.1) - this process will process raw traffic image data received from sensors located on the road (surface street) and freeway network served by the Manage Traffic function. The process will transform the raw data into images that can be sent to another process within the Manage Incidents facility. It will also act as the control interface through which the images of traffic conditions which are analyzed for incidents can be changed by the traffic operations personnel, who will also be supplied with images for viewing.

(b) Review and Classify Possible Incidents (1.3.2.2) - this process will review input data about possible incidents and provide verification of the incident. The process will have the capability of using algorithms to automatically identify and verify an incident. The process will have the capability to classify an incident as current or a planned event (e.g. a planned road closure) and will be load the data into the store of possible incidents as either current incidents or planned events. The process reports any incidents that it is unable to verify or classify to the traffic operations personnel for manual verification and classification. The process will allow the traffic operations personnel to request all possible incidents and carry out the verification and classification process manually.

(c) Review and Classify Planned Events (1.3.2.3) - this process will receive updates of planned events and review the complete list to determine when an incident should be reclassified from planned event to current incident. It will carry out the re-classification process automatically either upon receiving notice that the store of planned events has been updated, or at some periodic rate. The criteria for reclassifying an incident could be that the planned start time of the event has passed. The process will request details of planned events from the process that manages their data store and will send details of any new (re- classified) current incidents to the process that manages their data store. It will also provide updates of planned events and current incidents to other ITS functions, and details of any new planned events to the process responsible for the output of data to vehicle signage functions.

(d) Provide Planned Events Store Interface (1.3.2.4) - this process will provide the interface to, and manage the use of the store containing details of planned events. The process will enter details of all new planned events into the store, retrieve details on request, and delete details of an incident when it has been re-classified as a current incident. The process will be able to receive details of planned events from within the local Manage Incidents facility, and from similar facilities in other Traffic Management Subsystems (TMSs). When requested, the process will also be able to provide details of its planned events to the Manage Incidents facilities in other TMSs.

(e) Provide Current Incidents Store Interface (1.3.2.5) - this process will provide the interface to, and manage the use of the store of current incident details. The process will enter the details of all new current incidents into the store, retrieve details on request, and delete details of incidents when they cease to be current. The process will be able to receive details of current incidents from within the local Manage Incidents facility, and from similar facilities in other Traffic Management Subsystems (TMSs). When requested, the process will also be able to provide details of its current incidents to the Manage Incidents facilities in other TMSs.

Data on possible incidents in provided to process (a), which analyses it and if it has enough confidence that the incident is genuine, will upgrade its status to that of a planned event. The data is then passed to process (b) which again analyses it to determine whether the incident is current or is a planned event. Those in the former category are loaded into the store of planned events which process (c) will review periodically. Data about incidents that become current are sent to process (e) and on to process (c) in the Manage Incidents facility - see DFD 1.3, for response implementation. Process (d) acts as the interface to the store of planned events and also accepted data about such incidents in geographic areas served by other Manage Traffic functions.

Although these processes feed each other data they will operate continuously and independently in order that incidents are detected and acted upon in a timely manner. They should be implemented as a group since incident data is designed to be fed from one process to another as its status changes.

Provide Operator Interfaces for Incidents (1.3.4)

This DFD shows the processes that make up the Provide Operator Interfaces for Incidents facility within the Manage Traffic function. These processes provide the interfaces for traffic operations personnel to manage incidents, and the media to gain access to incident information. The key points about the facility are as follows:

* - incident data output to traffic operations personnel and media operator using digitized map display;
* - traffic operations personnel can provide incident data and set up defined incident responses;
* - warning of incidents can be output through media system.

There are five processes in this DFD and they each provide different parts of its overall functionality in the following ways.

(a) Retrieve Incident Data (1.3.4.1) - this process will retrieve incident data from the stores of planned events and current incidents that are managed by other processes in the Manage Incidents facility of the Manage Traffic function. The process will retrieve data as the result of a request comes from the traffic operations personnel or the media operator. The output will be returned to the source of the request, except where the media operator has specified that the data should be output to the media system.

(b) Provide Traffic Operations Personnel Incident Data Interface (1.3.4.2) - this process will provide the interface between the traffic operations personnel and the Manage Incidents facility of the Manage Traffic function. It will enable the personnel to request and amend details of planned events and current incidents and predetermined incident responses, obtain and control incident video image data and manually re-classify incidents as possible incident, planned event or a current incident. It will also output to the traffic operations personnel incident details to which no predetermined response currently exists. The process will support inputs from and outputs to the traffic operations personnel. Where appropriate and/or requested by the traffic operations personnel, the process will provide the output display in a form incorporating a map of the relevant part(s) of the surface street and freeway network served by the function. The process will obtain the map from a local data store, which it will request to be updated by another process as and when required.

(c) Provide Media Incident Data Interface (1.3.4.3) - this process will provide the interface between the Media and the Manage Incidents facility. It will enable the media to request details of incidents and will allow transmission of incident information to the media. The media will also provide raw input data on possible incidents. The process will enable the output to incorporate a map of the area to which the incidents relate.

(d) Update Incident Display Map Data (1.3.4.4) - this process will provide updates to the store of digitized map data used with displays of incident data produced by processes in the Manage Incidents facility of the Manage Traffic function. The process will obtain the new data from a map provider or other appropriate data source, on receiving an update request from the traffic operations personnel interface process within the Manage Incidents facility.

(e) Manage Resources for Incidents (1.3.4.5) - this process will provide the capability for the Manage Traffic function to generate and receive requests for resources in responding to incidents. The process will provide the capability for traffic operations personnel to request resources from the Construction and Maintenance to provide equipment and support for incident response and clean up. The process will be able to receive resource requests from the Manage Emergency function and respond with the status of the response by Construction and Maintenance or the traffic operations personnel.

The interfaces for the traffic operations personnel and the media operator are provided through processes (b) and (c). Both use process (a) as the mechanism for obtaining data about possible incidents planned events, and current incidents. Process (b) also enables the traffic operations personnel to have access to data in other parts of the Manage Incidents facility such as that for defined incident responses - see DFD 1.3, to control the use and set up of these responses, and to see the video images being used for incident analysis obtained by the Traffic Data Analysis for Incidents facility - see DFD 1.3.1. As well as enabling incident data to be displayed, process (c) enables the media operator to report incidents. These will reports will be based on data received by the media from those of their customers who are travelers.

One of the features of the structure of the processes in this DFD is that it enables the media operator to have direct access to the lists of both current incidents and planned events using processes (a) and (c). However this access will be controlled through data in the store of defined responses and can be set up by the traffic operations personnel. This enables the personnel to set up the type and extent of incident information to which the media can have direct access, so that those incidents of a “sensitive” nature can be deleted as far as direct media access is concerned. The same mechanism is used to control the output of incident warnings to the media system through process (e). This is a one way output such as highway advisory radio (HAR).

Manage Travel Demand (DFD 1.4)

This DFD shows the processes that make up the Manage Travel Demand facility within the Manage Traffic function. These processes enable travel demand to be predicted and managed to make the most efficient use of the road, highway and other parts of the transportation network served by the function. The key points about the facility are as follows:

* - demand forecasts are based on current operational data and policy data;
* - current operational data provided by Manage Traffic and other ITS functions;
* - policy data is set up by the traffic operations personnel, who also run the forecast process;
* - demand forecast results are implemented by requesting action by ITS functions.

There are five processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Provide Traffic Operations Personnel Demand Interface (1.4.1) - this process will analyze the data in the log of incident responses within the Manage Incidents facility of the Manage Traffic functions. The process will analyze the log so that possible standard predetermined incident responses can be identified from the data in the incident_response_log data store. Any such possible standard predetermined responses that are identified will be passed by this process to the process that manages the store of possible predetermined responses.

(b) Collect Demand Forecast Data (1.4.2) - this process will collect data from other ITS functions for use as input to the demand forecasting process within the Manage Demand facility of the Manage Traffic function. The process will support data retrieval from other functions on request from the traffic operations personnel and through the receipt of unsolicited data from ITS functions. It will load all the data that it receives in a consistent format into the input store used by the demand forecasting process.

(c) Update Demand Display Map Data (1.4.3) - this process will provide updates to the store of map data used for displays of forecast traffic and travel demand produced by processes in the Manage Travel Demand facility of the Manage Traffic function. The process will obtain the new data from a

specialist map data supplier or some other appropriate source, on receiving an update request from the traffic operations personnel interface process within the Manage Travel Demand facility.

(d) Implement Demand Management Policy (1.4.4) - this process will implement the traffic and travel demand forecast data produced by the demand forecasting process in the Manage Travel Demand facility of the Manage Traffic function. The new demand forecast data will be implemented in such a way that it can influence the demand from travelers for various types of services provided by ITS functions. The process will when required, request changes to transit services, and/or the charges for tolls, and/or the use of parking lot spaces (as per the locally determined demand policy). It will communicate the results of its policy implementation to the process that provides the interface to the traffic operations personnel.

(e) Calculate Forecast Demand (1.4.5) - this process will provide a forecast of traffic and travel demand in the geographic area served by the Manage Traffic function to which this instance of the Manage Travel Demand facility belongs. The process will base its forecast on the current and predicted traffic levels traveler demand patterns obtained from an analysis of data obtained from elsewhere within the Manage Traffic function and from other ITS functions as well as locally determined demand policy. The process will produce a demand forecast that changes the way that services are provided by ITS functions according to locally determined demand policy.

The operation of the demand forecasting facility is controlled by the traffic operations personnel through process (a). This enables operational data to gathered by process (b) and loaded into the store of demand input data. This data will originate from sources such as the current use of the road network, transit services and other modes, weather predictions, the predictive model of traffic conditions, the status of the current transit services and their schedules, current charges for tolls, parking lots and public transit fares, plus current pollution levels. Policy data, which is the other input to the demand forecasting carried out by process (e) is provided directly by the traffic operations personnel.

Preparation of a demand forecast by process (e) is initiated by the traffic operations personnel, who can review the results and request their implementation by process (d). This process will report the results of its implementation back to the traffic operations personnel. All output to the personnel can be shown against a background of digitized map data provided through process (c).

The processes themselves do not need to know anything about the structure of responsibility in the geographic area they control. For example it will be possible for process in (b) to receive data from several Provide Traffic Surveillance facilities each of which serves a different part of the total geographic area served by the Manage Traffic function.

The processes are structured in the manner shown above to allow for easy replacement and updating, particularly as new demand management algorithms are developed.

Manage Emissions (DFD 1.5)

This DFD shows the processes that make up the Manage Emissions facility within the Manage Traffic function. These processes monitor atmospheric pollution levels and provide details of those that are above pre-set limits to other facilities. The key points about the facility are as follows:

* - current pollution levels monitored both on an area basis and from individual vehicles;
* - area pollution levels above permitted levels reported as incidents to the Manage Incidents facility;
* - driver and law enforcement agency(ies) notified of vehicle pollution levels above permitted levels;
* - Provide Traffic Surveillance facility sent pollution data for loading into current and long term stores;
* - pollution data also provided to Manage Archived Data function.

There are eight processes in this DFD and they each provide different parts of its overall functionality in the following ways.

(a) Provide Traffic Operations Personnel Pollution Data Interface (1.5.1) - this process will provide the interface between the traffic operations personnel and the processes and data stores used within the Manage Emissions facility of the Manage Traffic function. The process will enable the personnel to access and update the pollution reference data used by other processes within the facility, and to access the pollution state data provided by those processes. The process will support inputs from the traffic operations personnel. Where appropriate and/or requested by the traffic operations personnel, the process will incorporate map data of the relevant part(s) of the surface street and freeway network served by the Manage Traffic function. The process will obtain the map from a local data store, which it will request to be updated by another process as and when required.

(b) Process Pollution Data (1.5.2) - this process will process the pollution data being collected from sensors in the geographic area being served by the Manage Traffic function. The process will integrate data from distributed roadside sensors (provided by another process) with that obtained directly from sensors looking at the general (wide area) environment. The data will be checked by the process against the pollution levels that have been set up as reference points. If the process finds that the detected levels of pollution exceed the reference levels it will generate pollution warnings. The process will send these warnings to other processes in the Manage Traffic function for output to drivers and travelers.

(c) Update Pollution Display Map Data (1.5.3) - this process will provide updates to the map data used in displays of pollution data produced by processes in the Manage Emissions facility of the Manage Traffic function. The process will obtain the map data from a specialist map data supplier or some other appropriate data source, on receiving an update request from the traffic operations personnel interface process within the Manage Emissions facility.

(d) Manage Pollution State Data Store (1.5.4) - this process will manage the store of pollution state data in the Manage Emissions facility of the Manage Traffic function. The data in the store will be that which has been received by the process from other processes within the facility. The process will manage the data in the store to enable its contents to be available to other processes within the Manage Traffic function, and to traffic operations personnel, via an interface process within the Manage Emissions facility.

(e) Process Vehicle Pollution Data (1.5.5) - this process will obtain pollution data about individual vehicles and analyze it against reference data obtained from another process within the Manage Emissions facility of the Manage Traffic function. The process will use this reference data to determine whether or not a vehicle is possibly violating the acceptable levels of pollution output. When the process determines that a possible violation has occurred, it will send the detected pollution levels and the vehicle identity to the process responsible for law enforcement in the Manage Emergency Services function for action.

(f) Detect Roadside Pollution Levels (1.5.6) - this process will process the local area pollution data analyzed by sensors looking at the levels of pollution at the roadside within the geographic area served by the Manage Traffic function. The process will pass the data on to another process within the Manage Emissions facility for integration with wide area pollution data and comparison with thresholds for pollution incidents.

(g) Manage Pollution Data Log (1.5.7) - this process will manage the log of pollution data within the Manage Emissions facility of the Manage Traffic function. The process will receive data for entry into the log from other processes within the facility. It will also send the contents of the log to the Manage Archived Data function for use in planning.

(h) Manage Pollution Reference Data Store (1.5.8) - this process will manage the store of pollution reference data within the Manage Emissions facility of the Manage Traffic function. It will make the contents of the store available to other processes within the facility that are responsible for emissions management, and on request to the traffic operations personnel interface process. The process will accept updates to the stored data from the traffic operations personnel interface process.

(i) Manage Pollution Archive Data (1.5.9) - This process collects and stores the pollution data being collected from sensors in the geographic area being served by the Manage Traffic function. The process integrates data from distributed roadside sensors (provided by another process) with that obtained directly from sensors looking at the general (wide area) environment.

Pollution levels are detected at the roadside by process (f), in the wider geographic area by process (b) and from vehicles by process (e). The data from these three processes is supplied to process (d) which maintains and stores the data for access by the traffic operations personnel through process (a). Process (d) also supplies a copy of the stored pollution data on request to the Manage Demand facility - see DFD 1.4. The wide area and vehicle pollution data is also supplied to process (g) for loading into the log of pollution data. A copy of this is periodically sent to the Manage Archived Data function - see DFD 8.

The need for are pollution levels to be reported as incidents by process (b), or vehicle drivers and the law enforcement agency notified of high pollution by process (e), depends on the pollution reference data. This is contained in a store managed by process (h). It can be monitored and updated by the traffic operations personnel through process (a). The output of data by process (a) may be against a background of a digitized map supplied by process (c).

Although these processes are shown as a coherent group, they can be implemented in part if needed. For example, the monitoring of either area or vehicle pollution can be omitted. Data about the ownership of polluting vehicles is obtained from the relevant Department of Motor Vehicles by the process responsible for law enforcement - see DFD 5.4.

Manage Highway Rail Intersections (DFD 1.6)

This DFD shows the processes that make up the Highway Rail Intersection facility within the Manage Traffic function. The process in this DFD contains the principal functions that provide User Service 30, Highway Rail Intersection management. The key points about the facility are as follows:

* - management of the HRI is accomplished by direct interfaces to railroad operations,

* - wayside equipment interface provides real-time information about approaching trains,

* - provides a two way interactive exchange of traffic data between ITS and a railroad operator.

* - provides inputs to ITS traffic demand management,

* - receives traffic surveillance data from sensors

* - provides real-time crossing status

* - controls devices at the grade crossing and nearby intersections by passing device control requests

* - provides status of device controls to the Manage HRI Traffic process.

* - provides grade crossing status and information to detect and manage incidents around grade crossings.

* - reports incident information that may be important to trains and grade crossing operation

* - reports HRI status to the Manage Travel Demand process so that HRI operations can be factored into demand management algorithms and decisions.

There are five processes in this DFD, each of which is its own DFD, and they divide its overall functionality between themselves in the following ways.

(a) Manage HRI Vehicle Traffic (1.6.1) - this process is responsible for managing traffic volume at an HRI and in the immediate vicinity. It uses data collected from the Manage HRI Rail Traffic function (i.e., real-time train data), and local sensor data from traffic surveillance (which may include traffic conditions at other intersections or HRI's). The processes within this DFD generate control information for local traffic devices (lights, barriers, signs, etc.) and also provide alerts or advisories to local and remote processes. Local control of HRI traffic volume is based on preprogrammed strategies. These strategies may be preempted by Traffic Management.

(b) Interact with Rail Operations (1.6.2) - this process is responsible for interacting with railroad owned and operated operations management facilities. It acquires data (e.g., schedules) on request for use by other ITS functions, and also accepts unsolicited inputs (e.g., incident notifications) from railroad facilities. It maintains and provides access to a data store of current and historical railroad operations data for access by other ITS functions. The three processes within this DFD communicate with rail operations, manage alerts and advisories and manage the store of current data for ITS access.

(c) Manage HRI Rail Traffic (1.6.3) - this process is primarily responsible for monitoring rail traffic at an HRI and providing train approach information to the Manage HRI Vehicle Traffic function. It also provide the track status input to the Monitor HRI Status process. It uses data collected from railroad operated and maintained wayside equipment as well as inputs from Rail Operations (which may include preemptions based on rail conditions other than at the HRI). The processes within this DFD use HRI status information to provide alerts or advisories to railroad crews. Local control of devices at the HRI is based on information provided by this process to the Manage HRI Vehicle Traffic process.

(d) Interact with Traffic Management(1.6.4) - this process is responsible for interacting with the other ITS Traffic Management functions. Traffic Management surveillance data and control strategies are used to advise Monitor HRI Status process of local and regional conditions that might impact the HRI status (nearby incidents, emergency vehicle preemptions of roadways, etc.). Traffic Management overrides and coordination requests are also fielded by this process and forwarded to Manage HRI Vehicle Traffic for incorporation in the local control plan. The Interact with Traffic Management process also provides local HRI status and information to the Manage Travel Demand process (DFD 1.4) and the Manage Incidents process (DFD 1.3).

(e) Monitor HRI Status(1.6.5) - this process contains the processes associated with monitoring the overall operation of the HRI, maintaining a consistent “health status” and reporting to both Traffic Management and Rail Operations. Monitor HRI Status also provides the critical HRI health indicator to the Manage HRI Rail Traffic process (DFD 1.6.3) for real-time notices and warnings to train or hi-rail vehicle crews. The health of the HRI is based on roadway state, traffic device self test routines, the track status and advisory data from other functions within Traffic Management (e.g., nearby incidents).

All of the data about traffic at an HRI is collected and managed by processes within DFD (a) and (c). The processes in (d) interact with other ITS Traffic Management functions to obtain surveillance data and control strategies used by the processes in (e).

Manage HRI Vehicle Traffic (DFD 1.6.1)

This DFD shows the processes which are responsible for managing traffic volume at an HRI and in the immediate vicinity. The key points about the facility are as follows:

* - monitors local sensor data obtained from traffic surveillance,

* - detects hazardous conditions or potential hazards at an HRI,

* - detects real-time HRI blockages or collisions,

* - provides advanced warnings where warranted.

There are three processes and four DFDs in this DFD and they each provide different parts of its overall functionality in the following ways.

(a) Detect Roadway Events (1.6.1.1) - this process is responsible for monitoring local sensor data obtained from traffic surveillance and then determining and reporting the current state of all traffic in the HRI vicinity. The process provides triggers for other processes within Manage HRI Vehicle Traffic. It also monitors the device controls as they are initiated by the Activate HRI Device Controls process.

(b) Activate HRI Device Controls (1.6.1.2) - this process is a DFD which controls different types of devices for translating traffic management strategies into the appropriate sequences of traffic device control requests. It is triggered by monitoring hri_device_sense from traffic surveillance and the

hri_control_message from the Execute Local Strategy process (DFD 1.6.1.7). A single P-Spec within this DFD controls the standard traffic volume controls associated with the HRI. Separate HSR and SSR processes (P-Specs) are both defined. Generally speaking any given HRI would only implement the HSR or the SSR process, not both, as they perform identical functions but with different performance requirements. Finally, a separate P-Spec is defined to control grade crossing barrier systems and warning lights, if they are implemented within ITS. ITS deployments where gates and barriers are operated and maintained by the railroad independently would not implement the barrier device P-Spec. Requests from the device control P-Specs are forwarded to the Provide Device Control process in Traffic Management.

(c) Perform Equipment Self-Test (1.6.1.3) - this process is responsible for performing real-time equipment checks and reporting the status of the equipment associated with an active grade crossing. Based on receipt of the sensor data of the surrounding highway and rail traffic and receipt of any near term events this process can execute a real-time check of the equipment and determine the relative health and status of the active grade crossing equipment. The output is sent onto the Monitor HRI Status process for further processing with other diagnostic data.

(d) Provide Advisories and Alerts (1.6.1.4) - this process, which is a DFD, generates and reports on conditions at the HRI. Theses are messages based on the HRI health, traffic status and approaching train data. This process is triggered by detection of a hazard, or potential hazard, at an HRI (hazard_condition issued by the Detect HRI Hazards process). Separate outputs are generated for traffic volume (roadway_message) and for rail traffic (train_message).

(e) Detect HRI Hazards (1.6.1.5) - this process is responsible for detecting real-time HRI blockages or collisions in the vicinity of an HRI that create a blockage or other hazard at the HRI. Based upon information received from the Provide Advance Warnings process this process can send a request to the Control Vehicle Traffic at Active HRI that the local signal strategy be preempted. A hazard condition message can also be sent to the Generate Alerts and Advisories process for further action or the Provide Closures Parameters process to possibly adjust the time to closing.

(f) Provide Advance Warnings (1.6.1.6) - this process, which is a DFD, is responsible for predicting likely conditions at the HRI and providing advance warnings where warranted. Such warnings are based on the current state of the HRI, advisories from rail operations and the local traffic control plan. Outputs are provided for rail operations (rail_operations_message) and for a real-time hazard detection process. The Perform Equipment Self Test process monitors the near term status of the HRI as provided by Provide Advance warnings and actual HRI device conditions.

(g) Execute Local Control Strategy (1.6.1.7) - this process, which is a DFD, is responsible for maintaining the local traffic control parameters and for selecting the appropriate strategy, based on roadway events and detected hazards. The local strategy may be preempted by Traffic Management or by the Detect HRI Hazards process. Based on the execution of a specific local strategy, device control instructions are passed to the Activate HRI Device Controls process.

The collected data is by process (a). Process (a) is responsible for detecting any roadway events and then determining and reporting the current state of traffic. Processes (a), (e), and (f) depend on processes in (d) and (g). Processes in (d) are responsible for providing advisories and alerts as well as the conditions at the HRI. The processes in (g) are responsible for managing and executing control strategies at the HRI.

Activate HRI Device Controls (DFD 1.6.1.2)

This DFD controls different types of devices for translating traffic management strategies into the appropriate sequences of traffic device control requests. The key points about the facility are as follows:

* - interprets HRI control messages,

* - activates HRI control devices.

There are six processes in this DFD and they each provide different parts of its overall functionality in the following ways.

(a) Control HRI Traffic Signals (1.6.1.2.1) - this process is responsible for interpreting the hri_control message and safely directing the activation of the appropriate devices. This process will both directly command devices at the HRI and will disseminate necessary control information to the Process Indicator Output Data for Roads function to allow integrated control of adjacent traffic signals. Data will also be sent to SSR and/or HSR Device Control functions to control these specialized devices at the crossing. When sensor data indicates an approaching train this process notifies the Process Indicator Output Data for Roads function to allow the signal timing to be adjusted and dynamic message signs, if available, to be updated. This allows the traffic signals in the area adjacent to an HRI to be used to clear the Storage Area in advance of an approaching train and to manage traffic around the intersection.

(b) Control HRI Warnings and Barriers (1.6.1.2.2) this process is responsible for initiating the activation of HRI barriers at active vehicular and pedestrian grade crossings. When a request is sent to activate the HRI barriers perhaps because of a detection of an oncoming train, this process sends the device control signal to the Manage Device Controls process to activate the barriers. This process also returns state information to the Maintain Device State process concerning the commands that have been initiated by this process.

(c) Provide SSR Device Controls (1.6.1.2.3) this process is responsible for initiating the activation of HRI Standard Speed Rail control devices at active vehicular and pedestrian grade crossings. This process responds to requests sent by the Control HRI Traffic Signals process based on detection of an oncoming train. This process sends command information to the Manage Device Control containing control signals and commands that are unique to the SSR functions. State information is also sent to the Maintain Device State process to monitor the last known state of the controls commands being processed.

(d) Provide HSR Device Controls(1.6.1.2.4) This process is responsible for initiating the activation of HRI devices, barriers and other special safety features for High Speed Rail at active vehicular and pedestrian grade crossings. This process responds to requests sent by the Control HRI Traffic Signals process based on detection of an oncoming train. This process sends command information to the Manage Device Control containing control signals and commands that are unique to the HSR functions, such as trapped vehicle detection. State information is also sent to the Maintain Device State process to monitor the last known state of the controls commands being processed.

(e) Manage Device Control (1.6.1.2.5) This process is responsible for managing and selecting the appropriate device control messages. This process gathers the control signals from the other Activate HRI Device Control processes and forwards them as needed to the Process Indicator Output Data for Roads process within Provide Device Control. These control signals are used to activate all of the HRI unique roadside devices such as gates or other barriers, lights, adjacent traffic signals, message signs or in-vehicle signage beacons.

(f) Maintain Device State (1.6.1.2.6) This process is responsible for managing and selecting the appropriate device control state messages. This process collects the device state messages that are produced by the other Activate HRI Device Controls processes and forwards the appropriate signals to the Detect Roadway Events process that monitors the status of the HRI commands being processed. This information is also used in the equipment diagnostic monitoring and testing.

The collected data is received by process (a). Process (a) distributes the data to all other processes within the DFD. Processes (e) and (f) distribute the data to other facilities in the Manage Traffic function.

Provide Advisories and Alerts (DFD 1.6.1.4)

This DFD generates and reports on conditions at the HRI. The key points about the facility are as follows:

* - generated the message to advise and protect all persons approaching and crossing railroad crossings,

* - reports real-time HRI traffic volume advisories as they approach an HRI.

There are four processes in this DFD and they each provide different parts of its overall functionality in the following ways.

(a) Generate Alerts and Advisories (1.6.1.4.1) - This process is responsible for generating the messages to advise and protect motorists, travelers and train crews approaching and crossing railroad grade crossings. Based on the severity of the hazard condition sent by the Detect HRI Hazards process this process will either send an hri_advisory command for non-time critical data or an hri_alert command for time critical data to the Report Alerts and Advisories. These users that will receive these messages include drivers, bicyclists, and pedestrians.

(b) Provide Closure Parameters (1.6.1.4.2) - This process is responsible for providing the HRI predicted time to closure to be used in broadcast message alerts to approaching vehicles. This time is calculated from data provided by the Detect HRI Hazards process.

(c) Report Alerts and Advisories (1.6.1.4.3) - This process is responsible for reporting real-time HRI traffic volume advisories and real-time highway traffic alerts. Depending on the input received from the Generate Alerts and Advisories process, this process sends alerts or advisories to a train to describe the operational status of the intersection and alerts about any hazards. This process also sends the commands to Output Control Data for Roads process that will control the dynamic message signs in the area of an HRI to display the appropriate alert or advisory. Messages for local beacon broadcast are processed and sent to the Report HRI Status on Approach process.

(d) Report HRI Status on Approach (1.6.1.4.4) - This process is responsible for providing real-time HRI status to vehicles as they approach an HRI. It must discriminate between vehicles near, but not approaching, the HRI (e.g. on parallel side streets, etc.). This process develops the message to be broadcast to nearby vehicles by receiving time_to_closing data and the hazard_condition signal and calculating the appropriate window of time to display the message. The message is built from the approach_warning data received from the Report Alerts and Advisories process.

The collected data is received by processes all processes to determine the need to generate an alert, to provide closure, and to report HRI status. Process (a) and (c) depend on processes (b) and (d). Processes (c) and (d) distribute data to other facilities in the Manage Traffic function.

Provide Advance Warnings (DFD 1.6.1.6)

This DFD is responsible for predicting likely conditions at the HRI and providing advance warnings where warranted. The key points about the facility are as follows:

* - detect HRI closure,

* - detect vehicle/train collisions.

There are two processes in this DFD and they each provide different parts of its overall functionality in the following ways.

(a) Close HRI on Detection(1.6.1.6.1) This process is responsible for protecting highway vehicles approaching and crossing railroad grade crossings by initiating the closure up to 3 minutes before train arrival. This process receives the near term status of the crossing including any approaching trains or trapped vehicles. With this information along with the local control plan data the predicted hri state is computed and sent to the Detect Imminent Vehicle/Train Collision process. If a hri_predicted_collision message is returned then this process sends out an hri_hazard message to the Detect HRI Hazard which will in turn result in a change to the device control strategy. This process also receives rail operations advisories for processing along with the state and control plan data. As needed this process will output any rail_operations_message data to the Interact with Rail Operations process.

(b) Detect Imminent Vehicle/Train Collision(1.6.1.6.2) This process is responsible for detecting imminent collisions between vehicles and trains at railroad grade crossings. Using the data contained in the predicted_hri_state message this process performs the necessary calculations to determine whether a collision is imminent. If so, this process returns a hri_predicted_collision message to the Close_HRI_on_Detection process.

All data is received by process (a) and also sent to other facilities within the Manage Traffic function. Process (b) reports any vehicle/train collisions and reports the collision to process (a).

Execute Local Control Strategy (DFD 1.6.1.7)

This DFD is responsible for maintaining the local traffic control parameters and for selecting the appropriate strategy, based on roadway events and detected hazards. The key points about the facility are as follows:

* - responsible for controlling traffic volume at passive grade crossings,

* - responsible for closing the HRI to traffic.

There are three processes in this DFD and they each provide different parts of its overall functionality in the following ways.

(a) Control Vehicle Traffic at Passive HRI (1.6.1.7.1) - this process is responsible for controlling traffic volume at passive grade crossings. It provides a mechanism for rail operations to close grade crossings that have active traffic devices but no real-time train detection mechanisms. This process also will allow for a train crew member to manually activate closure of the crossing. In such an event a crew_close_hri signal is sent to the Close_HRI_on_Command process.

(b) Control Vehicle Traffic at Active HRI (1.6.1.7.2) - This process is responsible for controlling vehicular traffic at an active HRI by controlling the operation of traffic control devices in accordance with a predetermined local control plan. The local_control_plan is communicated to the Close_HRI_on_Detection process. This local control plan can be preempted by a strategy_preemption message from the Detect_HRI_Hazards process or by such inputs as an event_notice from the Detect_Roadway_Events process or hri_traffic_surveillance data. The outputs of this process include the command messages to close the HRI, requests for information from the Manage Traffic function, and information about the current hri_traffic_data.

(c) Close HRI on Command (1.6.1.7.3) - This process is responsible for closing the HRI to vehicular traffic, either on command from the Control Vehicle traffic at Active HRI process, or from direct command from rail operations (as an override). A third mechanism for closing the HRI is defined for passive crossings, i.e. crossings without active train detection systems. Upon command from rail operations, or via manual operation by a train crewman, active traffic devices at an otherwise passive grade crossing may be activated to close the crossing.

The collected data is received and sent to other Manage Traffic functions by process (b). Processes (a) and (b) depend on process (c). Data is collected from process (a) and (b) which pass HRI closure messages to process (c).

Interact with Rail Operations (DFD 1.6.2)

This DFD is responsible for interacting with railroad owned and operated operations management facilities. The key points about the facility are as follows:

* - exchanges data with rail operations,

* - provides and maintains a current store of rail operations data.

There are three processes in this DFD and they each provide different parts of its overall functionality in the following ways.

(a) Exchange Data with Rail Operations (1.6.2.1) - This process is responsible for exchanging routine data with rail operations. Such data being sent to the rail operators includes event schedules, requests for information from the Rail Operators, incident notification based on rail operations messages received from Close_HRI_on_Detection process and hri_priority_message data received from the Manage Alerts and Advisories process. This process receives maintenance schedules, train schedules, and incident notifications from the rail operators. This information is used to develop the rail operations

update data that is passed onto the Manage Rail Traffic Control Data process and the rail operations priority data that is sent to the Manage Alerts and Advisories process.

(b) Manage Alerts and Advisories (1.6.2.2) - This process is responsible for acquiring HRI advisory or alert data from rail operations and for providing HRI status to rail operations. The data managed by this process may be time critical, as in the case of alerts or priority messages, or not time critical, as in the case of advisories.

(c) Manage Rail Traffic Control Data (1.6.2.3) - This process is responsible for providing and maintaining a current store of rail operations data. The data is assembled from the rail_operations_update information sent by the Exchange Data with Rail Operations process. Queries for this information are received from the Manage Alerts and Advisories process and the Interact with Vehicle Traffic Management processes.

The collected data is received by process (a) which is dependent on processes (b) and (c). Process (s) is responsible for exchanging data with rail operations. The data collected in process (a) is also distributed to other Manage Traffic function.

Manage HRI Rail Traffic (DFD 1.6.3)

This DFD is responsible for performing real-time equipment checks and reporting the status of the equipment associated with an active grade crossing. The key points about the facility are as follows:

* - responsible for generating advisories/ alerts,

* - responsible for protecting all traffic approaching and crossing grade crossings.

There are three processes in this DFD and they each provide different parts of its overall functionality in the following ways.

(a) Interact with Wayside Systems (1.6.3.1) - This process is responsible for interfacing to railroad owned and maintained wayside equipment, such as Wayside Interface Units, Crossing Gate Controllers, etc. All these devices are expected to provide real-time information to the HRI about approaching trains and their own health. In addition, advanced implementations will make use of a communications path back to approaching trains provided by the railroad's equipment.

(b) Advise and Protect Train Crews (1.6.3.2) - This process is responsible for generating advisories/ alerts that are routed to the wayside equipment for transmission to the train crews. If the intersection is blocked, or there is an incident at the intersection this information will be passed to the Interact with Wayside Systems process for routing to the wayside equipment. The wayside equipment can then route the information directly to the train crews, or to rail operations.

(c) Provide ATS Alerts (1.6.3.3) - This process is responsible for automatically protecting commuter, inter-city, transit and freight trains as they approach and cross grade crossings. It also reports HRI rail traffic advisories to traffic management and rail operations. It is responsible for verifying and reporting overall HRI status to approaching trains so that crews can act within safe service braking distances. It provides for notification of Automatic Train Stop systems (ATS, PTS, etc.) with sufficient advance warning to allow emergency brake application time to stop a train before it encounters an HRI hazard. Finally, it provides automatic status indications about the HRI to the crews of approaching trains.

The collected data is received by process (b). Process (a) interacts with the wayside equipment system and reports the status to process (c). Data collected in process (b) is distributed to process (a) to report HRI data. All of the process distribute data to other Manage Traffic functions.

Interact with Vehicle Traffic Management (DFD 1.6.4)

This DFD generates and reports on conditions at the HRI. The key points about the facility are as follows:

* - coordinate and manage HRI closures,

* - exchange data with other traffic management processes.

There are two processes in this DFD and they each provide different parts of its overall functionality in the following ways.

(a) Manage HRI Closures (1.6.4.1) - This process is responsible for coordination and managing of HRI closures at the Traffic management Center. It interfaces with Manage Incidents process to provide incident information and to receive strategy overrides as required by the larger incident management function.

(b) Exchange Data with Traffic Management (1.6.4.2) - This process is responsible for interacting with traffic management processes. It collects data from processes that are within the HRI elements located at the roadside and forwards the data as needed to other processes within traffic management. It also acts as the interface between rail operations and traffic management processes through its interface with the Interact with Rail Operations process.

The collected data is received by process (b). Process (a) is responsible for managing HRI closures and receiving HRI real time traffic data. Data is distributed to other processes within the Manage Traffic function by process (b).

Monitor HRI Status (DFD 1.6.5)

This DFD contains the processes associated with monitoring the overall operation of the HRI, maintaining a consistent "health status" and reporting to both Traffic Management and Rail Operations. The key points about the facility are as follows:

* - initiates reports of health status of HRI to Traffic Management and Rail Operations,

* - manages a data log of HRI operations .

There are three processes in this DFD and they each provide different parts of its overall functionality in the following ways.

(a) Provide Interactive Interface(1.6.5.1) - This process is responsible for initiating reports of the health status of the HRI to both Traffic Management and Rail Operations. In addition the process initiates reporting of the health status of the HRI to the wayside interface equipment (and ultimately to the train when the advanced HRI functionality is in place).

(b) Determine HRI Status (1.6.5.2) - This process is responsible for monitoring critical HRI functions and merging them into a single coherent picture of the state of the hri. It also is responsible for assuring that the HRI always reverts to the safest possible operating condition in the event of any operational malfunctions.

(c) Maintain HRI Closure Data (1.6.5.3) - This process is responsible for managing a log of the HRI operation for use in strategy planning, demand management and traffic management.

The collected data is received by process (b) which depend on both processes (a) and (c). Process (b) determines the status of a HRI and reports the status to processes (a) and (c).

1.6.1.3. Manage Commercial Vehicles (DFD 2)

The processes in this DFD make up the Manage Commercial Vehicles function. This function of responsible for providing facilities for the management of commercial vehicle operations. The key points about the function are as follows:

* - facilities provided for commercial vehicle managers and drivers who are their own managers;

* - trip planning and electronic credential and tax filing provided for managers and owner drivers;

* - managers and owner drivers may pre-clear vehicles through roadside check station facilities;

* - roadside facilities can check vehicles for pre-clearance, safety and international border clearance;

* - CVO inspectors can override pass/pull-in decisions at roadside facilities;

* - facility provided for exchange of data with government administrators;

* - details of actions at roadside facilities recorded on vehicle's on-board tag;

* - vehicle collects data about its operation and stores it on-board;

* - manager can access on-board vehicle data and exchange messages with driver.

Of the seven processes in this DFD, six are in fact themselves DFDs each containing their own sets of processes. They and the one process divide the overall functionality of the main DFD each perform the following functions.

(a) Manage Commercial Vehicle Fleet Operations (2.1) - these processes enable commercial fleet managers to plan commercial vehicle routes taking into account the needs of this type of vehicle, as well as the electronic credential and tax filing needed to use the route. Details of the route, credentials required and taxes payable are provided by the processes in (e). Having decided on a route, a designated vehicle can be pre-cleared through the roadside check facilities so that it does not have to stop. The manager is provided with facilities to use the route data to set up a set of delivery instructions for the driver. Information can also be exchanged between the manager and the driver, and the manager can up-load and review a copy of the data that has been collected on-board the vehicle by the Provide Commercial Vehicle Data Collection facility - see processes in (d) below.

(b) Manage Commercial Vehicle Driver Operations (2.2) - these processes enable commercial vehicle drivers who manage their own vehicles, to plan commercial vehicle routes taking into account the needs of this type of vehicle, as well as the electronic credential and tax filing needed to use the route. Details of route, the credentials needed and taxes payable are again provided by the processes in (e). Having decided on a route the driver can have the vehicle pre-cleared through the roadside check facilities so that it does not have to stop. The driver is provided with facilities to up-load and review a copy of the data that has been collected on-board the vehicle by the Provide Commercial Vehicle Data Collection facility - see processes in (d) below.

(c) Provide Commercial Vehicle Roadside Facilities (2.3) - these processes provide the functions for the roadside check facilities. They enable commercial vehicles to be pre-cleared through screening and border crossing checks and to carry-out safety checks. If the vehicle is not pre-cleared, or it fails its safety checks then a message will be displayed requesting it to pull into the facility. The inspector at the roadside facility may override the decision to pull-in (or not) and may also select manual pull-in. Vehicle safety inspections can also be carried out at the roadside using a hand held terminal.

(d) Provide Commercial Vehicle Data Collection (2.4) - these processes are responsible for collecting data from on-board sensors and from the driver. The data is kept in an in-vehicle data store which can be transmitted to the roadside check facility to enable safety checks and roadside inspections. The contents of the store can also be sent to the commercial vehicle driver and fleet manager. The manager can also exchange messages of a general nature with the commercial vehicle driver.

(e) Administer Commercial Vehicles (2.5) - these processes provide the electronic credential and tax filing functions for the processes in (a) and (b). The details of the required credentials and tax filing are provided from the appropriate Government Administrators, e.g., the Office of Motor Carriers (OMC). Lists of cleared vehicles and are sent to the roadside facilities to enable them to pass the screening checks. The log of operations at the roadside facilities is also analyzed by processes in this DFD and details of vehicles, carriers and drivers failing checks at one facility notified to others. Details of those with safety problems are sent to all roadside facilities to highlight the need for future safety checks. Violation information is also sent to the Manage Emergency Services function (see DFD 5) for processing and transfer to the appropriate law enforcement agency for possible prosecution.

(f) Provide Commercial Vehicle On-board Data (2.6) - these processes enable the commercial vehicle manager or driver to load the commercial vehicle's on-board tag with data. This data will enable it to be recognized at each roadside check facility and can be used by the facility for pre-

clearance and safety checks. The data is requested by each roadside facility approached by the vehicle and the results of the checking written back to the tag. For clearance at border crossings, the contents of the lock tag can also be sent to the roadside facility on request.

(f) Manage Cargo (2.7) - this process is responsible for providing facilities for the management of cargo shipments. The process will enable these shipments to be routed via intermodal shippers and depots and may not need the services of a commercial vehicle manager or driver.

The processes in (a) will support a number of commercial vehicle managers, each with their own interface. Some may be local to the source of the processing whilst others may be remote. Those in the latter group may be commercial vehicle drivers who are also the vehicle owners and who have engaged a central facility to provide them with the vehicle management functions.

The processes in (b) provide similar facilities to those in (a) but are designed for drivers who are the vehicle owners and who wish to do their own management. The ability to generate driver load instructions and to exchange general information with the vehicle driver are not needed in this case.

The key to the whole electronic credential and tax filing process and the interface between the vehicle and the roadside check facility is the accurate detection of the vehicle's identity. Without this, the vehicle will be stopped at every roadside check facility. If the identity can be accurately determined and pre-clearance obtained, the vehicle will be able to pass those roadside check facilities where electronic credential and tax filing has been completed. However vehicles may still be called into those roadside facilities that carry-out safety checks if they have has a previous safety problem.

Data for routes which go outside of the surface street and freeway network served by the local Provide Driver and Traveler Services function (see DFD 6) will be obtained by that function itself. This makes the extent of the area served by the route selection facility which forms part of the Provide Driver and Traveler Services function transparent to the processes in (a), (b) and (e) above. Details of routes for vehicles with HAZMAT classified loads, or loads that are in other ways unusual, e.g., oversize. over weight, etc. are sent to the Manage Incidents facility (see DFD 1.3) to be recorded as planned events. This enables the disruption that they cause to other traffic on the surface street and freeway network to be minimized.

Individual implementations of this function may contain all the processes described above. There may of course be several sets of the processes in (c) and (d), for each roadside facility and commercial vehicle respectively. Processes (a) and (b) are complementary and will have their own set(s) of the processes in (d). The processes in (c) are associated with those in (e) and may be omitted if no roadside facilities are to be provided.

Manage Commercial Vehicle Fleet Operations (DFD 2.1)

The processes in this DFD make up the Manage Commercial Vehicle Fleet Operations facility within the manage Commercial Vehicles function. These processes provide commercial vehicle managers with the facility to manage one or more fleets of vehicles. The key points about the facility are as follows:

* - commercial vehicle mangers may be part of large haulage companies;

* - commercial vehicle mangers may also provide a service to owner drivers and small fleet operators;

* - managers may plan trips using either static route selection, or request a dynamic route selection;

* - static route selection is based on surface street and freeway network geometry;

* - dynamic route selection based on current and future traffic conditions;

* - managers do credential and tax filing to pre-clear vehicles at roadside checkstation facilities;

* - managers store routes for access by drivers with cargo drop-off/pick-up details added;

* - managers can access on-board vehicle data and exchange general data with the driver.

There are six processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Manage Commercial Fleet Electronic Credentials and Tax Filing (2.1.1) - this process is responsible for providing the commercial vehicle manager with the ability to manage the activities of commercial vehicles. The process will provide the capability for the manager to obtain commercial vehicle routes. When a route has been confirmed, the process will enable the manager to enroll commercial vehicles for electronic clearance at roadside check station facilities, to process and pay for electronic credential and tax filing, to send tag data to the Provide Commercial Vehicle On-board data facility, and to provide vehicle route instructions for use by the commercial vehicle driver. Periodically it will also send reports about taxes that have been paid to the Administer Commercial Vehicles facility. The process will also enable the manager to obtain commercial vehicle activity reports from the logs provided by roadside checkstation facilities. It is possible to obtain these reports either on request or at periodic intervals.

(b) Provide Commercial Fleet Static Route (2.1.2) - this process is responsible for providing a static commercial vehicle route using data provided by the commercial vehicle manager. A static route is one which is based on geographic data and therefore takes no account of current or predicted traffic conditions, incidents, etc. The process will provide the route using its own route generation algorithms and data from its own store of digitized map information.

(c) Provide Flt Mgr Electronic Credentials and Tax Filing Interface (2.1.3) - this process is responsible for providing an interface for the commercial vehicle manager. The process will enable this interface to provide the manager with facilities for the input of data used to set up commercial vehicle routes, to pay the necessary taxes and duties so that a commercial vehicle can be enrolled for a particular route, to exchange general information messages with a driver in a vehicle, and to set up instructions for a driver to take a vehicle on a particular route. It is possible for the driver's route instructions input by the manager to include details of the cargo to be picked up and/or dropped off at each point along the route. The enrollment activity supported by the process will enable a commercial vehicle to pass through the roadside checkstations along its route without stopping, unless safety checks are required. The process will support inputs from the commercial vehicle manager in both manual and audio forms, and will provide its outputs in audible and visual forms. It will enable the visual output to be in hardcopy, or as a display.

(d) Provide Fleet Manager Commercial Vehicle Communications (2.1.4) - this process is responsible for providing the communications interface and data storage facility for data that is exchanged between the commercial vehicle manager and commercial vehicle drivers in their vehicles. The process will support the receipt of data from the vehicle consisting of that processed from input received by sensors on board the vehicle and text data used to exchange general information with the driver. Only the output to the vehicle of the data that contains the general text message is supported by the process. The process will enable access to the store of received data by the manager through the manager's interface process.

(e) Provide Commercial Vehicle Driver Routing Interface (2.1.5) - this process is responsible for providing the communications interface through which a commercial vehicle driver can obtain details of the vehicle route that has been provided by the commercial vehicle manager. The process will enable the output of the route instructions in audio and/or visual form. It is possible for the visual form to be either hardcopy output, or in the form of a display. The process will retain the data for a particular route internally, so that successive requests for details of the same route do not require use of the communications network.

(f) Manage Driver Instruction Store (2.1.6) - this process is responsible for managing the store of driver route instructions so that they can be loaded with data for retrieval by the commercial vehicle driver. The data for loading into the store is sent to the process from other processes in the Manage Commercial Vehicle Fleet Operations facility of the Manage Commercial Vehicles function. The process will enable the data to comprise vehicle route data and vehicle load information, including

the points along the route at which identified cargo is to be picked up and/or dropped off. The process will support the retrieval of this data by the commercial vehicle driver through the driver's interface process.

The manager interface is provided through process (c), which is used to gain access to the operation of four of the other processes. The exception is process (e) which provides the interface through which the driver obtains details of the route and the cargo pick-up and drop-off points. Processes (a), (b), (d) and (f) are all driven by inputs from process (c). Process (b) is driver by data from process (a).

Dynamic route selection is provided through processes in the Provide Guidance and Trip Planning Services facility - see DFD 6.6. The route request will use its preferences and constraints fields to specify that a route specifically for a commercial vehicle is required. Details of the cargo will also be provided so that those routes being used by vehicles with hazardous cargoes can be sent by the Provide Guidance and Trip Planning Services facility to the Manage Incidents facility - see DFD 1.3. Static route selection will be provided by one of the many proprietary packages that are available for selecting routes based on road and freeway geometry. It will enable selection of the shortest, or quickest, or most fuel efficient routes based on whatever historical data is available within itself, i.e., current or predicted traffic conditions will not be taken into account.

In any implementation it is possible for there to be several copies of process (c) to support managers in a large organization. Additionally some of the processes could be remote thus allowing one central agency to provide processes (a), (b) and (d) through (f), and thus act as the vehicle fleet management facility for several small carriers, or for owner/drivers who do not wish to be responsible for their own management.

Manage Commercial Vehicle Driver Operations (DFD 2.2)

This DFD shows the processes that make up the Manage Commercial Vehicle Driver Operations facility within the manage Commercial Vehicles function. These processes provide commercial vehicle owner/drivers with the facility to be their own fleet managers. The key points about the facility are as follows:

* - facilities provided for commercial vehicle owner/drivers who do their own management;

* - facilities available from a driver's personal portable device (ppd);

* - drivers may plan trips using either static route selection, or request a dynamic route selection;

* - static route selection is based on surface street and freeway network geometry;

* - dynamic route selection based on current and future traffic conditions;

* - drivers do credential and tax filing to pre-clear vehicles at roadside checkstation facilities;

* - drivers can access on-board vehicle data.

There are four processes in this DFD and they divide its overall functionality between themselves in the following way.

(a) Manage CV Electronic Credential and Tax Filing Interface (2.2.1) - this process is responsible for providing the commercial vehicle driver with the ability to manage the activities of a commercial vehicle. In this instance the driver is assumed to be acting in the role of a commercial vehicle manager, and is therefore probably the owner/driver of the vehicle. The process will provide the capability for the driver to obtain commercial vehicle routes, to enroll commercial vehicles for electronic clearance at roadside check station facilities, and to process and pay for electronic credential and tax filing.

(b) Provide Vehicle Static Route (2.2.2) - this process is responsible for providing a static commercial vehicle route using data provided by the commercial vehicle driver. A static route is one

which is based on geographic data and therefore takes no account of current or predicted traffic conditions, incidents, etc. The process will provide the route using its own route generation algorithms and data from its own store of digitized map information. In this instance the driver is assumed to be acting in the role of a commercial vehicle manager, and is therefore likely to be the owner/driver of the vehicle.

(c) Provide CV Driver Electronic Credential and Tax Filing Interface (2.2.3) - this process is responsible for providing an interface for the commercial vehicle fleet manager. In this instance the driver is assumed to be acting in the role of a commercial vehicle manager, and is therefore likely to be the owner/driver of the vehicle. The process will enable this interface to provide the driver with facilities for the input of data used to set up commercial vehicle routes, to pay all the necessary taxes and duties so that a commercial vehicle can be enrolled for a particular route, and to obtain a copy of the data collected by processes on-board the vehicle. The enrollment activity supported by the process will enable a commercial vehicle to pass through the roadside checkstations along its route without stopping, unless safety checks are required. The process will support inputs from the commercial vehicle driver in both manual and audio forms, and will provide its outputs in audible and visual forms. It will enable the visual output to be in hardcopy, or as a display.

(d) Provide Commercial Vehicle Driver Communications (2.2.4) - this process is responsible for providing communications between the commercial vehicle driver and the commercial vehicle. In this instance the driver is acting in the role of vehicle manager, and is therefore likely to be the owner/driver of the vehicle. The process will support the receipt of data from the vehicle consisting of that processed from input received by sensors on board the vehicle. The process will enable access to the store of received data by the driver through the driver's interface process.

The functionality provided by these processes is a reduced set of that provided by those in the Manage Commercial Fleet Operations facility - see DFD 2.1. They are design for use by drivers who are their own mangers, such as vehicle owner/drivers. Those facilities which are excluded, such as those for driver instruction preparation and the exchange of messages with the driver, are not needed because the driver is the manager. The driver interface is provided through process (c), which is used to gain access to the operation of four of the other processes. Processes (a) and (d) are all driven by inputs from process (c). Process (b) is driven by data from process (a).

Dynamic route selection is provided through processes in the Provide Guidance and Trip Planning Services facility - see DFD 6.6. The route request will use its preferences and constraints data items to specify that a route specifically for a commercial vehicle is required. Details of the cargo will also be provided so that those routes being used by vehicles with hazardous cargoes can be sent by the Provide Guidance and Trip Planning Services facility to the Manage Incidents facility - see DFD 1.3. Static route selection will be provided by one of the many proprietary (usually PC based) packages that are available for selecting routes based on road and freeway geometry. It will enable selection of the shortest, or quickest, or most fuel efficient routes using whatever historical data is available within itself, i.e., current or predicted traffic conditions will not be taken into account.

There would only be one driver interface process in this set of processes since they are for the commercial vehicle drivers either at home or in their vehicles. In this instance the driver is assumed to be acting in the role of a commercial fleet manger, and is therefore likely to be the owner/driver of the vehicle.

Provide Roadside Facilities (DFD 2.3)

The processes in this DFD are responsible for the Provide Roadside Facilities facility within the manage Commercial Vehicles function. These processes enable roadside checkstation facilities to selectively pull-in approaching vehicles. The key points about the facility are as follows:

* - credential, international border and safety clearance provided at roadside checkstations;

* - credential clearance given if vehicle of the same physical characteristics as that pre-cleared;

* - cargo lock tag checked at for tampering at international border crossing facilities;

* - safety clearance given if vehicle passes government criteria and no poor safety history found;

* - pass/pull-in request sent to driver by roadside sign(s) and in-vehicle display unit;

* - pass/pull-in decisions subject to override by CVO inspector at the roadside facility;

* - roadside facility activities logged and sent to government administrator as quarterly reports;

* - roadside facility may be configured for any of the credential, border crossing or safety checking.

There are two DFDs and six processes in this DFD and they divide its overall functionality between themselves in the following way.

(a) Produce Commercial Vehicle Driver Message at Roadside (2.3.1) - this process is responsible for the output of pull-in or pass messages to commercial vehicle drivers as they approach the commercial vehicle roadside checkstation or border crossing facilities. The process will support the use of roadside equipment such as dynamic message signs (DMS), or simple red-green lights, flashing orange lights, etc. to provide the output. These output messages are received by the process from other processes responsible for roadside facilities within the Manage Commercial Vehicles function. The process will support pull-in messages that are the result of checks on a commercial vehicle's electronic credentials, safety and border crossing data, the result of the vehicle's tag not being properly read, or the result of a general pull-in decision for all vehicles being issued by inspectors at the roadside facility. The process will also generate a message to be sent to the vehicle so that an indication can be output directly to the driver at the same time as it appears on the roadside equipment.

(b) Provide Commercial Vehicle Clearance Screening (2.3.2) - these processes store credentials data about vehicles that have been pre-cleared through a roadside checkstation. The credentials data for the pre-cleared vehicles is provided by the Administer Commercial Vehicles facility - see DFD 2.5, and is checked against that obtained by request from the tag on-board an approaching vehicle. Vehicles whose on-board data matches the pre-cleared credentials data are allowed to pass, whilst others are requested to pull-in. All pass/pull-in decisions are available for override by the roadside inspector and are written back to the tag on-board the vehicle.

(c) Provide Roadside Commercial Vehicle Safety (2.3.3) - these processes store data about vehicles that have safety problems and also enable roadside inspections. The credentials data about vehicles with safety problems is provided by the Administer Commercial Vehicles facility - see DFD 2.5, and is checked against that obtained by request from the tag on-board an approaching vehicle. Vehicles with safety problems are automatically requested to pull-in, whilst others are allowed to pass, unless the pass/pull-in decision is overridden by the roadside inspector. The roadside safety inspections are carried out at the request of the roadside inspector. Vehicles which are not pulled in can be flagged for possible pull-in at a later roadside facility.

(d) Detect Commercial Vehicle (2.3.4) - this process is responsible for detecting the presence of commercial vehicles through the use of sensors that can differentiate between the different types of vehicle. The process will use the sensors to determine the number of axles, gross vehicle weight and weight per axle data for use by inspectors at the roadside checkstation facilities. When a commercial vehicle is detected, the process will transmit a request for its on-board tag data, which when received is passed to other processes within the roadside facility. If no tag data is received, or the data cannot be interpreted correctly, the process will send a request for the vehicle to pull-in to be output by another process in the roadside checkstation facility.

(e) Provide Commercial Vehicle Roadside Operator Interface (2.3.5) - this process is responsible for providing the commercial vehicle inspector interface at the roadside checkstation facility. The process will provide an interface which enables the inspector to monitor and if necessary override the pull-in decisions made by those of the border crossing, credentials and safety data checking processes that

are present in the facility. The process will also make it possible for the inspector to issue a manual general pull-in request for all commercial vehicles to pull into the roadside checkstation facility, to have access the contents of the facility's log, and to obtain credentials or safety data on a selected combination of carrier, driver, and vehicle. The process will support inputs from the traffic operations personnel in both manual and audio forms, and will provide its outputs in audible and visual forms. It will enable the visual output to be in hardcopy, or as a display.

(f) Provide Commercial Vehicle Reports (2.3.6) - this process is responsible for collecting data from those of the border crossing, credential and safety checking processes that are present in a commercial vehicle roadside checkstation facility. The data is stored by the process in a roadside facility log, to which the roadside inspector interface process will have access. Once a day the process will make a copy of the roadside facility log and send it to the commercial vehicle administration facility for further processing.

(g) Produce Commercial Vehicle Driver Message on Vehicle (2.3.7) - this process is responsible for the output of the pull-in or pass messages to commercial vehicle drivers directly in their vehicles as they approach a commercial vehicle roadside checkstation facility. These messages is generated by other processes within the facility that are responsible for checking the commercial vehicle's credentials (including those for border crossing) and safety, or may be the result of the vehicle's tag not being properly read, or may be the result of a general pull-in decision for all vehicles being issued by inspectors at the roadside checkstation facility.

(h) Provide Commercial Vehicle Border Screening (2.3.8) - this process is responsible for checking a commercial vehicle and its cargo through a border crossing point. The checks carried out by the process will comprise a comparison of the trip identity already provided by the commercial vehicle administration processes, and held in a local data store. A check will also be made by the process to see if the lock tag attached to the vehicle's cargo has been changed. If either of these two checks produce negative results then the process will request the vehicle to pull-in, otherwise the vehicle is allowed to pass. The process will send its decision to the process that provides the roadside inspectors' interface, to enable an override to be applied if required. The decision of the process (with the override if it is applied) is sent to the message output process and be written back to the vehicle's on-board tag.

The credentials data for vehicles contains a combination of carrier, driver and vehicle identities. This combination will be the one that is used to load into the tag as well as pre-clearance of the carrier, driver and vehicle through the roadside facilities. The safety history records used to decide whether or not to pull-in a vehicle will use the individual carrier, driver and vehicle identities. This means that a carrier will be judged on its safety record, and a driver or vehicle's previous safety record will be taken into account regardless of the carrier to which they belong.

Processes in both (b) and (c) and process (h) support the facility for the CVO inspector to pull-in vehicles at random regardless of whether or not they have passed or failed at checks, have had their identity transaction completed, or have been pre-cleared. These processes will also check that the details about the detected vehicle received from process (d) match those for the pre-cleared vehicle and pull-in those vehicles for which this match is not true. This is to prevent one vehicle being pre-cleared and another actually passing the roadside facilities with its (different) tag data.

The CVO inspector interface is provided through process (e) which exchanges data with the processes in (b) and (c) and process (d) to enable the override facility mentioned previously. Process (e) also enables the roadside facility log maintained by process (f) to be output to the inspector. This log contains a record of activities at the roadside facility provided to process (f) by processes in (b) and (c). It is sent to the Administer Commercial Vehicles facility - see DFD 2.5 by process (f) every day.

With the exception of processes (a), (d) and (g), all the other processes will be located in the roadside checkstation facility. The pre-clearance, border crossing and safety checking processes - see (b), (h) and (c) above have been separated so that it will be possible for any individual roadside checkstation facility to have them in any combination. The vehicle detection process in (d) will be physically located some

distance upstream of the facility and process (a) between process (d) and the rest of the facility. This is to enable the appropriate pass/pull-in displays produced by processes (a) to be output in time for commercial vehicle drivers to safely take any maneuvering actions needed to comply with the decision. Process (a) may also have duplicate outputs within the facility itself, whilst process (g) will actually be in the vehicle.

Provide Commercial Vehicle Clearance Screening (DFD 2.3.2)

The processes in this DFD make up the Provide Commercial Vehicle Clearance Screening facility within the Manage Commercial Vehicles function. These processes enable roadside facilities to pull-in approaching vehicles whose credentials have not been pre-cleared. The key points about the facility are as follows:

* - pre-clearance of a commercial vehicle based on its identity plus size and weight is provided;

* - all pass/pull-in decisions may be overridden by the CVO inspector override and are logged.

There are two processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Administer Commercial Vehicle Credentials Database (2.3.2.1) - this process is responsible for receiving the electronic credentials sent to the roadside checkstation facility as part of a commercial vehicle's enrollment process. The process will store the data for use by another process and will also enable the inspector in the roadside facility to obtain a copy of the data in the store. If the requested data is not in the store, the process will request it from another process in the commercial vehicle administration facility.

(b) Process Screening Transactions (2.3.2.2) - this process is responsible for checking commercial vehicle credentials against those held in a store maintained by another process in the roadside checkstation facility. The process will send the result of each check to the roadside inspector interface process so that an override input can be generated if required. The process will send a request for the commercial vehicle to pull-in if the vehicle's credentials do not match those in the store, and will also send a record of each decision to the process that maintains the commercial vehicle roadside checkstation facility log.

Process (a) provides the credentials data against which the tag data from approaching vehicles is checked by process (b). This tag data is sent to process (b) by processes in the Provide Commercial Vehicle Roadside Facilities facility - see DFD 2.3. If a successful match is found by process (a), then the vehicle is cleared to pass, otherwise it is requested to pull-in. In both cases the pass/pull-in decision is sent to the Provide Commercial Vehicle Roadside Facilities facility to provide the CVO inspector with an opportunity for the automatic decision to be overridden. The CVO inspector must respond within a short time period for the an override to be implemented. The actual decision (with or without an override) and the identity of the roadside checkstation facility where it was made are written back to the tag by output from process (b) to the Provide Commercial Vehicle Roadside Facilities facility.

These processes will run in a roadside checkstation facility and communicate with other processes in the facility. These must be implemented as a pair, but, as noted in the previous section, can be omitted altogether from a facility if it does not require credential screening.

Provide Roadside Commercial Vehicle Safety (DFD 2.3.3)

The five processes in this DFD are responsible for the Provide Roadside Commercial Vehicle Safety facility within the manage Commercial Vehicles function. These processes enable roadside facilities to pull-in approaching vehicles with a poor safety history and to carry-out roadside inspections. The key points about the facility are as follows:

* - vehicles are pulled in if they, their owners or drivers have had previous safety problems;

* - roadside safety inspection may be carried out by CVO inspector using hand held terminal;

* - all pass/pull-in decisions may be overridden by the CVO inspector and are logged.

There are five processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Provide Commercial Vehicle Checkstation Communications (2.3.3.1) - this process is responsible for providing an interface through which a commercial vehicles roadside checkstation facility can communicate with a passing commercial vehicle. When a request for on-board data is received from another process within the facility, the process will issue a data request to the identified commercial vehicle. The data received by the process from the vehicle is stored in the store of collected data for use by the roadside inspection process.

(b) Provide Commercial Vehicle Inspector Hand Held Terminal Interface (2.3.3.2) - this process is responsible for providing an interface for a hand held terminal which can be used by a commercial vehicle inspector. The process will enable the inspector to start a commercial vehicle roadside inspection, to review the results, and to add comments to the results data. The process will support inputs from the inspectors in both manual and audio forms, and will provide its outputs in audible and visual forms. It will enable the form of the visual output to be in hardcopy, or as a display.

(c) Administer Commercial Vehicle Roadside Safety Database (2.3.3.3) - this process is responsible for maintaining in the commercial vehicle roadside checkstation facility a database of credentials for commercial vehicles with safety problems. This process will store the data about these vehicles received from the commercial vehicle administration facility. It will enable this data to be used by another process and will also enable the inspector in the roadside facility to obtain a copy of the data in the store. If the requested data is not in the store, the process will request it from another process in the commercial vehicle administration facility.

(d) Carry-out Commercial Vehicle Roadside Safety Screening (2.3.3.4) - this process is responsible for checking commercial vehicle credentials against the list of those known to have safety problems held in a store maintained by another process in the roadside checkstation facility. The process will send the result of each check to the roadside inspector interface process so that an override input can be generated if required. The process will send a request for the commercial vehicle to pull-in if the vehicle's credentials are in the list of those with safety problems, and will also send a record of each decision to the process that maintains the commercial vehicle roadside checkstation facility log.

(e) Carry-out Commercial Vehicle Roadside Inspection (2.3.3.5) - this process is responsible for carrying out roadside safety inspections at the request of the roadside facility inspector. The result of the inspection is sent by the process to the inspector, the commercial vehicle driver, the roadside checkstation facility log, and the commercial vehicle itself. The process will enable the inspector to add comments to the results of the inspection before it is sent to the above outputs. These comments are received by the process in form of data input from the inspector's hand held terminal interface.

Process (d) is responsible for checking the credentials obtained from the tags on-board approaching vehicles against the records of carriers, drivers and vehicles that have previously been found to have safety problems. These records are maintained by process (c), which also supports ad-hoc inquiries about safety history from the CVO inspector. Process (b) provides the interface through which the CVO inspector initiates roadside inspections by process (e), using data obtained from on-board the vehicle by process (a). The results of the inspection are sent to the roadside facility log and the vehicle driver. If a problem is found, the credentials are loaded into the store used by process (d) and are sent to the Administer Commercial Vehicles facility - see DFD 2.5, for use by other roadside facilities. The CVO inspector can add comments to the inspection results before they are sent back to the vehicle by process (a).

These processes should be implemented as part of a roadside checkstation facility, if that facility is to carry out safety screening of commercial vehicles. They are set up in such a way that it is possible to leave out the roadside inspection functions - see process (e) above. Alternatively, the safety screening function provided by process (d) can be omitted. This allows for both gradual implementation across all roadside facilities and for partial implementation at some.

Provide Commercial Vehicle Data Collection (DFD 2.4)

The processes in this DFD are responsible for the Provide Commercial Vehicle Data Collection facility within the manage Commercial Vehicles function. These processes enable commercial vehicles to collect and store data about their operation for use by other parts of the function. The key points about the facility are as follows:

* - automatic collection and processing of vehicle operational, safety and driver data;

* - commercial vehicle driver is able to enter data on cargo details, fuel consumed, etc.;

* - recorded data sent to the roadside checkstation facility or commercial vehicle manager on request;

* - commercial vehicle driver and vehicle manager can exchange general messages as textual data.

There are six processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Communicate Commercial Vehicle On-board Data to Roadside (2.4.1) - this process is responsible for providing the commercial vehicle end of the communications link between itself and a commercial vehicle roadside checkstation facility. The process will enable an inspector at the facility (or elsewhere, but with a suitably equipped hand held terminal) to have access to the data accumulated on-board the vehicle for use in a vehicle inspection. It will also enable the inspector to send back data about the result of the inspection for storage on-board the vehicle.

(b) Collect On-board Commercial Vehicle Sensor Data (2.4.2) - this process is responsible for continuously monitoring the conditions on-board a commercial vehicle. These inputs is processed by sensors, and if required converted from analog into a digital form. The process will load all collected into an on-board vehicle data store for use by other processes in the vehicle.

(c) Analyze Commercial Vehicle On-board Data (2.4.3) - this process is responsible for analyzing the data collected on-board a commercial vehicle, and sending it to another process for loading into a store on-board the vehicle. If the analysis of the data carried out by the process shows that there is a critical safety problem, the process will send data to the driver's interface process for output to the driver. The process will also accept input of data from the commercial vehicle driver via the interface process and load it into the same store.

(d) Provide Commercial Vehicle Driver Interface (2.4.4) - this process is responsible for providing the interface between the commercial vehicle driver and processes on-board the commercial vehicle. The process will provide interfaces to the processes responsible for collecting, analyzing and storing data about the vehicle, its cargo, the driver, etc., and for the exchange of data with the commercial vehicle manager. The process will support inputs from the driver in both manual and audio forms, and will provide its outputs in audible and visual forms. It will enable the visual output to be in hardcopy, or as a display.

(e) Communicate Commercial Vehicle On-board Data to Vehicle Manager (2.4.5) - this process is responsible for providing the communications interface through which the commercial vehicle manager (or commercial vehicle driver acting in the role of the manager) can access the data stored on-board a commercial vehicle. The process will also support the exchange of unformatted messages between the commercial vehicle manager and driver, and the ability of the driver to send the on-board data to the manager as an unsolicited data flow.

(f) Provide Commercial Vehicle On-board Data Store Interface (2.4.6) - this process is responsible for providing the interface through which data can be written to and read from the store of data that is held on-board a commercial vehicle. The data is provided by and on request from, other processes within the Manage Commercial Vehicles function that are on-board the vehicle.

Data is collected on-board the vehicle by process (b) and loaded into an intermediate store for analysis by process (c). The results of the analysis are sent by process (c) to process (f) for loading into the vehicle's on-board data store. Any critical safety problems found by process (c) are notified to the driver through process (d). This process is also the interface through which the driver can enter data for use by process (c), enter data into a driver's log, and both enter and receive general messages from the commercial vehicle manager. These messages and the output of the on-board data from the store administered by process (f), are communicated on request through process (e) to the Manage Commercial Vehicle Fleet Operations facility - see DFD 2.1. The same process will also send on request the data from the on-board store to the Manage Commercial Vehicle Driver operations facility - see DFD 2.2. Exchange of on-board vehicle data with the roadside checkstations for safety screening (see the Provide Commercial Vehicle Roadside Safety facility in DFD 2.3.3) is provided through process (a), again using process (f) to retrieve and load data in the store.

Individual vehicles may be configured without either of processes (b) or (d) above. This allows for progressive implementation, or for some vehicles (their owners or operators) to opt out of part of the automatic safety checking process. For both of these, the criteria used to determine whether or not a vehicle is pulled in at a roadside checkstation will have to be suitably modified as the in-vehicle functions are upgraded.

Administer Commercial Vehicles (DFD 2.5)

The processes in this DFD are responsible for the Administer Commercial Vehicles facility within the Manage Commercial Vehicles function. These processes enable commercial vehicle pre-clearance to be managed and data from roadside checkstation facilities to be analyzed. The key points about the facility are as follows:

* - provides a central facility for the processing of electronic credential and tax filing;

* - pre-clearance obtained for the selected route through roadside check facilities;

* - all permits and duties data provided by government administrators to one point;

* - roadside checkstation facility logs analyzed daily for safety problems and storage;

* - quarterly reports for government administrators produced from stored roadside facility logs;

* - stored roadside facility logs available for output to the commercial vehicle manager.

There are eight processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Manage Commercial Vehicle Trips and Clearances (2.5.1) - this process is responsible for the advance acquisition of electronic credentials and tax filing for commercial vehicles. The process will support the payment of the necessary taxes and duties that will enable a vehicle to be cleared through the credentials checks at the roadside checkstation facilities along its route, including those at border crossings. For this activity the process uses information about the vehicle's route provided by the commercial vehicle manager, or by the driver acting in that role when the vehicle is owned and operated by the driver. The actual payment activity and the subsequent notification of the roadside facilities along the route is carried out by other processes. Where the roadside facilities are outside the area served by the local ITS functions, the process requests that the necessary vehicle data is passed to the similar processes serving the appropriate areas.

(b) Obtain Electronic Credential and Tax Filing Payment (2.5.2) - this process is responsible for making payment for electronic credential and tax filing. The data on which the payment is based is that for a commercial vehicle's route as provided by the commercial vehicle manager or the commercial vehicle driver who is also the owner of the vehicle. The actual payment activity will be carried out by another process in the Provide Electronic Payment Services function.

(c) Update Permits and Duties Store (2.5.3) - this process is responsible for receiving data from Government Administrators. This data comprises updates to the list of electronic credentials and tax filing required for a commercial vehicle to pass each roadside checkstation facility, plus carrier safety ratings for use in roadside safety inspections. These updates are both loaded into a store used by other process in the commercial vehicle administration facility.

(d) Communicate with Other Commercial Vehicle Administration System (2.5.4) - this process is responsible for communicating with commercial vehicle administration facilities in ITS functions that serve areas outside that which is served by the local function. The communications supported by the process will enable the local function to enroll commercial vehicles in other areas, and for those other areas to enroll their commercial vehicles in the local area. The process will thus support the coordination and the determination of electronic credentials and tax filing across geographic and jurisdictional boundaries.

(e) Manage Commercial Vehicle Credentials and Enrollment (2.5.5) - this process is responsible for enabling commercial vehicle managers and drivers (who are owners) to enroll the electronic credentials for their vehicles. This enrollment is achieved by loading the credentials data into a data store from which such data is down loaded to the commercial vehicle roadside checkstation and border crossing facilities by another process. When the roadside facility is located in the area not served by the local Manage Commercial Vehicles function, the process sends the data to another process that is responsible for communicating with a similar function in other geographic and/or jurisdictional areas. The process will also be able to accept commercial vehicle enrollment requests from similar functions in other areas, query the enforcement agency databases for outstanding prosecutions, and is able to respond to requests for information from authorized entities, such as insurance underwriters.

(f) Output Commercial Vehicle Enrollment Data to Roadside Facilities (2.5.6) - this process is responsible for providing credentials, safety and border crossing data to commercial vehicle roadside checkstation and border crossing facilities. This data is output by the process periodically (e.g., daily) from an interrogation of the stores of safety history and credentials, and sent to the roadside facilities served by the local Manage Commercial Vehicles function. The process will also provide selected credentials and safety data on request from the commercial vehicle inspectors at particular roadside checkstation facilities.

(g) Process Commercial Vehicle Violations (2.5.7) - this process is responsible for sending details of commercial vehicle carriers and drivers that require prosecution to a process in the Manage Emergency Services function. The receiving process in that function will be responsible for sending the data to the appropriate law enforcement agency. This process will obtain the data by periodically (e.g., daily) scanning the data in the log obtained from the commercial vehicle roadside checkstation facilities.

(g) Process Data Received from Roadside Facilities (2.5.8) - this process is responsible for the examination of the daily logs received periodically from the commercial vehicle checkstation and border crossing facilities. It will also be responsible for the receipt in real time of data about commercial vehicles that have failed their safety inspections. The examination of the received data will lead the process to update the local stores containing the facility logs and vehicle safety history. This process will also issue quarterly reports for use by government administrators, send details of the activity at the roadside facility to the Manage Archived Data function. It will also provide responses to requests from the commercial vehicle manager for reports of fleet activity through roadside facilities, either on-demand or as periodic summaries.

(h) Manage Commercial Vehicle Archive Data (2.5.9) - This process is responsible for processing requests for archive data of commericial vehicle operations. This process receives operational data from the roadside check systems and administration and credentials data. This process receives and responds to requests from the Manage Archived Data process for either a catalog of the data contained with the commercial vehicle data stores or for the data itself. Additionally this process is able to produce sample products of the data available. As data is received into this process quality control metrics are assigned. The appropriate meta-data is generated and stored along with the data. A catalog of the data is maintained to allow requesters to know what data is available from the archive store. The process runs when a request for data is received from an external source, or when fresh data is received.

The pre-clearance of vehicles at roadside checkstation facilities is provided by processes (a), (d) and (e). Process (a) acts as the interface through which pre-clearance requests (enrollment) are received. These are passed to process (e) which checks for any outstanding violations with the law enforcement agency, and safety problems recorded in the local data store. If any problems are found, they are reported back through process (a). The required payments are made by process (a) through process (b) before the credentials data supplied with the request is loaded into the database by process (e) for down loading to each roadside checkstation facility by process (f). Process (e) determines the identity of the facilities on the vehicle route by looking in the store of facility locations maintained by process (c) with data from the government administrators. If any of the roadside checkstation facilities at which enrollment is required are outside the area served by this facility, process (e) will request enrollment through process (d). This process may also receive requests for enrollment at local roadside checkstation facilities from similar administration facilities serving other areas, and these are sent to process (a).

Process (g) receives the daily activity logs sent in by the roadside checkstation facilities - see the Provide Commercial Vehicles Roadside Facilities facility in DFD 2.3. This process analyzes the data to highlight any previously unreported safety problems and to produce a store of data from which quarterly reports can be sent to the government administrators by process (g). Process (h) is also responsible for acting as the interface through which activity reports for carriers, drivers and vehicles can be produced on request for the commercial vehicle manager and owner driver. These reports are sent to their respective operations management facilities - see DFDs 2.1 and 2.2.

It is expected that one of the sets of processes in this facility will serve several commercial vehicle managers and owner/drivers through their respective operations management facilities - see DFDs 2.1 and 2.2. This is intended to reduce the number of organizations with which the government administrators have to communicate, and who are in turn communicating with the roadside checkstation facilities. The processes are designed to be implemented as a group, although process (d) can be omitted if no communication with similar facilities in other areas is required.

Provide Commercial Vehicle On-board Data (DFD 2.6)

The processes in this DFD are responsible for the Provide Commercial Vehicle On-board Data facility within the manage Commercial Vehicles function. These processes enable data to be loaded into commercial vehicle tags by the vehicle manager, driver, or roadside facilities passed by the vehicle. The key points about the facility are as follows:

* - enables the vehicle tag to be loaded with the data by the commercial vehicle manager or driver;

* - tag data is output on request to each roadside facility approached by the vehicle;

* - tag data is updated by the roadside facility with the results of the pass/pull-in decision.

There are five processes in this DFD and they divide its functionality between themselves in the following ways.

(a) Provide Commercial Vehicle Manager Tag Data Interface (2.6.1) - this process is responsible for providing an interface through which the commercial vehicle manager can set up the data in the tag on-board a commercial vehicle. The data that the process enables the manager to write to the

tag will be that which identifies the carrier, driver and vehicle. The process will also enable the manager to read this data from the tag, but will not enable the reading of any other data from the tag. Data provided by the manager will also be sent by the process to the tag the process that manages electronic credentials and tax filing for use by the manager in future enrollments. The process will support inputs from the commercial vehicle manager in both manual and audio forms, and will provide its outputs in audible and visual forms. It will enable the visual output to be in hardcopy, or as a display.

(b) Transmit Commercial Vehicle Tag Data (2.6.2) - this process is responsible for providing the output of the data that has been previously stored on-board a commercial vehicle's tag on request from a commercial vehicle roadside checkstation facility. The process will also provide the current status of the lock tag, if one is attached to the vehicle's cargo. The data will only be sent by the process to the commercial vehicle roadside checkstation or border crossing facility that made the request. The output mechanism used by the process is an implementation issue, but it could be by radio, beacon, or a visual mechanism, such as a bar code.

(c) Provide Commercial Vehicle Driver Tag Data Interface (2.6.3) - this process is responsible for providing the interface through which the commercial vehicle driver can set up the data in an on-board vehicle unit (e.g., an electronic tag). In this instance the driver is assumed to be acting in the role of a commercial vehicle manager, and is thus likely to be the owner of the vehicle. The data the process enables the manager to write to the tag will be that which identifies the carrier, driver and vehicle. The process will also enable the read this data from the tag, but will not enable the manager to read any other data from the tag. The process will support inputs from the commercial vehicle driver in both manual and audio forms, and will provide its outputs in audible and visual forms. It will enable the visual output to be in hardcopy, or as a display.

(d) Provide Lock Tag Data Interface (2.6.4) - this process is responsible for producing an output of the current status of a lock tag that is being carried by the cargo of a commercial vehicle. The process will only produce the output in response to a request for data that is received from the other process on-board the vehicle that is responsible for communication with commercial vehicle roadside checkstation facilities. The actual output mechanism used by the process is an implementation issue, but it could be by radio or beacon.

(e) Manage Commercial Vehicle Tag Data Store (2.6.5) - this process is responsible for managing the store of data that is held by a commercial vehicle's on-board tag. It will manage all of the transactions that either write data to the store and read data from it, to ensure that the data retains its consistency. The process will ensure that the commercial vehicle manager or driver can only read the data that they are enabled to write to the store, and that the store only contains data from the last two roadside checkstation facilities passed by the commercial vehicle.

The commercial vehicle manager and owner/driver's interfaces are provided through processes (a) and (c) respectively. These enable the manager and the owner/driver to write and read credentials data to and from the tag, through process (e). Communication between the tag and the roadside checkstation facilities approached by the vehicle is provided through process (b), which again uses process (e) to read and write data to and from the tag. Process (d) provides the interface through which data can be requested and received from a lock tag when one is fitted to the vehicle's cargo.

Only four of these processes are needed for any one particular implementation. The combination will be either process (a) or (c) with processes (b) and (e), plus (optionally) process (d). Processes (b), (e) and optionally (e) will have to be provided for every vehicle in the commercial vehicle manager's fleet if automatic pull-in at roadside checkstation facilities is to be avoided.

1.6.1.4. Provide Vehicle Monitoring and Control (DFD 3)

This DFD shows the processes that make up the Provide Vehicle Monitoring and Control function. This function is responsible for providing facilities for the automatic control of vehicles, either in basic form,

or as required for operation in platoons or on Automatic Highway System (AHS) lanes. The key points about the function are as follows:

* - emergency services automatically notified when the vehicle is involved in a collision;

* - cargo information is provided to emergency services if any is present on the vehicle;

* - vehicle control provided at various levels of automation from basic to full AHS level;

* - automatic vehicle control canceled by driver action or failure of built in self test processes.

There are three DFDs and one process in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Monitor Vehicle Status (3.1) - this set of processes monitors the vehicle's operation, roadside conditions plus the vehicle's position and motion relative to surrounding objects. This data is used to provide status information to other processes and ITS functions plus the warning messages for output to the driver. If the vehicle is fitted with automatic control equipment, the data produced by these processes can be used to initiate corrective action .

(b) Provide Automatic Vehicle Operation (3.2) - this set of processes provide facilities to allow a vehicle to be automatically controlled. The processes are structured so that various levels of control may provided, starting with a simple driving aid for cruise control. The highest level of automatic control provided is that which can be used in conjunction with road and freeway lanes equipped for AHS operation.

(c) Provide Automatic Emergency Notification (3.3) - this set of processes enables the vehicle to automatically report its involvement in an incident to the Manage Emergency Services function (see DFD 5). This is designed to enable assistance to be summoned to the vehicle as soon as possible, without the (possibly incapacitated) driver having to take any action. If the vehicle is carrying cargo, its state is determined and included in the report.

(d) Enhance Driver's Vision (3.4) - this process is responsible for providing data from which a continuously updated display showing an enhanced version of the driver's vision. The process will produce the data for this display using inputs to sensors mounted on the vehicle. It will operate at all times and will send its output to another process for integration with other messages for the driver.

Although links are provided between the processes in (a) and those in (b) and (c), they can operate independently. All of the processes use the Provide Information Services facility - see DFD 6.2, to interface with the driver for the input of commands and the output of information. Another part of the Provide Driver and Traveler function (see DFD 6) is used to provide the vehicle's location for the automatic notification of emergency situations.

Monitor Vehicle Status (DFD 3.1)

The three processes in this DFD provide the Monitor Vehicle Status facility within the Provide Vehicle Monitoring and Control function. The processes in this facility monitor vehicle operation, driver performance and data provided from the roadway on which the vehicle is operating. This data is used to generate messages for output to the driver and may also provide input to the vehicle control facilities for automatic action. The key points about the facility are as follows:

* - potentially unsafe vehicle conditions detected by on-board vehicle sensors;

* - driver's condition continuously analyzed and warning data provided if found unsafe;

* - unsafe vehicle and driver conditions notified to the driver through safety and warning messages;

* - crash and collision avoidance data automatically provided if unsafe condition likely;

* - in the event of a potential collision, crash restraint deployment action is also initiated.

There are three processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Produce Collision and Crash Avoidance Data (3.1.1) - this process is responsible for sensing and evaluating the likelihood of a collision between two vehicles or a vehicle and a stationary object. The process will base its detection on input from two other processes. One of these processes is that which continuously processes sensor inputs on-board the vehicle and the second is that which detects collision situations at intersections. When either event is detected this process will output the appropriate messages to another process in the vehicle to warn the driver. If the vehicle is suitably equipped, the process will initiate the deployment of crash restraint devices in advance of the collision and/or generate data to initiate direct operation of the vehicle to take evasive maneuvers.

(b) Carry-out Safety Analysis (3.1.2) - this process is responsible for producing safety warnings for display to the driver and output to the vehicle control processes. The process will base its output on input from another process in the vehicle that is analyzing inputs to sensors. When data about a safety situation is received, the process will output the appropriate messages to another process in the vehicle to warn the driver. If the vehicle is so equipped, the process will send data to the process in the vehicle responsible for its control.

(c) Process Vehicle Safety On-board Data (3.1.3) - this process is responsible for processing data received as input to sensors located on-board a vehicle. The process will continuously analyze these inputs and produce data from which safety and/or position warnings and actions can be produced by another process. It will also analyze the data to check for hazardous roadside conditions such as flooding, ice, snow, etc. and if detected will output this data to processes in the Manage Traffic function.

The above processes provide an early form of vehicle control that is limited to on-board vehicle safety analysis and crash avoidance functions. The analysis of data collected on-board the vehicle or from its surroundings is carried out by process (c). Safety analysis of the data from process (c) is carried out by process (b) and potential collision analysis by process (a). The safety and position warnings that they generate will be output to the Provide Information Services facility - see DFD 6.2. These two processes will also output data to the Provide Vehicle Control facility - see DFD 3.2.3, for action, if the vehicle is so equipped. These processes can be applied to all types of vehicle with the exception of the safety analysis in process (b), which need not be applied commercial vehicles as they have their own on-board safety analysis systems.

Provide Automatic Vehicle Operation (DFD 3.2)

This DFD shows the six processes that make up the Provide Automatic Vehicle Operation facility within the Provide Vehicle Monitoring and Control function. The processes in this facility provide automatic vehicle operation, either for a single vehicle, or as part of a platoon, and may use AHS lanes. The key points about the facility are as follows:

* - automatic vehicle control functions provided for speed, lane position and platoon following;

* - driver activation of vehicle controls will cancel automatic vehicle control;

* - failure of built in self test function for critical processes will also cancel automatic vehicle control;

* - AHS operating parameters may be changed to improve lane utilization efficiency;

* - AHS facilities provided in separate processes for implementation when the technology matures.

There is one DFD and six processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Provide Driver Interface (3.2.1) - this process is responsible for providing an interface through which a vehicle driver can initiate, monitor and terminate automatic control of the vehicle. The output that any of these actions generates in terms of messages to the driver is sent by this process to another process that is in the Provide Driver and Traveler Services function and in the vehicle. The driver inputs is received by this process from another process that is also in the Provide Driver and Traveler Services function and in the vehicle.

(b) Provide AHS Control (3.2.2) - this process is responsible for providing the facility that enables vehicles to operate in automatic highway system (ahs) lanes. This mode of operation will only be initiated by the process when a request is received from the driver via other processes in the vehicle. The first action of the process must be to send data to the process that provides the ahs check-in facility. If a positive response is received from that process, i.e., the vehicle's check in is accepted, then the process will enable ahs operation by sending the data to the vehicle control processes. Once the vehicle is in ahs operation, the process will continuously monitor for an input from the driver that cancels ahs mode, and when this is received send mode canceling data to the vehicle control processes. Similarly the process will also continuously monitor input from the process analyzing vehicle condition and the vehicle's presence on an ahs lane. The process will send mode canceling data to the vehicle control processes, if the condition does not support ahs lane operation, or the vehicle is no longer on an ahs lane.

(c) Provide Vehicle Control (3.2.3) - these processes provide facilities for various levels of vehicle automatic control, covering basic functions such as cruise control through to full automatic control in platoons on Automatic freeway System (AHS) lanes. They use data from on-board vehicle sensors and (optionally) from other vehicles in a platoon to determine any corrective action or changes in vehicle control that are needed. Automatic control is initiated by the driver and will be canceled if the driver moves the vehicle controls, or if the processes detect a fault within their own operation. The processes are also responsible for taking action when unsafe conditions are detected by the Monitor Vehicle Status facility - see DFD 3.1. AHS operation is initiated when the vehicle successfully passes the check-in procedure provided by other processes - see below.

(d) Process Sensor Data for AHS input (3.2.4) - this process is responsible for analyzing the input from the vehicle that provides information about its condition and that it is on an automatic highway system (ahs) lane. The process will continuously analyze this data and provide output to the process that provides ahs control.

(e) Check Vehicle for AHS eligibility (3.2.5) - this process is responsible for checking that vehicles are eligible for using the automated highway system (ahs) lanes on a highway. The process will decide whether or not the vehicle is suitable for has operation by checking locally stored data that has been provided by a process in the Manage Traffic function, against data from the vehicle provided through the check request by a process on-board the vehicle. The process will send the results of the check to the process on-board the vehicle that requested the ahs check-in. The vehicles that are successfully checked-in will also be down loaded with ahs control data from this process.

(f) Manage AHS Check-in and Check-out (3.2.6) - this process is responsible for managing the checking in and checking out of suitably equipped vehicles requesting to use automated highway system (ahs) lanes. The process will provide the special vehicle control parameters needed for ahs operation to the process that manages ahs check-in and collect data on vehicles that request check-in and check-out from that process. This process will send a record of all check-in and check-out transactions regardless of whether they are successful or not, to the process responsible for managing ahs operational data.

(g) Manage AHS Operations (3.2.7) - this process is responsible for recording data about vehicles that have requested check-in and check-out for the use of the automated highway system (ahs) lanes, and for receiving ahs control parameters from a process in the Manage Traffic function. The process will provide a process at the roadside with the vehicle control parameters needed for ahs operation. The process will keep a log of all ahs check-in and check-out transactions received from the

roadside process regardless of whether they are successful or not, and periodically pass this data on to the Manage Archived Data function.

Process (a) provides the means by which these processes can communicate with the driver interface provided in the Provide Information Services facility - see DFD 6.2. This is also the mechanism by which information about the status of automatic vehicle control is output to the driver.

The AHS check-in and check-out facility is provided by processes (e) through (g). They are provided with AHS operational data by the Manage Demand facility - see DFD 1.4, through process (g). This process also provides AHS operational data to the Manage Traffic function which forwards the data to the Manage Archived Data function - see DFD 8.

The processes in this DFD can be divided up into two groups, those concerned with basic automatic vehicle control (processes (a) and (c)) and those concerned with the AHS facilities (processes (b), plus (d) through (g)). This is to enable the latter to be deployed after those for those in the former group and allows for the later development of a mature AHS technology.

Provide Vehicle Control (DFD 3.2.3)

This DFD shows the processes that make up the Provide Vehicle Control facility within the Provide Vehicle Monitoring and Control function. The processes in this facility provide automatic vehicle control including the interface to the platoon in which it may be running. The key points about the facility are as follows:

* - simple speed, headway and lane position control functions are provided;

* - the more complicated platoon following function is provided as a separate facility;

* - incorrect vehicle control command response feedback will cause automatic control to be disabled;

* - vehicle control disabled if driver activation of the controls detected;

* - any failure of built in self test in control processes will also disable vehicle control.

There are six processes and one DFD in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Provide Command Interface (3.2.3.1) - this process is responsible for providing the interface through which all driver commands are passed to the correct processes in the vehicle for action. The process will also pass all messages about vehicle control status on to another process in the vehicle for output to the driver. It will also monitor the health of the other in-vehicle processes involved in automatic vehicle control. This process will take the appropriate mode canceling action when any failures are detected in these processes.

(b) Manage Platoon Following (3.2.3.2) - this process is responsible for providing the facility for the automatic control of vehicles to be extended to cover the platooning of vehicles. The process will enable vehicles to follow each other very closely (inches apart) in a platoon, responding to changes in speed and direction of the lead vehicle. The process will monitor data from other vehicles in the platoon received via another process, and will also send data about itself to the same process for communication to other platoon vehicles. If the data received from the process shows that the vehicle has been left on its own, i.e., there are no other vehicles in front or behind, the process will send data to another process in the vehicle to increase speed and catch up with any platoon that may be ahead. The process will only allow the vehicle to join or continue running in a platoon if it and/or the driver are considered to be in a safe condition, using data received from other processes in the vehicle.

(c) Process data for Vehicle Actuators (3.2.3.3) - this process is responsible for providing the interface between other automatic vehicle control process and the actuators which actually change the vehicle's controls. The process will both implement commands and monitor the operation of the

actuators to check that they only move when requested. If they move for any other reason, e.g., the driver has touched the vehicle controls, the process will disable automatic operation. The process will perform its own built-in self test (BIST) analysis. It will report any errors that this shows to another process in the vehicle and will cease to accept further requests to change the vehicle's actuators.

(d) Provide Servo Controls (3.2.3.4) - these processes provide facilities for basic vehicle control. They provide for the control of vehicle speed, headway, lane following and lane changing. They base their control decisions on input from the in-vehicle, driver commands, and other platoon vehicles, plus feedback of actuator operation. Control data is provided to the actuators and feedback of process operation to the driver and the other platoon vehicles. The processes monitor their own operation through a built-in self test function and will cancel automatic control is an error is detected.

(e) Process Vehicle Sensor Data (3.2.3.5) - this process is responsible for providing the facility to decode the input being sent to on-board vehicle sensors. The process will support inputs to those sensors that monitor conditions both on-board the vehicle and in the way the vehicle relates to its surroundings. The data produced by the process is sent to another process which will determine if any action is required.

(f) Communicate with other Platoon Vehicles (3.2.3.6) - this process is responsible for communicating with the other vehicles that are in a platoon. The process will support communications with the platoon vehicles that are both immediately in front of and behind the vehicle in which it operates. The passing of data in both directions, i.e., both to and from the vehicles, is supported by the process.

The basic vehicle control facilities are provided through processes (c) and (d), with inputs being provided from on-board vehicle sensors through process (e) and the driver through process (a). Output of the control status to the driver is provided through process (a). Optionally the exchange of data with other vehicles to enable their operation as part of a platoon can be provided through processes (b) and (f). These two processes can be implemented at a later date from the others, enabling basic vehicle control to be introduced ahead of the more advanced facilities for platooning vehicles.

Provide Servo Controls (DFD 3.2.3.4)

This DFD shows the processes that are in the Provide Servo Controls facility within the Provide Vehicle Monitoring and Control function. The processes in this facility provide automatic control of the basic vehicle functions such as speed and position. The key points about the facility are as follows:

* - separate processes provided for control of throttle, brake and steering;

* - one or more of these processes may be implemented on a vehicle;

* - driver use of the vehicle controls immediately cancels automatic control operation;

* - all processes have built in self test functions canceling automatic control when a failure is detected.

There are five processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Provide Speed Servo Control (3.2.3.4.1) - this process is responsible for providing data which enables the vehicle's throttle to be regulated in such a way that a desired vehicle speed is maintained. The process will enable the throttle to be overridden temporarily in order to maintain a desired headway between the vehicle and others in a platoon. The data that actually changes the throttle's position is sent to the process that provides data to in-vehicle actuators. The process will perform its own built-in self test (BIST) analysis. It will report any errors that this shows to another process in the vehicle and will cease to accept further requests to change the vehicle's throttle position.

(b) Provide Headway Servo Control (3.2.3.4.2) - this process is responsible for providing data which enables the vehicle's brake and throttle to be regulated in such a way that its headway, i.e., the distance between it and the vehicle in front, is maintained. The process will support the brake movements

that either maintain the vehicle's headway for normal operation, or hold it at the value used in platoon following, whether on or off automated highway system (ahs) lanes. The process will perform its own built-in self test (BIST) analysis. It will report any errors that this shows to another process in the vehicle and will cease to accept further requests to change the vehicle's brake setting.

(c) Provide Lane Servo Control (3.2.3.4.3) - this process is responsible for providing the data which enables the vehicle's steering to be adjusted so that it maintains a position that is in the middle of its current lane. The process will enable this to be temporarily overridden as a result of action being taken by other processes to change lanes. The process will perform its own built-in self test (BIST) analysis. It will report any errors that this shows to another process in the vehicle and will cease to accept further requests to change the vehicle's throttle position.

(d) Provide Change Lane Servo Control (3.2.3.4.4) - this process is responsible for providing the data which enables the vehicle's steering to be adjusted so that it will move either left or right from one lane to another. The process will enable this to temporarily override the lane center holding facility available from another process in the vehicle. The process will perform its own built-in self test (BIST) analysis. It will report any errors that this shows to another process in the vehicle and will cease to accept further requests to change the vehicle's throttle position.

(e) Provide Vehicle Control Data Interface (3.2.3.4.5) - this process is responsible for providing a communications and data processing interface between processes in the Provide Vehicle Control and Monitoring function. These processes will comprise those responsible for controlling individual functions, e.g., throttle, brake, etc., and those that interface to actuators and those that monitor vehicle operation.

The five processes have been organized so they can be implemented separately and not necessarily at the same time. Processes (a) through (d) provide particular control functions, whilst process (d) provides interfaces for communications with other processes and with the store of vehicle control data. This store is provided as part of the vehicle's control system. and is pre-loaded with data during its manufacture. It may be changed centrally from the Manage Demand facility - see DFD 1.4. This enables the way in which AHS lane operation is carried out to be adjusted to suit demand management strategies. Any such changes will be lost and the store returned to its original settings when the vehicle is switched off. This is to prevent the data being changed by unauthorized means which could be prejudicial to automatic vehicle operation.

Provide Automatic Emergency Notification (DFD 3.3)

This DFD shows the processes that provide the Provide Automatic Emergency Notification facility within the Provide Vehicle Monitoring and Control function. The processes in this facility enable the vehicle to automatically inform the Manage Emergency Services function of its involvement in an incident. The key points about the facility are as follows:

* - automatic emergency notification provided in the event of an accident regardless of driver condition;

* - cargo details provided for those vehicles carrying cargoes;

* - vehicle location and identity provided automatically.

There are three processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Provide Cargo Data for Incident Notification (3.3.1) - this process is responsible for providing data about a commercial vehicle's cargo in the event that the vehicle is involved in some type of emergency. The process will produce the output on request from another process in the vehicle regardless of whether the cargo has itself suffered from any damage. The cargo data being provided by the process will cover all types, regardless of whether or not they are classified as HAZMAT cargoes.

(b) Provide Communications Function (3.3.2) - this process is responsible for sending messages it receives from other processes in this facility to the Manage Emergency Services function. It will also be responsible for passing on the resulting response to the driver via processes in the Provide Driver and Traveler Services function.

(c) Build Automatic Collision Notification Message (3.3.3) - this process is responsible for preparing and submitting data for transmission to the Manage Emergency Services function. The data is sent by this process when an emergency situation is detected by analyzing inputs from the vehicle. This process will produce its outputs regardless of any action by the driver and is designed to be as the result of a crash which may have prevented the driver from initiating the emergency request personally.

These processes are designed to enable notification of an accident or other kind of emergency involving any combination of the driver, the vehicle or its cargo, to be sent as soon as possible to the Manage Emergency Services function - see DFD 5. The data from the vehicle will be generated automatically by process (c), plus process (a) if the vehicle is carrying any cargo. This enables the data to reach the emergency services though process (b) even if the driver is unable to initiate the action. Although the processes depend on others in the facility for data, they will each operate continuously and independently so that the data can processed, stored and accumulated as fast as possible bearing in mind the urgency with which their work has to be done.

1.6.1.5. Manage Transit (DFD 4)

The processes in this DFD comprise the Manage Transit function. This function is responsible for the management of transit operations within some or all of the areas served by ITS. The key points about the function are as follows:

* - monitoring of transit services operation uses data collected on-board transit vehicles;
* - strategies available for returning late running transit vehicles to normal operation;
* - transit services planned using current operational data and input from various other sources;
* - demand responsive transit provides personalized transport for travelers on request;
* - security coordination and monitoring provides links to the Manage Emergency Services function;
* - transit driver activities can be assigned using past performance and other factors;
* - transit vehicle maintenance can be scheduled and work assigned to technicians;
* - transit fares can be collected either on-board the vehicle or at the roadside;
* - transit service information and data from approaching transit vehicles available at the roadside.

There are seven DFDs subordinate to this DFD. Overall functionality is divided between them in the following ways.

(a) Operate Vehicles and Facilities (4.1) - These processes provide information on the current state of operation of transit vehicles, and how they are performing against the schedules. The processes are responsible for keeping vehicles on schedule and taking action to get them back on schedule when any deviations are found. Two types of actions are supported, one for single vehicles and the other for when several vehicles are affected. In both cases, instructions will be sent to the vehicle driver(s) and vehicle priority requested through the Manage Traffic function - see DFD 1. This function includes sending transit probe and vehicle location data to the Manage Traffic function and receiving data concerning current incidents in the roadway that affect transit operations. The processes also collect data about the operation of the transit vehicles themselves and make this information available to processes in this and other ITS functions.

(b) Plan and Schedule Transit Services (4.2) - These processes provide the management of the route planning and scheduling of both regular and demand responsive transit services. The generation of new regular transit routes and schedules is done at the request of the transit fleet manager and takes into account the operational data plus input from a variety of other sources. New schedules can be generated separately from routes, and can be produced in response to inputs from parking lots if a change to the current park and Ride (P+R) service is needed. The new routes and services are made available to this and other ITS functions, plus external agencies. The generation of demand responsive transit services is provided in response to requests from the Provide Driver and Traveler Services function - see DFD 6. The services will be personalized to suit the traveler's request and will make use of regular transit services where possible.

(c) Schedule Transit Vehicle Maintenance (4.3) - These processes are responsible for the management of transit vehicle maintenance and the assignment of technicians to carry out the maintenance. They use the operational data provided by the processes in (a) and the maintenance specifications for each type of vehicle. A log is maintained of all maintenance activity so that current progress on activities and individual technician assignments can be tracked and monitored by the transit fleet manager.

(d) Support Security and Coordination (4.4) - These processes manage the actions which are taken when an emergency occurs on-board a transit vehicle or within a transit facility, modal interchange facility, or transit depot. Notification of an emergency may come from transit users via such things as panic buttons, from a transit vehicle driver, or from surveillance equipment located at transit stops and other parts of the transit network. The processes work to pre-defined plans of action for each type of emergency situation and communicate with the Manage Emergency Services function (see DFD 5) for coordination of emergency service activities and multiple agency responses to incidents. The processes also communicate with the transit system operator and fleet manager to both gain approval for and keep informed of, the actions being taken, and for actual input of actions if none are defined. Automatic output of information about emergencies to the media is also provided.

(e) Generate Transit Driver Schedules (4.5) - These processes are responsible for the management of transit driver working schedules, routes, etc. Drivers are assigned to their duties based on a number of criteria, including availability, previous experience, performance on previous assignments, seniority, and personal preferences. Activities are monitored by the transit fleet manager who can update the data about individual drivers.

(f) Collect Transit Fares in the Vehicle (4.6) - These processes collect fares from transit users on-board a transit vehicle, for the use of current transit services, advanced payments for transit services, and for other (yellow pages) services. The fare payment processing may be carried out interactively from on-board the vehicle, or may be held until the vehicle reaches a convenient point and then carried out as a batch transaction. The processes support the use of debit/credit cards, including those with stored credit value, as may be issued by transit operators as well as financial institutions. When a violation of an interactive payment transaction is detected, an image of the offending transit user will be obtained from the vehicle for use by the law enforcement agency.

(g) Provide Transit User Roadside Facilities (4.7) - These processes act as the interface through which the transit user can obtain information and pay for the use of services at a roadside location, such as a transit stop. The information provided includes transit services in general, and the time at which the next service is due to arrive at the location. Information provided by transit vehicles approaching the location is also automatically output to the transit user. Payment by the transit user for the use of current transit services, advanced payments for transit services and for other (yellow pages) services, is supported by the processes, as is the use of debit/credit cards, including those with stored credit value, as may be issued by transit operators as well as financial institutions. When a violation of a payment transaction is detected, an image of the offending transit user will be obtained from the roadside for use by the law enforcement agency.

The key processes in this function are those provided by the facilities in (a) and (b), since they both provide data to other parts of the function, and in the case of process (b) to other ITS functions.

Implementation of the processes in (c) through (g) without these two facilities will limit the effectiveness of their operation. However stand-alone implementation of some or all of the processes in (c) through (g) is possible if particular implementations do not require the full functionality. It is also not necessary to include the transit fare collection facilities provided by processes in both (f) and (g) in the same implementation.

Although many of the processes and some of the variables they use refer to a "transit vehicle", the definition of what this actually means is flexible. Thus the processes can be applied to a fleet of Light Rail Vehicles (LRVs) or Light Rail Trams (LRTs), or taxis used for demand responsive transit services, as well as a fleet of buses used in the roadway.

The term "transit system operator" is frequently used within the descriptions of the facilities in this function. It is intended to represent an employee of the functional entity that is providing transit services. This employee is expected to oversee the operation of the transit services and to provide inputs to aid its operation, as required by the various facilities. A "transit fleet manager" is someone who is also employed by the functional entity that is providing transit services, but who has more decision making authority than a transit system operator.

The transit route data is supplied to the map update provider to enable the supplier to produce transit route maps and include them in the digitized map databases sent to other ITS functions. The raw route data is also made available to other ITS functions so that where possible they can display transit route maps using their current map display data.

Operate Vehicles and Facilities (DFD 4.1)

The processes in this DFD provide the Operate Vehicles and Facilities feature for the Manage Transit function. They provide the facility for the collection of operational data from transit vehicles for use by other facilities in the Manage Transit and by other ITS functions, and for the management of the deviation of transit vehicles from their schedules. The key points about the facility are as follows:

* - data from sensors on-board transit vehicles is stored centrally for use within the rest of the facility;

* - data is used to provide other ITS functions with information about transit system performance;

* - information about arrival time of the next service is provided for use at roadside locations;

* - correction of service deviations is provided separately for single and multiple vehicles;

* - single vehicle corrective action uses priority at intersections and driver instructions;

* - multiple vehicle corrective action uses service changes and wide ranging intersection preemption;

* - current incidents data is received by this function for use in determining deviations from transit routes and schedules.

There are eight processes and one DFD subordinate to this DFD. Overall functionality is divided between them in the following ways.

(a) Process Transit Vehicle Sensor Trip Data (4.1.1) - This process will collect and process data available to sensors on-board transit vehicles. This data will be sent by this process to other processes on-board the transit vehicle and elsewhere in the Manage Traffic function for use in determining vehicle schedule deviations and for storage as operations data.

(b) Determine Transit Vehicle Deviation and Corrections (DFD 4.1.2) - These processes use the data provided by process (a) plus the current transit routes and schedules to determine the expected time of arrival (ETA) of a transit vehicle and its deviation (if any) from the schedule. Information concerning current incidents on a transit route also affect the transit vehicle deviation from the route or schedule. All of this information is sent for storage so that it can be used by other ITS

functions, and is also sent to a process in the main facility in case several vehicles are involved. When the deviation only involves one vehicle, corrective instructions are sent to the driver, individual vehicle priority is requested at intersections, and data is sent to the multimodal transportation service provider to enable coordination with other services.

(c) Provide Transit Vehicle Location Data (4.1.3) - This process will provide the transit vehicle's current location with a high degree of accuracy. The location will be computed by this process from data sent by other processes that provides basic vehicle location and on-board vehicle conditions, such as proximity to transit stop, vehicle doors opened or closed, etc. The data will be output continuously by the process and sent to other processes for their use and for storage.

(d) Manage Transit Vehicle Deviations (4.1.4) - This process will manage large deviations of individual transit vehicles, deviations in rural areas, and deviations of large numbers of vehicles. The process will generate the necessary corrective actions which may involve more than the vehicles concerned and more far reaching action, such as, the introduction of extra vehicles, wide area signal preemption by the Manage Traffic function, the premature termination of some services, etc. All corrective actions generated by this process will be subject to the approval of the transit fleet manager before being implemented. Confirmation that the requested overall priority has been given by the Manage Traffic function will be received by the process.

(e) Provide Transit Vehicle Status Information (4.1.5) - This process will provide transit vehicle operational data to processes within the Manage Transit function, and on request to the transit fleet manager and the Manage Travel Demand facility in the Manage Traffic function. This process will also provide transit probe and AVL information to the Manage Traffic function. The data will be obtained by this process from another process that manages a store of transit vehicle operating data.

(f) Manage Transit Vehicle Operations Data (4.1.6) - This process will manage the store of transit vehicle operating data. When any new data is received from another process, this process will load it into the data store. This process will also retrieve selected data on request from other processes in the Manage Transit function.

(g) Provide Transit Vehicle Deviation Data Output Interface (4.1.7) - This process will provide the interface through which multimodal transportation service providers are informed of transit vehicle schedule deviations. The output delivered by the process will result from input received from another process in the Manage Transit function, and will relate to the deviation of a number of transit vehicles such that the disruption will affect several services, possibly on different routes. The process will provide the output in a form that enables adjustments to be made to any connecting services being provided by the multimodal supplier so that transit users are not inconvenienced by the deviations. A zero (or null) output will be provided when no deviations are present.

(h) Provide Transit Operations Data Distribution Interface (4.1.8) - This process will provide customized sets of transit vehicle schedule deviations to travelers and to the media. The process will only provide data to the media when prompted by the arrival of new deviation data in the transit_vehicle_operational_data store, which is maintained by another process in the Manage Transit function. The outputs will be made available following a direct request from the other ITS function, or as part of a subscription process relating to a traveler's transit profile. The process will obtain the required data from the process that manages the store of transit vehicle operating data.

(i) Process Transit Vehicle Sensor Maintenance Data (4.1.9) - This process will collect and process vehicle maintenance data available to sensors on-board transit vehicles. When processed, the data will be sent by this process on request to another process in the Manage Transit function for storage as transit vehicle operating data so that it can subsequently be used for work on future vehicle maintenance.

Data from on-board the transit vehicle is provided by process (a) and (on request) from process (i). It is supplied to process (f) for storage. The data from process (a) is also provided to processes in (b), and to process (c). This process is responsible for providing the vehicle location based on the standard location

data received from the Provide Driver and Traveler Services function (see DFD 6), plus inputs peculiar to transit vehicle operation, e.g., passenger doors opening. The location data is again sent for storage by process (f) and used by processes in (b), and process (d) for the management of deviations from schedules. Processes (e) and (h) provide access to the stored operational data to other parts of the Manage Transit function, the transit fleet manager, and to other ITS functions. Process (d) determines the corrective action for service deviations that are large or in the rural environment, where the effects can be different from those in the urban environment. Output of service corrections produced by this process is provided to multimodal transportation service providers through process (g), and to transit vehicle drivers through the interface process in (b).

The above processes form a cohesive group. Partial implementation could be provided if, for example, the facility for the organized restoration of transit services after any kind of deviation was not required. Process (g) can be omitted where there are no other transportation services with which coordination needs to be maintained.

Determine Transit Vehicle Deviation and Corrections (DFD 4.1.2)

The processes in this DFD provide the Determine Transit Vehicle Deviation and Corrections facility within the Manage Transit function. They are responsible for providing a facility which enables transit vehicle deviations to be calculated and corrective instructions provided to the driver when the deviation is small or in an urban environment. The key points about the facility are as follows:

***** - schedule deviations and corrections are determined from transit vehicle position and current schedules;

***** - corrective instructions are provided to the driver where deviation is small and in urban environments;

***** - local roadside preemption is requested from Manage Traffic function for late running transit vehicles;

***** - deviation data is sent to other processes for use within this function and by other ITS functions;

***** - deviation data is also sent to the multimodal transportation service provider for service coordination.

There are five processes in this DFD. Overall functionality is divided between them in the following ways.

(a) Determine Transit Vehicle Deviation and ETA (4.1.2.1) - This process will determine the schedule deviation and estimated times of arrival (ETA) at transit stops of a transit vehicle. The data will be sent by this process to other processes in the Manage Transit function for use in calculating corrective instructions for output to the transit vehicle drivers, for use in calculation of a much wider return to schedule strategy where more than one vehicle and/or service is involved, and for storage as transit vehicle operational data. This process will also send the data to the transit driver interface process, so that the driver is aware of the actual schedule deviation. This output will be set to zero (no deviation) when that condition occurs, even when it has followed a period of deviation from schedule.

(b) Determine Transit Vehicle Corrective Instructions (4.1.2.2) - This process will generate outputs that enable a transit vehicle schedule deviation to be corrected. The process will derive its outputs from data received from another process in the Manage Traffic function. The outputs produced by the process will consist of corrective instructions for output to the transit vehicle driver by a process on-board the vehicle, and preemption requests for traffic signal controllers at road and freeway intersections. The process will only produce this output when another process has determined that deviation is small, or the transit vehicle is operating in an urban area. In all other conditions, the process will provide an output that shows that there are no corrective instructions.

(c) Provide Transit Vehicle Driver Interface (4.1.2.3) - This process will provide a schedule correction interface for the transit driver in the transit vehicle. The interface will provide data to the driver about how far the vehicle is from its schedule and what corrective action the driver must take. The data will be received by the process from other processes in the Manage Traffic function. The output

delivered by the process will be available in audio or visual form in such way that while alerting the driver to the information it contains, it will in no way impair the driver's ability to operate the vehicle in a manner that is both safe to its passengers and to other vehicles on the roads and freeways. The process will maintain the output until new data is received from the other processes.

(d) Provide Transit Vehicle Correction Data Output Interface (4.1.2.4) - This process will provide the interface through which multimodal transportation service providers are informed of a transit vehicle schedule deviation. The output delivered by the process results from input received from another process in the Manage Transit function, and will relate to the deviation of an individual transit vehicle. The process will provide the output in a form that enables adjustments to be made to any connecting services being provided by the multimodal supplier so that transit users are not inconvenienced by the deviation of a transit vehicle on one service. A zero (or null) output will be provided when no deviations are present.

(e) Request Transit Vehicle Preemptions (4.1.2.5) - This process will provide the interface through which requests for preemption can be output from a transit vehicle. The output will be received by the process as a result of data sent from another process in the Manage Transit function. The process will provide the output in a form that can be used by the controllers at intersections, pedestrian crossings and multimodal crossings on the roads (surface streets) and freeway network served by the Manage Traffic function to provide priority of the transit vehicle. If no data is received from the other process, or it shows that no preemption is needed, the process will produce no output.

The determination of transit vehicle deviation and estimated time of arrival (eta) is carried out by process (a). The data is passed to process (b) for determination of the corrective instructions and to process (c) for output to the transit vehicle driver. When the instructions are produced by process (b) they are also output to the driver by process (c) and are sent to the multimodal transportation service provider through process (d). Requests for priority for the transit vehicle at traffic intersections are sent to the Provide Device Control facility (see DFD 1.2) through process (e).

The above processes form a cohesive group from which only process (d) could be omitted without loss of facilities. This process is not needed where there are no other transportation services with which coordination has to be maintained.

Plan and Schedule Transit Services (DFD 4.2)

The processes in this DFD provide the Plan and Schedule Transit Services facility within the Manage Transit function. It includes the provision of both regular and demand responsive transit facilities. The term “transit services” is used as the collective name for transit routes and schedules. The key points about the facility are as follows:

* - transit service determination is initiated by the transit fleet manager and uses a variety of inputs;

* - transit service details are sent to other Manage Transit facilities and ITS functions;

* - transit service details are sent to other transit centers and multimodal transportation service providers;

* - transit service details are sent to Manage Archived Data function;

* - transit route details can be used to overlay route data onto existing digitized map data;

* - demand responsive transit facility provides personalized transport for travelers;

* - demand responsive transit services will use regular services where and when possible.

There are two DFDs and one process subordinate to this DFD. Overall functionality is divided between them in the following ways.

(a) Provide Demand Responsive Transit Service (DFD 4.2.1) - These processes provide the response to a traveler's request for a demand responsive transit service. This request is received from the Provide Driver and Traveler Services function and will therefore be made as part of a trip plan by the traveler. Details of the proposed service are sent back to the traveler for confirmation, after which they are sent to both the transit driver and the transit fleet manager.

(b) Provide Transit Plans Store Interface (4.2.2) - This process will provide the interface to the store of current regular transit plans, i.e., routes and schedules and demand responsive transit schedules. The process will enable the store to be used by the Demand Responsive Transit facility as a source of data about regular transit services when it is generating its schedules. The demand responsive transit schedule data will be accessible as input to the regular transit route and schedule generation processes.

(c) Generate Transit Routes and Schedules (DFD 4.2.3) - These processes determine the routes and schedules for regular transit services and output them to other processes within the Manage Transit and other ITS functions. The determination processes use parameters provided by the transit fleet manager, data from other transit centers (Other TRM) and multimodal transportation service providers, operational data from the current regular transit services, as well as the current regular transit routes and schedules, plus the most popular demand responsive transit services. New routes are always determined first and then new schedules applied to them. However new schedules can be determined for an existing set of routes. The route and schedule generation processes are run at the request of the transit fleet manager, but requests for the generation of new schedules can also come from parking lots to accommodate the fluctuating demands of park and ride (P+R) sites. Details of the new services are sent to the sources of input data listed above. They are also sent to other processes in this and other ITS functions. In some cases, this data may also be requested by these processes where it is possible that they have missed an update.

(d) Manage Transit Archive Data (4.2.4) - This process obtains transit passenger and deployment data, transit user payment transaction data, transit emergency data, transit security data, maintenance and personnel data, and distribute it to the Manage Archive Data function. The process runs when a request for data is received from an external source, or when fresh data is received.

The details of transit routes generated by processes in (c) can be used by other facilities as the background to transit data displays. They are also sent to the map update provider. This enables the provider to generate the route details in digitized form as part of the next map data update, and to provide transit route information by other means, such as printed transit maps, etc.

The processes are organized so that either the demand responsive transit or regular transit service determinations can be omitted from any particular implementation. To this end they each have their own separate communication links with the transit fleet manager and other ITS functions.

Provide Demand Responsive Transit Service (4.2.1)

The processes in this DFD provide the Provide Demand Responsive Transit Service facility within the Manage Transit function. The processes in this facility generate transit schedules that are tailored to the specific needs of travelers. The key points about the facility are as follows:

* - demand responsive transit services tailored to a traveler's needs are requested as part of trip plans;

* - demand responsive transit services will be integrated into regular transit services if possible;

* - demand responsive transit service is only activated after confirmation from the traveler;

* - demand responsive transit service details are made available for regular transit service generation.

There are six processes in this DFD. Overall functionality is divided between them in the following ways.

(a) Provide Demand Responsive Transit Trip Request (4.2.1.1) - This process will provide the interface through which processes in the Provide Driver and Traveler Service function can gain access to the Provide Demand Responsive Transit Service facility. The process will enable the interface to support the receipt of trip requests, their transfer to another process for the actual demand responsive schedule generation, the output of the proposed schedule and their (possible) subsequent confirmation. The process will store the input and schedule data relating to each request until such time as the request is confirmed or the data in the request is no longer valid, e.g. the time(s) used in the proposed schedule has(ve) passed. The confirmation of a particular schedule will be sent by the process to another process that will enable the schedule to be implemented.

(b) Compute Demand Responsive Transit Vehicle Availability (4.2.1.2) - This process will provide the facility for the calculation of the location and availability of transit vehicles for use in demand responsive transit operations. The process will base its calculation on the vehicle's current location and on the output from a process that determines vehicle availability from data input to sensors. The output will be loaded by the process into a store for use by another process.

(c) Generate Demand Responsive Transit Schedule and Routes (4.2.1.3) - This process will provide dynamic routing and scheduling of transit vehicles so that a demand responsive transit service can be provided. The generation of the specific route and schedule by the process will be initiated by a request from the management process. The choice of route and schedule produced by the process will depend on what other demand responsive transit schedules have been planned, the availability and location of vehicles, and the relevance of any regular transit routes and schedules. The process will send its output to another process for output to the requesting process, and will also load it into a data store for use if the schedule is later confirmed.

(d) Confirm Demand Responsive Transit Schedule and Route (4.2.1.4) - This process will provide output when a demand responsive transit schedule is confirmed. The outputs will contain details of the schedule and will be sent to the transit fleet manager and to processes that provide interfaces to the transit driver, a store of data used by the regular transit routes and schedule generation processes, and the transit driver schedule generation processes. The process will obtain the data for the outputs from the store of data provided by the schedule generation process.

(e) Process Demand Responsive Transit Vehicle Availability Data (4.2.1.5) - This process will manage data input to sensor(s) on board a transit vehicle. Data including the vehicle's availability for use in demand responsive transit services will be provided by this process to other processes within the Manage Transit function.

(f) Provide Demand Responsive Transit Driver Interface (4.2.1.6) - This process will provide the interface through which a transit driver will be sent instructions about the demand responsive transit schedule that has been confirmed. The process will send the data in a format that will enable the driver to implement the schedule. The output provided by the process will be available in audio or visual form in such a way that while alerting the driver to the information it contains, it will in no way impair the driver's ability to operate the vehicle in a manner that is both safe to its passengers, and to other vehicles on the roads and freeways. The input and output forms will also include those that are suitable for travelers with physical disabilities.

The request from the traveler for a demand responsive transit service originates in the Provide Driver and Traveler Services function and is received by process (a). It is passed to process (c) which generates details of the service, using details of the regular transit services, plus the vehicle availability provided through processes (b) and (e). Details of the newly generated service are sent back to the traveler through process (a) and are stored to await confirmation. This is again received by process (a) which passes it on to process (d). This generates the data for the transit driver, the transit fleet manager, the Generate Transit Driver Schedules facility - see DFD 4.5, and for loading into a store for use by the Generate Transit Routes and Schedules facility - see DFD 4.2.3 below.

The processes above form a cohesive group. They have their own links to other ITS functions and only require a link to the store of regular transit services within the Manage Transit function. However it would be possible for these processes to operate without reference to the regular transit services if coordination with their activities is not required.

Generate Transit Routes and Schedules (DFD 4.2.3)

The processes in this DFD provide the Generate Transit Routes and Schedules facility within the Manage Transit function. The processes in this facility generate new routes and schedules for regular transit operations. The key points about the facilities that these processes provide are as follows:

* - transit service determination is initiated by the transit fleet manager;

* - transit service determination uses data from many sources;

* - transit schedule determination can be initiated from parking lots to suit park and ride (P+R) needs;

* - transit services data is automatically output to other service providers and Manage Transit facilities;

* - transit services data is automatically output to the Manage Archived Data function;

* - transit services data is available for use by other ITS functions on request.

There are nine processes in this DFD. Overall functionality is divided between them in the following ways.

(a) Generate Transit Routes (4.2.3.1) - This process will generate new transit routes. The process will use parameters set up by the transit fleet manager, operational data for the current routes and schedules, plus the current routes and digitized map data, as sources of input from which the new routes are generated. The process will also use the requested input data containing the demand responsive transit routes and schedules. The generation of new routes by the process will be initiated as a result of data received from the transit fleet manager interface process, with the output being sent to other processes for storage. The output data produced by the process will include sufficient data for a specialist map data provider to generate maps showing transit routes and stops, either as separate data or as part of the general digitized map data provided to other ITS functions.

(b) Generate Schedules (4.2.3.2) - This process will generate new transit schedules for use by the regular transit operation. The process will use parameters set up by the transit fleet manager, operational data for the current routes and schedules, plus the current routes and schedules themselves, as sources of input from which the new schedules are generated. The process will also use the data containing the demand responsive transit routes and schedules to generate the new schedules. The generation of new schedules by the process will be initiated as a result of data received from the transit fleet manager interface process or a request for services to a parking lot. The process will send its output to another process for storage.

(c) Produce Transit Service Data for External Use (4.2.3.3) - This process will obtain transit routes and services data and distribute it to ITS functions that are outside the transit center. The process will run when a request for data is received from an external source, or when fresh data is received. In the latter case, the data will only be sent by the process to the multimodal transportation service provider. For data requests that include an origin and a destination, the process will only provide details of the transit service(s) that link the two points. The details will only cover those portion(s) of the service(s) that are needed to complete the requested trip and not full details of the services.

(d) Provide Transit Fleet Manager Interface for Services Generation (4.2.3.4) - This process will provide the interface through which the transit fleet manager controls the generation of new routes and schedules (transit services). The transit fleet manager will be able to review and update the parameters used by the routes and schedules generation processes and to initiate these processes. This process will also act as the interface through which the Manage Demand facility in the Manage Traffic

function can request changes to the current routes and schedules in its efforts to adjust the modal split of travelers' trips in order to make the most efficient use of the road and highway network served by the local ITS functions. The input and output forms will include those that are suitable for travelers with physical disabilities.

(e) Manage Transit Operational Data Store (4.2.3.5) - This process will collect transit operational data and load it into a data store for use by the routes and schedules generation processes. The data will be provided to this process by other processes in the Manage Transit function and will enable an accurate picture of how routes and schedules are currently operating in terms of the numbers of vehicles that are available, the numbers of passengers that they are carrying, and the numbers of passengers passing through each roadside facility (transit stop).

(f) Produce Transit Service Data for Manage Transit Use (4.2.3.6) - This process will obtain transit routes and services data and distribute it internally to other processes in the Manage Transit function. The process will only provide its outputs when fresh data is received from another process. If this does not happen for a long period of time (days), then the process will initiate its own request for fresh data.

(g) Provide Interface for Other TRM Data (4.2.3.7) - This process will provide the interface through which transit routes and schedules can be exchanged with other transit centers (Other TRM). This data will be output when data is received from another (local) process and will enable coordination between services provided by adjacent transit operations, particularly where they serve the same geographic areas. The process will also provide routes and schedules to the local process when the data is received from other transit centers.

(h) Provide Interface for Transit Service Raw Data (4.2.3.8) - This process will provide and manage the interface to the store in which the raw transit service data is held. This data will be sent to the process by the routes and schedules generation processes, which are the only other processes permitted to access the store, and then in read-only mode. The received data will be loaded into the store and distributed by this process to the three processes that are responsible for distributing the data within the transit center (TRM), to other local ITS functions, and to other transit centers (Other TRM), respectively. The process will read data from the store and return it to whichever of the other three processes has made a data request. Data will also be received by the process from other transit centers (Other TRM) and from multimodal transportation service providers. The process will load this data into the data store for use by the local route and schedule generation processes.

(i) Update Transit Map Data (4.2.3.9) - This process will provide updates to the store of digitized map data used by the transit route generation process and as the background for displays of transit services requested by the transit fleet manager. The process will obtain the new data from a specialist data supplier or some other appropriate data source, after receiving an update request from the transit fleet manager interface process within the function. The processes requiring data for use in transit route generation and as the background to displays will read the data from the store loaded by this process.

Transit routes and schedules are generated by processes (a) and (b), at the instigation of the transit fleet manager through process (d). They use data from the stores of operational data provided by process (e), parameters provided by the fleet manager through process (d), the most popular demand responsive transit services, and the current regular transit routes and schedules. The results are sent to the store of raw routes and schedules data through process (h). Data about transit services is automatically sent to other parts of the function through process (f), and on request to other ITS functions through process (c). The exchange of service data with other transit centers is provided through process (g) and only takes place when a new set of services is generated. Transit map data is updated in process (i) from data received from process (d), and placed in a data store for use by other processes in the Manage Transit function.

The determination of routes and schedules for use by the regular transit operation also takes into account data provided by other transit centers and multimodal transportation service providers. This is designed to achieve coordination between geographically adjacent transit operations areas, and between transit and other types of passenger service provision, e.g., heavy rail, ferries and airlines.

Schedule Transit Vehicle Maintenance (DFD 4.3)

The processes in this DFD provide the Schedule Transit Vehicle Maintenance facility within the Manage Transit function. These processes enable transit vehicle maintenance to be scheduled and monitored, and for the work to be assigned to maintenance technicians. The key points about the facility are as follows:

* - maintenance is scheduled from operational data collected by the transit vehicles;

* - maintenance schedules include the assignment of technicians to carry out specific tasks;

* - the transit fleet manager has ultimate control over all maintenance activities.

There are seven processes in this DFD. Overall functionality is divided between them in the following ways.

(a) Monitor Transit Vehicle Condition (4.3.1) - This process will monitor the condition of a transit vehicle. It will use the transit vehicle maintenance specification to analyze brake, drive train, sensors, fuel, steering, tire, processor, communications equipment, and transit vehicle mileage to identify mileage based maintenance, out-of-specification or imminent failure conditions. The data resulting from this analysis will be loaded by the process into the store of transit vehicle operations data, through the output flow transit vehicle maintenance. This data is then sent to the process that generates transit vehicle maintenance schedules.

(b) Generate Transit Vehicle Maintenance Schedules (4.3.2) - This process will generate transit vehicle maintenance schedules and includes what and when maintenance or repair is to be performed. Transit vehicle availability listings (current and forecast) will also be generated by the process to support transit vehicle assignment planning. The maintenance and/or repair that is to be performed on the transit vehicle will be scheduled by the process for a specific month, week, day(s), and hour(s). The availability of the transit vehicle that is also output by the process will be based upon the transit vehicle maintenance schedule. The process will load each transit vehicle maintenance schedule that it produces into the store of transit vehicle operations data, through the process that maintains this data store.

(c) Generate Technician Work Assignments (4.3.3) - This process will assign transit maintenance personnel to a transit vehicle maintenance schedule. The maintenance schedule will be received from another process and will define what and when maintenance repair is to be performed to a specific transit vehicle. The process will base the personnel assignment upon details about the personnel obtained from the transit fleet manager and held in a local data store. These details will comprise personnel eligibility, work assignments, preferences and seniority. The process will also provide these details to the transit fleet manager on request. When a work assignment has been generated, the process will send it to the transit maintenance personnel and also to the process that monitors and verifies maintenance work activity. The input and output forms will include those that are suitable for travelers with physical disabilities.

(d) Monitor and Verify Maintenance Activity (4.3.4) - This process will verify that the transit vehicle maintenance activities were performed correctly and that a time stamped maintenance log for record keeping was generated. The correctness of the maintenance activities will be judged by the process against the transit vehicle's status, the maintenance personnel's work assignment, and the transit maintenance schedules produced by other processes. The process will save a time stamped record of all the maintenance activities performed on the vehicle into the transit vehicle maintenance log.

(e) Report Transit Vehicle Information (4.3.5) - This process will provide the transit fleet managers with the capability of requesting and receiving transit vehicle maintenance information. The process will obtain the data for each request from the store of transit vehicle operations data, through the process that manages the data store, and will produce the output to the transit fleet manager in an easily understood form. The input and output forms will include those that are suitable for travelers with physical disabilities.

(f) Update Transit Vehicle Information (4.3.6) - This process will provide the transit maintenance personnel with the capability to update transit vehicle maintenance information. The process will send the data received from the transit maintenance personnel to the transit vehicle operations data store management process for use by other processes.

(g) Manage Transit Vehicle Operations Data Store (4.3.7) - This process will manage the store of transit vehicle operations data. It will be able to load data it receives about vehicle maintenance into the store and provide that data on request to other processes.

The current transit vehicle condition is provided to process (a), which compares it against the vehicle's maintenance specifications obtained from the store of transit vehicle operations data managed by process (g). When maintenance is found to be required, data is sent to process (b) which generates the maintenance schedules. These are passed to process (c) which assigns the work to a particular technician according to their availability and skills. Process (d) monitors the state of the maintenance activity from the vehicle status and receives updates from the maintenance technician through process (f) and the transit vehicle operations data store managed by process (g). It sends the results back to process (c) to enable the technician to be assigned new work. The transit fleet manager can monitor the state of maintenance activity using the data in the transit vehicle operations data store and update vehicle maintenance specifications through process (e). The above processes form a tightly coupled group, although they are able to operate independently.

Support Security and Coordination (DFD 4.4)

The processes in this DFD make up the Support Security and Coordination facility within the Manage Transit function. These processes enable incidents that occur either on-board transit vehicles or in other parts of the transit network to be reported and actions coordinated with the emergency services. The key points about the facility are as follows:

* - transit system operators can monitor and respond to incidents detected in the transit system;

* - details of incidents are sent to the Manage Emergency Services function for a response;

* - transit fleet managers can define responses to incidents and the way activities are coordinated;

* - incidents may be reported by transit drivers and users, or detected by sensors in the transit system;

* - information about incidents is automatically passed to the media.

There are two processes and a DFD subordinate to this DFD. Overall functionality is divided between them in the following ways.

(a) Provide Transit Security and Emergency Management (DFD 4.4.1) - These processes collect incident and emergency notification data from both transit vehicles and from fixed facilities within the transit operations network. This data may be generated by transit users or transit drivers on-board transit vehicles recognizing that an incident or emergency has occurred. It may also be produced by the analysis of video image and transit user input from fixed facilities such as transit stops and modal interchange points. The data is sent to the transit system operator, to process (b) below for the coordination of response activities, and is also made available for use by the media. Acknowledgment of the receipt of the original incident or emergency notification data is sent back to the transit user and/or driver.

(b) Coordinate Multiple Agency Responses to Incidents (4.4.2) - This process will provide transit fleet managers with an interface through which they can control the coordination data sent to the Manage Emergency Services function following the detection of a security problem or emergency within the transit operations network by other processes. The process will use data from the store of predefined responses to security problems and emergencies in the outputs that it sends to the Manage Emergency Services function. If no match can be found then the process will send all the available data to the transit fleet manager for action. The input and output forms will include those that are suitable for travelers with physical disabilities.

(c) Generate Responses for Incidents (4.4.3) - This process will provide the interface through which the transit fleet manager can enter and review predefined responses to security problems and emergencies that have been detected by other processes within the Manage Transit function. This data will be stored in a form which can be used by another process to provide coordination data to the Manage Emergency Services function. The input and output forms will include those that are suitable for travelers with physical disabilities.

The incident and emergency data obtained by the processes in (a) is passed to process (b). This is responsible for coordinating activities with the emergency services and uses a pre-planned sequence of activities prepared by the transit fleet manager. If there are no pre-planned activities to suit a particular incident or emergency, the fleet manager will be prompted to provide the activities in real time. These processes may be implemented as a single coordinated group. For some implementations, process (c) may be omitted so that the transit fleet manager must always actively participate in the response to incidents and emergencies.

Provide Transit Security and Emergency Management (4.4.1)

The processes in this DFD make up the Provide Transit Security and Emergency Management facility within the Manage Transit function. The processes respond to notifications of incidents and emergencies, and make the data available for activity coordination and use by the media. The key points about the facility are as follows:

* - incidents and emergencies are detected on transit vehicles and in fixed facilities;

* - a media interface is provided for the output of messages about incidents and emergencies;

* - traffic system operators are involved in the response actions for all incidents and emergencies.

There are eight processes in this DFD. Overall functionality is divided between them in the following ways.

(a) Manage Transit Security (4.4.1.1) - This process will manage the security in the transit system by monitoring for potential incidents. Data will be obtained by the process from a variety of sources and assessed for any security problems. Problems will be passed by the process to the transit system operator for review and the required action. Information about incidents will also be sent by this process to another process for output to the media, using interface parameters set up by the transit system operator.

(b) Manage Transit Emergencies (4.4.1.2) - This process will support the management of emergencies that occur in the transit system by processing information received from transit vehicles. The process will accept inputs from either the transit vehicle driver or a transit user, the latter through such interfaces as panic buttons, alarm switches, etc. The reported emergencies will be sent to another process for action by the transit system operator and subsequently for output to the media. The process will also send acknowledgment data to the process providing the interface to the transit driver.

(c) Provide Transit System Operator Security Interface (4.4.1.3) - This process will provide an interface for the transit system operator to identify and act upon potential information security problems and emergencies. This information will be provided by other processes through input data

flows. This process will also provide the capability for the transit system operator to update parameters that control the output of data about the potential security problems to the media. The input and output forms will include those that are suitable for travelers with physical disabilities.

(d) Provide Transit External Interface for Emergencies (4.4.1.4) - This process will provide the interface through which information about security problems and emergencies detected within the transit system are distributed directly to the media and other information systems. This process will construct its output from the data supplied by other processes. This data will contain parameters that define the way (format, content, etc.) in which the information is output by the process. The input and output forms will include those that are suitable for travelers with physical disabilities.

(e) Provide Transit Driver Interface for Emergencies (4.4.1.5) - This process will provide an interface to the transit vehicle through which the driver can both report an emergency situation and receive an acknowledgment. The process will provide this interface in such a way that its operation for both inputs and outputs will be transparent to transit users on board the vehicle and to anyone outside the vehicle, and will not compromise the safe operation of the vehicle by the driver.

(f) Collect Transit Vehicle Emergency Information (4.4.1.6) - This process will collect data about emergencies that occur on-board transit vehicles for output to the media and the Manage Emergency Services function. These emergencies may be reported by either the transit driver or a transit user, the latter through such interfaces as panic buttons, alarm switches, etc. For output to the media interface process, the data will be combined with the data in the media interface parameters data store.

(g) Monitor Secure Area (4.4.1.7) - This process will monitor the secure area environment. Data will be obtained by the process from a variety of sources and assessed for any security problems. Problems will be passed by the process to other processes for review and the required action. Information about incidents will also be sent by this process to another process for output to the media, using interface parameters set up by the transit system operator. The process will also provide facilities for the control of video cameras and audio output in the secure area environment.

(h) Report Traveler Emergencies (4.4.1.8) - This process will provide an interface in the Provide Driver and Traveler Services function through which travelers can declare emergencies. The traveler may be at a kiosk or other device, transit stop, transit depot, etc. The input and output forms will include those that are suitable for travelers with physical disabilities.

Incidents in fixed facilities and emergencies on-board vehicles are detected by processes (a) and (b). They rely on input to sensors, input from panic buttons which can be activated by travelers, transit users, video image input (process (a) only, via processes (g) and (h)), or for process (b) input from the transit vehicle driver, via process (e). The transit system operator is kept informed of all these inputs via process (c), and can change the parameters used to set up data for output to the media and control the video images. The data about the incident or emergency is output by processes (a) and (b) to the coordination process in the Support Security and Coordination facility - see DFD 4.4. These processes also send an acknowledgment of receipt of the input to its source, this again being via process (e) for the transit vehicle driver. Process (f) is used to collect transit emergency information from the other processes in this DFD, and place it in a data store. Process (d) receives this data and distributes it to the media and to the Provide Driver and Traveler Services function for use by the traveler – see DFD 6.

The above processes may be implemented as a single coordinated group or in part. For any individual implementation, process (a) or (b) and (e) may be omitted. Alternatively process (d) may be omitted from any implementation involving a combination of the others.

Generate Transit Driver Schedules (DFD 4.5)

The processes in this DFD make up the Generate Transit Driver Schedules facility within the Manage Transit function. These processes produce transit driver work assignments based on such things as previous work history and seniority. The key points about the facility are as follows:

* - the transit fleet manager can manage the allocation of transit drivers to routes and schedules;

* - transit drivers' allocation depends on performance, cost effectiveness, preferences, and availability;

* - transit driver allocations are provided for both regular and demand responsive (paratransit) services.

There are eight processes in this DFD. Overall functionality is divided between them in the following ways.

(a) Assess Transit Driver Performance (4.5.1) - This process will assess the transit driver's performance at previous work assignments. The process will carry out this activity by 1) utilizing standardized performance evaluation criteria set forth by governmental regulations and transit operating company policies, 2) assessing the transit driver's driving history, and 3) assessing comments from the transit driver's supervisor(s). It will also use the details of any moving violations or accidents, supervisor comments, government regulations, and company policies. The data will be sent to this process by the process that provides the interface to a local data store, each time that the store is updated with driver performance data.

(b) Assess Transit Driver Availability (4.5.2) - This process will assess the transit driver's availability based on previous work assignments plus health and vacation commitments. The process will carry out this activity by 1) utilizing standardized transit driver work criteria set forth by governmental regulations and company policies, 2) monitoring the transit driver's health status and vacation status, and 3) monitoring the transit driver's accumulated work hours. The data will be sent to this process by the process that provides the interface to a local data store, each time that the store is updated with driver availability data.

(c) Assess Transit Driver Cost Effectiveness (4.5.3) - This process will assess the transit driver's cost effectiveness when carrying out previous work assignments. The process will perform this activity by 1) utilizing standard transit driver cost criteria set forth by governmental regulations and company policies, and 2) monitoring the transit driver's hourly wage and accumulated work hours. The data will be sent to this process by the process that provides the interface to a local data store, each time that the store is updated with driver cost effectiveness data.

(d) Assess Transit Driver Eligibility (4.5.4) - This process will assess the transit driver's eligibility for future work assignments. The process will carry out this activity by 1) monitoring the transit driver's performance, availability and cost effectiveness, 2) utilizing standardized transit driver eligibility criteria set forth by governmental regulations and company policies, and 3) ensuring that the transit driver has the required experience, education and certifications. The data will be sent to this process in one of two ways: 1) by the process that provides the interface to a local data store, each time that the store is updated with driver eligibility data, or 2) the data is produced as the result of analysis work carried out by other processes within the Manage Traffic function.

(e) Generate Transit Driver Route Assignments (4.5.5) - This process will assign transit drivers to transit schedules. The transit driver's eligibility, route preferences, seniority, and transit vehicle availability will be used by the process to determine the transit driver's route assignment. The output produced by the process will be sent to the transit driver in the form of the next work assignment. The input and output forms will include those that are suitable for travelers with physical disabilities.

(f) Update Transit Driver Information (4.5.6) - This process will provide the interface through which the transit driver can input data to the store of transit driver information. The interface provided by this process will enable the transit driver to update personal availability and route assignment information. The input and output forms will include those that are suitable for travelers with physical disabilities.

(g) Report Transit Driver Information (4.5.7) - This process will provide the interface between the transit fleet manager and the store of driver information. The interface provided by the

process will enable the fleet manager to review and update transit driver information. The input and output forms will include those that are suitable for travelers with physical disabilities.

(h) Provide Transit Driver Information Store Interface (4.5.8) - This process will provide the read and write interface to the store of transit driver information. The interface enables the contents of the store to be updated with inputs received from the transit driver and transit fleet manager via other processes, as well as, inputs resulting from analysis of driver availability, cost effectiveness, eligibility, and performance carried out by other processes. The process will also supply data to these processes when the store is updated with information from the transit driver and fleet manager. It will also supply data to the process that generates driver route assignments when any of the analysis inputs is received.

Transit driver route assignments are produced by the process in (e). This uses the data from the store of transit driver information, managed by process (h), to match drivers with the routes and schedules provided by the Plan and Schedule Transit Services facility. It runs when it receives a new set of regular or demand responsive (paratransit) transit services. The data in the store of transit driver information is updated as a result of data being supplied by the transit fleet manager through processes (f) and (g). When process (h) loads the data into the store, it also sends the data to each of the processes (a) through (d) for analysis. These processes return the results of their analysis to process (h), which when they are all done will send the resulting complete set of data to process (e) to generate a new set of assignments.

The above processes may be implemented as a single coordinated group or in a reduced form leaving out some or all of processes (a) through (d). The result of the omission of some or all of these processes will be to reduce the factors that are taken into account when making transit driver route assignments.

Collect Transit Fares in the Vehicle (DFD 4.6)

The processes in this DFD make up the Collect Transit Fares in the Vehicle facility within the Manage Transit function. These processes collect payment from transit users as they board transit vehicles for the service(s) that they require. The key points about the facility are as follows:

* - transit vehicle fare collection is provided without transit users needing to be stopped as they board;

* - fare processing can be interactive, or as a batch when the vehicle reaches a convenient point;

* - advanced payment of transit fares, tolls and parking lot charges are supported.

The are eight processes in this DFD. Overall functionality is divided between them in the following ways.

(a) Detect Transit User on Vehicle (4.6.1) - This process will detect embarking transit users on-board a transit vehicle and read data from the payment instrument that they are carrying. The process will provide an image of all transit users which will be used for violation processing of those who do not have a payment instrument or whose transit fare transaction fails. It will obtain an image of the required accuracy under all lighting conditions and over the range of speeds with which transit users will pass through the fare collection point on a transit vehicle.

(b) Determine Transit User Needs on Vehicle (4.6.2) - This process will determine the transit user's travel routing based on the transit vehicle's current location and the user's destination. The process will support the transit user's routing, enabling it to include travel on the vehicle for all or part of its route and (possibly) transfer to another vehicle on another route. In order to achieve this capability, the process will have access to the complete range of transit services (routes and schedules) that are available to the transit user. The transit vehicle's location will be provided by other processes within the Manage Transit function. Details of all transactions with the transit user's payment details removed, will be sent by this process to the interface process for loading into a data store.

(c) Determine Transit Fare on Vehicle (4.6.3) - This process will calculate the transit user's fare based on the origin and destination provided by the user. The process will calculate the fare using the

transit routing, transit fare category, and transit user history components of the ride data, in addition to information provided by the interface process for the transit fares data store. The accumulated data will be sent by this process to another process for the actual implementation of the fare payment transaction.

(d) Manage Transit Fare Billing on Vehicle (4.6.4) - This process will manage the transit user fare payments on-board a transit vehicle. The process will receive information about the fare that is to be paid and the method of payment adopted by the transit user. It will always support two modes of operation to complete the back end financial processing: infrastructure interactive, or semi-autonomous batch processing. The interactive method will be used for individual transactions, such as those in paratransit type operations where value/volume ratios are high. It will send transit user fare payment data to processes in the Provide Electronic Payment Services function for financial authorization and transaction processing, plus the return of the result for display to the transit user. A failed transaction will result in the transmission of an image of the transit user to another process. Batch processing will be used by the process for routes where value/volume ratios are low. It will be performed using all the same data flows and processes as in the interactive method, except that transaction records are queued in a transaction buffer store which will be maintained by this process. The accumulated data for the fare transactions will be sent to the Provide Electronic Payment Services function on command from the transit vehicle driver, or when the transit vehicle has reached a convenient point on its route. The transit vehicle driver will be notified when batch processing has completed successfully. In either mode of operation, a record of the status of all transit fare processing will be sent to an interface process for the fare collection storage database.

(e) Provide Transit User Fare Payment Interface on Vehicle (4.6.5) - This process will provide the fare payment interface for the transit user on-board a transit vehicle. The process will prompt the transit user for information necessary that has not been provided for the transaction. The result of the transit service ride fare payment plus other services request and payment, will be reported back to the transit user by the process. The input and output forms will include those that are suitable for travelers with physical disabilities.

(f) Update Transit Vehicle Fare Data (4.6.6) - This process will provide a database on-board the transit vehicle for use in fare processing. The database will contain transit fare information from which the fares for all possible trips within the transit operational network can be determined.

(g) Provide Transit Vehicle Passenger Data (4.6.7) - This process will provide passenger loading and fare statistics data to other ITS functions. The process will send the data automatically at regular periodic intervals using data collected in the store of fare transaction data. This store receives data from the process that interfaces to the user on-board a transit vehicle.

(h) Manage Transit Vehicle Advanced Payments (4.6.8) - This process will act as the interface for advanced payment of tolls and parking lot charges from the transit user. Requests for these advanced payments will be passed to other processes in the Provide Electronic Payment Services function for transaction processing. The process will ensure that the response to these requests from transit users is returned to the transit vehicle from which it was made.

Detection of a transit user by process (a) and the collection of the desired destination data by process (e) enables the transit fare to be calculated by processes (b) and (c). This data is passed to process (d) which determines whether the payment will be processed interactively, i.e., as transit users board the vehicle, or as a batch. Batch processing will take place either when the vehicle reaches a convenient point on its route or at the request of the transit driver. In both cases the tag data provided by the transit user will be checked against the list of bad payers requested by process (d) from the Provide Electronic Fare Collection facility of the Provide Electronic Payment Services function - see DFD 7.3. If a match is found, the transit user is informed and the payment transaction is aborted. Transit users are also informed of the successful completion of a payment transaction.

The selection of the appropriate fare processing option is made by the transit vehicle driver. Failure of the transfer of data for batch processing will be notified to the driver who can then request a re-

transmission of the data. These two fare processing options are provided to enable the optimum use of the vehicle to the central transit management facility communications network. Thus for example, in urban environments where there may be many transit users boarding vehicles, the batch mode of processing will be employed, while in rural environments or for demand responsive transit operation, where the number of users may be less frequent, interactive processing can be used. The actual fare payment processing will be carried out by processes in the Provide Electronic Fare Collection facility of the Provide Electronic Payment Services function - see DFD 7.3. Facilities for transit users to pay for transit fares, tolls and parking lot charges in advance are also provided through process (e) and (advanced payments only) process (h). Processes (f) and (g) are used to manage data stores containing information about transit fares and transit passengers and trips.

The above processes are intended to be implemented as a single coordinated group. However some of the interfaces in process (e) could be omitted if only transit fare processing is to be provided, and the reporting process (g) could also be left out if its functionality is not required by a particular transit operation.

Provide Transit User Roadside Facilities (DFD 4.7)

The processes in this DFD make up the Provide Transit User Roadside Facilities facility within the Manage Transit function. These processes provide transit users at the roadside with information and the collection of payment for services that they require. The key points about the facility are as follows:

* - transit users can request transit service information and can receive data about approaching services;

* - transit fares can be collected at the roadside before transit users board a vehicle.

There are two DFDs subordinate to this DFD. Overall functionality is divided between them in the following ways.

(a) Provide Transit User Roadside Information (DFD 4.7.1) - These processes enable the transit user to request information about transit services from the roadside, and to receive information about approaching transit vehicles. The transit service information may relate to any of the current transit services and will not necessarily be restricted to those that are available from the roadside location at which the request is made. The data about approaching transit vehicles will be automatically transmitted from the vehicles and will provide data about the vehicle's expected time of arrival and the service it is operating. This will enable transit users to make best use of their time, and may enable them to do other things while waiting for the approaching transit vehicle to arrive.

(b) Collect Transit Fares at the Roadside (DFD 4.7.2) - These processes enable transit fares to be collected at the roadside before transit users board the vehicle. The processes operate together in much the same way as those performing a similar function on-board the transit vehicle. They also enable the transit user to obtain information about and pay for other (yellow pages) services, and to pay for tolls and parking lot charges in advance.

These two sets of processes can be implemented independently at some or all roadside locations. They could share the same physical facilities such as power supply, communications interface, and be located within the same roadside physical structure.

Provide Transit User Roadside Information (DFD 4.7.1)

The processes in this DFD make up the Provide Transit User Roadside Information facility within the Manage Transit function. These processes enable transit users at the roadside to request information about transit services and obtain information about approaching transit vehicles. The key points about the facility are as follows:

* - data about transit services in general can be requested by transit users;

* - data from on-board approaching transit vehicles is automatically output to the transit user;

* - data is stored locally in case contact with the transit vehicle is lost and to avoid repetitive requests;

There are two processes in this DFD. Overall functionality is divided between them in the following ways.

(a) Provide Transit User Roadside Data Interface (4.7.1.1) - This process will communicate with the Transit Management Center (TRMC) by providing public transit information at roadside locations. These locations may consist of transit vehicle stops or other locations that provide general public transit information. The process will enable the roadside unit to obtain information about the transit services on request from the local transit user interface process and to receive data about late running services from other processes within the Manage Transit function. The received data will be loaded into a local data store for future use. The input and output forms will include those that are suitable for travelers with physical disabilities.

(b) Provide Transit User Roadside Vehicle Data Interface (4.7.1.2) - This process will provide the roadside (transit stop) interface through which transit users receive information about an approaching transit vehicle or one that has already arrived. The process will output the data to the transit user as soon as it is received and will load the data into the local store for future use. Output of the data will be maintained until the vehicle leaves the stop, when the process will cease output of the data and delete it from the local store. The input and output forms will include those that are suitable for travelers with physical disabilities.

The above processes are intended to be implemented as a single coordinated group. Transit users can request information about transit services through process (a), and automatically receive information from transit vehicles that are approaching the roadside location through process (b). The transit service information is obtained from the Transit Management Center by process (a). The transit vehicle information will provide details such as destination and expected time of arrival at the roadside location. All received data is stored and can be used again for subsequent requests if it is still relevant, i.e., the vehicle has not reached the roadside location. This enables data to be displayed even if contact with the vehicle is temporarily lost (the expected time of arrival would be omitted), or to avoid repetitive requests for the same transit service data by process (a). For some implementations it would be possible to omit process (b) if this facility was not required.

Collect Transit Fares at the Roadside (DFD 4.7.2)

The processes in this DFD make up the Collect Transit Fares at the Roadside facility within the Manage Transit function. These processes collect payment from transit users at the roadside for the service(s) that they require. The key points about the facility are as follows:

* - transit fare collection is provided without transit users needing to stop;

* - fare processing is interactive as the transit users pass through the roadside location;

* - transit users may request and pay for other (yellow pages) services;

* - advanced payment of transit fares, tolls and parking lot charges is supported.

The are seven processes in this DFD. Overall functionality is divided between them in the following ways.

(a) Detect Transit User at Roadside (4.7.2.1) - This process will detect transit users embarking at a roadside transit stop and read data from the payment instrument that they are carrying. The process will provide an image of all transit users which will be used for violation processing of those who do not have a payment instrument or whose transit fare transaction fails. It will obtain an image of the required accuracy under all lighting conditions and over the range of speeds with which transit users will pass through the fare collection point at the roadside, i.e., a transit stop.

(b) Determine Transit User Needs at Roadside (4.7.2.2) - This process will determine the transit user's travel routing based on the user's destination and the location of the roadside transit stop from which the route request is being made. The process will support the transit user's routing enabling it to include travel on all or part of the route(s) operating from the stop and (possibly) transfer to another route. In order for this to be achieved, the process requires access to the complete range of transit services (routes and schedules) that are available to the transit user. Details of all transactions with the transit user's payment details removed, will be sent by this process to the interface process for loading into the transit roadside fare collection data store.

(c) Determine Transit Fare at Roadside (4.7.2.3) - This process will calculate the transit user's fare based on the origin and destination provided by the user. The process will calculate the fare using the transit routing, transit fare category, and transit user history components of the ride data together with data provided by the interface process to the database of transit fares. The accumulated data will be sent by the process to another process for the actual implementation of the fare payment transaction.

(d) Manage Transit Fare Billing at Roadside (4.7.2.4) - This process will generate the data necessary to enable the financial transaction between the transit user and the transit provider to be completed at the roadside, i.e., at a transit stop. The process will accept and process current transit passenger fare collection information. The process will perform the front end transaction between the transit user and the transit system, and use the infrastructure interactive mode of operation to complete the back end processing. This means that the process will send data about each transaction to processes in the Provide Electronic Payment Services function for the back end financial authorization and transaction processing. The process will then await the return of the result for display to the transit user before accepting the next transaction. A failed transaction will result in the transmission of an image of the transit user to another process. A record of the status of all transit fare processing will be sent to another process for storage in a fare collection database.

(e) Provide Transit User Roadside Fare Interface (4.7.2.5) - This process will provide the interface for the transit user at the roadside, i.e., at a transit stop. The interface will enable the transit user to specify the required destination of a transit service ride and request other (yellow pages) services. The process will prompt the transit user for information necessary for the transaction that has not been provided. The result of the transit service ride fare payment plus other services request and payment, will be reported back to the transit user by the process. The input and output forms will include those that are suitable for travelers with physical disabilities.

(f) Update Roadside Transit Fare Data (4.7.2.6) - This process will provide a database at the roadside, i.e., a transit stop, for use in fare processing. The database will contain transit fare information from which the fares for all possible trips within the transit operational network can be determined.

(g) Provide Transit Roadside Passenger Data (4.7.2.7) - This process will create passenger loading and fare statistics data based upon data collected at the roadside and send this data to the store of transit operations data. The process may send the data at regular periodic intervals, on-demand, or through some other trigger mechanism. The process will create its outputs using information collected in the store of fare transaction data. This data is received from other processes at the roadside, i.e., at a transit stop.

Detection of a transit user passing through the roadside facility by process (a) and the collection of the desired destination data by process (e) enables the transit fare to be calculated by processes (b) and (c). This data is passed to process (d) which sends the data to the Transit Management Center for payment processing. This is always carried out interactively as even with large numbers of transit users, there should be no constraints on the communications with the Transit Management Center that there would be with a transit vehicle. Interactive processing also enables the images of all users making invalid payments to be obtained. Facilities for transit users to pay for transit fares, tolls and parking lot charges in advance are also provided through process (e). Processes (f) and (g) are used to manage data stores containing information about transit fares and transit passengers and trips obtained at the roadside.

The above processes are intended to be implemented as a single coordinated group. However some of the interfaces in process (e) could be omitted if only transit fare processing is to be provided, and the reporting process (g) could also be left out if its functionality is not required by a particular transit operation.

1.6.1.6. Manage Emergency Services (DFD 5)

This DFD shows the processes that provide the Manage Emergency Services function. This function is responsible for the management of the emergency services' response to incidents and communications with law enforcement agencies. The key points about the function are as follows:

* - ITS functions can automatically call-out appropriate emergency services to an incident;

* - confirmation of response action is provided to the emergency services operator;

* - emergency telephone and E911 systems can call-out appropriate emergency services to an incident;

* - information about incidents can be exchanged with the Manage Incidents facility;

* - emergency vehicles can be provided priority routing (e.g."green waves") along their routes to an incident;

* - incident responses can be coordinated with other Emergency Management Systems;

* - ITS functions provided with access to law enforcement agencies for action on violations.

There are two processes and three DFDs in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Provide Emergency Service Allocation (5.1) - these processes allocate emergency services in response to requests received from a range of inputs, including other ITS functions, plus Emergency Telecommunications Systems, and other Emergency Management Systems. The basis for the allocation process is predefined criteria, which the emergency services operator has the facility to set up and override - see process (b). If there are no criteria to fit an incident, then using process (b) the operator is requested to provide the required allocation.

(b) Provide Operator Interface for Emergency Data (5.2) - this process is responsible for providing the emergency services operator with an interface to the other processes in the Manage Emergency Services function.. The process will enable the operator to review and update the data used to allocate emergency services to incidents, applying temporary overrides to current emergency service allocations to suit the special needs of a current incident, and requesting output of the log of emergency service actions. It will also enable the output of a message showing the failure of an emergency vehicle dispatched in response to an incident. This output will override all other outputs. The process will support inputs from the emergency services operator in both manual and audio form, and will provide its outputs in audible and visual forms. The visual output may appear in either hardcopy or as a display, or both, and an audible output will accompany the emergency vehicle dispatch failure message.

(c) Manage Emergency Vehicles (5.3) - these processes are responsible for the management of emergency service vehicles when they are dispatched to an incident. The most appropriate vehicle(s) will be dispatched with instructions to emergency personnel about the incident to which the response is being directed. Once at the incident, emergency personnel can report back with updates on the progress being made with the incident response.

(d) Provide Law Enforcement Allocation (5.4) - these processes are responsible for allocating violation data produced by other ITS functions to the appropriate law enforcement agency so that prosecution of offenders may result.

(e) Update Emergency Display Map Data (5.5) - this process is responsible for providing updates to the store of digitized map data used as the background for displays of incidents and emergencies produced by processes in the Manage Emergency Services function. The process will obtain the new data from a specialist data supplier or some other appropriate data source, on receiving an update request from the emergency system operator interface process within the function.

(f) Manage Emergency Services Data (5.6) - This process collects emergency service data, emergency vehicle management data, emergency vehicle data, and incident data. It distributes this data to the Manage Archive Data function where it can be archived and accessed upon request or upon receipt of fresh data.

Data about incidents is received by the processes in (a) which determine the response plan from data set up by the emergency services operator. This data is then passed to the processes in (c) for the dispatch of suitable vehicles, and back to the source of the incident information via a process in (a). The processes in (c) monitor the activities of all vehicles and maintain a store of vehicle status from which availability can be determined. They also obtain the route for the vehicle(s) from the Provide Driver and Traveler Services function and send data about the route to the Manage Traffic function to enable an emergency vehicle priority routing (e.g. green wave) to be provided.

There can be several sets of the processes in (c) above, one for each type of emergency service. The processes in (a) will then send their dispatch data to the most appropriate set(s) of processes in (c). The link to other Emergency Management Services enables coordination to be achieved across jurisdictional and/or operational boundaries thereby helping to achieve the best possible response to an incident.

Provide Emergency Services Allocation (DFD 5.1)

This DFD shows the processes that make up the Provide Emergency Services Allocation facility within the Manage Emergency Services function. These processes receive reported incident data and initiate the appropriate response. The key points about the facility are as follows:

* - facilities are provided to identify the type of emergency dependent on source;

* - response plan is determined from allocation criteria and sent to the vehicle dispatch function;

* - emergency services status reporting facility is provided for other ITS functions.

There are five processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Identify Emergencies from Inputs (5.1.1) - this process will enable existing emergency centers to receive the calls, determine response requirements (enough to determine what responding agencies to notify), and route distress calls to those predesignated responding agencies. This process will provide the identified emergency information in a standard format as required. Every set of emergency data received will be assigned a level of confidence by the process depending on its source, so that the subsequent processes can assess the level of response to be provided. This process will include verification, in that it will determine if a number of inputs might all be referring to the same incident, then designate that incident in its notifications to responding agencies. By reconciling numerous reports and other collaborative information from the field (e.g., CCTV images, reports from field staff), the verification function confirms the existence, location, and nature of a reported emergency

(b) Determine Coordinated Response Plan (5.1.2) - this process will determine the appropriate response for a verified emergency. The process will classify and prioritize the emergency and use this assessment to determine an appropriate response plan. A detailed description of the emergency and the suggested response plan will be sent to other processes for implementation. The same information will also be forwarded to other emergency centers (other EM) for information and possible action.

(c) Communicate Emergency Status (5.1.3) - this process will receive the emergency service response plans and the status of their implementation for dissemination to other ITS functions. That dissemination will be subject to sanitization according to pre-arranged rules, implemented in this process. The process will also read data about emergency responses from the emergency services action log. All data will be communicated by the process in standard formats to travelers, drivers, and other ITS functions. In the case of in-vehicle, personal traveler, and transit emergencies, after each emergency becomes a verified incident, the data will be sent as soon as new status or plan data is received. Dissemination will be controlled according to rules determined in this process to limit the information transmitted to that information useful to the receiver. Emergency information that is received from the emergency telephone system or E911 operators, will be disseminated only when the response plan data is first received. That has the effect of only disseminating data on incidents that have been verified, since only verified incidents will have response plans. The process will also extract data from the emergency service action log on request from processes in other ITS functions, and from the emergency services operator.

(d) Manage Emergency Response (5.1.4) - this process will enable existing emergency centers to receive emergency calls, determine response requirements to the extent necessary to route the information, and route distress calls and emergency information to predesignated responding agencies and vehicles. All identified emergency information will be provided by the process in a standard format as required. The process will also communicate with commercial fleet managers to obtain details of cargo and other vehicle data where this will affect the response of the emergency services, e.g., in the case of a vehicle carrying a HAZMAT load. The current status of all emergency service responses will be stored by the process in an action log, for access by the communications process.

(e) Manage Emergency Service Allocation Store (5.1.5) - this process will manage the store of data that defines the way in which the emergency service resources will be deployed in response to emergencies. Deployment will vary by certain criteria, such as, type of emergency, source of information, time of day, location, etc. Parameters to define this allocation will be loaded into the data store following receipt from the process that provides the emergency services operator interface.

(f) Process Mayday Messages (5.1.6) - This process receives mayday messages from vehicles and drivers, determines whether the mayday message indicates an emergency that requires the attention of public safety agencies, and forwards mayday emergency data to the appropriate agency when assistance is required. The content of the data flow 'mayday emergency data' includes all the key data from the incoming data flow 'emergency request details' and an agency ID indicating the mayday provider that received and processed the mayday message. While not depicted in the logical architecture, the process is also heavily dependent on voice communications to better ascertain the nature and severity of the emergency and to report this information to the appropriate local agency. This process also receives and keeps a historical log of signals sent in the tracking_vehicle data flow.

The data about incidents is received by process (a) which formats it and passes it to process (b). This process requests the appropriate response data from the store of predefined responses through process (e). The response is loaded into a coordination plan which is sent to processes (c) and (d). Process (c) sends data acknowledging the receipt of the incident data back to the source of the data and also provides access to the log of incident responses maintained by process (d). This process manages the response to the incident, sending data to the dispatch vehicles facility and obtaining data about hazardous cargoes when commercial vehicles are involved. It also manages any response overrides provided by the emergency system operator and the coordination of responses to transit incidents. The process keeps a record of all activities in the log of incident responses.

These process are intended to work as a coordinated group in a single implementation. If necessary some of the sources of emergency data for process (a) can be omitted if they do not exist in some implementations.

Manage Emergency Vehicles (DFD 5.3)

The five processes in this DFD provide the Manage Emergency Vehicles facility within the Manage Emergency Services function. These processes dispatch the appropriate emergency vehicles to the incident and monitor their status. The key points about the facility are as follows:

* - vehicle type is selected to suit the incident details;

* - status of vehicles monitored at all times to determine availability;

* - routes provided by the Provide Driver and Traveler Services function for vehicles to get to incidents;

* - vehicle priority along routes and at intersections provided via the Manage Traffic function.

There are six processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Select Response Mode (5.3.1) - this process is responsible for selecting the appropriate emergency services and their vehicle(s) to respond to incidents. The process will determine the type and number of vehicles to be dispatched, and provide the vehicle(s) with information on the type and location of the incident. It will request data about the vehicles that are available from the interface process to the data store of emergency vehicle status. Once the vehicle determination has been made, the status data will be changed by the process, and incident data sent to the process responsible for the actual dispatch of the vehicle(s).

(b) Dispatch Vehicle (5.3.2) - this process will direct selected emergency vehicles and drivers to respond to an incident, receive acknowledgment that they will in fact respond, and provide them with the location and details of the incident. The data about the incident will be received from the process in the Manage Emergency Services function responsible for selecting the vehicles for the response. If called for, the process will also request emergency vehicle routing from the Provide Driver and Traveler Services function and send details to the Manage Traffic function to request a priority routing (e.g. green wave) be provided for the vehicle(s) if that mode of priority is available and chosen. The data for the emergency vehicle driver will be sent to the driver interface process.

(c) Track Vehicle (5.3.3) - this process will manage information about the location of all emergency vehicles available for dispatch and that have been dispatched, and the ETA for vehicles en route. The process will send this data to the store of emergency vehicle status data. If the vehicle is on its way to an emergency, as indicated by the received vehicle status, the process will also send data to processes in the Manage Traffic function that will enable the vehicle to have whatever level and mode of priority is available and granted at traffic signals.

(d) Assess Response Status (5.3.4) - this process will assess the status of emergency vehicles that are responding to an incident. In making its assessment, the process will use data from the process managing a store of vehicle status, plus data from the emergency vehicle driver interface process. The process will send the results of the assessment to the process responsible for managing emergency and emergency response information and update the store of vehicle status.

(e) Provide Emergency Personnel Interface (5.3.5) - this process is will provide an interface for emergency personnel, through which data can be exchanged with other processes in the Manage Emergency Services function. It will support the exchange of incident data to which responses are being made by emergency personnel. The process will support inputs from emergency personnel in both audible and manual forms, with outputs being available in both audio or visual forms. The visual form may include display and hardcopy formats. Both inputs and outputs will be provided in such a way that while alerting the driver to the information they contain, they will in no way impair the driver's ability to operate the vehicle in a safe manner.

(f) Maintain Vehicle Status (5.3.6) - this process will maintain a data store of the current status of all emergency vehicles available for dispatch and that have been dispatched. It will provide data from the store on request from other processes and will update the contents of the store with new data received from other processes. The process will output the status of a vehicle to the process responsible for vehicle tracking for as long as it is on its way to an incident, to update ETA estimates and enable local vehicle priority to be given at intersections, if that mode of priority is chosen and granted.

Details of an incident are received by the process in (a) which dispatches the appropriate vehicle(s). It obtains current vehicle status from the store of this data via process (f) and sends the dispatch information to the selected vehicle(s) and driver(s) via processes (b) and (e). If the correct number of vehicles are not available, the process reports this information back to the management process in the Provide Emergency Services Allocation facility - see DFD 5.1. Process (b) requests a route for the vehicles from the Provide Driver and Traveler Services function, setting the preferences and constraints in the route request data to those that are appropriate for an emergency vehicle. Vehicles that are dispatched provide updates to their status through process (d). Process (c) is able to provide local priority at intersections for vehicles on their way to incidents. This will supplement the "green wave" route requested by process (b) from the Manage Traffic function.

It should be noted that in determining the emergency vehicle's route, the route selection facility in the Provide Driver and Traveler Services function requests and continuously advises the Manage Traffic function, specifically the Select Strategy facility, of emergency vehicle routing, location, etc. in order to allow implementation of a dynamic junction priority system (e.g. a "green wave") for the vehicle.

Provide Law Enforcement Allocation (DFD 5.4)

The seven processes in this DFD provide the Provide Law Enforcement Allocation function. These processes receive violation data from other ITS functions and send it to the appropriate law enforcement agency. The key points about their functions are as follows:

* - the law enforcement agency tasked with responding to each type of violation is pre-defined;

* - these processes just report the violations, responsibility for eventual prosecution of offenders rests with the law enforcement agency;

There are seven processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Process TM Detected Violations (5.4.1) - this process will manage the details of high occupancy vehicle (HOV) lane use, wrong-way vehicle detection in reversible lanes, and pollution violations reported by the Manage Traffic function. The process will use the parameters in the store of traffic management (TM) violation (enforcement) data to obtain the vehicle registration data from the appropriate State Department of Motor Vehicles (DMV) office, before sending all of the received information to the correct law enforcement agency. This process will also maintain the TM enforcement data store, entering all information received from other processes.

(b) Process Violations for Tolls (5.4.2) - this process will manage the details of toll payment violations reported by the Provide Electronic Payments Services function. The process will use the parameters in the store of toll payment violation (enforcement) data to obtain the vehicle registration data from the appropriate State Department of Motor Vehicles (DMV) office (or alternate source) for vehicles that are not equipped with a tag, before sending all of the received information to the correct law enforcement agency. This process will also maintain the toll payment enforcement datastore, entering all information received from other processes.

(c) Process Parking Lot Violations (5.4.3) - this process will manage the details of parking lot payment violations reported by the Provide Electronic Payment Services function. The process will use the parameters in the store of parking lot violation (enforcement) data to obtain the vehicle

registration data from the appropriate State Department of Motor Vehicles (DMV) office (or alternate source) for vehicles that are not equipped with a tag, before sending all of the received information to the correct law enforcement agency. This process will also maintain the store of parking lot violation (enforcement) data, entering all information received from other processes.

(d) Process Fare Payment Violations (5.4.4) - this process will manage the details of fare payment violations reported by the Provide Electronic Payments function. The process will use the parameters in the store of fare payment violation (enforcement) data to process and send the data to the correct law enforcement agency. This process will also maintain the fare payment enforcement data store, entering all information received from other processes.

(e) Process Vehicle Fare Collection Violations (5.4.5) - this process will manage the details of fare collection violations reported by the Manage Transit function that have taken place on-board a transit vehicle. The process will use the parameters in the store of vehicle fare collection violation (enforcement) data to process and send the information to the correct law enforcement agency. This process will also maintain the vehicle fare collection enforcement data store, entering all information received from other processes.

(f) Process CV Violations (5.4.6) - this process will manage the details of violations committed by commercial vehicles, their drivers and/or operators, reported by the Manage Commercial Vehicles function. The process will use the parameters in the store of commercial vehicle violation (enforcement) data to obtain the vehicle registration data from the appropriate State Department of Motor Vehicles (DMV) office, before sending all of the received data to the correct law enforcement agency. This process will also maintain the commercial vehicle violation (enforcement) data store.

(g) Process Roadside Fare Collection Violations (5.4.7) - this process will manage the details of fare collection violations reported by the Manage Transit function that have taken place at the roadside, i.e., at a transit stop. The process will use the parameters in the store of roadside fare collection violation (enforcement) data to process and send the information to the correct law enforcement agency. This process will also maintain the roadside fare collection enforcement data store, entering all information received from other processes.

These processes each provide interfaces to law enforcement agencies for different ITS functions. With the exception of processes (a) and (f) the data about violators is provided by facilities in the Provide Electronic Payment Services function - see DFD 7. The data provided by this function concerns those drivers or transit users who are trying to make invalid toll, parking lot charge or transit fare payments. Process (a) receives data from the Manage Traffic function - see DFD 1, about high occupancy vehicle (HOV) lane and pollution violations. Process (f) receives data from the Manage Commercial Vehicles function - see DFD 2 about invalid payments for electronic credentials and tax filing by commercial vehicle managers or commercial vehicle owner drivers. Processes (a), (b) and (c) which all deal with violations by drivers, will request details of their vehicles from the appropriate Department of Motor Vehicles office. This data will be added to that already provided by the particular ITS function.

These processes enable data about violators and the offenses that they have committed to be sent to the appropriate law enforcement agency(ies) for them to take the necessary action. This may involve prosecution, but it is not the purpose of the ITS functions and these processes to recommend or require this form of action. The processes can be implemented individually as required by each associated ITS function.

1.6.1.7. Provide Driver and Traveler Services (DFD 6)

The processes in this DFD provide the Provide Driver and Traveler Services function. This function is responsible for providing drivers and travelers with trip planning, traffic and transit information, and route guidance facilities. The key points about the function are as follows:

***** - travelers may plan, confirm and be guided along single mode or multimodal trips;

* - en-route advisory traffic and transit information provided for drivers and transit users;

* - drivers provided with vehicle interface for automatic control and output of warning/safety messages;

* - travelers and transit users can obtain information on and pay for yellow pages services;

* - vehicle and personal traveler guidance may be provided dynamically or autonomously;

* - dynamic guidance provided centrally using current traffic and transit information;

* - autonomous guidance uses in-vehicle data that can be supplemented with current traffic information;

* - autonomous personal traveler guidance uses a personal navigable database;

* - traveler may use home, office, or travel agent's computer, kiosk, or personal portable device (ppd);

* - personal security provided for drivers, and travelers through ppd's and kiosks.

The eight processes are all DFDs and they divide the overall functionality of this DFD between themselves in the following ways.

(a) Provide Trip Planning Services (6.1) - these processes produce a trip plan to meet the requirements of a traveler's trip request. Facilities are also provided for subsequent trip confirmation and to enable the traveler to make advanced payments for such things as yellow pages services. The trip plan can be multimodal and is generated using the facilities provided by the processes in (f) below. It may also include demand responsive transit services provided through the Manage Transit function (see DFD 4), ridesharing provided through the processes in (d) below, and the use of services from multimodal transportation service providers such as heavy rail, airlines, etc. The traveler may be using a home, office or travel agent's computer, a kiosk, or a personal portable device (ppd) using the facilities provided through the processes in (c) and (h) below.

(b) Provide Information Services (6.2) - these processes provide information to drivers and to transit users. These users can receive advisory and broadcast information. Advisory information is requested by the driver or transit user and broadcast information is output automatically. Both types of information may include traffic and transit data obtained from the Manage Traffic and Manage Transit functions - see DFDs 1 and 4 respectively. Drivers may also receive data about the roadway environment in which the vehicle is operating, enhanced vision displays, plus various types of warning messages generated from within the vehicle by processes in the Provide Vehicle Monitoring and Control function - see DFD 3. Both drivers and transit users may also request information about yellow pages services. Advisory information can be filtered to only output that which is relevant to the vehicle's current location.

(c) Provide Traveler Services at Kiosks (6.3) - these processes provide the interface through which the traveler can plan trips and obtain traffic and transit information from a kiosk. The trips can be multimodal and the traveler can alter the data on which the trip is based until a satisfactory solution is provided. Any reservations and/or advanced payments can be made as part of the trip confirmation. The traveler may also access information about yellow pages services and make reservations of these services. These processes make use of the facilities provided by processes in (a) above and (e) below to produce the trip plan and service information. They request traffic and transit data from the Manage Traffic and Manage Transit functions - see DFDs 1 and 4 respectively. The display of traffic and transit information can be shown against a background of map display obtained from digitized data stored locally within the kiosk, or the information can be provided in other forms not containing a map display.

(d) Manage Ridesharing (6.4) - these processes provide a ride sharing service. Travelers using private cars who have the same destination and expected arrival time will be matched so that they can share rides for all or part(s) of their journeys. This will enable them to make best use of their private cars, possibly taking advantage of being able to travel in high occupancy vehicle (HOV) lanes. The

journey details for travelers for whom no match is found will be retained in case a suitable traveler asks for a ride share at a later date.

(e) Manage Yellow Pages Services (6.5) - these processes provide travelers with access to data about yellow pages services, weather information, and tourist information. They also enable travelers to make reservations and payments for these services. Data about services is obtained from the media, or yellow pages service providers (who have registered and made their contact details available).

(f) Provide Guidance and Trip Planning Services (6.6) - these processes provide route guidance for drivers, plus route guidance and trip planning for travelers. Multimodal routes are provided to travelers for both on-line personal traveler guidance and for trip planning. Centralized route determination facilities are provided for in-vehicle dynamic guidance, or for generating link travel times to be used in autonomous guidance. Vehicle routes are also provided for commercial vehicle route planning and for emergency vehicles dispatched in response to incidents.

(g) Provide Driver Personal Services (6.7) - these processes enable drivers to call emergency services and obtain in-vehicle route guidance. Processes enable a driver to summon the emergency services in the event of an incident involving the vehicle. The call is activated by the driver using a device such as a MAYDAY button in the vehicle. Acknowledgment of the receipt of the call-out request by the Manage Emergency Services function (see DFD 5) is provided through the processes in (b) above. Three types of in-vehicle route guidance are provided, comprising centralized dynamic, autonomous and autonomous with link journey times provided from a central source.

(g) Provide Traveler Personal Services (6.8) - these processes provide the traveler with facilities for on-line guidance, personal security and trip planning. The on-line guidance is provided dynamically from a central service and will enable the traveler to be guided along a multimodal route. The personal security facility provides the traveler with a mechanism to call emergency services in the event of an incident. The call is activated by the traveler using a device such as a “panic” button on a personal portable device (ppd). Acknowledgment of the receipt of the message by the Manage Emergency Services function (see DFD 5) is provided through the processes in (e) above. The trip planning facilities are similar to those provided in (c) above except that they are designed to be used from a traveler’s personal device (portable or non portable).

The traveler is able to obtain route information including several variations on the original trip request until one that completely fulfills the requirements is produced. Each trip may by single mode or multimodal and in the latter instance may be limited by the number of mode changes that are allowed by the traveler, or the length of transfer time. Only when the traveler is completely satisfied with the route is it necessary to confirm it and make any advanced payments for services such as hotel bookings, restaurants, etc.

A wide range of guidance facilities is provided for the driver and traveler, including the retention of details about the most commonly used routes to prevent repeated data entry. Three types of on-line vehicle guidance are supported, comprising autonomous, autonomous but using traffic data obtained from a central source and dynamic. Two types of on-line traveler guidance are provided, comprising the first and last of the vehicle facilities just described. The highest level of guidance available will always be used and only degrade if communication with the source of dynamic guidance is lost. When in dynamic guidance, a new route will be calculated at selected points as the vehicle or traveler moves towards the final destination. This ensures that the route takes account of the most up to date traffic and transit data.

The term “ISP” is used in this function. It stands for Information Service Provider, and is the generic name given to the functional entity that is actually implementing the facility. Thus an ISP operator is someone who works for the ISP organization in much the same way as a transit system operator.

Manage Trip Planning Services (DFD 6.1)

The four processes in this DFD provide the Manage Trip Planning Services facility within the Provide Driver and Traveler Services. These processes enable travelers to plan trips and make other (yellow pages) service reservations. The key points about the facility are as follows:

* - multimodal trip planning available to include private car, transit, demand responsive transit, ridesharing and other modes, e.g., walking and cycling, plus services from Multimodal Transportation Service Providers;

* - trip planning available for routes using all modes of transportation;

* - traveler provided with details of the best possible route including its cost;

* - trip confirmation reserves any included services e.g., demand responsive transit and ridesharing;

* - trip confirmation may also involve payment for services it includes;

* - yellow pages services may be included in trip plan, confirmation and payment;

* - ISP operator controls parameters used in selecting the best modes for trips.

There are four processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Provide Trip Planning Information to Traveler (6.1.1) - this process will obtain all the information needed to fulfill the traveler's request for a trip. The process will support the request for trips that require the use of one or more modes of transport, and will use the preferences and constraints specified by the traveler in the trip request, plus data from the store of trip planning parameters, to select the most appropriate modes. It will send details of the trip requirements to the specialized processes that provide route information for the different modes of transport. When route data is received back from these processes, this process will ensure that the whole trip is covered by one coherent route for which all the data such as costs, arrival times, and modal change points are known. The information provided to the traveler by the process will be sufficient to enable the traveler to understand the routing, modes and cost of the trip. The trip information will be stored for possible use in subsequent trip confirmation. This process will exchange all input and output data from and to the traveler with the appropriate traveler interface process.

(c) Confirm Traveler’s Trip Plan (6.1.2) - this process will confirm a trip previously requested by a traveler and any financial transactions that this may require. The process will base the trip confirmation upon information created by the process responsible for trip planning and stored locally. Confirmation details will be sent to specialized processes (such as those responsible for demand responsive transit, ridesharing, etc.) to make reservations for their services. The response to these reservation requests and any necessary payment transactions will be sent to the traveler. This process will exchange all input and output data to and from the traveler via the appropriate traveler interface process.

(d) Manage Multimodal Service Provider Interface (6.1.3) - this process will collect data about services that are available to travelers from multimodal service providers. These suppliers will be those that provide travel services that are not part of regular transit or demand responsive transit operations, e.g. heavy rail, and may not involve surface transportation, e.g. ferry and airline operations. The process will provide data formatted for use as part of a traveler's multimodal trip, and will support subsequent confirmation of any portion provided by the Multimodal Transportation Service Provider.

(e) Provide ISP Operator Interface for Trip Planning Parameters (6.1.4) - this process will manage the data store containing parameters used by the trip planning processes. These parameters will govern the way in which multimodal trips are planned by other processes within Provide Trip Planning Services. This process will accept inputs from the ISP Operator to define or update trip planning parameters. This process will output these trip planning parameters to the ISP Operator.

(f) Collect Service Requests and Confirmation for Archive (6.1.5) - This process receives all traveler requests, such as requests for traffic and transit information, requests for current conditions such as weather, trip requests, guidance route requests, advisory requests, yellow page information requests, and service confirmations. These requests are stored in the service_req_and_confirm_data data store and output to the traveler information data archive. The process runs when a new request or confirmation is received from an external source.

(g) Manage Traveler Info Archive Data (6.1.6) - This process accepts traveler information service requests and confirmations, parking management information, payment transaction data, rideshare requests, commercial and non-commercial probe data, route guidance data, and origin/destination data, and stores it in its local traveler info data archive data store, together with a catalog to describe the data. When requested by the Manage Archive Data function, this information is sent to that function. The process also provides a control interface to the ISP Operator, responding with the status received from the requester of the archive. The process runs when a request for data or a catalog is received from an external source, when a command is received from the ISP Operator, or when fresh data is received.

The traveler's trip request is received by process (a) which determines the route that provides the best match to the request. In doing this the process will be guided by the traveler's requirements and by the parameters set up by the ISP operator through process (d). Process (a) will obtain vehicle, transit and other mode route details from the Provide Guidance and Trip Planning Services facility - see DFD 6.6. If required the process will also obtain details of multimodal services from process (c), a demand responsive transit service from the Provide Demand Responsive Transit Service facility (see DFD 4.2.1), or details of a rideshare that fits in with the trip plan from the Manage Ridesharing facility - see DFD 6.4. The travelers' confirmation of a previously requested trip and any required payments are received by process (b). This makes any necessary reservations with the previously mentioned facilities and gets the payments transacted by the Collect Advanced Payments facility - see DFD 7.4.1. These four processes are coupled through their joint use of the two data stores. However some implementations could omit the process in (c) if no interface to multimodal transportation service providers is required.

The parameters set up through process (d) by the ISP operator for use in trip planning, influence the type of trip that is provided in response to requests from travelers. They will control the degree to which the preferences and constraints specified by the traveler in the trip request should be ignored, and to set the priority that will be given to the use of non-private vehicle modes. For example, the parameters will give the weighting that should be applied to one preference, e.g., start and arrival time, over that which requests the use of several modes. Thus for example, a traveler may find that proposed trip starts earlier or finishes later (and therefore takes longer) than requested in order to accommodate the use of modes other than the private car

Provide Information Services (DFD 6.2)

This DFD shows the five processes that make up the Provide Information Services facility within the Provide Driver and Traveler Services function. This facility provides advisory and broadcast information to drivers and transit users. The key points about the facility are as follows:

* - advisories provided to drivers about traffic, transit and yellow pages services;

* - the traveler can make a specific request for information or can submit a travel profile for subsequent transmission of information to the traveler.

* - driver advisories are selected to be relevant to the vehicle's current location;

* - drivers are also provided with warning messages produced by the vehicle control functions;

* - advisories provided to Transit Users about traffic, transit and yellow pages services ;

* - travelers and Transit Users are able to make and pay for yellow pages reservations.

There are five processes and one DFD in this DFD and they divide the overall functionality in the following way.

(a) Provide Advisory and Broadcast Data (6.2.1) - these processes collect traffic and transit information from the Manage Traffic and Manage Transit functions - see DFDs 1 and 4. This data is stored and output in response to requests for advisory information. The output data can be filtered to only include information which is relevant to the traveler's location provided with the data request. The data is also analyzed against parameters provided by the ISP operator to determine if any of it should be included in broadcast information.

(b) Prepare and Output In-vehicle Displays (6.2.2) - this process will provide in-vehicle advisory and broadcast data for output to drivers and transit users. The process will format requests from users for advisory data and output the requests to other processes. The request for advisory data will allow the user to request only information relevant to the location of the vehicle. The request may be repeated, periodically, or when the vehicle changes location by a distance determined by the implementation. Data broadcast to the driver will include traffic related data(incidents, link data and in-vehicle signage), as well as data from the vehicle itself. This vehicle data includes vehicle conditions, smart probe data, safety and position warnings, and enhanced vision images. Safety and warning messages will be prioritized by the process to supersede advisory and broadcast messages. The process will also support the transfer of reservation requests from the users in vehicles for other services such as yellow pages.

(c) Provide Transit User Advisory Interface (6.2.3) - this process will provide a data input and output interface for a transit user on-board a transit vehicle. The process will enable traffic and travel advisory information, plus yellow pages information to be requested and output to the transit user. When constructing the outputs the process will use the data in the store of vehicle display definitions data. In addition to the traveler's request/ response for information, broadcast advisories about the imminent arrival of the transit vehicle at the next stop are also displayed for the transit user. The process will handle all inputs and outputs in such a way that they do not impair the vehicle driver's ability to control the transit vehicle in a manner that is safe to both its occupants, to other road and freeway users, and to pedestrians. The input and output forms will also include those that are suitable for travelers with physical disabilities.

(d) Collect Yellow Pages Data (6.2.4) - this process will collect and fuse data about (yellow pages) services in order to provide information to users in vehicles. The process will fuse all the received yellow pages data into a coherent set and loaded into the yellow_pages_information_data store for access by processes in response to requests from users in vehicles.

(e) Provide Driver Interface (6.2.5) - this process will provide a user interface for a driver through which traffic and travel advisory information can be obtained. The process will enable traffic and travel advisory information to be requested and output to the driver, and will also support the automatic output of wide area broadcast information (including in vehicle signage) to the driver. The process will support output of safety and vision enhancement information to the user. When constructing all outputs the process will use the vehicle_display_definitions_data store parameters. One purpose of the vehicle_display_definitions_data store is to provide a translation table for road sign and message templates used for in-vehicle display. Part of the input interface provided by the process will enable the driver to invoke and cancel automatic control of the vehicle including the use of automated highway system (ahs) lanes. The process will support inputs from the driver in manual or audio form, and will provide its outputs in audible or visual forms. Visual output may be either in hardcopy, or as a display. Both types of output will not impair the driver's ability to control the vehicle in a safe manner.

(f) Provide Yellow Pages Data and Reservations (6.2.6) - this process will extract data from the yellow_pages_information_data store upon request for data from the driver or a transit user in a vehicle. The data read from the store may be filtered, by the process, so that output only contains that which is relevant to the current location of the vehicle. The process will also enable the user to make reservations for yellow pages services from a vehicle.

Requests for advisory information are input by the driver and transit user through processes (e) and (c) respectively. These are sent to process (b) which adds the vehicle location and sends the necessary data requests to processes in (a), and to process (f). The responses are received by process (b) are sent back to whichever process was the source of the request. Process (b) will also receive broadcast data from processes in (a) and the output from various in-vehicle functions from facilities in the Provide Vehicle Monitoring and Control function - see DFD 3. It will be responsible for setting different priority levels for the outputs to the driver though process (e) so that advisory, broadcast, safety and warning messages are overlaid on top of vision enhancement data, with safety or warning messages themselves taking priority over and overlaying advisory or broadcast messages.

Although all of these processes depend on others in the group for data, they will each operate continuously and independently so that the data can processed, stored and accumulated in a timely fashion. The vehicle location data needed by process (b) above will be provided by the Provide On-line Vehicle Guidance facility - see DFD 6.7.2.

The data store of display definitions will be prepared by agencies such as vehicle manufacturers, or producers of after-market products. The store will be able to hold its data in different languages to cater to English, Spanish, or other language preferences of the driver or user and be available for different types of vehicles, with a different set of messages being provided for each type of vehicle.

Provide Advisory and Broadcast Data (DFD 6.2.1)

This DFD shows the processes that make up the Provide Advisory and Broadcast Data facility within the Provide Driver and Traveler Services function. These processes obtain traffic and transit data from other ITS function for use in advisory and broadcast data outputs. The key points about the facility are:

* - traffic and transit data is requested from the Manage Traffic and Manage Transit functions;

* - data from the Manage Traffic function regarding traffic state and incidents provided as they occur;

* - data for advisory information output provided on request and can be filtered by vehicle location;

* - data for broadcast information output determined using parameters set up by the ISP operator.

There are five processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Collect Traffic Data for Advisory Messages (6.2.1.1) - this process will collect and fuse traffic data that will be used to create broadcast or advisory messages to travelers. The input data for this process will consist of historical, current, and predicted traffic and incident data. The process will extract from the data those elements appropriate for advisory or broadcast messages and load it into the store of traveler_traffic_information_data store. The data can be provided to the process either via direct request from the process or as a result of periodic (unrequested) updates.

(b) Provide Traffic and Transit Advisory Messages (6.2.1.2) - this process will provide advisory data to users in vehicles (drivers or transit users) as a result of a request from the driver or transit user. (e.g. This process supports a request/response type of exchange with the user.) The advisory information is extracted from the data stores of traveler traffic and transit information. The process will have the capability to filter the advisory data, read from the data stores, store so that the output only contains data that is relevant to the current location of the vehicle from which the request was made. When the user requests location specific data, the vehicle's location will be provided to the process in the request message.

(c) Collect Transit Data for Advisory Messages (6.2.1.3) - this process will collect and fuse transit advisory data that will be used to create broadcast or advisory messages to travelers. The process

will extract from the data those elements appropriate for advisory or broadcast messages and load it into the traveler_transit_information_data store. The data can be provided to the process either via direct request from the process or as a result of periodic (unrequested) updates. The process will fuse all the received data into a coherent set, which is loaded into a traveler_transit_information_data store for access by other processes.

(d) Provide Traffic and Transit Broadcast Messages (6.2.1.4) - this process will extract advisory data from stores of traveler traffic and transit information at locally determined intervals and send it out to drivers or transit users in vehicles as wide area broadcast messages. The content and rate of these messages will be based upon parameters from the broadcast_parameters_data store, which is managed by the ISP operator.

(e) Provide ISP Operator Broadcast Parameters Interface (6.2.1.5) - this process will provide the interface through which the ISP operator can manipulate data in the broadcast_parameters_data store. The data, in this store, will be used by another process to define the scope and rate of wide area broadcast messages to vehicles. The process will provide the ISP operator with the ability to request parameter data output and/or update the data store with new parameter values.

(f) Provide Transit Advisory Data On Vehicle (6.2.1.6) - this process will gather transit advisory data and provide it via another process to the transit user on-board a transit vehicle. The interface will receive requests from the transit user specifying the required destination of a transit service ride and other (yellow pages) type services. The transit user may also request and receive information about the state of traffic on the roadway, as well as transit route and stop data (i.e., traffic and transit advisory data). This process extracts data from the store of traveler transit information upon request for advisory data from the driver or transit user in a vehicle. The process will filter the data read from the store so that output only contains that which is relevant to the current location of the vehicle from which the request was made. The vehicle's location will be provided to the process in the request data. The input and output forms will include those that are suitable for travelers with physical disabilities.

Process (a) requests traffic data from the Display and Output Traffic Data facility - see DFD 1.1 and is sent data about planned events by the Review and Manage Incident Data facility - see DFD 1.3.2. Transit data is requested by process (b) from the Operate Vehicles and Facilities, and Generate Transit Routes and Schedules facilities - see DFDs 4.1 and 4.2.3 respectively. Each process loads the data it receives into its own data store, from which it can be retrieved by processes (b), (d) and (f). Process (b) retrieves data when requests are received from the Provide Information Services facility - see DFD 6.2, and can filter the output to only include that which is relevant to the vehicle location supplied with the request. Broadcast data is output periodically by process (b) when an analysis of the two data stores shows that they contain information that is of importance. The analysis is carried out using stored parameters provided by the ISP operator through process (e).

These processes may be used in several combinations to suit individual implementation requirements. For example, processes (a), (b) (c) and (f) may be implemented as a group to provide advisory data. Processes (d) and (e) could be added later to provide a broadcast data facility. Alternatively either processes (a) or (c) and (f) could be omitted to provide a service of just traffic or just transit information respectively.

Provide Traveler Services at Kiosks (DFD 6.3)

The processes in this DFD provide the Provide Traveler Services at Kiosks facility within the Provide Driver and Traveler Services function. These processes enable the traveler to obtain traffic and transit information and to plan trips from a kiosk. The key points about the facility are as follows:

* - travelers can plan trips and get traffic, transit and yellow pages services information;

* - trips may be multimodal, including such things as demand responsive transit and ridesharing;

* - planned trips may be confirmed and paid for in advance as may yellow pages services;

* - travelers may also obtain traffic and transit information without planning any trips;

* - kiosks may be at the roadside, in shopping malls, and at other major trip generation sites.

There are four processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Get Traveler Request (6.3.1) - this process will receive input data from a traveler located at a kiosk and send requests to the appropriate processes within the Provide Driver and Traveler Services function for further processing. The process will provide support for trip planning, traffic, transit, yellow pages services information requests, trip confirmation, yellow pages confirmation, and payment requests. The actual interface to the traveler is provided through a separate process, which creates the input flow to this process.

(b) Inform Traveler (6.3.2) - this process provides the traveler (located at a kiosk) with data about all requested trip, traffic, transit, yellow pages services information, confirmation of any requested reservations, and payments made as part of confirmed trip plans. The data is sent by the process to an interface process that is responsible for its actual output to the traveler. This data may include digitized map data to act as the background to the output when the data is to be shown in a suitable format. This process will receive data from other ITS functions by requesting it or be sent data as a result of requests from another process.

(c) Provide Traveler Kiosk Interface (6.3.3) - this process will provide an interface at a kiosk through which travelers can input data and can receive data. The functions that the traveler can perform include plan and confirm trips, obtain current traffic and transit information, and declare emergencies. The process will support the inclusion of yellow pages services such as lodging, restaurants, theaters, and other tourist activities as a part of trip planning and confirmation. The process will be able to store frequently used data, such as the kiosk location, to reduce the amount of input needed by the traveler for each request. The process will also carry out input data verification and require input confirmation before passing any of the traveler data to other processes (except when an emergency is being declared). The traveler's payment information will be obtained by this process from another process specially designed for that purpose. The process will support traveler inputs in manual or audio form, and will provide its outputs in audible or visual forms consistent with a kiosk. These forms will include those that are suitable for travelers with hearing or vision physical disabilities. The process will enable viewing of data that has been previously output. Where it is appropriate, the process will use the kiosk's location to filter data being displayed to only show information relevant to the kiosk's location, or to a specific location requested by the user.

(d) Update Traveler Display Map Data at Kiosk (6.3.4) - this process will provide updates to the digitized map data used as the background for displays of trip, traffic and transit information. This data will be suitable for use in kiosk displays. The process will obtain the new data from map data suppliers or some other appropriate data source.

The traveler provides trip planning, trip confirmation, plus traffic and transit information requests through process (c). These are sent to process (a) which distributes the trip planning and confirmation requests to the appropriate processes in the Provide Trip Planning Services facility - see DFD 6.1. Requests for traffic and transit information are sent for implementation by process (b) which also receives the results from the trip planning requests made by process (a). All data received by process (b) is sent to process (c) for output to the traveler. Travelers can request as many trip plans as are needed before an acceptable match is found to their trip requirements. Data used for previous inputs and regularly used data is kept in the store of traveler regular data by process (c). The traveler can also enter or update a traveler profile which allows the traveler to receive information either at that time or at later times. The outputs produced by process (c) may be shown against a background of digitized map data produced by process (d).

These processes form a tightly coupled group and communicate with many other ITS functions. Update of the digitized map data used as the background to traffic and transit data displays is requested automatically because these processes are designed for use by the “general public”, none of whom would want to assume responsibility for obtaining display updates. The frequency of the update requests will be set up in process (d) when it is installed within the kiosk, by the supplier or owner.

Manage Ridesharing (DFD 6.4)

The four processes in this DFD provide the Manage Ridesharing facility within the Provide Driver and Traveler Services function. These processes enable travelers whose destinations and time of travel match to share rides for some or all of their trip. The key points about the facility are as follows:

* - travelers are matched to share transport (private car or van) for as much of their trip as possible;

* - travelers must specify the time of day, source and destination of their trip;

* - travelers may also specify any preferences or constraints with whom they wish to travel;

* - once a rideshare is confirmed, the traveler may make a payment to the service(if required);

There are four processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Screen Rider Requests (6.4.1) - this process will accept and screen traveler requests for ride-sharing. These requests will be sent to the process as a result of trip plan requests received from travelers by other processes. This process will use eligibility data from a local rideshare_data store, to screen travelers before they are matched with other travelers and to enable ridesharing for all or part of their proposed trips.

(b) Match Rider and Provider (6.4.2) - this process will match travelers for ridesharing trips. The process will attempt to achieve a match by considering some or all of the following: the origin and destination of the traveler's proposed trip, any routing constraints, preferences specified by the traveler, compatibility of this rideshare with rideshares confirmed by other travelers, the requesting traveler's eligibility data, and traffic data obtained on request from the Manage Traffic function. The process will consider the possible disbenefits to other travelers who will be part of the same rideshare when finding the rideshare best suited to the traveler’s requirements. The process will store data about selected rideshares in the rideshare_data store, and will update the data when confirmation of the rideshare acceptance is received from another process.

(c) Report Ride Match Results to Requestor (6.4.3) - this process will report ridesharing match results to requesters. The data for the results will be provided to this process by other processes responsible for assessing traveler eligibility, and the actual match with travelers in other rideshares. The process will output data indicating a failure when either the data from the eligibility process shows a failure, or no ridesharing match can be found. The process will also determine that no ridesharing match can be found if no match is found between the traveler's rideshare request and the rideshare data provided as input to it by another process. When a successful match is found, the process will output the rideshare data to the process from which the traveler's request was received.

(d) Confirm Traveler Rideshare Request (6.4.4) - this process will confirm the traveler's rideshare match and initiate a payment transaction where appropriate. The process will send the payment transaction data for action by a process in the Provide Electronic Payment Services function. The results of this transaction will be sent by this process to the process providing the overall trip confirmation. Once a rideshare match is confirmed, this data is sent to the rideshare match process where it can be factored in to subsequent matches.

The traveler’s rideshare request is received by process (a) from the Provide Trip Planning Services facility - see DFD 6.1. It checks the data to see if the traveler is eligible for ride sharing and if not, sends

a negative response to process (c) which sends it back to the process from which the request originated. If the traveler is eligible, process (a) sends the data to process (b). This process tries to match the traveler's trip data with both existing ridesharing travelers and those for whom no match could previously be found. The results are sent to process (c) which compares the result with the original request and if satisfactory again sends the result back to the process from which the request originated. Traveler ride share confirmations are received by process (d) which obtains payment for the service through the Collect Advanced Payments facility - see DFD 7.4.1. If payment is successfully completed it then sends the ride share details to process (b) for the records of successful ride shares to be updated.

These processes form a tightly coupled group and cannot be implemented other than as a group. Travelers are themselves expected to contact others in the matched rideshare, or those who have yet to find a match. Once this has been successfully done, the travelers will be expected to make their own arrangements for sharing the cost of each trip. Processes (a) and (b) will require sophisticated screening techniques to highlight any travelers making repeated requests for the wrong reasons.

Manage Yellow Pages Services (DFD 6.5)

The processes in this DFD provide the Manage Yellow Pages Service facility within the Provide Driver and Traveler Services function. They enable the traveler to be provided with information about yellow pages services, and to make payment for those services that they need. The key points about the facility are as follows:

* - yellow pages services information is obtained from many sources in response to traveler requests;

* - some data is provided automatically without the need for a specific traveler request;

* - yellow pages providers register (and possibly pay for this registration) before their data can be sent to travelers.

There are three processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Collect and Update Traveler Information (6.5.1) - this process will collect and update data about incidents, road construction, weather, events and yellow pages data. This data will be obtained by the process from other ITS functions and from outside sources such as the weather service, yellow pages service providers and the media. The process will load the data into a local store for use by the process that provides yellow pages information and reservations.

(b) Provide Traveler Yellow Pages Information and Reservations (6.5.2) - this process will provide information and reservation services obtained from yellow pages service providers. The process will provide the information and reservation data so that it can easily form part of a traveler's information request or trip planning activities. The process will be able to request additional yellow pages information if the process cannot find the required data in the tourist_information data store. The process will send requests for payment to a process in the Provide Electronic Payment Services function for action, and will send the response back to the process from which the payment request was received.

(c) Register Yellow Pages Service Providers (6.5.3) - this process will register yellow pages service providers. The process will accept requests for registration from the providers and will pass the data to a process in the Provide Electronic Payment Services function for action. The process will send the result of this action to the provider, and if successful, will send a request for the process that manages the contents of the store of tourist information to request data from the provider. The details of the provider will also be loaded into the store used by that process, so that data from the provider can readily be obtained in the future. This process will perform updating of the yellow pages service provider details.

Data about other (yellow pages) services is obtained by process (a), either by requesting it from the media or yellow pages service providers, or by receiving it as unsolicited input, e.g., weather information. All the data that the process receives is loaded into the store of tourist information for access by process (b).

This process receives requests for information and payments for services from travelers via processes in the Provide Traveler Services at Kiosks and Provide Traveler Services at Personal Devices facilities - see DFDs 6.3 and 6.8.3 respectively. If the information requested by the traveler is not in the store of tourist information, process (b) requests process (a) to obtain the missing data. Payment transactions are passed by process (b) to the Collect Advanced Payments facility - see DFD 7.4.1. Yellow pages service providers can enable details of their services to be made available to travelers be requesting and paying for registration through process (c).

These processes form a tightly coupled group. The requirement that yellow pages service providers must pay to register before details of the service(s) that they provide are made available to travelers provided through process (c), could be omitted from individual implementations, if the ISP did not want to use this as a source of income.

Provide Guidance and Trip Planning Services (DFD 6.6)

This DFD shows the processes that make up the Provide Guidance and Trip Planning Services facility in the Provide Driver and Traveler Services function. These processes select vehicle routes for a variety of applications using current, historic and predicted traffic conditions. The key points about the facility are as follows:

* - routes provided for trip planning, dynamic guidance and specialist uses;

* - traveler routes and guidance may be multimodal using private cars, transit and other modes;

* - route selection takes account of current, historic and predicted conditions;

* - current, historic and predicted conditions obtained from Manage Traffic and Transit functions;

* - other route selection data provided by weather services and map update provider;

* - route details for commercial vehicles with unusual cargoes sent to the Manage Incidents facility.

There are four processes and one DFD within this DFD and they divide its overall functionality between themselves in the following ways.

(a) Provide Multimodal Route Selection (6.6.1) - this process will manage the creation of multimodal routes (those with one or more modes in them) in response to traveler's trip or route requests. It will support on-line route guidance for travelers using personal devices, route guidance for vehicles, selection of specialized vehicle based routes for other ITS functions, (such as Manage Emergency Services and Manage Commercial Vehicles), and selection of multimodal routes in response to trip planning requests from travelers. The multimodal routes provided by the process will take account of the traveler's preferences and constraints. Constraints can include the access needs of those with disabilities. Preferences can include minimizing waiting time at modal interchange points, level of traveler security, or minimum cost.

(b) Select Vehicle Route (6.6.2) - these processes select routes for vehicles and provide dynamic in-vehicle guidance. They are provided with current, historic and predicted traffic data by the Manage Traffic function - see DFD 1. They also collect vehicle probe data as an alternative means of calculating journey times and make this data available for use by autonomous in-vehicle guidance. If a route goes outside the area served by the processes, data will be requested from the ITS function(s) serving the area(s) concerned. Data about routes selected for guidance is sent to the Manage Traffic function to assist in the predictive model generation and demand forecasting.

(c) Update Other Routes Selection Map Data (6.6.3) - this process will provide the interface to a map update providers through which to obtain fresh updates of digitized map data used in identification of non-vehicle portions of routes. The process will request new data from the provider on request from the ISP operator interface process. The data received from the supplier will be loaded into the map_data_for_general_use data store by the process in such a way that it can be easily used by the

route selection process in determining non-vehicle routes for use in on-line traveler guidance and trip planning.

(d) Select Transit Route (6.6.4) - this process will determine routes that are based on regular transit services. Routes will be provided by the process to travelers in response to trip planning and on-line personal guidance requests. The data provided by the process will be different for the two types of requests since trip planning information will not need the detail that guidance data requires. The process will base routes on the current state of the regular transit services using data obtained from processes in the Manage Transit function. It will also respond to any preferences and constraints, such as those for travelers with special needs, that are specified in the route request. Data on the current use of transit routes in on-line guidance will be provided by the process to the Manage Demand function to aid in demand management. This data on current use of the transit routes in on-line guidance is stored in the transit_mode_routes data store.

(e) Select Other Routes (6.6.5) - this process will determine routes, or portions of routes, not based on use of vehicles or regular transit services. Routes will be provided by the process for travelers in response to trip planning, and on-line personal guidance requests. Data provided by the process will be different for the two types of requests since the data for trip planning will not need the level of detailed that guidance data requires. The process will calculate its routes using digitized map data obtained and updated by another process. It will make use of the alternative modes, (such as ferries, walking, cycling, etc.) that have been specified in the route request, and will also take account of any preferences and constraints, (such as those for travelers with special needs). Data on current use of routes in on-line guidance will be provided by the process to the Manage Demand function.

Requests for traveler guidance and trip planning, plus commercial and emergency vehicle routes are received by process (a). The traveler requests are received from the Provide Traveler Services at Kiosks and at Personal Devices facilities - see DFDs 6.3 and 6.8.3 respectively. The vehicle route requests are received from the Manage Commercial Vehicle Fleet Operations and Driver Operations - see DFDs 2.1 and 2.2), and from the Manage Emergency Vehicles facility - see DFD 5.3. The requests for vehicle routes are passed directly to the processes in (b) and the results returned to the requesting facilities. The traveler requests are analyzed by process (a) to see which modes of travel can be used. Based on this analysis, it sends route requests to the processes in (b), and/or process (d), and/or process (e) to build up a contiguous route for the trip plan or guidance. Process (a) may iterate the requests, changing the modal transfer points until it arrives at an optimal solution to suit the traveler's trip plan or guidance request. Process (c) runs at the request of the ISP operator through the interface process in (b), and updates the store of map data used by process (f).

Drivers are in fact a special group of travelers and it will be possible for a traveler to become a driver for part of a trip. Both mobile and infrastructure based guidance systems can be supported since the processes are not aware of how information on traveler location is provided. Autonomous vehicle guidance is supported either as the prime function or when no guidance information is received by the vehicle from the central facility. In the latter situation the guidance process will continue operating in the vehicle using the most recently obtained route until new data is received. Autonomous vehicle guidance can be provided in basic form using an on-board navigable map database which contains details of all route segments, plus average historical journey times and queue times. This may be supplemented with more up to date journey and queue times that are available from the central facility to provide an enhanced autonomous guidance. The choice of which of the three forms of guidance to use (dynamic, autonomous, or enhanced autonomous) is up to the driver either through the type of equipment that is installed in the vehicle, or through choice when guidance is requested.

Disabled travelers (including drivers) are accommodated through the use of variables that identify their unique preferences and constraints. These variables are part of the data used to request a route. They enable the special needs of these groups of travelers to be taken into account when preparing routes and when giving guidance.

Select Vehicle Route (DFD 6.6.2)

This DFD shows the processes that provide the Select Vehicle Route facility within the Provide Driver and Traveler Services function. The processes are responsible for selecting routes that are only for use by private cars, emergency and commercial vehicles. The key points about the facility are as follows:

* - routes are selected using a variety of parameters, e.g., safest, least used, etc. and traffic data;

* - additional data requested from ITS functions serving other areas when routes go outside local area;

* - traffic and vehicle probe data plus previously selected routes can be used in calculation of route;

* - route data can be used in predictive model generation and demand forecasting by Manage Traffic function;

* - map updates describing the surface street and freeway network are provided by the map update supplier;

* - parameters controlling route selection set up by ISP operator;

* - in-vehicle guidance only provided when acceptance received from the vehicle.

There are six processes in this DFD and they divide its overall functionality between themselves in the following ways.

(a) Calculate Vehicle Route (6.6.2.1) - this process will calculate trip planning and real-time dynamic guidance routes for all types of vehicles. The route data provided by the process in response to requests from vehicles using infrastructure based in-vehicle guidance will only contain data necessary for the vehicle to provide guidance (since the data is intended for use by an in-vehicle navigation unit). The route provided for trip planning purposes will contain data in a form which can be presented to a user via display (or alternatively in audio form). The process will select the route according to the data included in the route request. Data provided by the requesting process includes preferences and constraints. The process will have the capability of using current and/or predicted conditions of the road network in route calculation. The process will have the capability of including additional factors such as current or predicted weather in the calculation of route. If the process cannot find the data it needs in the route_segment_details_data store, it will request the process responsible for providing route calculation data to obtain it from the appropriate source. The process will have the capability of outputting routes for special priority vehicles to the Manage Traffic function so that signal preemption could be provided for the special priority vehicle. The process will send details of routes for commercial vehicles with hazardous or unusual loads to the Manage Incidents function for monitoring (as a potential, or a planned event).

(b) Provide Vehicle Route Calculation Data (6.6.2.2) - this process will update the data stores containing information which is used by the another process to calculate vehicle routes. This process will also provide data about links (speed or travel times), and queues to be broadcast to vehicles (to support autonomous guidance with dynamic link updates). The process will fuse link and queue data received from Manage Traffic sources with probe data received from vehicles under infrastructure based route guidance, or with probe data obtained from other sources (such as from an electronic toll collection system). The process will obtain route segment data as requested data or as data received at periodic intervals from other ITS functions. The process will have the capability to request data about route segments outside its own area by sending a data request to the process that provides the interface with other ISP's. Link addresses, mapped to other ISP’s, will be maintained by this process and stored in the link_data_store.

(c) Provide Route Segment Data for Other Areas (6.6.2.3) - this process will obtain from another ISP current or predicted data for road links that are outside the area served by the local supplier. This area, which may be defined on a geographic or jurisdictional basis, is the portion of the transportation network on which the ISP maintains real time information. Identification of which ISP to contact is based upon a store that maps a link to the ISP which maintains real time information about this

link. If there is no map to another ISP in the data store, then the process will return default or static data for the link(s). This process will also respond to similar requests from other ISP's for real time data on links within the local database.

(d) Update Vehicle Route Selection Map Data (6.6.2.4) - this process will provide the interface to map update providers, or other appropriate data sources, through which updates of the digitized map data can be obtained. The process will request new data from the provider on request from the ISP operator interface process. The data received from the supplier will be loaded into a the map_data_for_route_selection data store by the process in such a way that it can be easily used by the route selection process in determining vehicle routes, trip planning, and on-line vehicle guidance.

(e) Provide ISP Operator Route Parameters Interface (6.6.2.5) - this process will provide the interface through which the ISP operator can input and update route calculation parameters used by the Provide Driver and Traveler Services function. The process will provide an interface through which the ISP operator can review and request update of map data. The operator will be able to use the process to request digitized map updates from suppliers, request output of trip planning and route selection control parameters, or to update the control parameters in the route_selection_parameters data store. The process will support inputs from the ISP operator in manual or audio form, and will provide its outputs in audible or visual forms. It will enable the visual output to be in hardcopy, and/or display.

(f) Calculate Vehicle Probe Data for Guidance (6.6.2.6) - this process will calculate route segment travel times from vehicle probe data. The probe data will be accepted by the process from a variety of sources including toll collection points and vehicles receiving on-line infrastructure based guidance. The process will be responsible for combining the data obtained from these sources and producing one set of route segment travel times or route segment speeds. The process will indicate route segments for which no data, or insufficient data, is available (this indication could be by setting the link time or speed to zero).

Requests for vehicle routes and in-vehicle guidance are received by process (a). This selects a route using the parameters in the store set up by the ISP operator through process (e), the road and freeway geometry provided by the map update provider through process (d), traffic data provided by process (b) and data from the store of previously selected routes. In-vehicle guidance uses the same sources of data, except that the road and freeway geometry is much more detailed so that the driver can be given detailed instructions, such as which lane to take. When the route for guidance is first selected, it is sent to the vehicle, but guidance will only begin once the driver has positively accepted the route. Traffic data for use by process (a) is provided by process (b) using data requested from the Display and Output Traffic Data facility - see DFD 1.1.4, plus data provided by the predictive model (see process (c) in DFD 1.1), vehicle probes through process (f) and the Determine Road and Freeway State and Review and Manage Incident Data facilities - see DFDs 1.2.2 and 1.3.2. If process (a) cannot find the data that it needs, it requests process (b) to obtain the data from ITS functions in other areas. Process (b) uses the link data provided by the Manage Traffic function to request the required data through process (c).

When determining a route, process (a) will use the preferences and constraints specified in the route request and the parameters set up by the ISP operator. The first two data items enable the requester to influence the route that the process chooses. For example, if the surface street constraint is set, then the process will calculate a route that uses route segments that are surface street roads and will ignore those that are freeways. The constraint data item is also used when specialist routes are required, such as those involving ahs lanes. In this instance, the constraints on surface street and freeways will not be set so that the process will not use this type of route segment, unless ahs lanes are unavailable. The parameters take preference over the data items in a route request, and are designed to enable the use of certain types of road, modes, etc. to be given priority. So for example, all routes could be directed to avoid surface street roads in a particular area, even though they are open to traffic, or give priority to transit modes when determining a route.

The processes also provide routes for two groups of specialized users, emergency vehicles and commercial vehicles, when requested by the appropriate supporting functions. Route selection for transit vehicles has not been included since they operate over pre-determined routes which in surface street areas

at least, are rarely subject to dynamic change. For inter-surface street public transport routes, especially those used by express bus services, guidance could be obtained by the driver in the same way as the driver of any other vehicle. It will be possible for the appropriate preferences and constraints to be set up for this service.

The processes (a) and (b) run continuously, but independently. This allows the route calculation work to proceed while new or additional data is being obtained. The calculation process is prompted to refine its results every time the data in either of the two stores of road data is updated, ensuring that the routes being used by the vehicles take account of the latest changes in traffic conditions.

Provide Driver Personal Services (DFD 6.7)

This DFD shows the processes that make up the Provide Driver Personal Services facility within the Provide Driver and Traveler Services function. These processes provide in-vehicle security and guidance services to the driver. The key points about the facility are as follows:

* - personal security is provided through driver action, e.g., pressing a panic button;

* - vehicle guidance can be dynamic or autonomous.

The two processes in this DFD are in fact DFDs and they divide its overall functionality between themselves in the following ways.

(a) Provide Driver Personal Security (6.7.1) - these processes provide a mechanism for a driver to call emergency services in the event of an incident involving the vehicle. The call is activated by the driver using a simple device such as a MAYDAY button in the vehicle. Output of an acknowledgment of the receipt of the message by the Manage Emergency Services function is provided through the Provide Information Services facility - see DFD 6.2.

(b) Provide On-line Vehicle Guidance (6.7.2) - these processes act as the interface to the route calculation processes (see DFD 6.6) when on-line vehicle guidance is requested by the driver. They process the driver's requests making use of any previously used guidance data and, when the route data is received from route calculation processes, pass it on to the driver in sequence as the vehicle moves through the surface street and freeway network. Three types of on-line vehicle guidance are supported, starting with that for autonomous vehicles at the lowest level. The next level up is also autonomous but uses traffic data obtained from a central source, while the highest level is dynamic guidance taking full account of current traffic conditions and predictions available from a central source. If the highest level of guidance is selected, and communication with the centralized source of guidance data is lost, the processes will fall back to autonomous guidance if the necessary navigable map databases are available in the vehicle. Once dynamic guidance has been requested and implemented, the processes will keep track of the vehicle location and automatically request updates to the route guidance data as that location changes. These processes will also continue to provide the driver with guidance if the link to the route calculation processes fails, or if so configured, provide static guidance without any reference to the dynamic data available from these processes.

The processes in the two DFDs are intended to be provided separately, with the exception that the security processes in (a) makes use of the vehicle location provided by a process in (b). It is also expected that they will share a common data output mechanism through the functionality provided by the Provide Information Services facility in DFD 6.2.

Provide Driver Personal Security (DFD 6.7.1)

This DFD shows the process that make up the Provide Driver Personal Security facility within the Provide Driver and Traveler Services function. The processes enable the driver to call emergency services in the event of an incident. The key points about the facility are as follows:

* - driver has only to initiate emergency message building process;

* - output of messages provided through the driver advisory message interface.

There are two processes in this DFD and they divide up its overall functionality between themselves in the following ways.

(a) Build Driver Personal Security Message (6.7.1.1) - this process will respond to the input of a request from a driver for action by the emergency services. Input of the request will be received by the process from the driver via a panic button or some other functionally similar form of input device provided as part of the in-vehicle equipment. When the input is received, the process will send a message to the communications process, containing the vehicle's current location, its identity and basic vehicle data relevant to its current condition, as well as any other data, such as personal medical history, vehicle orientation, etc., that may be developed in-vehicle by other systems.

(b) Provide Driver In-vehicle Communications Function (6.7.1.2) - this process will prepare and send an emergency message from a driver to the Manage Emergency Services function. The message will only be sent by the process in response to data received from another process that monitors driver inputs. Once an emergency message has been sent, the process will send a message to that effect to another process in the Provide Vehicle Monitoring and Control function for output to the driver. The process will then await a response from the Manage Emergency Services function, and then send a detailed message to the other process for output to the driver. Output of the emergency message to the Manage Emergency Services function will be repeated by the process at regular intervals until a response is received.

These processes must be implemented together. Process (a) supports the driver's ability to call the emergency services in the event that the vehicle is involved in an accident, or an incident occurs to which the driver wishes to summon the emergency services. In both cases only one input is required and all output is passed through process (b) to the Provide Emergency Service Allocation facility - see DFD 5.1. The emergency message received in acknowledgment by process (b) is sent to the Provide Information Services facility - see DFD 6.2 for output to the driver. The store containing the vehicle identity will be set up by the manufacturer.

Provide On-line Vehicle Guidance (DFD 6.7.2)

This DFD shows the processes that make up the Provide On-line Vehicle Guidance facility within the Provide Driver and Traveler Services function. These processes provide in-vehicle guidance on request from the driver. The key points about the facility are as follows.

* - three types of in-vehicle guidance are available, comprising dynamic and two types of autonomous;

* - dynamic guidance is provided by a centralized route selection function;

* - autonomous guidance uses in-vehicle database which may be enhanced by link journey times obtained centrally;

* - driver may choose the guidance type depending upon vehicle equipment and communications links;

* - in-vehicle trip planning available by specifying a route start time later than the current time;

* - if dynamic guidance fails, the guidance will continue based on the last data received.

There are three processes and one DFD in this DFD and they divide up its overall functionality in the following way.

(a) Provide Vehicle Guidance (6.7.2.1) - when vehicle guidance is requested by the driver, these processes gather the data needed to calculate the route. If dynamic guidance is specified and available, the data is sent to the Select Vehicle Route facility - see DFD 6.6.2. The response from the facility is passed back to the driver interface provided through process (c) below. If autonomous guidance is required, the process will use the data in the in-vehicle navigable map database, supplementing it with more up to date link journey if that mode is requested by the and driver they are available from the Select Vehicle Route facility. These processes will always use dynamic guidance if it is available and has been selected by the driver. If however, it has been selected but becomes unavailable, the processes will revert to autonomous guidance until contact can be re-established with the Select

Vehicle Route facility. These processes also maintain a store of commonly used input data, e.g., an often used destination, certain constraints and preferences, vehicle identity, etc. to relieve the driver of some data input effort.

(b) Process Vehicle Location Data (6.7.2.2) - this process will provide the vehicle's current location. It will calculate the location from one or more sources of position data such as GPS, DGPS, odometer and differential odometers, and will refine its calculations using techniques such as map matching, etc. Location data (intended for use by in-vehicle navigation, guidance systems, and any emergency notification systems) should be provided by the process in a manner that is as precise as is practical within cost and technology constraints. Location data intended for transit vehicles and driver advisories may be less precise.

(c) Provide Driver Guidance Interface (6.7.2.3) - this process will provide a user interface for the vehicle's driver through which route guidance is provided. Three types of route guidance provided by other processes will be supported by this process(dynamic infrastructure based, autonomous with infrastructure data update, and autonomous). The process will enable input by the driver of the type of guidance required, the data from which the route is to be determined and output of the resulting route. The process will not provide on-line guidance until the route has been accepted by the driver. For those forms of guidance that require an on-board map database, the process will provide an interface through which the driver may obtain and pay for an initial copy of the database plus updates when needed. The process will support inputs from the driver in either manual or audio form, and will provide its outputs in audible or visual forms. It will enable the visual output to be either in hardcopy, and/or display. Both types of output will not impair the driver's ability to control the vehicle in a safe manner.

(d) Update Vehicle Navigable Map Database (6.7.2.4) - this process will update the vehicle's navigable database based on digitized data obtained from a map provider, or other appropriate data source. The update will be initiated by the driver through another process .The process will have the capability to allow a financial transaction (to pay for the update) to be successfully completed using processes in the Provide Electronic Payment Services function. When the new map data is received, it will be loaded by the process into the vehicle_map_database data store for use by other processes. The result of the update request (successful or not) will be sent back to the driver interface process for output

Guidance requests from drivers are received by process (c) and passed to the processes in (a) for implementation. Depending on the type of guidance selected (and available), they will communicate with a central facility (dynamic guidance) or use the store of navigable map data maintained by process (d) to provide the requested guidance. This will only commence when the driver provides positive acknowledgment of the message that the processes in (a) have a route and are ready to begin guidance. All guidance output to the driver is sent to process (c) and provided in a form that does not impair the driver’s ability to control the vehicle.

The data in the store of navigable map data is updated by process (d) when a request is received from the driver through process (c). The completion of the update depends on successful completion of the payment transaction sent by process (d) to the Collect Advanced Payments facility - see DFD 7.4.1. Vehicle location data is provided by process (b) for use by the processes in (a) and for use by other facilities and ITS functions.

Disabled drivers are accommodated by specifying their needs using the preferences and constraints variables in the data used for the guidance request input to process (c). This ensures that they are guided to such things as the parking spaces for the disabled, etc.

In-vehicle trip planning is available by specifying a start time that is later than the current time, e.g., five minutes ahead. In this case no guidance data is provided by the processes in (a), and is replaced by simple route data, i.e., a list of route segments that will make up the proposed trip. In-vehicle guidance assumes that the start time is almost immediate.

Provide Vehicle Guidance (DFD 6.7.2.1)

This DFD shows the three processes that make up the Provide Vehicle Guidance facility within the Provide Driver and Traveler Services function. These processes determine the actual vehicle guidance method, and generate the route and guidance instructions. The key points about the facility are as follows:

* - guidance type depends on driver's request and on the availability of in-vehicle equipment;

* - dynamic guidance type requires a communications link to a central facility;

* - if dynamic guidance fails then autonomous guidance is provided until it is restored;

* - autonomous guidance may use link travel times provided centrally, at the driver's request.

There are three processes in this DFD and they divide up its overall functionality between themselves in the following ways.

(a) Determine In-vehicle Guidance Method (6.7.2.1.1) - this process will act as the interface for guidance requests received from drivers in vehicles. The process will select the best method for in-vehicle guidance based on data in the driver's request. Three general methods of route guidance are supported: 1) dynamic (infrastructure based guidance is provided to the vehicle unit), 2) dynamic autonomous (link and queue speed or travel times are obtained from the infrastructure and used by the autonomous in vehicle unit), and autonomous (the in vehicle unit uses only locally available data- there is no information provided by the infrastructure). When dynamic guidance is selected, the vehicle's travel time for each link will be provided by the process back to a central source of data. If the communications link to the central source fails in either of the modes that use it, the process will automatically revert to the use of local data only. When the original mode was centralized guidance, the process will use the last set of guidance data that was received, and if this is not sufficient for the vehicle to reach the requested destination, automatically revert to autonomous guidance using local data only.

(b) Provide Dynamic In-vehicle Guidance (6.7.2.1.2) - this process will enable dynamic vehicle route guidance data to be calculated. The process will perform the same dynamic vehicle route guidance services for vehicles that are under automatic control using automatic highway system (ahs)lanes. When providing dynamic guidance, the process provides vehicle travel times as probe data to another process in the Provide Driver and Traveler Services function. The process will base its guidance request on data input by the driver through another process, and on the vehicle's current location as provided by another process.

(c) Provide Autonomous In-vehicle Guidance (6.7.2.1.3) - this process will provide autonomous in-vehicle guidance. It will calculate the route using data obtained from an in-vehicle navigable map database which can be supplemented with link queue and travel time data obtained from a central source, if specified by the driver and available. The process will provide guidance in the form of actual driving instructions, e.g. turn left at the next intersection, take the right lane, etc. When link queue and travel time data are being used, the process will provide guidance for the best route for current traffic conditions, within the preferences and constraints specified by the driver in the guidance request.

The process in (a) is responsible for deciding on the type of guidance to be used and setting up the data sent to the chosen route calculation process. This data defines the type of route and the preferences and constraints that are to be applied to the calculation process. These will have been set up by the driver through the interface process in the Provide On-line Vehicle Guidance facility - see DFD 6.7.2, except when the request is for a route involving automatic highway system (ahs) lanes. In this instance the constraints in particular will be set by process (b) so that this type of lane is used. If these lanes are not available at some point, the route will be specified with the end of the last ahs lane as a new route calculation point, so that alternative preferences and constraints can be used. If the driver omits data from the guidance request, the option is provided for its direct input, or the use of data from the store of retained data.

If dynamic guidance is selected then process (a) sends the route request to process (b) for the addition of the vehicle location and communication with the Select Vehicle Route facility - see DFD 6.6.2. The data that is returned to process (b) is sent to process (a) and then to the driver interface. If no route can be provided by process (b), then process (a) sends the request to process (c) which provides autonomous guidance. At the driver's request, this may make use of link journey times provided by the Select Vehicle Route facility. Failure of dynamic guidance will cause process (a) to request autonomous guidance from process (c) starting at the vehicle's current location.

When providing dynamic guidance, process (b) will continually monitor the vehicle's location. When the vehicle reaches pre-defined points on the route (way points), it will request a new route from the Select Vehicle Route facility. It will also provide the facility with its location at the end of each route segment so that the facility has a feedback of the actual segment journey times (probe data).

The processes (b) or (c) above may be omitted from any particular implementation or offered as options since they are independent. However if the process in (c) is not included, and the communications link with the source of dynamic guidance data fails, then the vehicle will be left to depend on the last set of dynamic guidance data that it received. This cannot now be updated if the vehicle departs from the originally specified route since no autonomous guidance will be available.

Provide Traveler Personal Services (DFD 6.8)

This DFD shows the processes that make up the Provide Traveler Personal Services facility within the Provide Driver and Traveler Services function. These processes provide personal security, on-line guidance and traveler information to a traveler using a personal portable device. Traveler information and trip planning is provided for travelers using a personal (but not portable) device. The key points about the facility are as follows:

* - to access the security or on-line guidance features, the traveler must be using a personal portable device (ppd);

* - personal security is provided through traveler action, e.g., pressing a panic button, on the ppd;

* - on-line traveler guidance can be dynamic or autonomous;

* - traveler information is requested and provided in a similar way to that at a kiosk.

The three processes in this DFD are all DFDs and they divide its overall functionality between themselves in the following ways.

(a) Provide On-line Traveler Guidance (6.8.1) - these processes act as the interface to the Provide Guidance and Trip Planning facility - see DFD 6.6, when on-line guidance is requested by the traveler. They process the traveler's requests making use of any previously used input data and, when the guidance data is received from route calculation processes, pass it on to the traveler in sequence as the they move through the transportation network. Two types of guidance are supported, comprising autonomous and dynamic. The autonomous guidance uses data from a navigable map database within the traveler's personal portable device (ppd). Dynamic guidance uses current traffic and transit conditions and predictions available from a central source. If dynamic guidance is selected, and communication with the centralized source of guidance data is lost, the processes will fall back to autonomous guidance. Once dynamic guidance has been requested and implemented, the processes will keep track of the vehicle location and automatically request updates to the guidance data as that location changes. These processes will also continue to provide the traveler with guidance if the link to the route calculation processes fails, or if so configured, provide static guidance without any reference to the dynamic data available from these processes.

(b) Provide Traveler Personal Security (6.8.2) - these processes provide a mechanism for a traveler to call emergency services in the event of a personal incident. The call is activated by the traveler using a simple device such as a MAYDAY button on their ppd. Output of an acknowledgment of the receipt of the call-out message by the Manage Emergency Services function is provided back to the ppd.

(c) Provide Traveler Services at Personal Devices (6.8.3) - these processes provide the interface through which the traveler can plan trips and obtain traffic and transit information using a personal device (either portable or non-portable). The trips can be multimodal and the traveler can alter the data on which the trip is based until a satisfactory solution is provided. Frequently used input data such as traveler preferences, etc. can be retained in the traveler device for use in subsequent trip requests. Any reservations and/or advanced payments can be made as part of the trip confirmation. The traveler may also access information about yellow pages services and make reservations of these services. The display of traffic and transit information can be shown against a background of map display obtained from digitized data stored locally within the traveler device, and updated at the traveler's request.

These three sets of processes can form a coupled group. The processes (b) and (c) could be provided as options in any implementation, because they both make use of the traveler location provided by a process in (a).

Provide On-line Traveler Guidance (DFD 6.8.1)

This DFD shows the processes that make up the Provide On-line Traveler Guidance facility within the Provide Driver and Traveler Services function. These processes provide the traveler with on-line guidance which may be dynamic or autonomous. The key points about the facility are as follows:

* - on-line guidance provides detailed instructions for a traveler along a route;
* - guidance request includes preferences and constraints for travelers with special needs;
* - trip planning available by specifying a route start time that is later than the current time;
* - guidance and trip planning available for multimodal routes, including heavy rail and airline services;
* - often used traveler data can be retained for future re-use;
* - traveler can obtain information about and make reservations for yellow pages services.

There are four processes and one DFD in this DFD and they divide up its overall functionality between themselves in the following ways.

(a) Provide Traveler Guidance (6.8.1.1) - when on-line guidance is requested by the traveler, these processes gather the data needed to calculate the route. If dynamic guidance is specified and available, the data is sent to the Provide Guidance and trip Planning Services facility - see DFD 6.6. The response from the facility is passed back to the traveler interface provided through process (b) below. If autonomous guidance is specified, the processes will use the data in the navigable map database stored within the personal portable device. These processes will always use dynamic guidance if it is available and has been selected by the traveler. If however, it has been selected but becomes unavailable, the processes will revert to autonomous guidance until contact can be re-established with the Provide Guidance and trip Planning Services facility. These processes also maintain a store of commonly used input data, e.g., an often used destination, certain constraints and preferences, traveler identity, etc. to relieve the traveler of some data input effort.

(b) Provide Personal Portable Device Guidance Interface (6.8.1.2) - this process will be responsible for providing a user interface for the traveler through which personal guidance can be delivered. The process will enable the traveler to input data to request a suitable route. This process will be capable of supporting two types of route guidance: dynamic (infrastructure based guidance is provided to the personal portable device), and autonomous (the personal portable device uses only locally available data- there is no information provided by the infrastructure). The process will also act as the interface for output of on-line guidance to the traveler. Multimodal routes will be supported by the process. The process will not provide on-line guidance until the route has been accepted by the traveler. For those forms of guidance that require an on-board map database, the process will provide an interface through which the traveler may obtain and pay for an initial copy of the database plus updates when needed. The process will support inputs from the traveler in either manual or audio form, and will provide outputs in audible or visual forms. It will enable the visual output to be either in hardcopy, or display. Both types

of output will be produced in such a way that in using them the traveler does not become a hazard to other travelers.

(c) Process Personal Portable Device Location Data (6.8.1.3) - this process will provide the traveler's current location. It will calculate the location from one or more sources of position data such as GPS or DGPS, and will refine its calculations using techniques such as map matching, dead reckoning, etc. The process will provide the location to the to other processes for use in autonomous and dynamic guidance. This location should be precise as is practical within cost and technology constraints. It is intended for use by traveler personal navigation and guidance systems, as well as emergency notification systems.

(d) Update Traveler Navigable Map Database (6.8.1.4) - this process will update the traveler's navigable database based on digitized data obtained from a map provider, or other appropriate data source. The update will be initiated by the traveler through another process. The process will have the capability to allow a financial transaction (to pay for the update) to be completed using processes in the Provide Electronic Payment Services function. When the new map data is received, it will be loaded by the process into the traveler_map_database data store for use by other processes. The result of the update request (successful or not) will be sent back to the traveler interface process for output to the traveler.

(e) Provide Traveler Emergency Message Interface (6.8.1.5) - this process will provide an emergency notification interface for a traveler using a personal portable device. The emergency notification interface will enable the output of messages generated by a traveler's emergency request to another process.

Guidance requests from travelers are received by process (b) and passed to the processes in (a) for implementation. Depending on the type of guidance selected (and available), they will communicate with a central facility (dynamic guidance) or use the store of navigable map data maintained by process (d) to provide the requested guidance. This will only commence when the traveler provides positive acknowledgment of the message that the processes in (a) have a route and are ready to begin guidance. All guidance output to the traveler is sent to process (b) and provided in a form that does not distract the traveler so that they become a hazard or nuisance to others.

The data in the store of navigable map data is updated by process (d) when a request is received from the traveler through process (b). The completion of the update depends on successful completion of the payment transaction sent by process (d) to the Collect Advanced Payments facility - see DFD 7.4.1. Traveler location data is provided by process (c) for use by the processes in (a) and for use by other facilities and ITS functions. Process (e) provides output of the response to an emergency request from the traveler through processes in the Provide Traveler Personal Security facility - see DFD 6.8.2.

The above processes support the traveler’s use of multimodal routes, the choice of modes being specified by the traveler as part of the data input process (b). The resulting route will make the best use of some or all of the specified modes depending on what is available along the traveler’s route. Similarly travelers with special needs, e.g., those who are deaf, wheelchair bound, or have a guide dog, can register their special requirements as part of the input data. This ensures that they are guided to such things as lifts, seats for disabled travelers and warned of such thins as escalators, road crossings, etc.

The actual guidance information provided as output from process (b) will have enough detail for travelers to ’navigate’ themselves through the transportation network. The type of information provided will include such things as when to cross the street, the name of the street to use, which transit service to take, where to change from one service to another, etc.

Provide Traveler Guidance (DFD 6.8.1.1)

This DFD shows the processes that make up the Provide Traveler Guidance facility within the Provide Driver and Traveler Services function. These processes determine the actual traveler guidance method, and generate the route and guidance instructions. The key points about the facility are as follows:

* - type of guidance provided depends on the traveler's request;

* - dynamic guidance requires communications links to other processes for its use;

* - if dynamic guidance fails then autonomous guidance automatically provided.

There are three processes in this DFD and they divide its overall functionality in the following way.

(a) Determine Personal Portable Device Guidance Method (6.8.1.1.1) - this process will act as the interface for personal guidance requests received from travelers with personal portable devices. The process will select the best method for personal guidance based on data in the traveler's request. Two methods will be available to the process, comprising dynamic infrastructure based guidance is provided to the personal portable device), and autonomous (the personal portable device uses only locally available data- there is no information provided by the infrastructure). If the communications link to the central source fails, the process will use the last set of guidance data that was received, and if this is not sufficient for the traveler to reach the requested destination, automatically revert to the use of autonomous guidance using local data only.

(b) Provide Personal Portable Device Dynamic Guidance (6.8.1.1.2) - this process will enable dynamic traveler guidance data to be calculated. The process will base its guidance request on the data input by the traveler from a personal portable device through other processes, and on the traveler's current location as provided by another process.

(c) Provide Personal Portable Device Autonomous Guidance (6.8.1.1.3) - this process will provide autonomous on-line guidance when requested by the traveler from a personal portable device. It will calculate the route using data obtained from a navigable map database stored in the traveler's personal portable device. Guidance will be provided by the process in the form of actual instructions to the traveler, e.g. cross the road here, take the subway to a specific station. The process will provide guidance for the shortest route, within the preferences and constraints specified by the traveler in the guidance request.

The process in (a) is responsible for deciding on the type of guidance to be used and setting up the data sent to the chosen route calculation process. This data defines the type of route and the preferences and constraints which are to be applied to the calculation process. These will have been set up by the traveler through the interface process in the Provide On-line Traveler Guidance facility - see DFD 6.8.1. If the traveler omits data from the guidance request, the option is provided for its direct input, or the use of data from the store of retained data.

If dynamic guidance is selected then process (a) sends the route request to process (b) for the addition of the traveler's location and communication with the Provide Guidance and Trip Planning Services facility - see DFD 6.6. The data that is returned to process (b) is sent to process (a) and then to the traveler interface. If no route can be provided by process (b), then process (a) sends the request to process (c) which provides autonomous guidance. Failure of dynamic guidance will cause process (a) to request autonomous guidance from process (c) starting at the traveler's current location. When providing dynamic guidance, process (b) will continually monitor the traveler's location. When pre-defined points on the route (way points) are reached, it will request a new route from the Provide On-line Traveler Guidance facility.

The processes (b) or (c) above may be omitted from any particular implementation or offered as options since they are independent. However if the process in (c) is not included, and the communications link with the source of dynamic guidance data fails, then the traveler will be left to depend on the last set of dynamic guidance data that they received. This cannot now be updated if the traveler departs from the originally specified route since no autonomous guidance will be available.

Provide Traveler Personal Security (DFD 6.8.2)

This DFD shows the processes that make up the Provide Traveler Personal Security facility within the Provide Driver and Traveler Services function. The processes enable the traveler to use a personal

portable device (ppd) to call emergency services in the event of an incident. The key points about the facility are as follows:

* - driver has only to initiate emergency message building process;

* - output of messages provided through the traveler guidance interface.

There are two processes in this DFD and they divide up its overall functionality between themselves in the following ways.

(a) Build Traveler Personal Security Message (6.8.2.1) - this will respond to the input of a request from a traveler for action by the emergency services. Input of the request will be received by the process from the traveler via a panic button or some other functionally similar form of input device provided as part of the traveler's personal portable device. When the input is received, the process will send a message to the communications process, containing the traveler's current location and identity.

(b) Provide Traveler Emergency Communications Function (6.8.2.2) - this process will prepare and send an emergency message from a traveler's personal portable device to the Manage Emergency Services function. The message will only be sent by the process in response to data received from another process that monitors traveler inputs. Once an emergency message has been sent, the process will send a message to that effect to another process for output to the traveler. The process will then await a response from the Manage Emergency Services function, and when received again send a message to the other process for output to the traveler. Output of the emergency message to the Manage Emergency Services function will be repeated by the process at regular intervals until a response is received.

These processes must be implemented together. Process (a) supports the traveler's ability to call the emergency services following involvement in an accident, or an incident occurs to which the traveler wishes to summon the emergency services. In both cases only one input is required and all output is passed through process (b) to the Provide Emergency Service Allocation facility - see DFD 5.1. The emergency message received in acknowledgment by process (b) is sent to the Provide Traveler On-line Guidance facility - see DFD 6.8.1 for output to the traveler. The store containing the traveler identity will be set up by the manufacturer of the personal portable device.

Provide Traveler Services at Personal Devices (DFD 6.8.3)

The processes in this DFD provide the Provide Traveler Services at Personal Devices facility within the Provide Driver and Traveler Services function. These processes enable the traveler to obtain traffic and transit information and to plan trips from a personal device. The key points about the facility are as follows:

* - travelers can plan trips and obtain traffic, transit, and yellow pages services information;

* - trip plans may be multimodal, including such things as demand responsive transit and ridesharing;

* - trip plans may be confirmed and paid for in advance as may yellow pages services;

* - travelers may obtain traffic and transit information without making any trip plans or reservations;

* - provides "kiosk" type facilities for travelers using their own personal devices.

There are four processes in this DFD and they divide its overall functionality in the following way.

(a) Get Traveler Personal Request (6.8.3.1) - this process will receive traveler requests from a personal device (portable, or non portable) then provide support for trip planning, traffic, transit and yellow pages services information, trip confirmation, yellow pages services confirmation, and payment requests. The process will send these requests to the appropriate processes within the Provide Driver and Traveler Services function for further processing to generate responses. The interface to the traveler will be provided through a separate process, from which input to this process originates.

(b) Provide Traveler with Personal Traveler Information (6.8.3.2) - this process will provide the traveler (using a personal device) with data about all requested trip, traffic, transit, yellow pages services information, confirmation of any requested reservations, and payments made as part of confirmed trip plans. The data will be sent by the process to an interface process which is responsible for its actual output to the traveler. This data will include digitized map data to act as the background to the output when the data is shown in a suitable format. This process will request data from other ITS functions or be sent it as a result of requests from another process.

(c) Provide Traveler Personal Interface (6.8.3.3) - this process will provide an interface in a personal device through which travelers can plan and confirm trips, as well as obtain current traffic and transit information. The process will support trip planning and confirmation of other (yellow pages) services such as lodging, restaurants, theaters, and other tourist activities. The process will be able to load in the traveler_personal_regular_data store frequently used information such as traveler identity (the owner of the personal device), home and work locations, etc. This will reduce the amount of input needed by the traveler for each trip request. The process will also carry out input data verification and require input confirmation, with the traveler, before passing the data to other processes. The traveler's payment information and location (when traveler is using a portable device) will be obtained by this process from other processes. The process will support inputs from the traveler in both manual and audio form, and will provide its outputs in audible and visual forms that are consistent with a personal device. This process will include forms suitable for travelers with hearing and vision physical disabilities. The process will display data for as long as required by the traveler and must enable viewing of previously output data. When used with a portable device, the process will provide the traveler the option to filter the data (to be displayed) relevant to the travelers current location.

(d) Update Traveler Personal Display Map Data (6.8.3.4) - this process will provide updates to the digitized map data used as the background for displays on travelers' personal devices. These displays include details of traffic, trip and travel information for use by travelers. The process will obtain the new map data from a map provider process or some other appropriate data source on request from the traveler via the traveler interface process. The process will load data into the map_data_for_traveler_personal_displays data store. The data will be compatible with the types of displays that are found on personal devices.

The traveler provides trip planning, trip confirmation, plus traffic and transit information requests through process (c). These are sent to process (a), which distributes the trip planning, and confirmation requests to the appropriate processes in the Provide Trip Planning Services facility - see DFD 6.1. Requests for traffic and transit information are sent for implementation by process (b) that also receives the results from the trip planning requests made by process (a). All data received by process (b) is sent to process (c) for output to the traveler. Travelers can request as many trip plans as are needed before an acceptable match is found to their trip requirements. Data used for previous inputs and regularly used data is kept in the store of traveler regular data by process (c). The outputs produced by process (c) may be shown against a background of digitized map data produced by process (d). This process will also update the store of map data on request from the traveler through process (c), and successful completion of payment through the Collect Advanced Payments facility - see DFD 7.4.1.

These processes form a tightly coupled group and communicate with many other ITS functions. They can only be implemented as a group, except that process (d) may be omitted if digitized map data is not to be used as the background for data output.

1.6.1.8. Provide Electronic Payment Services (DFD 7)

The processes in this DFD are responsible for the Provide Electronic Payment Services function. This function is responsible for enabling drivers, transit users and travelers to pay for their journeys and for other services. The key points about their functions are as follows:

* - facilities are provided for non-stop toll, fare and parking lot charges collection;

* - drivers and travelers can pay for tolls, fares, parking lot charges in advance;

* - additionally travelers can only pay for yellow pages services in advance;

* - images of those making invalid payments are sent to the Manage Emergency Services function;

* - the only item of data required by the driver for toll or parking lot charges is an identity.

The four processes subordinate to this DFD are all DFDs. Overall functionality is divided between them in the following ways.

(a) Provide Electronic Toll Payment (DFD 7.1) - These processes provide facilities for the electronic collection of tolls from vehicles as they pass through toll plazas. They also enable drivers to pay for transit fares and parking lot charges in advance. Images of violators are captured and sent with other data to the Manage Emergency Services function (see DFD 5) for processing and forwarding to the appropriate law enforcement agency. A record of all transactions is periodically sent to the toll operator, toll service provider, and in a sanitized form, to the Manage Archived Data function - see DFD 8.

(b) Provide Electronic Parking Payment (DFD 7.2) - These processes provide the facilities for the electronic collection of parking lot charges from vehicles as they pass through parking lot entrances or exits. They also enable drivers to pay for tolls and transit fares in advance, and to request and reserve parking lot space. Images of violators are captured and set with other data to the Manage Emergency Services function (see DFD 5) for processing and forwarding to the appropriate law enforcement agency. A record of all transactions is sent to the parking service provider on request.

(c) Provide Electronic Fare Collection (DFD 7.3) - These processes provide facilities for billing transit users with the cost of their fares as they pass through boarding points for transport services. They also enable the transit user to pay for yellow pages services, tolls, and parking lot charges in advance. Billing can be for fares collected either on-board transit vehicles, or at the roadside. Images of violators are captured and sent with other data to the Manage Emergency Services function (see DFD 5) for processing and forwarding to the appropriate law enforcement agency. A record of all transactions is periodically sent to the transit system operator and transit fleet manager.

(d) Carry-out Centralized Payments Processing (DFD 7.4) - These processes are responsible for maintaining a centralized store of data on the prices being charged for tolls, spaces at parking lots, and transit fares. They also enable drivers and travelers to pay for tolls, fares and parking lot charges, plus other (yellow pages) services in advance and in the case of travelers, as part of their trip planning facilities.

(e) Provide Payment Instrument Interfaces (DFD 7.5) - These processes are responsible for providing the interfaces through which data can be collected from the payment instruments being used by drivers and travelers. This data may consist of the credit identity or stored credit value depending on the type of instrument being used. The payments may be for such things as navigable map database updates, display map updates, and advanced payments as part of trip confirmations. Payment by the commercial vehicle manager for electronic credentials and tax filing is also supported. The processes support the reduction in the value of any stored credit that the payment instrument may be carrying in payment for the requested service.

The above processes are able to implement a flexible toll, fare, and parking lot charging policy that enables each of these to change or be changed by time of day, day or week, or in response to input from the service providers, who may themselves be influenced by the Manage Travel Demand facility - see DFD 1.4. This is designed to provide some influence over the modal split of travelers' journeys between the private car and transit modes of transportation.

Provide Electronic Toll Payment (DFD 7.1)

The processes in this DFD are responsible for the Provide Electronic Toll Payment facility within the Provide Electronic Payment Services function. These processes transact the payments for tolls either for current use by drivers, or as advanced payments by transit users and travelers. The key points about the facility are as follows:

* - drivers can pay tolls without stopping or slowing down as they pass toll plazas;

* - drivers can also pay in advance for transit fares and parking lot charges;

* - images of drivers making invalid payments are sent to the Manage Emergency Services function.

There are five processes and one DFD in this DFD. Overall functionality is divided between them in the following ways.

(a) Process Electronic Toll Payment (DFD 7.1.1) - These processes obtain the vehicle type and tag identity and, if the toll has not already been paid, request payment through the Payment Instrument. Data is provided for display to the driver of the transaction result - see (b) below. If the transaction is unsuccessful a command is sent to the process in (c) to obtain an image of the violator and details sent to the Financial Institution. Periodically (e.g., daily), payment for the tolls is requested from the Financial Institution and transaction reports are sent to the Toll Operator and Toll Service Provider. The toll transaction data is analyzed at more frequent intervals (e.g., every five minutes) to provide probe data in the form of the average journey time between toll plazas, which is sent to the Manage Traffic and Provide Driver and Traveler Services functions. The processes are also able to initiate advanced toll payment transactions, storing the vehicle/traveler identities until the vehicle appears at the toll plaza.

(b) Produce Roadside Displays (7.1.2) - This process will be responsible for driving the displays that tell vehicles whether or not their driver's toll payment has been confirmed or rejected. The process will receive the data for output via the displays from other processes. The process will provide its outputs in audible and visual forms, with the latter using an appropriate form of display that will be easily readable under all lighting conditions and over the range of speeds that vehicles are expected to use when passing through the toll plaza.

(c) Obtain Toll Violator Image (7.1.3) - This process will be responsible for obtaining an image of a violator for use by other processes. The form of the image data obtained by this process will be very accurate so that there can be no mistake of the determination of the identity of the vehicle and/or driver, and will be easily passed on by the other processes to the appropriate law enforcement agency(ies) so that punitive action may be taken. The process will be capable of obtaining an image of the required accuracy under all lighting conditions and over the range of speeds with which vehicles will pass through the toll plaza.

(d) Provide Driver Toll Payment Interface (7.1.4) - This process will be responsible for providing an interface through which drivers can request and pay for other services when paying their tolls at toll plazas. The services supported by this process include advanced payment for parking lot charges and transit fares. The process will query the driver for sufficient information to enable the advanced parking lot charge and/or transit fare to be determined and the cost either billed to a credit identity provided by the driver's payment instrument, or deducted from credit stored on the instrument. The input and output forms will include those that are suitable for travelers with physical disabilities.

(e) Detect Vehicle for Tolls (7.1.5) - This process will be responsible for producing a vehicle's characteristics from data received by sensors located at the roadside, at or near the toll collection point. The data will be sent by the process to another process in a form suitable for use in calculating the toll cost for the vehicle. The process will ensure that the data includes such things as vehicle size, weight, axle count, type, identifiable features, etc.

(f) Distribute Advanced Charges and Fares (7.1.6) - This process will be responsible for receiving requests for advanced payment of tolls from the parking lot charge or transit fare collection facilities within the Provide Electronic Payment Services function. It will pass the requests on to another process in the toll collection facility, and will return transaction success or failure details to the requesting process. The process will also receive requests for the advanced payment of parking lot charges and transit fares from the toll payment interface process. It will send these requests to other processes in the Provide Electronic Payment Services function and when received, return the results to the toll payment interface process.

(f) Provide Payment Instrument Interface for Tolls (7.1.7) - This process will be responsible for providing the interface through which the payment information can be read from a vehicle tag. The process will enable the use of the data from the tag for the purposes of paying for current tolls, plus if required, the cost of advanced parking lot charges, and/or transit fares, as well as providing the data for use in traffic flow analysis. The tag data which can be collected by the process will include credit identity, stored credit value, and the toll segment identity at the vehicle's entry point so that closed toll system can be used. When stored credit is used, the process will enable the deduction of the cost of the toll and (possibly) advanced payments from the credit value on the tag. The process will support collection of data from tags on-board a range of vehicle types including private cars or vans, commercial vehicles, transit vehicles, including those used for demand responsive transit services.

Process (e) detects the presence of a vehicle and passes this to the processes in (a). These processes collected the tag data from the vehicle and process the toll payment transaction. The success or failure of this transaction is output by these processes through process (b). If a collection or payment violation is detected, then the processes in (a) request process (c) to obtain an image of the violator and to pass this on to the Provide Law Enforcement Allocation facility - see DFD 5.4.

Requests from drivers to pay for parking lot charges and transit fares in advance are received by process (d), which passes them to process (f). This acts as the communications interface through which the drivers' requests are sent to the Provide Electronic Parking Payment and Provide Electronic Fare Collection facilities - see DFDs 7.2 and 7.3 respectively. These facilities may also send this process requests from drivers and transit users to pay for tolls in advance, which when received are passed on to processes in (a).

Process (g) provides the interface through which data can be collected from the payment instruments being used by drivers. This data may consist of the credit identity or stored credit value depending on the type of instrument being used. It can be used for the payment of tolls and/or the advanced payment of parking lot charges and transit fares. For payment instruments containing a credit identity, the process will return an indication that this will be used to collect payment through the financial institution. Those payment instruments containing stored credit will have the amount that they contain debited by the cost of the transaction.

The processes in this group provide all the facilities for handling both current and advanced toll payments. They form a tightly coupled group that should be implemented in their entirety. However process (f) could be omitted if particular implementations are not supporting the advanced payments of tolls, parking lot charges, and transit fares.

Process Electronic Toll Payment (DFD 7.1.1)

The processes in this DFD are responsible for the Process Electronic Toll Payment facility within the Provide Electronic Payment Services function. These processes transact the payments for current and advanced tolls. The key points about the facility are as follows:

* - tolls are calculated by vehicle characteristics and are set by the toll service provider;
* - support is provided for the "closed" type of toll system;
* - a record of all transactions is provided for the toll operator and service provider;
* - all vehicles are checked for advanced payment before being billed for the current toll;
* - average journey time between toll plazas is provided as probe data to other ITS functions.
* - operational data is provided to the Manage Archived Data function.

There are ten processes in this DFD. Overall functionality is divided between them in the following ways.

(a) Read Tag Data for Tolls (7.1.1.1) - This process will be responsible for requesting the data from the toll tag being carried on-board the vehicle and used as a payment instrument. If there is no

tag or the data it contains cannot be properly read, this process will provide a message for the vehicle operator to contact the toll authority (or toll system operator). The process will send a request to other processes to obtain an image of the vehicle. If the vehicle is exiting a closed toll system the data will be checked by this process to see if it contains an entry point toll segment number. If not present, the process would be referred to another process for off-line resolution. If the toll segment identity is present, it will be combined with the vehicle characteristics, e.g., size, type, etc., to form the data upon which the toll payment transaction can be based, and the data sent to another process. If the vehicle is entering a closed toll system, the entry point toll segment will be written onto the tag so that it can be used as the mechanism for charging for the use of the toll road.

(b) Calculate Vehicle Toll (7.1.1.2) - This process will be responsible for calculating the toll for the detected vehicle based on the vehicle's characteristics and data obtained from the tag being carried by the vehicle. This process will calculate the cost of the toll using segment(s) traveled by the vehicle. Segment information is obtained by reading data from a store that contains standard prices for toll segments.

(c) Manage Bad Toll Payment Data (7.1.1.3) - This process will be responsible for maintaining a data store containing a list of invalid driver credit identities. This process will use this data to verify credit identities and commercial vehicle carrier numbers provided for checking by the billing process. Verification will ensure that the current toll payment transaction is using a credit identity or carrier identity that has not previously had an invalid transaction. Details of potential invalid credit identities or carrier numbers will be sent by this process to the financial institution for verification. This process will also receive from the financial institution details of invalid payment instrument data that has been found by other means.

(d) Check for Advanced Tolls Payment (7.1.1.4) - This process will be responsible for checking to see if the required toll payment has already been made. The process will determine the existence of an advance payment for the toll segment(s) by comparing the received payment information with that in the store containing the list of advanced payments. If the payment has already been made then the process will remove the requirement for local billing and remove the record of the advanced payment from the store. Details of each payment transaction will be sent by the process to another process with the payment information received from the driver removed.

(e) Bill Driver for Tolls (7.1.1.5) - This process will be responsible for either obtaining payment for the current or advanced toll. The process will achieve this either by requesting that the toll cost be deducted from the credit being stored by the toll tag that is acting as the payment instrument, or by informing the driver that payment for the toll will be debited to the credit identity provided by the tag. Before sending data to the tag, the process will check that either the credit identity is not already in the list of bad payers, or the stored credit is not less that the toll cost. If either of these conditions is true, the process will obtain an image of the driver and vehicle which can be forwarded to the appropriate enforcement agency via another process. When the appropriate payment transaction has been completed, the toll entry segment identity will be cleared from the tag so that it can be used the next time that the vehicle is on a toll road. The tag may be in the form of some type of credit or debit card, or an electronic purse. Details of the transaction will always be sent by this process to the process that manages toll transactions. Where an advanced toll payment is identified, the process will take no action if the credit identity is on the bad payers list, or the stored credit is less than the toll cost, other than the payment is not confirmed.

(f) Collect Probe Data from Toll Transactions (7.1.1.6) - This process will calculate the time taken for vehicles to travel between successive toll plazas and send it to the Manage Traffic and Provide Driver and Traveler Services functions. The process will periodically request the data from the process that manages toll financial processing and ensure that any references to the driver and/or vehicle identity plus any other payment information are removed from the data before it is sent to the other functions.

(g) Update Toll Price Data (7.1.1.7) - This process will be responsible for maintaining a store of data containing the toll price, which may vary according to the type of vehicle. The process will

also act as the interface for the output and input of responses to toll price change requests from the Manage Traffic function, the provision of toll price information to the Centralized Payments facility, and to the toll service provider to enable changes to be made to the stored data. The input and output forms will include those that are suitable for travelers with physical disabilities.

(h) Register for Advanced Toll Payment (7.1.1.8) - This process will be responsible for responding to requests for tolls to be paid in advance. It will provide the toll service provider with the opportunity to deny the request for an advanced toll. If approved, the advanced toll data will be forwarded by the process to other processes for the actual toll cost to be obtained and payment transactions initiated.

(i) Manage Toll Financial Processing (7.1.1.9) - This process will be responsible for maintaining a log of all toll transactions that are carried out by other processes in the toll payments facility. At periodic intervals the process will output the accumulated records to the toll service provider, the toll operator and the Manage Archived Data function. It will also output the data on request to the process that calculates probe data from the average travel time between toll plazas. The identity of the payee will be removed from the data before it is used in any of these outputs. The process will also be responsible for sending details of transactions to the financial institution to enable the users to be billed through their credit identities. For commercial vehicles, this will be done using the data provided by the vehicle's on-board tag and will enable billing to the financial institution to be made by carrier.

(j) Determine Advanced Toll Bill (7.1.1.10) - This process will be responsible for receiving a request to pay an advanced toll. It will obtain the price of the toll segment(s) for which advanced payment is being requested from a local data store and will then forward it to the billing processes. The store of toll prices will be maintained by another process.

(k) Manage Toll Archive Data (7.1.11) - This process obtains toll operational data and toll pricing data and distributes it to the Manage Archived Data function. As data is received into this process quality control metrics are assigned. The appropriate meta-data is generated and stored along with the data. A catalog of the data is maintained to allow requesters to know what data is available from the archive store. The process runs when a request for data is received from an external source, or when fresh data is received.

Vehicle toll characteristics information is received by process (a) which then requests data from the vehicle’s toll tag. If the tag data is unreadable, then process (a) sends a pull-in message and requests an image of the violator. Processes in the Provide Electronic Toll Payment facility (see DFD 7.1) provide the vehicle characteristics data, send output of the pull-in message, and respond to the two requests for data from process (a). Valid characteristics data is passed from process (a) to process (b), which calculates the vehicle’s toll, using a store of toll prices maintained by process (g). This calculation may be based on such things as the vehicle characteristics and time at which the vehicle is using the toll segment. It may also use the identity of the toll segment which was stored on the tag when the vehicle entered the toll road. This provides support for the “closed” type of toll system.

The cost of the toll is passed from process (b) to process (d) which checks to see if the driver has paid the toll in advance and is therefore in the store containing the list of advanced payments. Data from drivers not on the advanced payments list is sent to process (e) which carries out the actual billing of the driver. If a driver is on the advanced payments list for the toll transaction, then the data is deleted from the list and a no payment required message is sent to process (e).

The first action of process (e) is to check that the driver is not a bad payer by sending a look-up request to process (c) which maintains a list of bad payers. Drivers found not to be on the list by process (c) and whose toll tag provided a credit identity, will have their details sent to process (i) for billing by the financial institution. In this instance a payment completed indication is output by process (e) to the driver through the Provide Electronic Toll Payment facility. Those drivers not on the bad payers list whose toll tag provided a stored credit value, will have this debited by the toll cost, again through the Provide Electronic Toll Payment facility. This facility will also provide data to show that this debiting transaction

was successful. If a “closed” type of toll system is being used, process (e) will clear from the tag the identity of the toll segment at which the vehicle entered the toll road.

Those drivers whose payment transaction fails (by either method) are requested to pull-in by process (e) sending an output message to the Provide Electronic Toll Payment facility. Their details are also sent to process (c) for entry into the list of bad payers and output to the financial institution. Drivers found to be already on the bad payers list by process (c) are also requested to pull-in through output to the Provide Electronic Toll Payment facility. This facility will also be requested by process (e) to obtain an image of those on the bad payers list and those actually trying to complete an invalid payment, and to send this data to the Provide Law Enforcement Allocation facility - see DFD 5.4.

Requests for advanced payment of tolls from drivers and travelers are received by process (h) and sent to the toll service provider for acceptance. When this is received the details are sent to process (j) which calculates the cost of the advanced toll from the store of toll prices maintained by process (g). Process (j) sends its price and other advanced payment details to process (d), which sends it on to process (e). This process goes through the same payment processes as for payment of current tolls (see previous paragraph), except that an image of bad payers or those attempting invalid payments is not requested. Successful completion of the payment transaction will cause process (e) to load details of the transaction into the store containing the advanced payments list. The process will send data about the results of the transaction (success or failure) to process (h) for return to the requester.

A store containing a record of all transactions is maintained by process (i), using data sent to it by process (e) and (d). Data from this store, without payee identities and other financially sensitive information, is periodically sent to the toll system operator and service provider, and also to the Manage Archived Data function - see DFD 8 by process (i). The data in the store can also be requested by process (f) which provides vehicle probe data based on vehicle journey times between toll plazas to the Select Vehicle Route facility - see DFD 6.6.2, and for storage by the Process Traffic Data for Storage facility - see DFD 1.1.2.1. Again all payee identities and other financially sensitive information will be removed from the data before it is used by process (f).

The processes in this group enable payments for tolls to be made by drivers without stopping and also support a flexible toll price structure. Toll prices may be changed at any time by the service provider through process (g). They are implemented immediately by this process, which also sends them to the store of prices maintained by the Carry-out Centralized Payments Processing facility - see DFD 7.4, for use by the Provide Driver and Traveler Services function - see DFD 6. This last set of data may be sent on request or whenever a change in price is made. Price changes may come directly on the initiative of the toll service provider or indirectly through a request to the provider from the Manage Travel Demand facility - see DFD 1.4, via process (g). Toll charges paid in advance will be unaffected by any new price structure.

Provide Electronic Parking Payment (DFD 7.2)

The processes in this DFD are responsible for the Provide Electronic Parking Payment facility within the Provide Electronic Payment Services function. These processes transact the payments for parking lot charges either for current use by drivers, or as advanced payments by drivers, transit users, and travelers. The key points about the facility are as follows:

* - drivers can pay parking lot charges without leaving their vehicles or stopping the vehicle;

* - drivers can also pay in advance for tolls and transit fares;

* - images of drivers making invalid payments are sent to the Manage Emergency Services function.

There are five processes and one DFD in this DFD. Overall functionality is divided between them in the following way.

(a) Process Electronic Parking Lot Payment (DFD 7.2.1) - These processes obtain the vehicle type and tag identity and, if the parking lot charge has not already been paid, request payment through the Payment Instrument. Data is provided for display to the driver of the transaction result - see

(b) below. If the transaction is unsuccessful, a command is sent to the process in (c) to obtain an image of the violator and details are sent to the Financial Institution. Periodically (e.g., daily), payment for the parking lot charges is requested from the Financial Institution and transaction reports are sent to the Parking Operator and Parking Service Provider. The processes are also able to initiate advanced payment transactions, the identities for which they will store until the vehicle appears at the parking lot.

(b) Produce Parking Lot Displays (7.2.2) - This process will be responsible for driving the displays that tell vehicles whether or not their parking lot charge payment has been confirmed or rejected. The process will receive the data for output via the displays from other processes. The data input and output formats will use an appropriate form of display that will be easily readable under all lighting conditions and over the range of speeds that vehicles are expected to use when entering or leaving a parking lot. The input and output forms will include those that are suitable for travelers with physical disabilities.

(c) Obtain Parking Lot Violator Image (7.2.3) - This process will be responsible for obtaining an image of a violator for use by other processes. The form of the image data obtained by this process will be very accurate so that there can be no mistake of the determination of the identity of the vehicle and/or driver, and will be easily passed on by the other processes to the appropriate law enforcement agency(ies) so that punitive action may be taken. The process will be capable of obtaining an image of the required accuracy under all lighting conditions and over the range of speeds with which vehicles will enter or leave parking lots.

(d) Provide Driver Parking Lot Payment Interface (7.2.4) - This process will be responsible for providing an interface through which drivers can request other services when paying their charges at parking lots. The services supported by this process include advanced parking lot payment, as well as advanced payment for tolls and transit fares. The process will query the driver for sufficient information to enable the advanced toll, parking lot charge, and/or transit fare to be determined and the cost either billed to a credit identity provided by the driver's payment instrument, or deducted from credit stored on the instrument. The input and output forms will include those that are suitable for travelers with physical disabilities.

(e) Detect Vehicle for Parking Lot Payment (7.2.5) - This process will be responsible for producing a vehicle's characteristics from data received by sensors located at or near the parking lot entry and exit lanes. The data will be sent by the process to another process in a form suitable for use in calculating the parking lot charge for the vehicle. The process will ensure that the data includes such things as vehicle size, type, identifiable features, etc.

(f) Distribute Advanced Tolls and Fares (7.2.6) - This process will be responsible for receiving requests for advanced payment of parking lot charges from the toll or transit fare collection facilities within the Provide Electronic Payment Services function. It will pass the requests on to another process in the Provide Electronic Parking Lot Payment facility, and will return transaction success or failure details to the requesting process. The process will also receive requests for the advanced payment of tolls and transit fares from the parking lot payment interface process. It will send these requests to other processes in the Provide Electronic Payment Services function and when received, return the results to the Parking Lot payment interface process.

(g) Provide Payment Instrument Interface for Parking (7.2.7) - This process will be responsible for providing the interface through which the payment information can be read from a vehicle tag. The process will enable the use of the data from the tag for the purposes of paying the current parking lot charge and if required, advanced payments for tolls and/or transit fares. It will be possible for the process to collect either the credit identity or the stored credit value data from the tag, and to update the stored credit value as a result of the parking lot charge and (possibly) advanced charges having been paid. The time at which the vehicle entered the parking lot will also be collected from the tag by the process so that the charge for the use of the lot can be calculated. The process will support collection of data from tags on-board a range of vehicle types including private cars or vans, commercial vehicles, transit vehicles, including those used for demand responsive transit services.

Process (e) detects the presence of a vehicle and passes this to the processes in (a). These processes collect the tag data from the vehicle and process the parking lot charge payment transaction. The success or failure of this transaction is output by these processes through process (b). If a collection or payment violation is detected, then the processes in (a) request process (c) to obtain an image of the violator and to pass this on to the Provide Law Enforcement Allocation facility - see DFD 5.4.

Requests from drivers to pay for tolls and transit fares in advance are received by process (d), which passes them to process (f). This acts as the communications interface through which the drivers' requests are sent to the Provide Electronic Toll Payment and Provide Electronic Fare Collection facilities - see DFDs 7.1 and 7.3 respectively. These facilities may also send this process requests from drivers and transit users to pay for parking lot charges in advance, which when received are passed on to processes in (a).

Process (g) provides the interface through which data can be collected from the payment instruments being used by drivers. This data may consist of the credit identity or stored credit value depending on the type of instrument being used. It can be used for the payment of parking lot charges and/or the advanced payment of tolls and transit fares. For payment instruments containing a credit identity, the process will return an indication that this will be used to collect payment through the financial institution. Those payment instruments containing stored credit will have the amount that they contain debited by the cost of the transaction.

The processes in this group provide all the facilities for handling both current and advanced parking lot charge payments from vehicles without stopping. They form a tightly coupled group that should be implemented in their entirety. However process (f) could be omitted if particular implementations are not supporting the advanced payments of parking lot charges, tolls, and transit fares.

Process Electronic Parking Payment (DFD 7.2.1)

The processes in this DFD are responsible for the Process Electronic Parking Lot Payment facility within the Provide Electronic Payment Services function. These processes transact the payments for current and advanced parking lot charges. The key points about the facility are as follows:

* - charges are calculated by vehicle characteristics and are set by the parking service provider;
* - all vehicles are checked for advanced payment before being billed for the current charge.
* - a record of all transactions is provided for the parking lot operator and service provider;
* - operational data is provided to the Manage Archived Data function.

There are ten processes in this DFD. Overall functionality is divided between them in the following ways.

(a) Read Parking Lot Tag Data (7.2.1.1) - This process will be responsible for requesting the data from the parking lot tag being carried on-board the vehicle and used as the payment instrument being read. If there is no tag or the data it contains cannot be properly read, the process will send a message for the vehicle to pull in for output by another process, and send a request to other processes to obtain an image of the vehicle. If there is no entry time data on the tag, then the process will re-write this data plus the number of the entry lane onto the tag, so that it can be used as the mechanism for charging for the use of the parking lot. If the entry time is present, the process will combine it with the vehicle characteristics, e.g., size, type, etc. to form the data upon which the parking lot payment transaction can be based, and send it to another process.

(b) Calculate Vehicle Parking Lot Charges (7.2.1.2) - This process will be responsible for calculating the parking lot charge for the detected vehicle based on its characteristics and data obtained from the tag being carried by the vehicle. The process will obtain the cost of the use of the parking lot by reading data from a store that contains the standard prices for parking lot charges.

(c) Collect Bad Charge Payment Data (7.2.1.3) - This process will be responsible for maintaining a data store containing a list of invalid driver credit identities. The process will use this data

to check credit identities provided for checking by the billing process. This checking will ensure that the current parking lot payment transaction is using a credit identity that has not previously had an invalid transaction. Details of possible invalid credit identities will be sent by the process to the financial institution for verification. The process will also receive from the financial institution details of invalid payment instrument data that has been found by other means.

(d) Check for Advanced Parking Lot Payment (7.2.1.4) - This process will be responsible for checking to see if the required parking lot charge payment has already been made. The process will determine the existence of an advanced payment for the parking lot charges by comparing the received payment information with that in the store containing the list of advanced payments. If the payment has already been made then the process will remove the requirement for local billing and remove the record of the advanced payment from the store. Details of each payment transaction will be sent by the process to another process with the payment information received from the driver removed.

(e) Bill Driver for Parking Lot Charges (7.2.1.5) - This process will be responsible for either obtaining payment for the current or advanced parking lot charge. The process will achieve this either by requesting that the charge be deducted from the credit being stored by the parking lot tag that is acting as the payment instrument, or informing the driver that payment for the charge will be debited from the credit identity provided by the tag. Before sending data to the tag, the process will check that either the credit identity is not already in the list of bad payers, or the stored credit is not less that the parking lot charge. If either of these conditions is true the process will obtain an image of the driver and vehicle which can be forwarded to the appropriate enforcement agency via another process. When the appropriate payment transaction has been completed, the parking lot entry time data will be cleared from the tag so that it can be used for the next visit by the vehicle to a parking lot. The tag may be in the form of some type of credit or debit card, or an electronic purse. Details of the transaction will always be sent to the process that manages parking lot transactions which will also send details to the financial institution if a credit or debit card is involved. Where an advanced parking lot charge payment is identified, no action is taken if the credit identity is on the bad payers list, or the stored credit is less than the charge, other than the payment is not confirmed.

(f) Manage Parking Lot Financial Processing (7.2.1.6) - This process will be responsible for maintaining a log of all transactions that are carried out by other processes in the Process Electronic Parking Lot Payment facility. The identity of the payee will have been removed from the data before it is stored. At periodic intervals the process will output the accumulated records to another process in the Provide Electronic Payment Services function. It will also output the same data on request to the parking service provider, either in hardcopy form, or as a visual display. The process will be responsible for sending details of transactions to the financial institution to enable the users to be billed through their credit identities. The input and output forms will include those that are suitable for travelers with physical disabilities.

(g) Update Parking Lot Data (7.2.1.7) - This process will be responsible for maintaining a store of data containing the parking lot charges, which may vary according to the type of vehicle. The process will also act as the interface to the parking service provider to enable changes to be made to the stored data, for the output and input of responses to parking lot price change requests from the Manage Traffic function, and for requests for parking lot price data from the Centralized Payments facility. The input and output forms will include those that are suitable for travelers with physical disabilities.

(h) Register for Advanced Parking Lot Payment (7.2.1.8) - This process will be responsible for responding to requests for parking lot charges to be paid in advance. It will provide the parking service provider with the opportunity to deny the request for advanced payment of a parking lot charge. If approved, the advanced parking lot charge data will be forwarded by the process to other processes for the actual cost to be obtained and the payment transactions initiated.

(i) Manage Parking Lot Reservations (7.2.1.9) - This process will be responsible for maintaining a store of parking lot data. This data will cover the capacity of the parking lot, i.e., the maximum number of spaces available, which may vary according to the type of vehicle. The process will

also act as the interface for inquiries from other ITS functions both for details of parking lot capacity, both now and in the future and for the reservation of spaces as part of travelers' confirmed trips.

(j) Determine Advanced Charges (7.2.1.10) - This process will be responsible for receiving a request to pay an advanced parking lot charge. It will obtain the required parking lot charge from a data store and will then forward the data to the billing processes. The store of parking lot charges will be maintained by another process.

Vehicle parking lot characteristics information is received by process (a) which then requests data from the vehicle's parking lot tag. If the tag data is unreadable, then process (a) sends a pull-in message and requests an image of the violator to be obtained and sent to the Provide Law Enforcement Allocation facility - see DFD 5.4. Processes in the Provide Electronic Parking Lot Payment facility (see DFD 7.2) provide the vehicle characteristics data, send output of the pull-in message, and respond to the two requests for data from process (a). Valid characteristics data is passed from process (a) to process (b) which calculates the vehicle's parking lot charge, using a store of parking lot prices maintained by process (g). This data is passed to process (d) which checks to see if the driver has paid the parking lot charge in advance and is therefore on the list of advanced payments. Data for drivers not on the advanced payments list is sent to process (e) which carries out the actual billing of the driver. If a driver is on the advanced payments list for the current parking lot transaction, then the data is deleted from the list and a "no payment required" message sent to process (e).

The first action of process (e) is to check that the driver is not a bad payer by sending a look-up request to process (c) which maintains a list of bad payers. Drivers not found on the list by process (c) and whose parking lot tag provided a credit identity, will have their details sent to process (f) for billing by the financial institution. In this instance, a payment completed indication is output by process (e) to the driver through the Provide Electronic Parking Lot Payment facility. Those drivers not on the bad payers list whose parking lot tag provided a stored credit value, will have this debited by the parking lot charge, again through the Provide Electronic Parking Lot Payment facility. This facility will also provide data to show that this debiting transaction was successful.

Those drivers whose payment transaction fails (by either method) are requested to pull-in by process (e) sending an output message also to the Provide Electronic Parking Lot Payment facility. Their details are also sent to process (c) for entry into the list of bad payers and output to the financial institution. Drivers found to be already on the bad payers list by process (c) are also requested to pull-in through output to the Provide Electronic Parking Lot Payment facility. This facility will also be requested by process (e) to obtain an image of those on the bad payers list or those actually trying to complete an invalid payment, and to send this data to the Provide Law Enforcement Allocation facility - see DFD 5.4.

Requests for advanced payment of parking lot charges from drivers and travelers are received by process (h) and sent to the parking lot service provider for acceptance. When this is received, the details are sent to process (i) which reserves a space in the parking lot, and if this is successful to process (j), which calculates the cost of the advanced parking lot charge from the store of parking lot prices maintained by process (g). Process (j) sends its price and other advanced payment details to process (d) which sends it on to process (e). This process goes through the same payment activities as for payment of current parking lot charges (see previous paragraph), except that an image of bad payers or those attempting invalid payments is not requested. Successful completion of the payment transaction will cause process (e) to load details of the transaction into the store containing the advanced payments list. The process will send the results of the transaction (success or failure) to process (h) for return to the requester.

A store containing a record of all transactions is maintained by process (f), using data sent to it by processes (e) and (d). Data from this store, without payee identities and other financially sensitive information, is sent to the parking lot service provider on receipt of a request by process (f).

The processes in this group enable payments for parking lot charges to be made by drivers without stopping and also support a flexible parking lot charge structure. Parking lot prices may be changed at any time by the service provider through process (g). This data is implemented immediately by this process, which also sends it to the store of prices maintained by the Carry-out Centralized Payments

Processing facility - see DFD 7.4, so that it can be used by the Provide Driver and Traveler Services function - see DFD 6. This last set of data may be sent on request or whenever a change in price is made. The price changes may come directly on the initiative of the parking service provider or indirectly through a request to the provider from the Manage Demand facility - see DFD 1.4, via process (g). Parking lot charges paid in advance will be unaffected by any new price structure.

Provide Electronic Fare Collection (DFD 7.3)

The processes in this DFD provide the Electronic Fare Collection facility within the Provide Electronic Payment Services function. These processes transact the payments for transit fares either for current trips by transit users, or as advanced payments by drivers, transit users, and travelers. The key points about the facility are as follows:

* - transit users can pay fares without stopping as they board the transit vehicle or at a transit stop;

* - transit users can also pay in advance for tolls and parking lot charges, as well as for yellow pages services;

* - transit users may request payment of the fare by a third party;

* - images of transit users making invalid payments are sent to the Manage Emergency Services function.

There are two processes and one DFD in this DFD. Overall functionality is divided between them in the following ways.

(a) Process Electronic Transit Fare Payment (DFD 7.3.1) - These processes perform the actual fare billing transactions in response to the detection of a Transit User by processes in the Manage Transit function. If the transaction is unsuccessful a command is sent to the process in (c) to obtain an image of the violator and details are sent to the Financial Institution. Periodically (e.g., daily), payment for the transit fares is requested from the Financial Institution and transaction reports are sent to the Transit System Operators and Fleet Manager. The processes are also able to initiate advanced payment transactions, storing the identities until the Transit User boards a vehicle or enters a transit facility.

(b) Distribute Advanced Tolls and Parking Lot Charges (7.3.2) - This process will be responsible for receiving requests for advanced payment of transit fares from the toll and parking lot charge collection facilities within the Provide Electronic Payment Services function. It will pass the advanced fare requests on to another process in the Process Electronic Transit Fare Payment facility, and when received, will return transit success or failure details to the requesting process. The process will also receive requests for advanced payment of tolls and parking lot charges from transit vehicle and roadside (transit stop) fare collection facilities. It will send these requests to other processes in the Provide Electronic Payment Services function and when received, return the results to the requesting process.

(c) Get Transit User Image for Violation (7.3.3) - This process will be responsible for obtaining an image of a transit user who is trying to carry out an invalid fare payment transaction. The process will send the image request to other processes either at the roadside, i.e., a transit stop, or on-board a transit vehicle, depending on where the transaction is being attempted. However if the collection method is set to batch, then the process will take no further action, as an image of the offending transit user will not be available. When the image is received, the process will use it to form part of the data sent to a process in the Manage Emergency Services function for forwarding to the appropriate enforcement agency.

(d) Provide Remote Terminal Payment Instrument Interface (7.3.4) - This process will be responsible for providing the interface through which payment information can be read from a transit user tag. The process will support reading this data from transit users at the roadside, e.g., a transit stop, for use in paying the current transit fare and (if required) advanced payments. The process will support advanced payments for tolls, parking lot charges, and/or transit fares. The process will collect either the

credit identity or the stored credit value data from the tag, and update the stored credit value as a result of the fare and (possibly) advanced charges.

(e) Provide Transit Vehicle Payment Instrument Interface (7.3.5) - This process will be responsible for providing the interface through which the payment information can be read from a transit user tag. The process will support the reading of this data from transit users embarking on-board transit vehicles, for use in paying the current transit fare, and if required, advanced payments. The process will support advanced payments for tolls, and/or parking lot charges, and/or transit fares. It will be possible for the process to collect either the credit identity or the stored credit value data from the tag, and to update the stored credit value as a result of the fare and (possibly) advanced charges having been paid.

Fare collection data is provided to processes in (a) by the Collect Transit Fares in the Vehicle and Collect Transit Fares at the Roadside facilities - see DFDs 4.6 and 4.7.2. If the processes in (a) detect a payment violation, they pass the data to process (c). This requests an image of the violator from the relevant Collect Transit Fares facility and when received sends it with the fare data to the Provide Law Enforcement Allocation facility - see DFD 5.4.

Process (b) acts as the communications interface through which the transit users' requests for advanced toll and parking lot payments are sent to the Provide Electronic Toll Payment and Provide Electronic Parking Payment facilities - see DFDs 7.1 and 7.2 respectively. These facilities may also send this process requests from drivers to pay for transit fares in advance, which when received are passed on to processes in (a).

Processes (d) and (e) provide the interface through which data can be collected from the payment instruments being used by transit users at the roadside and on-board vehicles respectively. This data may consist of the credit identity or stored credit value depending on the type of instrument being used. It can be used for the payment of transit fares and/or the advanced payment of tolls and parking lot charges. For payment instruments containing a credit identity, these processes will return an indication that this will be used to collect payment through the financial institution. Those payment instruments containing stored credit will have the amount that they contain debited by the cost of the transaction.

Two types of fare processing are supported by the processes in (a): interactive and batch. The first takes place in real time as the transit user requests payment either on a transit vehicle, or at the roadside, and will include the collection of images of transit users trying to make invalid payments through process (c). Batch processing is only provided as an alternative for fare payment on-board vehicles. In this instance the payment data for many transit users is collected into a combined set of data on-board the vehicle and transmitted to the processes in (a) when the vehicle reaches a convenient point on its route. This avoids continuous interactive use of what may be a wireless interface between the vehicle and the transit management center. However it does not support the collection of images of transit users making invalid payments because of the large in-vehicle storage unit needed to hold the images of all users until payments are processed, or because by the time the payments are processed, the user committing the violation may no longer be on-board the vehicle making it impossible to provide their image.

The processes in this group provide all the facilities for handling both current and advanced fares. They form a tightly coupled group that should be implemented in their entirety. However process (b) could be omitted if particular implementations are not supporting the advanced payments of parking lot charges, tolls, and transit fares. Similarly, either process (d) or (e) could be omitted if particular implementations are not supporting fare collection either at the roadside or on-board vehicles respectively.

Process Electronic Fare Payment (DFD 7.3.1)

The processes in this DFD are responsible for the Process Electronic Transit Fare Payment facility within the Provide Electronic Payment Services function. These processes transact the payments for current and advanced transit fares. The key points about the facility are as follows:

* - support is provide for transit fare collection on vehicles or at the roadside;

* - payment of transit fares collected on the vehicle may be processed interactively or in batches;

***** - all transit users are checked for advanced payment before being billed for the current fare.

There are seven processes in this DFD. Overall functionality is divided between them in the following ways.

(a) Register for Advanced Transit Fare Payment (7.3.1.1) - This process will be responsible for responding to requests for transit fares to be paid in advance. The advanced transit fare data will be forwarded by the process to other processes for the actual cost to be obtained and the payment transactions initiated.

(b) Determine Advanced Transit Fares (7.3.1.2) - This process will be responsible for receiving a request to pay an advanced transit fare. It will obtain the required transit fare data from a local store of transit fares and will then forward the data to the billing processes. The store of fare data will be maintained by another process.

(c) Manage Transit Fare Financial Processing (7.3.1.3) - This process will be responsible for maintaining a log of all the transactions carried out by other processes in the Process Electronic Transit Fare Payment facility. The identity of the payee will have been removed from the data before it is stored. At periodic intervals the process will output the accumulated records to the transit fleet manager, the transit system operator and to another process in the Provide Electronic Payment Services function. The process will also be responsible for sending details of transactions to the financial institution to enable the users to be billed through their credit identities. The input and output forms will include those that are suitable for travelers with physical disabilities.

(d) Check for Advanced Transit Fare Payment (7.3.1.4) - This process will be responsible for checking to see if the required toll payment has already been made. The process will determine the existence of an advanced payment for the toll segment(s) by comparing the received payment information with that in the store containing the list of advanced payments. If the payment has already been made then the process will remove the requirement for local billing and remove the record of the advanced payment from the store. Details of each payment transaction will be sent by the process to another process with the payment information received from the driver removed.

(e) Bill Transit User for Fare (7.3.1.5) - This process will be responsible for either obtaining payment for the current or advanced toll. The process will achieve this either by requesting that the toll cost be deducted from the credit being stored by the toll tag that is acting as the payment instrument, or by informing the driver that payment for the toll will be debited to the credit identity provided by the tag. Before sending data to the tag, the process will check that either the credit identity is not already in the list of bad payers, or the stored credit is not less that the toll cost. If either of these conditions is true, the process will obtain an image of the driver and vehicle which can be forwarded to the appropriate enforcement agency via another process. When the appropriate payment transaction has been completed, the toll entry segment identity will be cleared from the tag so that it can be used the next time that the vehicle is on a toll road. The tag may be in the form of some type of credit or debit card, or an electronic purse. Details of the transaction will always be sent by this process to the process that manages toll transactions. Where an advanced toll payment is identified, the process will take no action if the credit identity is on the bad payers list, or the stored credit is less than the toll cost, other than the payment is not confirmed.

(e) Collect Bad Transit Fare Payment Data (7.3.1.6) - This process will calculate the time taken for vehicles to travel between successive toll plazas and send it to the Manage Traffic and Provide Driver and Traveler Services functions. The process will periodically request the data from the process that manages toll financial processing and ensure that any references to the driver and/or vehicle identity plus any other payment information are removed from the data before it is sent to the other functions.

(f) Update Transit Fare Data (7.3.1.7) - This process will be responsible for maintaining a store of data containing the toll price, which may vary according to the type of vehicle. The process will also act as the interface for the output and input of responses to toll price change requests from the Manage Traffic function, the provision of toll price information to the Centralized Payments facility, and

to the toll service provider to enable changes to be made to the stored data. The input and output forms will include those that are suitable for travelers with physical disabilities.

Requests for fare payment are received by process (d). They come from the Collect Transit Fares on the Vehicle and Collect Transit Fares at the Roadside facilities - see DFDs 4.6 and 4.7.2 respectively. The details of the transit user and the fare for which payment is required are checked against the advanced payments list, and if no match is found, sent to process (e) for the actual payment transaction. If a match is found, the details are deleted from the advanced payments list, and a no payment required message sent to process (e).

The first action of process (e) is to check that the transit user is not a bad payer by sending a look-up request to process (f) which maintains a list of bad payers. Transit users found not to be on the list by process (f) and whose tag provided a credit identity, will have their details sent to process (c) for billing by the financial institution. In this instance a payment completed indication is output by process (e) to the transit user through the Provide Electronic Fare Collection facility. Those transit users not on the bad payers list whose tag provided a stored credit value, will have this debited by the value of the transit fare, again through the Provide Electronic Fare Collection facility. This facility will also provide data to show that this debiting transaction was successful. Process (e) will on request provide data about current known bad payers to the Collect Transit Fares in the Vehicle facility - see DFD 4.6, to enable some of its checking to be performed on-board the vehicle.

Those transit users whose payment transaction fails (by either method) are sent a transaction failed message by process (e), which also sends an output message to the Provide Electronic Fare Collection facility. Their details are also sent to process (c) for entry into the list of bad payers and output to the financial institution. Transit users found to be already on the bad payers list by process (c) are also sent a transaction failed message again through output to the Provide Electronic Fare Collection facility. For interactive fare payment transactions, this facility will also be requested by process (e) to obtain an image of those on the bad payers list and those actually trying to complete an invalid payment, and to send this data to the Provide Law Enforcement Allocation facility - see DFD 5.4.

Requests for advanced payment of transit fares from drivers and travelers are received by process (a) and sent to process (b), which calculates the cost of the advanced fare from the store of transit fares maintained by process (g). Process (b) sends its price and other advanced payment details to process (d) which sends it on to process (e). This goes through the same payment processes as for payment of current transit fares (see previous paragraphs), except that an image of bad payers or those attempting invalid payments is not requested. Successful completion of the payment transaction will cause process (e) to enter the data into the store containing the advanced payments list. The process will send the results of the transaction to process (a) for return to the requester.

A store containing a record of all transactions is maintained by process (c), using data sent to it by processes (d) and (e). Data from this store, without payee identities and other financially sensitive information, is periodically sent to the transit fleet manager and system operator by process (c).

The processes in this group enable fare payments to be made by transit users without stopping and also support a flexible fare price structure. Fares may be changed at any time by the transit operator through input to process (g). This process implements the new fares immediately by sending data to the Collect Transit Fares on the Vehicle and Collect Transit Fares at the Roadside facilities - see DFDs 4.6 and 4.7.2 respectively, and also for use by the Provide Driver and Traveler Services function (DFD 6) through the store of prices maintained by the Carry-out Centralized Payments Processing facility - see DFD 7.4. This last set of data may be sent on request, or whenever a change is made by the transit operator. The validity of transit fares already paid in advance is unaffected by any new price structure.

Carry-out Centralized Payments Processing (DFD 7.4)

The processes in this DFD provide the Carry-out Centralized Payments Processing facility within the Provide Electronic Payment Services function. These processes provide a central store for pricing information and a central payments facility. The key points about the facility are as follows:

* - central store of prices is provided for use by the Provide Driver and Traveler Services function;

* - yellow pages services cost processing is provided for advanced traveler payments.

* - interface is provided for collection of payee data from the payment instrument.

There are two processes and one DFD in this DFD. Overall functionality is divided between them in the following ways.

(a) Collect Advanced Payments (DFD 7.4.1) - These processes manage transactions for several of the Manage Commercial Vehicles, Manage Transit, and Provide Driver and Traveler Services functions. The transactions are forwarded to the financial institution for payment. A central store of all transactions is maintained, and is periodically sent without the identities of payees and recipients, to the Manage Archived Data function - see DFD 8. Facilities are also provided for the advanced payment of tolls, parking lot charges, transit fares, and yellow pages services (lodging, restaurants, etc.) required by a traveler's confirmed trip - see also (c) below.

(b) Collect Price Data for ITS Use (7.4.2) - This process will be responsible for collecting data about the prices being charged for tolls, parking lots, and transit fares. This process will accept data sent to it by the other processes when they have updated their data and automatically sent it, or this process will request a transfer of data from the other processes. The process will load the data into the price_data_for_services data store from which some or all of it can be read on request from processes in other ITS functions.

(c) Route Traveler Advanced Payments (7.4.3) - This process will be responsible for receiving a traveler's request for advanced payment (for tolls, parking lot charges, and/or transit fares) and routing it to the appropriate part of the Provide Electronic Payment Services function. The process will also receive responses to the advanced payment requests and will return them to the originating process.

The processes in (a) and (c) must be implemented together to support traveler advanced payments for confirmed trips. Process (c) acts as the communications interface for advanced payments with the toll, parking lot charge, and transit fare collection facilities in the Provide Electronic Payment Services function - see DFDs 7.1, 7.2, and 7.3. Process (b) maintains a store of prices that are provided by these other facilities. It operates independently and need only be implemented if needed.

Collect Advanced Payments (DFD 7.4.1)

The processes in this DFD provide the Collect Advanced Payments facility within the Provide Electronic Payment Services function. These processes enable payments to be made for services provided as part of several ITS functions. The key points about the facility are as follows:

* - all transactions are sent to the financial institution for clearance and payment;

* - processes for specific types of payments can be implemented individually.

There are eight processes in this DFD. Overall functionality is divided between them in the following way.

(a) Process Commercial Vehicle Payments (7.4.1.1) - This process will be responsible for transacting payments for electronic credential and tax filing by processes in the Manage Commercial Vehicles function. The payment transaction will be initiated by processes in the Administer Commercial Vehicles facility which may accept inputs from both the commercial vehicle fleet manager and the commercial vehicle driver acting in the role of fleet manager, i.e., the owner driver. The process will send the transaction data to the financial institution and report the response back to the requesting process.

(b) Process Yellow Pages Services Provider Payments (7.4.1.2) - This process will be responsible for transacting payments for the registration of other (yellow pages) service providers. The process will be initiated by receiving data from a process in the Provide Driver and Traveler Services function and will send the data to the financial institution. The process will send the response from the

financial institution to the requesting process and will send details of the transaction to another process for entry into a store of transaction records.

(c) Process Driver Map Update Payments (7.4.1.3) - This process will be responsible for transacting payments from the driver for updates to the navigable map database in the vehicle. The process will receive the transaction request data from a process in the Provide Driver and Traveler Services function and will send the data to the financial institution for action. The process will send the response from the financial institution to the requesting process and will send details of the transaction to another process for entry into the payment_transaction_records data store.

(d) Process Traveler Map Update Payments (7.4.1.4) - This process will be responsible for transacting payments from the traveler for updates to the navigable map database carried in the personal device. The process will receive the transaction request data from a process in the Provide Driver and Traveler Services function and will send the data to the financial institution. The process will send the response from the financial institution to the requesting process and will send details of the transaction to another process for entry into the payment_transaction_records data store.

(e) Process Transit User Other Services Payments (7.4.1.5) - This process will be responsible for collecting advance payments for other (yellow pages) services. The transaction data will be provided by processes in the Manage Transit function in response to reservation requests from a transit user either at the roadside, i.e., a transit stop, or on-board a transit vehicle. The process will send the received transaction data to the financial institution and will send the response to the requesting process. It will also send details of the transaction to another process for entry into a store of transaction records.

(f) Process Traveler Trip and Other Services Payments (7.4.1.6) - This process will be responsible for transacting advanced payments required for the confirmation of a trip by a traveler. Payments supported by the process will comprise those for any tolls, parking lot charges, transit fares, or other (yellow pages) services that need to be paid for the trip to be confirmed. The process will receive the transaction data from a process in the Provide Driver and Traveler Services function (DFD 6) and will send the data to the financial institution. Tolls, fares and parking lot charges are sent to the Route Traveler Advanced Payments function (P-spec 7.4.3) for processing. The process will send the response from the financial institution to the requesting process and will send details of the transaction to another process for entry into the payment_transaction_records data store.

(g) Collect Payment Transaction Records (7.4.1.7) - This process will be responsible for the collection and maintenance of a data store that contains transaction records for payments made for various services provided. The process will load information into the payment_transaction_records data store for services comprising electronic credential and tax filing purchases for commercial vehicle operations, updates of map databases for drivers and travelers, registration of other (yellow pages) service providers (so that information about what they have to offer is available to travelers and transit users), advanced payment of tolls, parking lot charges, transit fares and other (yellow pages) services that form part of travelers' trips. The data will be stored by the process with all references to the identity of the payment source, i.e., driver, traveler, commercial vehicle fleet manager, and any other payment information, removed.

(h) Process Traveler Rideshare Payments (7.4.1.8) - This process will be responsible for transacting payments for ridesharing that are required for the confirmation of a traveler's trip. The process will start the transaction by receiving data from a process in the Provide Driver and Traveler Services function and will send the data to the appropriate financial institution. The process will send the response from the financial institution to the requesting process and will send details of the transaction to another process for entry into a store of transaction records.

These processes are each responsible for transacting payments with the financial institution. The payments transacted comprise those for commercial vehicle administration (see DFD 2.5), yellow pages provider registration (see DFD 6.5), map updates for drivers and travelers (see DFDs 6.7.2, 6.8.1, and 6.8.3), other (yellow pages) services for transit users (see DFDs 4.6 and 4.7.2), and ridesharing (see DFD 6.4). The results of the transaction are always returned to the requesting process, and are also sent to

process (g) which maintains a store of transaction records. A summary report, without the identities of the payees or other sensitive financial information, is periodically sent by process (g) to the Manage Archived Data function - see DFD 8.

These processes can be implemented separately with the obvious exception of that in (g) which depends on one or more of the others for its source of data. If the process in (f) is implemented, it will require the distribution process described in the previous DFD for the advanced payment of toll, parking lot charges, and transit fares to be completed. The process in (b) enables the Provide Driver and Traveler Services function (DFD 6) to obtain income from giving travelers and transit users access to details of the services available from yellow pages service providers.

Provide Payment Instrument Interface (DFD 7.5)

The processes in this DFD make up the Provide Payment Instrument Interface facility within the Provide Electronic Payment Services function. These processes enable drivers and travelers to pay for services provided by ITS functions. The key points about the facility are as follows:

* - payment instrument may be credit/debit card or some form of electronic purse;

* - credit identity from credit/debit card is used for service payment billing through financial institution;

* - stored credit value from electronic purse is directly decreased by the cost of the service.

There are five processes in this DFD. Overall functionality is divided between them in the following ways.

(a) Provide Vehicle Payment Instrument Interface (7.5.1) - This process will be responsible for providing the interface through which driver credit identities and stored credit may be entered into the ITS from on-board vehicle tags. The types of vehicles from which data is collected will include private cars or vans, commercial vehicles, and transit vehicles, including those used for demand responsive transit services. This process will also provide an interface through which the stored credit held by the tag can be debited for the payment of current or advanced tolls, plus advanced parking lot charges, and/or transit fares.

(b) Provide Transit User Roadside Payment Instrument Interface (7.5.2) - This process will be responsible for providing the interface through which credit identities and stored credit values may be collected from tags being used by transit users. The process will support the collection of this data at the roadside (which in this instance is a transit stop). Payments by the transit user for fares, other services, payment of advanced tolls, and/or parking lot charges will be supported by the process. It will also provide an interface through which stored credit held by the tag can be debited for the same types of payment.

(c) Provide Personal Payment Instrument Interface (7.5.3) - This process will be responsible for providing the interface through which credit identity or stored credit may be collected from the tag being used by a traveler with a personal device. The process will support the collection of this data from any location in which the device (and hence the tag) is being used. It will provide an interface through which the credit identity can be used for the payment of advanced tolls, parking lot charges, transit fares, display updates, and/or map updates. The process will also enable the stored credit value on the tag to be used for the same purposes.

(d) Provide Commercial Fleet Payment Instrument Interface (7.5.4) - This process will be responsible for providing the interface through which credit identity or stored credit values may be collected from the tags used by commercial fleet managers. The process will support the use of the tag data to complete payment for the filing of electronic credentials and tax information that will enable a commercial vehicle to be cleared to travel within the geographic area served by a particular jurisdictional authority. This process will also enable the stored credit value to be debited as an alternative method of payment.

(e) Provide Traveler Kiosk Payment Instrument Interface (7.5.5) - This process will be responsible for providing the interface through which credit identities and stored credit values may be collected from payment instruments being used by travelers. The process will support the collection of data at the roadside (which in this instance is a kiosk) and use this data for payments needed to confirm a traveler's trip. Payments supported by the process will include those for advanced tolls, parking lot charges, transit fares, and/or other (yellow pages) services. It will also provide an interface through which the stored credit held by the tag can be debited for the same types of payment.

Each of these processes can be implemented separately. They each provide an interface that is linked to a particular ITS function. This interface enables the driver, traveler, transit user, commercial vehicle manager, or commercial vehicle owner/driver to provide data that enables them to pay for services provided by ITS functions. These services comprise such things as updates to navigable map databases and digitized map displays, payment for other (yellow pages) services, advanced payments, and payments for electronic credentials and tax filing.

In each process, the payment instrument may provide a credit identity or a stored credit value. The former is sent to the financial institution for use in subsequent billing so that the payment instrument functions as a credit or debit card. The stored credit value will be decreased by the cost of the service for which payment is being made, and will only occur if there is sufficient stored credit to pay for the service. In this instance the payment instrument is functioning as an electronic purse, or stored value card of the type used by transit operators, and those toll operators using a “closed” toll payment system.

1.6.1.9. Manage Archived Data (DFD 8)

This DFD shows the processes that provide the Manage Archived Data function. This function is responsible for providing facilities to collect ITS and related data, archive it, and make it available to other user systems for use in transportation administration, policy evaluation, safety, planning, performance monitoring, program assessment, operations, and research applications. The key points about the function are as follows:

* - data collected from each ITS function and center-type terminators
* - collected data formatted and stored into a permanent data store
* - schema and format of data managed through the interface with the Archived Data Administrator
* - coordination with other archives allows data to be shared across multiple sites
* - user systems request data or a catalog of data
* - user systems request analyses of the archive data such as fusion, mining, or aggregations
* - data extracted from the archive to support government reporting requirements
* - archive on-demand allows additional data to be selected for import into the archive by users systems
* - roadside data collected directly for archive purposes

There are nine processes in this DFD. Overall functionality is divided between them in the following ways.

(a) Get Archive Data (8.1) – This process collects data from each major function within ITS and external sources for archive purposes that may not exist within current ITS data sources. This process responds to requests from the Manage Archive Data Administrator Interface process to import data or data catalogs. This process sends requests for data or a catalog of available data to the other functions and terminators, either a subscription for data or a one-time request. This process receives meta-data along with the data to describe the conditions under which the data was collected or any other information about the operational data. When data is received, this process performs quality checks such as range validation or reformatting of the data as necessary to meet the archive schema. This process executes methods on the incoming data such as cleansing, summarizations, aggregations, or transformations applied to the data before it is stored in the archive. Any changes made to the data are recorded in the meta-data stored in the

archive to assist in the reconstruction of the original data if possible. This process receives inputs from the Manage Archive Data Administrator Interface that contain the parameters for managing the processing on the data. This process forwards the collected onto the Manage Archive function along with updated meta-data and a record of any methods applied to the incoming data. This process also supports the notification of the operational source functions of any errors that may be present in the data that could be caused by equipment failures or a transmission error.

(b) Manage Archive (8.2) – This process stores the collected and formatted data in a permanent archive datastore. This process receives the formatted data from the Get Archive Data function accompanied by any updates to the meta-data that would describe the formatting operations performed on the data as it was imported. This process responds to requests from the administrator interface function to maintain the schema of the archive data, set update frequencies, and backup schedules, user authentication schemes, cleansing algorithms. This process provides the administrator interface function with status of the data quality in the archive, frequency reports on use of the archive, updates to the measure of the volume of the data and other data archive metrics. This process receives inputs from the Coordinate Archives function to provide data and information about the archive schema to other archives. In turn, the process receives data and schema of other archives to use to build a global schema. The process uses the global schema to support requests from user systems for data that may be spread across multiple archives. The process maintains the access privileges information for the data held in the archive to maintain the security of the archive. The process employs such techniques, as necessary to maintain the integrity of the data and ensure no data is lost from the archive. The process responds to requests for data to support user data products, user analysis, and inputs to government reporting systems. The process responds to such requests by authenticating the originator of the request and providing the data that is available. The process is also capable of providing a sample or catalog of data contained within the archive to support the user requests.

(c) Manage Archive Data Administrator Interface (8.3) – This process interfaces with the Archive Data Administrator terminator and receives inputs from the administrator concerning the management and administration of the archive. The process establishes user authentication controls for the archive and sends the information to the Manage Archive function. The process maintains the schema of the archive, including the data and meta-data contained within the archive data. Updates to the schema shall be distributed to the Manage Archive function as well as the Get Archive Data function. The process sends the parameters and requests to the Get Archive Data function to control what data is imported into the archive and how the data is to be formatted when it is received. The parameters sent include such things as the schema, data format, methods to apply to the data, cleansing parameters, quality metrics, and checking specifications. The process sends requests to the Get Archive Data function for new data or a catalog of data that may be available. The process responds to requests from the Manage On Demand Archive Requests function by making requests of the Get Archive Data function to establish the source and identity of the data that may exist in ITS or non-ITS sources. Then the process responds to the user request with the confirmation that the request can be satisfied and specifications about the data once it is imported. In cases where the Manage Archive function will be managing a roadside data collection function, this process initiates and controls the function by sending commands and requests to the Manage Roadside Data Collection function. This process receives the status from the other functions within Manage Archived Data and presents them to the administrator.

(d) Coordinate Archives (8.4) – This process coordinates the information exchange between different Manage Archived Data functions represented through the Other Archives terminator. This process allows other archives to share data collected by other archive functions to share the data in response to local requests from users systems. This process uses data collected from different archives to build a set of global schema which the data archive definitions for the local archive plus any archives known to the local archive. This process provides the global schema to the local Manage Archive function. This process receives the schema of the local archive to share with other archive functions. This process provides data to those other archives when requested. This process supports analysis, data fusion, and data mining of archived information across geographically dispersed archives.

(e) Process Archived Data User System Requests (8.5) – This process monitors the archive data user systems interface for requests for data from the archive. This process supports requests from users involved in planning, research, safety, as well as operations of transportation functions. This process receives requests for data and catalogs of data that may be contained in the archive. This process translates the requests into a format that can be understood by the Manage Archive function to retrieve data from the archive. When data or a catalog of data is received from the archive, this process generates the requested data product for the users systems. For archive data requiring financial payment this archive processes the financial requests and manages an interface to a Financial Institution.

(f) Analyze Archive (8.6) – This process supports the interface with Archive Data User Systems for requests for analysis of the archive data. This process supports analysis products that can provide users with the ability to perform activities such as data mining, data fusion, summarizations, aggregations, and recreation from archive data. This process receives the users systems requests and develops the request that the Manage Archive function can process to retrieve the data from the archive. This process is able to respond to users systems requests for a catalog of the analysis products available. When data and meta-data are returned from the archive and the analysis is performed this process produces the output for the Archive Data User Systems terminator. For archive data requiring financial payment this archive processes the financial requests and manages an interface to a Financial Institution.

(g) Process On Demand Archive Requests (8.7) – This process receives requests for data to be imported into the archive that is not already in the archive. The process forwards the request to the Manage Archive Data Administrator Interface function for the administrator to handle the user request. The process receives the response from the administrator and forwards the information to the Archive Data User System.

(h) Prepare Government Reporting Inputs (8.8) – This process supports the preparation of inputs to reporting systems of the federal or state governments that require data from the ITS archive. This process responds to requests from the Government Reporting Systems terminator for data from the archive and generates the request in a form understood by the Manage Archive function. The data and any meta-data necessary are returned from the Manage Archive function. This process receives the data and formats it as requested and send it to the Government Reporting Systems terminator where it may be combined with other data before final submission.

(i) Manage Roadside Data Collection (8.9) – This process manages the collection of archive data directly from collection equipment located at the roadside. This process collects traffic information as well as environmental or other information that may be collected by roadside devices. This process responds to requests from the Manage Archive Data Administer Interface process to input the parameters that control the collection process. The request for data and control parameters is sent to the Manage Traffic function where the information is collected and returned. This process forwards the data onto the Get Archive Data function for import into the archive. The Get Archive Data function is able to return status about the imported data. This process uses the status information to adjust the collection function and report to the administrator function.

A.0 List of Acronyms

A

ABS	Antilock Brake System
ADA	Americans with Disabilities Act
ADMS	Archived Data Management subsystem
AFD	Architecture Flow Diagram
AID	Architecture Interconnect Diagram
AHS	Automated Highway System
AMPS	Advanced Mobile Phone System
ATC	Automatic Train Control
ATIS	Advanced Traveler Information System
ATM	Asynchronous Transfer Mode
ATMS	Advanced Traffic Management System
AVCS	Advanced Vehicle Control System
AVI	Automated Vehicle Identification
AVL	Automated Vehicle Location
AVO	Automated Vehicle Operation

C

CAAA	Clean Air Act Amendment
CASE	Computer Aided Systems Engineering
CCTV	Closed Circuit TV
CDMA	Code Division Multiple Access
CDPD	Cellular Digital Packet Data
CMS	Changeable Message System
COTR	Contracting Officer Technical Representative
CSP	Communication Service Provider
CVAS	Commercial Vehicle Administration Subsystem
CVCS	Commercial Vehicle Check Subsystem
CVISN	Commercial Vehicle Information Systems and Networks
CVO	Commercial Vehicle Operations
CVS	Commercial Vehicle Subsystem

D

DAB	Digital Audio Broadcast
DD	Data Dictionary
DDE	Data Dictionary Element
DFD	Data Flow Diagram
DGPS	Differential Global Positioning System
DMS	Dynamic Message Sign
DMV	Department of Motor Vehicles
DOD	Department of Defense
DOT	Department of Transportation
DSRC	Dedicated Short Range Communications
DTA	Dynamic Traffic Assignment

E

ECPA	Electronic Communications Privacy Act
EDI	Electronic Data Interchange
EM	Emergency Management Subsystem
EMC	Emergency Management Center
EMMS	Emissions Management Subsystem
EPA	Environmental Protection Agency
ESMR	Enhanced SMR
ETA	Expected Time of Arrival
ETTM	Electronic Toll and Traffic Management
EVS	Emergency Vehicle Subsystem

F

FARS	Fatal Accident Reporting System
FCC	Federal Communications Commission for the U.S.
FHWA	Federal Highway Administration
FIPS	Federal Information Processing Standard
FMS	Fleet Management Subsystem
FOT	Field Operational Test
FPR	Final Program Review
FTA	Federal Transit Administration

G

GIS	Geographic Information System
GPS	Global Positioning System

H

HAR	Highway Advisory Radio
HAZMAT	HAZardous MATerial(s)
HOV	High Occupancy Vehicle
HRI	Highway Rail Intersection
HSR	High Speed Rail
HUD	Head–Up Display

I

IEEE	Institute of Electrical and Electronics Engineers, Inc.
IP	Internet Protocol
IPR	Interim Program Review
ISO	International Standards Organization
ISP	Information Service Provider
ISTEA	Intermodal Surface Transportation Efficiency Act
ITE	Institute of Transportation Engineers
ITI	Intelligent Transportation Infrastructure
ITS	Intelligent Transportation Systems
ITS AMERICA	Intelligent Transportation Society of America
IVHS	Intelligent Vehicle Highway Systems
IVIS	In Vehicle Information System

L

LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LEO	Low–Earth Orbit satellite system

LPD	Liability and Property Damage
LRMP	Location Reference Messaging Protocol
LRMS	Location Reference Messaging Standard

M

MAN	Metropolitan Area Network
MAUT	Multiattribute Utility Theory
MMI	Man–Machine Interface (or Interaction)
MOE	Measure Of Effectiveness
MPH	Miles per Hour
MPO	Metropolitan Planning Organization
MTC	Metro Traffic Control

N

NA	National Architecture
NAR	National Architecture Review
NEMA	National Electrical Manufacturers Association
NHPN	National Highway Planning Network
NHTSA	National Highway Traffic Safety Administration
NII	National Information Infrastructure (aka Information Superhighway)
NTCIP	National Transportation Communications for ITS Protocol

O

OEM	Original Equipment Manufacturer
OSI	Open Systems Interconnection
OTP	Operational Test Plan

P

PCS	Personal Communications System
PDA	Personal Digital Assistant
PIAS	Personal Information Access Subsystem
PMS	Parking Management Subsystem
PS	Planning Subsystem
PSA	Precursor System Architecture
PSPEC	Process Specification
PSTN	Public Switched Telephone Network
PTS	Positive Train Separation

Q

QFD	Quality Functional Deployment

R

R&D	Research and Development
RDS	Radio Data Systems
RDS–TMC	Radio Data Systems incorporating a Traffic Message Channel
RS	Roadway Subsystem
RTA	Regional Transit Authority
RTS	Remote Traveler Support Subsystem

S

SAE	Society of Automotive Engineers
SDO	Standards Development Organization
SMR	Specialized Mobile Radio
SONET	Synchronous Optical Network
SOV	Single Occupancy Vehicle

SQL	Standard Query Language
SSR	Standard Speed Rail
STMF	Simple Transportation Management Framework

T

TAS	Toll Administration Subsystem
TCS	Toll Collection Subsystem
TDM	Travel Demand Management
TDMA	Time Division Multiple Access
TIGER	Topologically Integrated Geographic Encoding & Referencing files
TMC	1. Traffic Management Center 2. Traffic Message Channel. See RDS–TMC
TMS	Traffic Management Subsystem
TRMC	Transit Management Center
TRMS	Transit Management Subsystem
TRT	Technical Review Team
TRVS	Transit Vehicle Subsystem

V

VRC	Vehicle/Roadside Communications
VS	Vehicle Subsystem

W

WAN	Wide Area Network
WIM	Weigh–in Motion
WWW	World Wide Web

B.0 Hierarchy of DFDs and Process Specifications

Document Control Information
CASE Model: 09/03/99
Logical Database 09/03/99

DFD 1	Manage Traffic
DFD 1.1	Provide Traffic Surveillance
DFD 1.1.1	Process Sensor Data
PS 1.1.1.1	Process Traffic Sensor Data
PS 1.1.1.2	Collect and Process Sensor Fault Data
PS 1.1.1.3	Process Environmental Sensor Data
PS 1.1.1.4	Manage Data Collection and Monitoring
DFD 1.1.2	Process and Store Traffic Data
PS 1.1.2.1	Process Traffic Data for Storage
PS 1.1.2.2	Process Traffic Data
PS 1.1.2.3	Update Data Source Static Data
PS 1.1.2.4	Monitor HOV lane use
PS 1.1.2.5	Process Tag /AVL Data for Link Time Data
PS 1.1.2.6	Process Collected Vehicle Smart Probe Data
PS 1.1.2.7	Monitor Reversible Lanes
PS 1.1.3	Generate Predictive Traffic Model
DFD 1.1.4	Display and Output Traffic Data
PS 1.1.4.1	Retrieve Traffic Data
PS 1.1.4.2	Provide Traffic Operations Personnel Traffic Data Interface
PS 1.1.4.3	Provide Direct Media Traffic Data Interface
PS 1.1.4.4	Update Traffic Display Map Data
PS 1.1.4.5	Provide Media System Traffic Data Interface
PS 1.1.4.6	Provide Traffic Data Retrieval Interface
PS 1.1.4.7	Manage Traffic Archive Data
PS 1.1.5	Exchange data with Other Traffic Centers
PS 1.1.6	Collect Vehicle Tag Data for Link Time Calculations
PS 1.1.7	Collect Vehicle Smart Probe Data
DFD 1.2	Provide Device Control
PS 1.2.1	Select Strategy
DFD 1.2.2	Determine Road and Freeway State
PS 1.2.2.1	Determine Indicator State for Freeway Management
PS 1.2.2.2	Determine Indicator State for Road Management
PS 1.2.3	Determine Ramp State
DFD 1.2.4	Output Control Data
PS 1.2.4.1	Output Control Data for Roads
PS 1.2.4.2	Output Control Data for Freeways
PS 1.2.4.3	Output In-vehicle Signage Data
DFD 1.2.5	Manage Parking Lot State
PS 1.2.5.1	Determine Parking Lot State
PS 1.2.5.2	Coordinate Other Parking Data
PS 1.2.5.3	Provide Parking Lot Operator Interface
PS 1.2.5.4	Determine P+R needs for Transit Management
PS 1.2.5.5	Manage Parking Archive Data
PS 1.2.5.6	Calculate Parking Lot Occupancy
DFD 1.2.6	Maintain Static Data for TMC
PS 1.2.6.1	Maintain Traffic and Sensor Static Data
PS 1.2.6.2	Provide Static Data Store Output Interface
DFD 1.2.7	Provide Roadside Control Facilities

PS 1.2.7.1	Process Indicator Output Data for Roads
PS 1.2.7.2	Monitor Roadside Equipment Operation for Faults
PS 1.2.7.3	Manage Indicator Preemptions
PS 1.2.7.4	Process In-vehicle Signage Data
PS 1.2.7.5	Process Indicator Output Data for Freeways
PS 1.2.7.6	Provide Intersection Collision Avoidance Data
PS 1.2.7.7	Process Vehicle Smart Probe Data for Output
DFD 1.2.8	Collect and Process Indicator Fault Data
PS 1.2.8.1	Collect Indicator Fault Data
PS 1.2.8.2	Maintain Indicator Fault Data Store
PS 1.2.8.3	Provide Indicator Fault Interface for C and M
PS 1.2.8.4	Provide Traffic Operations Personnel Indicator Fault Interface
DFD 1.3	Manage Incidents
DFD 1.3.1	Traffic Data Analysis for Incidents
PS 1.3.1.1	Analyze Traffic Data for Incidents
PS 1.3.1.2	Maintain Static Data for Incident Management
PS 1.3.1.3	Process Traffic Images
DFD 1.3.2	Review and Manage Incident Data
PS 1.3.2.1	Store Possible Incident Data
PS 1.3.2.2	Review and Classify Possible Incidents
PS 1.3.2.3	Review and Classify Planned Events
PS 1.3.2.4	Provide Planned Events Store Interface
PS 1.3.2.5	Provide Current Incidents Store Interface
PS 1.3.3	Respond to Current Incidents
DFD 1.3.4	Provide Operator Interfaces for Incidents
PS 1.3.4.1	Retrieve Incident Data
PS 1.3.4.2	Provide Traffic Operations Personnel Incident Data Interface
PS 1.3.4.3	Provide Media Operator Incident Data Interface
PS 1.3.4.4	Update Incident Display Map Data
PS 1.3.4.5	Manage Resources for Incidents
PS 1.3.5	Manage Possible Predetermined Responses Store
PS 1.3.6	Manage Predetermined Incident Response Data
PS 1.3.7	Analyze Incident Response Log
DFD 1.4	Manage Travel Demand
PS 1.4.1	Provide Traffic Operations Personnel Demand Interface
PS 1.4.2	Collect Demand Forecast Data
PS 1.4.3	Update Demand Display Map Data
PS 1.4.4	Implement Demand Management Policy
PS 1.4.5	Calculate Forecast Demand
DFD 1.5	Manage Emissions
PS 1.5.1	Provide Traffic Operations Personnel Pollution Data Interface
PS 1.5.2	Process Pollution Data
PS 1.5.3	Update Pollution Display Map Data
PS 1.5.4	Manage Pollution State Data Store
PS 1.5.5	Process Vehicle Pollution Data
PS 1.5.6	Detect Roadside Pollution Levels
PS 1.5.7	Manage Pollution Data Log
PS 1.5.8	Manage Pollution Reference Data Store
PS 1.5.9	Manage Pollution Archive Data
DFD 1.6	Manage Highway Rail Intersections
DFD 1.6.1	Manage HRI Vehicle Traffic
PS 1.6.1.1	Detect Roadway Events
DFD 1.6.1.2	Activate HRI Device Controls
PS 1.6.1.2.1	Control HRI Traffic Signals

PS 1.6.1.2.2	Control HRI Warnings and Barriers
PS 1.6.1.2.3	Provide SSR Device Controls
PS 1.6.1.2.4	Provide HSR Device Controls
PS 1.6.1.2.5	Manage Device Control
PS 1.6.1.2.6	Maintain Device State
PS 1.6.1.3	Perform Equipment Self-Test
DFD 1.6.1.4	Provide Advisories and Alerts
PS 1.6.1.4.1	Generate Alerts and Advisories
PS 1.6.1.4.2	Provide Closure Parameters
PS 1.6.1.4.3	Report Alerts and Advisories
PS 1.6.1.4.4	Report HRI Status on Approach
PS 1.6.1.5	Detect HRI Hazards
DFD 1.6.1.6	Provide Advance Warnings
PS 1.6.1.6.1	Close HRI on Detection
PS 1.6.1.6.2	Detect Imminent Vehicle/Train Collision
DFD 1.6.1.7	Execute Local Control Strategy
PS 1.6.1.7.1	Control Vehicle Traffic at Passive HRI
PS 1.6.1.7.2	Control Vehicle Traffic at Active HRI
PS 1.6.1.7.3	Close HRI on Command
DFD 1.6.2	Interact with Rail Operations
PS 1.6.2.1	Exchange Data with Rail Operations
PS 1.6.2.2	Manage Alerts and Advisories
PS 1.6.2.3	Manage Rail Traffic Control Data
DFD 1.6.3	Manage HRI Rail Traffic
PS 1.6.3.1	Interact with Wayside Systems
PS 1.6.3.2	Advise and Protect Train Crews
PS 1.6.3.3	Provide ATS Alerts
DFD 1.6.4	Interact with Vehicle Traffic Management
PS 1.6.4.1	Manage HRI Closures
PS 1.6.4.2	Exchange Data with Traffic Management
DFD 1.6.5	Monitor HRI Status
PS 1.6.5.1	Provide Interactive Interface
PS 1.6.5.2	Determine HRI Status
PS 1.6.5.3	Maintain HRI Closure Data
DFD 2	Manage Commercial Vehicles
DFD 2.1	Manage Commercial Vehicle Fleet Operations
PS 2.1.1	Manage Commercial Fleet Electronic Credentials and Tax Filing
PS 2.1.2	Provide Commercial Fleet Static Route
PS 2.1.3	Provide Flt Mgr Electronic Credentials and Tax Filing Interface
PS 2.1.4	Provide Fleet Manager Commercial Vehicle Communications
PS 2.1.5	Provide Commercial Vehicle Driver Routing Interface
PS 2.1.6	Manage Driver Instruction Store
DFD 2.2	Manage Commercial Vehicle Driver Operations
PS 2.2.1	Manage CV Electronic Credential and Tax Filing Interface
PS 2.2.2	Provide Vehicle Static Route
PS 2.2.3	Provide CV Driver Electronic Credential and Tax Filing Interface
PS 2.2.4	Provide Commercial Vehicle Driver Communications
DFD 2.3	Provide Commercial Vehicle Roadside Facilities
PS 2.3.1	Produce Commercial Vehicle Driver Message at Roadside
DFD 2.3.2	Provide Commercial Vehicle Clearance Screening
PS 2.3.2.1	Administer Commercial Vehicle Roadside Credentials Database
PS 2.3.2.2	Process Screening Transactions
DFD 2.3.3	Provide Roadside Commercial Vehicle Safety
PS 2.3.3.1	Provide Commercial Vehicle Checkstation Communications

PS 2.3.3.2	Provide Commercial Vehicle Inspector Handheld Terminal Interface
PS 2.3.3.3	Administer Commercial Vehicle Roadside Safety Database
PS 2.3.3.4	Carry-out Commercial Vehicle Roadside Safety Screening
PS 2.3.3.5	Carry-out Commercial Vehicle Roadside Inspection
PS 2.3.4	Detect Commercial Vehicle
PS 2.3.5	Provide Commercial Vehicle Roadside Operator Interface
PS 2.3.6	Provide Commercial Vehicle Reports
PS 2.3.7	Produce Commercial Vehicle Driver Message on Vehicle
PS 2.3.8	Provide Commercial Vehicle Border Screening
DFD 2.4	Provide Commercial Vehicle Data Collection
PS 2.4.1	Communicate Commercial Vehicle On-board Data to Roadside
PS 2.4.2	Collect On-board Commercial Vehicle Sensor Data
PS 2.4.3	Analyze Commercial Vehicle On-board Data
PS 2.4.4	Provide Commercial Vehicle Driver Interface
PS 2.4.5	Communicate Commercial Vehicle On-board Data to Vehicle Manager
PS 2.4.6	Provide Commercial Vehicle On-board Data Store Interface
DFD 2.5	Administer Commercial Vehicles
PS 2.5.1	Manage Commercial Vehicle Trips and Clearances
PS 2.5.2	Obtain Electronic Credential and Tax Filing Payment
PS 2.5.3	Update Permits and Duties Store
PS 2.5.4	Communicate with Other Commercial Vehicle Administration System
PS 2.5.5	Manage Commercial Vehicle Credentials and Enrollment
PS 2.5.6	Output Commercial Vehicle Enrollment Data to Roadside Facilities
PS 2.5.7	Process Commercial Vehicle Violations
PS 2.5.8	Process Data Received from Roadside Facilities
PS 2.5.9	Manage Commercial Vehicle Archive Data
DFD 2.6	Provide Commercial Vehicle On-board Data
PS 2.6.1	Provide Commercial Vehicle Manager Tag Data Interface
PS 2.6.2	Transmit Commercial Vehicle Tag Data
PS 2.6.3	Provide Commercial Driver Tag Data Interface
PS 2.6.4	Provide Lock Tag Data Interface
PS 2.6.5	Manage Commercial Vehicle Tag Data Store
PS 2.7	Manage Cargo
DFD 3	Provide Vehicle Monitoring and Control
DFD 3.1	Monitor Vehicle Status
PS 3.1.1	Produce Collision and Crash Avoidance Data
PS 3.1.2	Carry-out Safety Analysis
PS 3.1.3	Process Vehicle On-board Data
DFD 3.2	Provide Automatic Vehicle Operation
PS 3.2.1	Provide Driver Interface
PS 3.2.2	Provide AHS Control
DFD 3.2.3	Provide Vehicle Control
PS 3.2.3.1	Provide Command Interface
PS 3.2.3.2	Manage Platoon Following
PS 3.2.3.3	Process data for Vehicle Actuators
DFD 3.2.3.4	Provide Servo Controls
PS 3.2.3.4.1	Provide Speed Servo Control
PS 3.2.3.4.2	Provide Headway Servo Control
PS 3.2.3.4.3	Provide Lane Servo Control
PS 3.2.3.4.4	Provide Change Lane Servo Control
PS 3.2.3.4.5	Provide Vehicle Control Data Interface
PS 3.2.3.5	Process Vehicle Sensor Data
PS 3.2.3.6	Communicate with other Platoon Vehicles
PS 3.2.4	Process Sensor Data for AHS input

PS 3.2.5	Check Vehicle for AHS eligibility
PS 3.2.6	Manage AHS Check-in and Check-out
PS 3.2.7	Manage AHS Operations
DFD 3.3	Provide Automatic Emergency Notification
PS 3.3.1	Provide Cargo Data for Incident Notification
PS 3.3.2	Provide Communications Function
PS 3.3.3	Build Automatic Collision Notification Message
PS 3.4	Enhance Driver's Vision
DFD 4	Manage Transit
DFD 4.1	Operate Vehicles and Facilities
PS 4.1.1	Process Transit Vehicle Sensor Trip Data
DFD 4.1.2	Determine Transit Vehicle Deviation and Corrections
PS 4.1.2.1	Determine Transit Vehicle Deviation and ETA
PS 4.1.2.2	Determine Transit Vehicle Corrective Instructions
PS 4.1.2.3	Provide Transit Vehicle Driver Interface
PS 4.1.2.4	Provide Transit Vehicle Correction Data Output Interface
PS 4.1.2.5	Request Transit Vehicle Preemptions
PS 4.1.3	Provide Transit Vehicle Location Data
PS 4.1.4	Manage Transit Vehicle Deviations
PS 4.1.5	Provide Transit Vehicle Status Information
PS 4.1.6	Manage Transit Vehicle Operations Data
PS 4.1.7	Provide Transit Vehicle Deviation Data Output Interface
PS 4.1.8	Provide Transit Operations Data Distribution Interface
PS 4.1.9	Process Transit Vehicle Sensor Maintenance Data
DFD 4.2	Plan and Schedule Transit Services
DFD 4.2.1	Provide Demand Responsive Transit Service
PS 4.2.1.1	Process Demand Responsive Transit Trip Request
PS 4.2.1.2	Compute Demand Responsive Transit Vehicle Availability
PS 4.2.1.3	Generate Demand Responsive Transit Schedule and Routes
PS 4.2.1.4	Confirm Demand Responsive Transit Schedule and Route
PS 4.2.1.5	Process Demand Responsive Transit Vehicle Availability Data
PS 4.2.1.6	Provide Demand Responsive Transit Driver Interface
PS 4.2.2	Provide Transit Plans Store Interface
DFD 4.2.3	Generate Transit Routes and Schedules
PS 4.2.3.1	Generate Transit Routes
PS 4.2.3.2	Generate Schedules
PS 4.2.3.3	Produce Transit Service Data for external use
PS 4.2.3.4	Provide Transit Fleet Manager Interface for Services Generation
PS 4.2.3.5	Manage Transit Operational Data Store
PS 4.2.3.6	Produce Transit Service Data for Manage Transit Use
PS 4.2.3.7	Provide Interface for Other TRM Data
PS 4.2.3.8	Provide Interface for Transit Service Raw Data
PS 4.2.3.9	Update Transit Map Data
PS 4.2.4	Manage Transit Archive Data
DFD 4.3	Schedule Transit Vehicle Maintenance
PS 4.3.1	Monitor Transit Vehicle Condition
PS 4.3.2	Generate Transit Vehicle Maintenance Schedules
PS 4.3.3	Generate Technician Work Assignments
PS 4.3.4	Monitor And Verify Maintenance Activity
PS 4.3.5	Report Transit Vehicle Information
PS 4.3.6	Update Transit Vehicle Information
PS 4.3.7	Manage Transit Vehicle Operations Data Store
DFD 4.4	Support Security and Coordination
DFD 4.4.1	Provide Transit Security and Emergency Management

PS 4.4.1.1	Manage Transit Security
PS 4.4.1.2	Manage Transit Emergencies
PS 4.4.1.3	Provide Transit System Operator Security Interface
PS 4.4.1.4	Provide Transit External Interface for Emergencies
PS 4.4.1.5	Provide Transit Driver Interface for Emergencies
PS 4.4.1.6	Collect Transit Vehicle Emergency Information
PS 4.4.1.7	Monitor Secure Area
PS 4.4.1.8	Report Traveler Emergencies
PS 4.4.2	Coordinate Multiple Agency Responses to Incidents
PS 4.4.3	Generate Responses for Incidents
DFD 4.5	Generate Transit Driver Schedules
PS 4.5.1	Assess Transit Driver Performance
PS 4.5.2	Assess Transit Driver Availability
PS 4.5.3	Access Transit Driver Cost Effectiveness
PS 4.5.4	Assess Transit Driver Eligibility
PS 4.5.5	Generate Transit Driver Route Assignments
PS 4.5.6	Update Transit Driver Information
PS 4.5.7	Report Transit Driver Information
PS 4.5.8	Provide Transit Driver Information Store Interface
DFD 4.6	Collect Transit Fares in the Vehicle
PS 4.6.1	Detect Transit User on Vehicle
PS 4.6.2	Determine Transit User Needs on Vehicle
PS 4.6.3	Determine Transit Fare on Vehicle
PS 4.6.4	Manage Transit Fare Billing on Vehicle
PS 4.6.5	Provide Transit User Fare Payment Interface on Vehicle
PS 4.6.6	Update Transit Vehicle Fare Data
PS 4.6.7	Provide Transit Vehicle Passenger Data
PS 4.6.8	Manage Transit Vehicle Advanced Payments
DFD 4.7	Provide Transit User Roadside Facilities
DFD 4.7.1	Provide Transit User Roadside Information
PS 4.7.1.1	Provide Transit User Roadside Data Interface
PS 4.7.1.2	Provide Transit User Roadside Vehicle Data Interface
DFD 4.7.2	Collect Transit Fares at the Roadside
PS 4.7.2.1	Detect Transit User at Roadside
PS 4.7.2.2	Determine Transit User Needs at Roadside
PS 4.7.2.3	Determine Transit Fare at Roadside
PS 4.7.2.4	Manage Transit Fare Billing at Roadside
PS 4.7.2.5	Provide Transit User Roadside Fare Interface
PS 4.7.2.6	Update Roadside Transit Fare Data
PS 4.7.2.7	Provide Transit Roadside Passenger Data
DFD 5	Manage Emergency Services
DFD 5.1	Provide Emergency Service Allocation
PS 5.1.1	Identify Emergencies from Inputs
PS 5.1.2	Determine Coordinated Response Plan
PS 5.1.3	Communicate Emergency Status
PS 5.1.4	Manage Emergency Response
PS 5.1.5	Manage Emergency Service Allocation Store
PS 5.1.6	Process Mayday Messages
PS 5.2	Provide Operator Interface for Emergency Data
DFD 5.3	Manage Emergency Vehicles
PS 5.3.1	Select Response Mode
PS 5.3.2	Dispatch Vehicle
PS 5.3.3	Track Vehicle
PS 5.3.4	Assess Response Status

PS 5.3.5	Provide Emergency Vehicle Driver Interface
PS 5.3.6	Maintain Vehicle Status
DFD 5.4	Provide Law Enforcement Allocation
PS 5.4.1	Process TM Detected Violations
PS 5.4.2	Process Violations for Tolls
PS 5.4.3	Process Parking Lot Violations
PS 5.4.4	Process Fare Payment Violations
PS 5.4.5	Process Vehicle Fare Collection Violations
PS 5.4.6	Process CV Violations
PS 5.4.7	Process Roadside Fare Collection Violations
PS 5.5	Update Emergency Display Map Data
PS 5.6	Manage Emergency Services Data
DFD 6	Provide Driver and Traveler Services
DFD 6.1	Provide Trip Planning Services
PS 6.1.1	Provide Trip Planning Information to Traveler
PS 6.1.2	Confirm Traveler's Trip Plan
PS 6.1.3	Manage Multimodal Service Provider Interface
PS 6.1.4	Provide ISP Operator Interface for Trip Planning Parameters
PS 6.1.5	Collect Service Requests and Confirmation for Archive
PS 6.1.6	Manage Traveler Info Archive Data
DFD 6.2	Provide Information Services
DFD 6.2.1	Provide Advisory and Broadcast Data
PS 6.2.1.1	Collect Traffic Data for Advisory Messages
PS 6.2.1.2	Provide Traffic and Transit Advisory Messages
PS 6.2.1.3	Collect Transit Data for Advisory Messages
PS 6.2.1.4	Provide Traffic and Transit Broadcast Messages
PS 6.2.1.5	Provide ISP Operator Broadcast Parameters Interface
PS 6.2.1.6	Provide Transit Advisory Data on Vehicle
PS 6.2.2	Prepare and Output In-vehicle Displays
PS 6.2.3	Provide Transit User Advisory Interface
PS 6.2.4	Collect Yellow Pages Data
PS 6.2.5	Provide Driver Interface
PS 6.2.6	Provide Yellow Pages Data and Reservations
DFD 6.3	Provide Traveler Services at Kiosks
PS 6.3.1	Get Traveler Request
PS 6.3.2	Inform Traveler
PS 6.3.3	Provide Traveler Kiosk Interface
PS 6.3.4	Update Traveler Display Map Data at Kiosk
DFD 6.4	Manage Ridesharing
PS 6.4.1	Screen Rider Requests
PS 6.4.2	Match Rider and Provider
PS 6.4.3	Report Ride Match Results to Requestor
PS 6.4.4	Confirm Traveler Rideshare Request
DFD 6.5	Manage Yellow Pages Services
PS 6.5.1	Collect and Update Traveler Information
PS 6.5.2	Provide Traveler Yellow Pages Information and Reservations
PS 6.5.3	Register Yellow Pages Service Providers
DFD 6.6	Provide Guidance and Trip Planning Services
PS 6.6.1	Provide Multimodal Route Selection
DFD 6.6.2	Select Vehicle Route
PS 6.6.2.1	Calculate Vehicle Route
PS 6.6.2.2	Provide Vehicle Route Calculation Data
PS 6.6.2.3	Provide Route Segment Data for Other Areas
PS 6.6.2.4	Update Vehicle Route Selection Map Data

PS 6.6.2.5	Provide ISP Operator Route Parameters Interface
PS 6.6.2.6	Calculate Vehicle Probe Data for Guidance
PS 6.6.3	Update Other Routes Selection Map Data
PS 6.6.4	Select Transit Route
PS 6.6.5	Select Other Routes
DFD 6.7	Provide Driver Personal Services
DFD 6.7.1	Provide Driver Personal Security
PS 6.7.1.1	Build Driver Personal Security Message
PS 6.7.1.2	Provide Driver In-vehicle Communications Function
DFD 6.7.2	Provide On-line Vehicle Guidance
DFD 6.7.2.1	Provide Vehicle Guidance
PS 6.7.2.1.1	Determine In-vehicle Guidance Method
PS 6.7.2.1.2	Provide Dynamic In-vehicle Guidance
PS 6.7.2.1.3	Provide Autonomous In-vehicle Guidance
PS 6.7.2.2	Process Vehicle Location Data
PS 6.7.2.3	Provide Driver Guidance Interface
PS 6.7.2.4	Update Vehicle Navigable Map Database
DFD 6.8	Provide Traveler Personal Services
DFD 6.8.1	Provide On-line Traveler Guidance
DFD 6.8.1.1	Provide Traveler Guidance
PS 6.8.1.1.1	Determine Personal Portable Device Guidance Method
PS 6.8.1.1.2	Provide Personal Portable Device Dynamic Traveler Guidance
PS 6.8.1.1.3	Provide Personal Portable Device Autonomous Guidance
PS 6.8.1.2	Provide Personal Portable Device Guidance Interface
PS 6.8.1.3	Process Personal Portable Device Location Data
PS 6.8.1.4	Update Traveler Navigable Map Database
PS 6.8.1.5	Provide Traveler Emergency Message Interface
DFD 6.8.2	Provide Traveler Personal Security
PS 6.8.2.1	Build Traveler Personal Security Message
PS 6.8.2.2	Provide Traveler Emergency Communications Function
DFD 6.8.3	Provide Traveler Services at Personal Devices
PS 6.8.3.1	Get Traveler Personal Request
PS 6.8.3.2	Provide Traveler with Personal Travel Information
PS 6.8.3.3	Provide Traveler Personal Interface
PS 6.8.3.4	Update Traveler Personal Display Map Data
DFD 7	Provide Electronic Payment Services
DFD 7.1	Provide Electronic Toll Payment
DFD 7.1.1	Process Electronic Toll Payment
PS 7.1.1.1	Read Tag Data for Tolls
PS 7.1.1.2	Calculate Vehicle Toll
PS 7.1.1.3	Manage Bad Toll Payment Data
PS 7.1.1.4	Check for Advanced Tolls Payment
PS 7.1.1.5	Bill Driver for Tolls
PS 7.1.1.6	Collect Probe Data From Toll Transactions
PS 7.1.1.7	Update Toll Price Data
PS 7.1.1.8	Register for Advanced Toll Payment
PS 7.1.1.9	Manage Toll Financial Processing
PS 7.1.1.10	Determine Advanced Toll Bill
PS 7.1.1.11	Manage Toll Archive Data
PS 7.1.2	Produce Roadside Displays
PS 7.1.3	Obtain Toll Violator Image
PS 7.1.4	Provide Driver Toll Payment Interface
PS 7.1.5	Detect Vehicle for Tolls
PS 7.1.6	Distribute Advanced Charges and Fares

PS 7.1.7	Provide Payment Instrument Interface for Tolls
DFD 7.2	Provide Electronic Parking Payment
DFD 7.2.1	Process Electronic Parking Lot Payment
PS 7.2.1.1	Read Parking Lot Tag Data
PS 7.2.1.2	Calculate Vehicle Parking Lot Charges
PS 7.2.1.3	Collect Bad Charge Payment Data
PS 7.2.1.4	Check for Advanced Parking Lot Payment
PS 7.2.1.5	Bill Driver for Parking Lot Charges
PS 7.2.1.6	Manage Parking Lot Financial Processing
PS 7.2.1.7	Update Parking Lot Data
PS 7.2.1.8	Register for Advanced Parking Lot Payment
PS 7.2.1.9	Manage Parking Lot Reservations
PS 7.2.1.10	Determine Advanced Charges
PS 7.2.2	Produce Parking Lot Displays
PS 7.2.3	Obtain Parking Lot Violator Image
PS 7.2.4	Provide Driver Parking Lot Payment Interface
PS 7.2.5	Detect Vehicle for Parking Lot Payment
PS 7.2.6	Distribute Advanced Tolls and Fares
PS 7.2.7	Provide Payment Instrument Interface for Parking
DFD 7.3	Provide Electronic Fare Collection
DFD 7.3.1	Process Electronic Transit Fare Payment
PS 7.3.1.1	Register for Advanced Transit Fare Payment
PS 7.3.1.2	Determine Advanced Transit Fares
PS 7.3.1.3	Manage Transit Fare Financial Processing
PS 7.3.1.4	Check for Advanced Transit Fare Payment
PS 7.3.1.5	Bill Transit User for Transit Fare
PS 7.3.1.6	Collect Bad Transit Fare Payment Data
PS 7.3.1.7	Update Transit Fare Data
PS 7.3.2	Distribute Advanced Tolls and Parking Lot Charges
PS 7.3.3	Get Transit User Image for Violation
PS 7.3.4	Provide Remote Terminal Payment Instrument Interface
PS 7.3.5	Provide Transit Vehicle Payment Instrument Interface
DFD 7.4	Carry-out Centralized Payments Processing
DFD 7.4.1	Collect Advanced Payments
PS 7.4.1.1	Process Commercial Vehicle Payments
PS 7.4.1.2	Process Yellow Pages Services Provider Payments
PS 7.4.1.3	Process Driver Map Update Payments
PS 7.4.1.4	Process Traveler Map Update Payments
PS 7.4.1.5	Process Transit User Other Services Payments
PS 7.4.1.6	Process Traveler Trip and Other Services Payments
PS 7.4.1.7	Collect Payment Transaction Records
PS 7.4.1.8	Process Traveler Rideshare Payments
PS 7.4.2	Collect Price Data for ITS Use
PS 7.4.3	Route Traveler Advanced Payments
DFD 7.5	Provide Payment Instrument Interfaces
PS 7.5.1	Provide Vehicle Payment Instrument Interface
PS 7.5.2	Provide Transit User Roadside Payment Instrument Interface
PS 7.5.3	Provide Personal Payment Instrument Interface
PS 7.5.4	Provide Commercial Fleet Payment Instrument Interface
PS 7.5.5	Provide Traveler Kiosk Payment Instrument Interface
DFD 8	Manage Archived Data
PS 8.1	Get Archived Data
PS 8.2	Mange Archive
PS 8.3	Mange Archive Data Administrator Interface

PS 8.4	Coordinate Archives
PS 8.5	Process Archived Data User System Requests
PS 8.6	Analyze Archive
PS 8.7	Process On Demand Archive Requests
PS 8.8	Prepare Government Reporting Inputs
PS 8.9	Manage Roadside Data Collection
PS 9	Satisfy Implementation Requirements