Development of a Multi-campus Multidisciplinary Transportation Curriculum for UTCA

By

Norbert Delatte
Department of Civil and Environmental Engineering
The University of Alabama at Birmingham
Birmingham, Alabama

Michael Anderson and Kathleen Leonard
Department of Civil and Environmental Engineering
The University of Alabama in Huntsville
Huntsville, Alabama

John McFadden
Department of Civil and Environmental Engineering
The University of Alabama
Tuscaloosa, Alabama

UTCA Theme: Management and Safety of Transportation Systems

Prepared by

UTCA

University Transportation Center for Alabama
The University of Alabama, The University of Alabama at Birmingham, and
The University of Alabama in Huntsville

UTCA Report 99249
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University Transportation Center for Alabama

About UTCA The University Transportation Center for Alabama (UTCA) is designated as a "university transportation center" by the US Department of Transportation. UTCA serves a unique role as a joint effort of the three campuses of the University of Alabama System. It is headquartered at the University of Alabama (UA) with branch offices at the University of Alabama at Birmingham (UAB) and the University of Alabama in Huntsville (UAH). Interdisciplinary faculty members from the three campuses (individually or operating in teams) perform research, education, and technology transfer projects using funds provided by UTCA and external sponsors. The projects are guided by the UTCA Annual Research Plan. The plan is prepared by the Advisory Board to address transportation issues of great importance to Alabama and the region.

Mission Statement and Strategic Plan The mission of UTCA is "to advance the technology and expertise in the multiple disciplines that comprises transportation through the mechanisms of education, research, and technology transfer while serving as a university-based center of excellence."

The UTCA strategic plan contains six goals that support this mission, as listed below:

- Education – conduct a multidisciplinary program of coursework and experiential learning that reinforces the theme of transportation;
- Human Resources – increase the number of students, faculty and staff who are attracted to and substantively involved in the undergraduate, graduate, and professional programs of UTCA;
- Diversity – develop students, faculty and staff who reflect the growing diversity of the US workforce and are substantively involved in the undergraduate, graduate, and professional programs of UTCA;
- Research Selection – utilize an objective process for selecting and reviewing research that balances the multiple objectives of the program;
- Research Performance – conduct an ongoing program of basic and applied research, the products of which are judged by peers or other experts in the field to advance the body of knowledge in transportation; and
- Technology Transfer – ensure the availability of research results to potential users in a form that can be directly implemented, utilized or otherwise applied.

Theme The UTCA theme is *"MANAGEMENT AND SAFETY OF TRANSPORTATION SYSTEMS."* The majority of UTCA's total effort each year is in direct support of the theme; however, some projects are conducted in other topic areas, especially when identified as high priority by the Advisory Board. UTCA concentrates upon the highway and mass transit modes, but also conducts projects featuring rail, waterway, air, and other transportation modes as well as intermodal issues.

Disclaimer

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16. Abstract

This project focused on the design of an ideal curriculum of multidisciplinary transportation course work for the three UA system campuses. The investigators evaluated existing curricula and courses on all three campuses, identified desired new courses, and prepared sample transportation curricula. A thorough review of competing programs throughout the U.S., with emphasis on the Southeast, was carried out to establish a benchmark to which to compare existing and proposed UTCA programs. The project team also identified barriers and incentives for adoption of the program. A team approach encompassing all three campuses (UAB, UA, and UAH) was used. Three different levels were investigated, all of which would have a multi-campus course requirement – an undergraduate area of emphasis (two or three courses), Master of Science in Civil Engineering and other Master's Degree options, and a shared Ph.D. program. The emphasis was on Master's Degree options and on developing a sound foundation for the shared Ph.D. program. The major objective of this project was to develop a unique multidisciplinary multi-campus transportation curriculum for all three UA System campuses. Graduate programs were developed to attract students who do not have an undergraduate civil engineering background to careers in transportation engineering as well as students with undergraduate civil engineering degrees. This coordinated curriculum will improve transportation engineering education in the University of Alabama System.

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Executive Summary

This project focused on identifying ideal curricula for multidisciplinary transportation course work for the three campuses of the University of Alabama System – the University of Alabama (UA), the University of Alabama at Birmingham (UAB), and the University of Alabama in Huntsville (UAH). The investigators evaluated existing curricula and courses on all three campuses, identified desired new courses, and prepared sample transportation curricula. A thorough review of competing programs throughout the U.S., with emphasis on the Southeast, was carried out to establish a benchmark to compare existing and proposed University Transportation Center for Alabama (UTCA) programs. The project team also identified barriers and incentives for adoption of the program.

Faculty members from all three System campuses composed the project team. Three different curricula levels were investigated, all of which involved multi-campus course requirements - an undergraduate emphasis area (two or three courses), a Master of Science in Civil Engineering and other Master's Degree options, and a shared Ph.D. program. All three campuses already have strong transportation engineering programs at the undergraduate level, and offer several graduate transportation courses. Including graduate courses outside of engineering could add breadth and depth to the proposed graduate degree program. The proposed graduate programs can be designed to attract to students to transportation careers regardless of whether or not they had undergraduate civil engineering backgrounds.

The review of graduate course offerings at other universities showed that opportunities exist in several categories where five or fewer courses are offered throughout the Southeast:

- Seaport Planning & Design
- GIS & Transportation
- Environmental Impacts
- Mass Transit
- Intelligent Transportation Systems

While Seaport Planning & Design does not appear to be an area of opportunity for UTCA, the other categories deserve serious consideration for inclusion in a multidisciplinary degree.

A good opportunity at the undergraduate level might be a "Certificate" in transportation. This represents a concentration of work in a specific topic and can be quite versatile in composition. Some existing certificates require that part of the work be beyond the undergraduate level, others allow the certificate work to be completed as electives during undergraduate study, and still others do not even require that the student be officially admitted to a degree program. UTCA can design a Certificate to fit its needs. For example, it might become an option for students in non-engineering majors to gain expertise in transportation programs in both the public and private sector. The Transportation Certificate program is anticipated to be 12 credit hours of

course work, initially from existing Civil Engineering courses; however, as the program progresses, courses from other disciplines can be added.

A number of specific recommendations for implementation have been made in this report, including the following:

- Development of new courses
- Recruitment of new faculty
- Distribution of transportation courses among the three campuses by distance learning
- Obtaining approval for a Transportation Certificate
- Obtaining approval for an MS transportation emphasis

The implementation of these programs will require intensive review and approval by the faculty of existing academic departments on the three campuses, and dedicated UTCA funding and support would enhance the chances of adoption.

Section 1
Introduction

Transportation is an industry that, as a whole, is estimated to comprise 20% of the gross domestic product and affects the lives of every citizen. Professional opportunities for those with the skills to plan, develop, and implement transportation operations have never been greater, and are expanding rapidly. To respond to this challenge, a number of students on the three campuses of the University of Alabama (UA) System enroll in Civil Engineering programs to become transportation professionals. However, transportation is more than just engineering, and students in other disciplines can be made aware of career opportunities in transportation and (upon graduation) can expand the expertise available to operate and manage the complex U.S. transportation system.

Because transportation is inherently interdisciplinary, solving complex transportation problems facing the next generation of professionals will require a multidisciplinary approach. The diversity of students participating in transportation education enriches the academic experience of all students, and allows students to see the strength of interdisciplinary approaches to planning, operating, managing and maintaining the next generation of transportation systems.

Education is one of the six primary goals of all federally supported University Transportation Centers. Thus, the UTCA Executive Committee designated the creation of a multidisciplinary, multi-campus curriculum as a high priority topic to enhance management and safety of transportation systems.

Project Objective

The major objective of this project was to develop a unique multidisciplinary multi-campus transportation curriculum for all three UA System campuses. Both undergraduate and graduate programs were needed to attract students who may or may not have civil engineering backgrounds, and to steer them to careers in transportation engineering. This coordinated curriculum will improve transportation education in the UA System.

Research Approach

A team approach was used, encompassing all three campuses – The University of Alabama (UA), The University of Alabama at Birmingham (UAB), and the University of Alabama in Huntsville (UAH). Three different levels were investigated, all of which would have a multi-campus course requirement – an undergraduate emphasis area (two or three courses), a Master of Science in Civil Engineering and other Master's Degree options, and a shared Ph.D. program.

The project team:

- Designed ideal curriculum of multidisciplinary transportation course work.

- Investigated existing curriculum and courses on all three campuses, identified desired new courses, and prepared a sample transportation curriculum.
- Identified barriers and incentives for adoption of the programs.

The work was accomplished through the following tasks.

1. Other transportation engineering programs at U.S. universities were investigated through published course catalogs and websites. Emphasis was placed on programs in the southeast. Results were analyzed and data was compiled.

2. Existing courses at all three campuses that could be applied to the multidisciplinary transportation curriculum were reviewed. Emphasis was placed on courses that could apply to management and safety.

3. Initial outlines of an undergraduate certificate (area of emphasis) and Master's options were developed. Graduate programs were developed for incoming students with and without civil engineering undergraduate degrees.

4. Project team members attended conferences to interact with other faculty in the area of transportation engineering.

5. Desired new courses were identified to enhance these programs, and suggested faculty were identified to offer them.

6. Important areas that suggest new faculty recruiting at one or more of the UTCA campuses were identified.

7. A distance learning strategic plan for the multi-campus multidisciplinary transportation curriculum was investigated.

8. All tasks above were documented in this project report.

Application of Results

Implementation of a new curriculum can be complex and time consuming, due to the myriad of academic approvals that must be acquired. The results of this study must be viewed as an ideal curriculum, and intensive efforts should be expended to encourage their adoption and implementation to the extent feasible on the three campuses. At this time it appears that institutional barriers might prevent the development of Ph.D. programs in the short term. As a result, this report is focused on the proposed Certificate and Master's programs. If these are successful, they will form a foundation for the development of future Ph.D. options.

Section 2
Background

In this section, current UA System course offerings and degree programs are discussed, as well as competing programs in the Southeast and the rest of the country. This information is analyzed to identify opportunities in transportation education.

Current UA, UAB, UAH programs

This report contains a synthesis of the courses and programs in transportation and related fields offered by UA, UAB, and UAH. A discussion of these programs is provided in Appendix A, and a listing of the transportation-related courses offered at the three campuses is provided in Appendix B.

Presently all three UA System campuses offer Bachelor of Science in Civil Engineering (BSCE) degrees that include a transportation emphasis and at least one required transportation engineering course. In addition, UA and UAB offer a CE minor that can be acquired by non-engineering students. All three campuses offer Master of Science (MS) degrees in Civil and Environmental Engineering. UA and UAB offer Master of Science in Civil Engineering (MSCE) degrees, and UAH offers a Master of Science in Engineering (MSE) degree. At both UA and UAB, students may specialize in particular areas within the MS field (i.e., environmental engineering, structural engineering, structural mechanics, etc.).

UA has a well-established Ph.D. program in Civil and Environmental Engineering. UAB has recently established a Ph.D. program in Environmental Health Engineering. Both programs can accommodate students who wish to major in transportation.

Related programs include the Master's of Business Administration (MBA) and Master's in Public Administration (MPA) at UA and UAB, and MSE in Engineering Management and MS in Materials Science at UAH.

Overall, the UA and UAB graduate programs appear to be similar, but UAH programs have significant differences from both UA and UAH.

Competing programs – Southeast and U.S.

The Research Team reviewed programs offering graduate level transportation courses and programs throughout the U.S., with special emphasis on the Southeast. A thorough review of programs in the Southeast, including course listings by category, is provided in Appendix C. Specialties offered in the Southeast are shown in Figure 2-1, and courses offered within these specialties are shown in Figure 2-2. The schools that were reviewed to develop these figures are listed in Table 2-1.

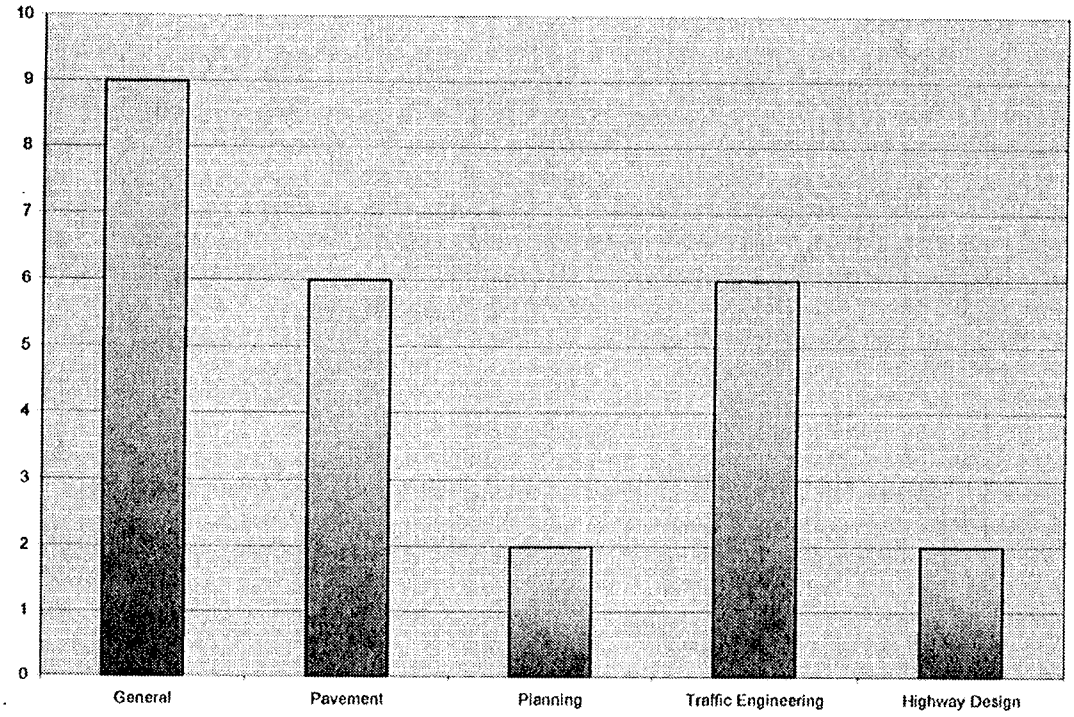

Figure 2-1. Transportation Specialties Offered in the Southeast

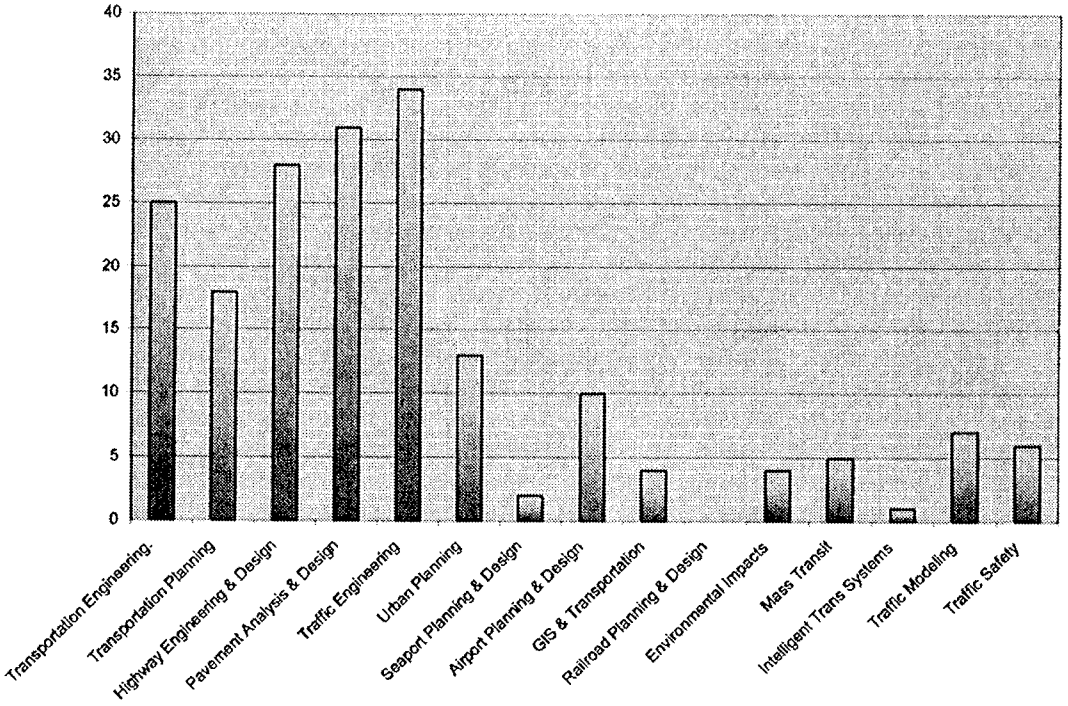

Figure 2-2. Transportation Courses Offered in the Southeast

Table 2-1. Programs Reviewed in the Southeast

Auburn University
University of Alabama
University of Alabama at Birmingham
Florida A&M
Florida Institute of Technology
Florida State University
Florida International University
Georgia Institute of Technology
Tennessee Technological University
University of Central Florida
University of Florida
University of Memphis
University of Mississippi
University of South Alabama
University of Tennessee
Vanderbilt University

A review of graduate course offerings was used to identify common categories and emphasis areas. The research team establish found that four topics had 25 or more courses, as listed below:

- transportation engineering
- highway engineering and design
- pavement analysis and design
- traffic engineering

Opportunities

The review of competing programs showed that most MS programs in Transportation are general, pavement oriented, and traffic engineering oriented. This suggests that opportunities for specialization exist in planning and highway design. No specializations in management or safety of transportation systems were found in the Southeast.

Based on the review of graduate course offerings, opportunities exist in several categories where five or fewer courses are offered throughout the Southeast:

- Seaport Planning & Design
- GIS & Transportation
- Environmental Impacts
- Mass Transit
- Intelligent Transportation Systems

While seaport planning & design does not appear to be an area of opportunity, the other categories deserve serious consideration for further development, especially if a need exists for such expertise in the Southeast.

Section 3
Proposed UTCA Certificate Program

Proposed in this report is a Certificate in Transportation to be sponsored by the University Transportation Center of Alabama (UTCA) and offered by UA, UAB, and UAH. The UA System recognizes a certificate as a concentration of work in a specific topic, the System allows certificates to be quite versatile in composition. Some existing certificates require that part of the work be beyond the undergraduate level, others allow the certificate work to be completed as electives during undergraduate study, and still others do not even require that certificate students be officially admitted to a degree program.

UTCA can design a certificate to fit its needs. For example, it might become an option for students in non-engineering majors to gain expertise in transportation programs in both the public and private sector. Or, it might initially be limited to civil engineering students as a means to complete a cluster of transportation courses that guarantee a certain level of transportation expertise beyond that of the typical BS degree.

The certificate recommended by the research team can be considered as an option for students in non-engineering majors to gain knowledge of transportation programs and employment in both the public and private sector. Students may be pursuing bachelor degrees in programs such as Business Administration, Economics, Geography, Sociology, or Urban Planning would be eligible, and should be within two years of obtaining their degree.

Completion of the Transportation Certificate Program is expected to support careers in:

Transportation Policy Analysis
Urban and State-wide Transportation Planning
Transportation and Development Economic Analysis
Federal and State Transportation Strategic Planning
Transportation Planning and Engineering Consulting
Transportation Systems Management

At present, it is proposed that the Transportation Certificate Program be comprised of 12 credit hours of course work. The coursework is initially expected to come from Civil Engineering courses; however, as the program progresses transportation courses in other disciplines will be added. Table 3-1 provides a candidate listing of possible courses a student in the Transportation Certificate Program would be expected to select. Course titles and descriptions are provided in Appendix B.

The UTCA Transportation Certificate Program would serve three purposes:

- It could provide an additional credential for BSCE students

- It could provide a way for non-BSCE majors to take courses in transportation and have that work formally recognized.
- It could define the required preliminary course work for non-BSCE graduates to enter the MS programs discussed in Section 4 of this report.

Implementation of the Transportation Certificate Program will be sponsored by UTCA, and students in the program will identified by the campus at which they are residents. It is proposed that the host campus upon completion of the bachelor's degree issue the certificates, and that they be signed by the UTCA director. It is also possible that the Transportation Certificate could be used as a basis for the development of a minor on one or more campuses in the future.

Table 3-1. UTCA Certificate Courses

Course Title	UA Course Number	UAB Course Number	UAH Course Number
Surveying	CE 262	CE 230	CE 284
Transportation Engineering	CE 450	CE 345	CE 321
Engineering Economics	IE 203	CE 395	ISE 321
Environmental Engineering	CE 420	CE 336	CE 449
Approved Transportation Elective	CE 445, CE 451, CE 452, CE 455, CE 457, CE 458, CE 459, CE 467	CE 442, CE 443, CE 444, CE 447, CE 457, CE 468, CE 611, CE 645, CE 646, CE 648	CE 384, CE 411, CE 420, CE 422

Final design of Certificate criteria will be tedious, especially if the program is to serve both engineering majors and other disciplines. Implementation of the Certificate concept will require a coordinated effort on the part of faculty members associated with UTCA, since adoption must be by individual academic departments.

Attracting students to the proposed Certificate program will be another challenge. One strategy might be for UTCA to induce students to enter the Certificate plan with scholarships, with enrollment in a certificate course a prerequisite for receiving the funding in any semester or quarter.

Section 4
Proposed MS Programs

The proposed MS programs will be parallel in configuration, but housed on the three respective home campuses. The programs will meet home campus requirements, as well as UTCA guidelines (a draft set of guidelines is shown in Table 4-1). Students will be encouraged (or required) to take at least one course on another UTCA campus. This requirement may be met through residence or distance learning (e.g., Intercampus Interactive Telecommunication System (IITS), as explained later in this report). Course descriptions are provided in Appendix B.

Table 4-1. Draft MS Transportation Program Courses and Requirements

Transportation Engineering: 12 Semester hours taken from the following courses:	
UA Course Number	CE 545, CE 551, CE 552, CE 555, CE 557, CE 558, CE 559, CE 567
UAB Course Number	CE 442, CE 443, CE 444, CE 447, CE 457, CE 468, CE 611, CE 645, CE 646, CE 648
UAH Course Number	CE 384, CE 411, CE 420, CE 422
Breadth and Depth: 6 Semester hours of 500 level or higher non-CE courses from the listing in Appendix B.	

The interdisciplinary aspect of the transportation specialization is recognized by the inclusion of multidisciplinary courses in the potential course offerings. Of particular interest are the courses listed in Appendix B offered by other colleges and schools, for example Public Administration. Incorporation of these courses will enhance the multidisciplinary nature of the program.

There are at least three options for the MS program:

- Specialization in Transportation – this might require a UTCA Transportation Certificate for admittance of non-civil engineers
- MSCE or MSE awarded by home campus – UA, UAB, UAH (UAH already has this major at the MSE level)
- Students may dual specialize – transportation/environmental (already in place at UAH)

To make more courses available on all three campuses and enhance the multi-campus nature of the program, transportation courses should be offered via distance learning techniques.

Since UA and UAB already have in place MSCE programs with specialization (i.e., structural engineering, environmental engineering), these programs were used as models to add a third specialization in transportation engineering. For these two campuses, an additional specialization will require little extra effort. Current UA system programs are reviewed in Appendix A, and course listings are provided in Appendix B.

Students may or may not have BSCE prior to acceptance. If they do not have a BSCE, a transportation certificate or civil engineering minor could constitute the required preliminary course work. It would seem logical to count these courses toward either the Transportation Certificate or an MS program, but not both.

The proposed outline of the MSCE with a specialization in transportation engineering option for UA and UAB is described in this section.

UA Requirements

It is expected that the students interested in a specialization in transportation engineering will be affiliated with the Plan I (thesis option) program at UA. This program requires a student to take 24 credit hours of course work and six hours of thesis research. For a specialization in transportation engineering, 18 semester hours of transportation (or approved equivalent) course work from the list of approved courses (Appendix B) must be completed successfully. Six hours of thesis research credit are required and may be counted in the 18 hours requirement. No more than six of these hours can be courses listed below the graduate level (500 level or above is graduate level for UA students). Other appropriate requirements may be established by the UA Civil & Environmental Engineering Department.

UAB Requirements

UAB students may pursue Transportation Engineering through any of the three existing options – Plan I (Thesis), Plan II (Non-thesis) Research/Design Emphasis, and Plan II (Non-thesis) Technology/Engineering Management Emphasis. These options are outlined in detail in Appendix A. Students will meet the requirements of those three plans as well as those finally adopted for this option (such as those outlined in Table 4-1). For UAB students, all courses must be taken at the 500 level or higher.

UAH Requirements

UAH currently has a MSE major in transportation engineering, with both the thesis and non-thesis options. The total number of hours required is 33 semester credits. It also has some flexibility existing since the UAH program requires two minors (one of which must be mathematics/statistics) that would allow for courses from another department or college to count for the MSE minor. Conversely, students enrolled in another college could complete the transportation certificate for the minor in the college of science or business. Students will meet the MSE requirements as well as those finally adopted for this option (such as those outlined in Table 4-1).

Section 5
Implementation Recommendations

The strategic approach in this research was to document current resources of the three campuses and benchmark to programs at other institutions. Although there are current courses and MS degrees within the UA system that could be used to execute a multidisciplinary program at each of the campuses, new upper-level courses are proposed for future growth. After a viable number of students are enrolled, then additional faculty and other resources may be required for the campuses and departments involved.

Recommended New Courses

The Research Team recommends the development of a number of new courses, shown below. These courses should be offered at the undergraduate level (400) as well as the graduate level (500 or higher) both for technical electives for BSE students and to assure adequate enrollment levels. These following courses can be added to the suggested Transportation Engineering courses listed in Table 4-1:

- Urban Mass Transit and Mobility
- Transportation Planning Laboratory
- Construction Project Management
- GIS in Transportation
- Highway Capacity
- Pavement Management Systems
- Transportation Economics
- Evaluation and Repair of Civil Infrastructure
- Contemporary Issues in Transportation Engineering – three campus IITS

As the program grows, the list of technical course options may expand as financial resources allow.

The Research Team further recommends that UTCA fund small course development grants for faculty to prepare innovative courses. Grants of approximately $15,000 would provide a powerful incentive for CEE faculty as well as faculty in other departments to develop new multidisciplinary graduate courses.

New Faculty Recruiting

New faculty recruiting for the three UA system campuses should address both educational and research needs and opportunities. The following specialty areas are recommended for the recruiting of new faculty members.

- Traffic operations and safety
- Mass transit

Engineering practitioners can make competent part-time instructors in their areas of expertise until full-time faculty can be hired. The business, engineering management and finance areas may also need more instructors if class size increases substantially.

IITS Program

The IITS system consists of direct televised classes via telephone cable between the three campuses. It provides an excellent mechanism for sharing transportation course offerings among the three UA system campuses. However, implementation will not reach full level until UAB converts to the semester system in the Fall of 2001. It is recommended that at least one transportation course be offered each term, with rotation among all three campuses to spread the teaching load. This would expose transportation students to faculty expertise at the other campuses, and would decrease the teaching load on two of the three campuses each semester.

For implementation, a teaching assistant is needed to help with student homework, test scheduling, advising and other day-to-day needs. The incentive to the faculty to take responsibility for the course should lie with the home institution, but a team teaching model that gives all three campuses credit for their own students (as in different class sections) and that gives the professor credit for the class load would be an inducement to make this system work.

Certificate Program Implementation

Certificate approval must be obtained on each campus. This suggests an early start for the paperwork. As each program is approved, UTCA could begin issuing the certificates.

At UAH, the process starts with the departmental curriculum committee, then college curriculum and university curriculum committees, and finally the Provost's office would make the final recommendation. According to the Provost's office, it can take one to two years to implement a new certificate program. However, the requirements are much less strict for offering a new degree program.

At UA, the process is similar. The home department proposes the certificate, and it must be approved by the College curriculum committee, the Dean's Advisory Committee, the Dean, and the Provost.

Multidisciplinary MS Degrees

The framework is in place at all three campuses to implement a multidisciplinary transportation MS degree. It appears that this can be accomplished with current shared UA System resources and current degree requirements with a little fine-tuning among the various departments. Annual meetings between the campuses (not just the civil & environmental engineering faculty) would help to continue open dialog among the faculty for program coordination and brainstorming. It is recommended that the departments of finance, engineering management and business be included in the meeting. Joint research projects among faculty and students would also benefit all campuses and keep the lines of communication open.

As with the certificates, each campus approves its own individual emphasis areas. There is no need to request approval from the UA System or the Alabama Commission on Higher Education (ACHE) to add new emphasis areas to an existing MS degree program.

Additional Resources Needed

The research team identified the following additional resources to facilitate the full implementation of the recommendations in this report.

- Dedicated IITS facility for UTCA, per campus
- Release time or similar incentive for faculty members to develop courses for IITS
- Graduate teaching assistants for each IITS course at each campus
- Graduate fellowships to build the student base (one per campus)
- Publicity for the certificate and MS programs through UTCA
- An education infrastructure funded by UTCA, similar to the administration infrastructure a each campus
- Open dialog and meetings across departments -- each department could appoint a representative to the annual meeting.

Section 6
Summary and Conclusions

This report provides a blueprint for development of a multi-campus multidisciplinary transportation curriculum for UTCA. There are considerable opportunities for developing unique transportation courses and programs.

Proposed in this report is a Certificate in Transportation (a concentration of work on a specific topic) sponsored by UTCA and offered by UA, UAB, and UAH. The certificate program is intended to become an additional option for students in non-engineering majors to gain expertise about transportation opportunities in both the public and private sector. Or, it might be used by civil engineering students as a means to complete a cluster of transportation courses that guarantee a certain level of transportation expertise beyond that of the typical BS degree. The research team recommends that a Transportation Certificate be used as a screening tool to qualify non-civil engineering candidates to enter the appropriate MS programs, and if possible to also allow its use by civil engineering students.

Existing MS programs on the three campuses can be supplemented by a new, formal, transportation emphasis. For students that do not have a BSCE degree, the Transportation Certificate will provide the necessary preparation.

A number of recommendations for implementation have been made in this report, including the following:

- Development of new courses
- Recruitment of new faculty
- Distribution of transportation courses among the three campuses by IITS
- Obtaining approval for the Transportation Certificate
- Obtaining approval for the MS transportation emphasis

The implementation of these programs will require intensive review and approval by the faculty of the existing academic departments on the three campuses, and dedicated UTCA funding and support would enhance the chances of adoption.

Appendix A
Current UA System Programs

In this appendix, the relevant degree programs currently offered by the three UA System campuses are reviewed in detail.

University of Alabama
There are a number of degrees offered at the University of Alabama related to Transportation Engineering, including:

MSCE in Civil and Environmental Engineering
Ph.D. in Civil and Environmental Engineering
MBA program in the School of Business
MPA program (Master's in Public Administration)

The following sections describe each of these programs.

Civil and Environmental Engineering Programs

Admission Requirements
In addition to the general Graduate School admission requirements, requirements for admission to the program leading to the Master of Science in Civil Engineering degree include the following criteria:

1. An applicant must have earned a baccalaureate degree from an institution accredited by the Accreditation Board for Engineering and Technology (ABET), and have a grade point average of at least 3.0 on a 4.0 scale, or at least 3.0 for the last 60 hours completed.

2. Applicants who are not graduates of ABET-accredited institutions must have Graduate Record Examination scores of 1500 (verbal plus quantitative plus analytical) or higher, and grade point averages of 3.0 or higher on a 4.0 scale.

MSCE Program Requirements
It is expected that master's students will pursue the Plan I (thesis) option. The Plan II (non-thesis) option may be pursued only with the approval of the faculty of the department.

Students wishing to pursue the Plan II option must formally petition the department faculty to be considered for approval and must present substantial reasons for seeking this variance.

A Bachelor of Science degree from an accredited engineering program is required as a prerequisite for a master of science in civil engineering degree.

The graduate student's supervisory committee will specify any remedial or preparatory work beyond that required by the Graduate School, as soon as practicable after its appointment.

Areas of Specialization
Specialization programs are available in the fields of environmental engineering, structural engineering/structural mechanics. Supporting courses are offered in transportation engineering, and geotechnical engineering.

University of Alabama at Birmingham
This section of the report identifies transportation-related programs offered at the University of Alabama at Birmingham. Courses and programs in transportation and related fields offered at UAB are identified below. They consist of:

MSCE and Ph.D. programs in Civil and Environmental Engineering
MBA program in the School of Business
MPA program (Master's in Public Administration)

Civil and Environmental Engineering Programs
Admission Requirements
In addition to the general Graduate School admission requirements, requirements for admission to the program leading to the Master of Science in Civil Engineering degree include the following criteria:

1. An undergraduate engineering degree from a program accredited by the Accreditation Board for Engineering and Technology. Applicants who do not meet this criterion but who have an outstanding academic record in an engineering degree program not accredited by ABET, or in a baccalaureate degree program in a related field, may be admitted on probation. Students admitted in this category will be required to complete a sequence of undergraduate courses in addition to the normal requirements of the MSCE degree. This set of extra requirements will be specified in writing at the time of admission to the program.

2. 3.0 (on a 4.0 scale) or better GPA in all undergraduate degree major courses attempted;

3. Three letters of evaluation concerning the applicant's previous academic and professional work; and

4. Submission of scores achieved on the GRE General Test. Scores above 500 on each component of the GRE General Test are preferred. Minimum scores of 550 on the Test of English as a Foreign Language (TOEFL) and a 3.5 on the Test of Written English (TWE) are also required for those applicants whose native languages are not English.

MSCE Program Requirements
It is expected that master's students will pursue the Plan I (thesis) option. The Plan II (non-thesis) option may be pursued only with the approval of the faculty of the department. Students wishing to pursue the Plan II option must formally petition the department faculty to be considered for approval and must present substantial reasons for seeking this variance.
A bachelor of science degree from an accredited engineering program is required as a prerequisite for a master of science in civil engineering degree. A student with an undergraduate degree in another field may also be accepted into the civil engineering program but will normally have to take additional preparatory coursework as part of an expanded plan of study.
The graduate student's supervisory committee will specify any remedial or preparatory work beyond that required by the Graduate School, as soon as practicable after its appointment.
Continuous enrollment for at least 3 units per term is required.

Plan I (Thesis Option)
1. The student must successfully complete at least 24 semester hours of coursework, including (in addition to the general Graduate School requirements): a minimum of 15 semester hours in civil engineering; and up to nine semester hours in disciplines outside civil engineering, such as other engineering disciplines, mathematics, earth science, physics, or urban affairs.

2. The student must pass a comprehensive examination on the content of the program. This examination may be written, oral or both and shall include an oral defense of a thesis. A student choosing this option must register for at least nine semester hours of CE 699 (master's degree thesis) in addition to the 24 semester hours of coursework.

Plan II (Non-thesis Option): Research/Design Emphasis
1. The student must successfully complete at least 33 semester hours of coursework, including a minimum of 24 semester hours in civil engineering, at least three but not more than nine semester hours of which must involve independent study under the direction of the graduate study committee chair, resulting in an acceptable written report (this requirement may involve registration for CE 691 and/or CE 698); and up to nine semester hours in disciplines outside civil engineering, such as other engineering disciplines, mathematics, earth science, physics, or urban affairs.

2. The student must pass a comprehensive examination on the content of the program. This examination may be written, oral, or both and shall include an oral defense of the independent study project.

Plan II (Non-thesis Option): Technology/Engineering Management Emphasis
1. The student must successfully complete at least 33 semester hours of coursework, including the following:

12 semester hours in a specific specialization program area of civil engineering;

Six semester hours in one of the following two mathematical application areas: MBA 660 and MBA 665 or MBA 660 and an advanced applied mathematics course;

12 semester hours in the following four courses in the concentration area: CE 547, EE 615, ME 601, and MBA 632; and

Three semester hours in a non-thesis design project (usually undertake after completion of all courses). This may be satisfied by registration in CE 691 or CE 698.

2. The student must pass a comprehensive examination on the content of the program. This examination may be written, oral, or both and shall include an oral defense of the independent study project.

Areas of Specialization
Specialization programs are available in the fields of environmental engineering and structural engineering/structural mechanics. Supporting courses are offered in transportation engineering, optimization, and other areas.

Required Courses for Specialization in Environmental Engineering
In addition to the MSCE Program requirements, the following undergraduate classes (plus all associated prerequisites) are generally required of all MSCE students specializing in environmental engineering:

CE 333 Water Supply and Drainage Design
CE 334 Environmental Engineering Laboratory
CE 335 Introduction to Water and Wastewater Treatment
CE 435 Environmental Engineering
CE 444 Civil Engineering Analysis
CE 484 Engineering Hydrology
CE 485 Hydraulic Engineering Systems

Classes will be taken in one of the following disciplines: general environmental engineering, stormwater management, wastewater treatment, air quality, or solid and hazardous waste management. Continuous enrollment in the environmental engineering seminar series (CE 641) will be expected of all environmental engineering graduate students.

Required Courses for Specialization in Structural Engineering/Structural Mechanics
In addition to the MSCE Program requirements, the following undergraduate classes (plus all associated prerequisites) are generally required of all MSCE students specializing in structural engineering/structural mechanics:

CE 360 Structural Analysis
CE 444 Civil Engineering Analysis
CE 450 Structural Steel Design
CE 455 Reinforced Concrete Design

Ph.D. Programs
A new Ph.D. program in Environmental Health Engineering is now offered by the Department of Civil and Environmental Engineering. An Environmental Health Engineer requires

multidisciplinary training in both environmental engineering and environmental health, plus advanced specialized training combining numerous attributes of these two fields. A typical student entering this program would already have an MSCE in Environmental Engineering. Non-engineering students in a health or science field would typically require an additional year of course work for the basic engineering prerequisites. However, because of the program's multidisciplinary nature, special efforts will be made to attract non-engineers to this program, as it is necessary to have students with diverse backgrounds in this field. The program contains at least 66 credit hours of classroom work, plus 24 credits for dissertation research, a total of 90 credit hours beyond the baccalaureate level. All students will be required to complete a basic undergraduate class sequence that is normally included in a civil and environmental engineering undergraduate program before any graduate classes can be taken. The program also contains a sequence of prerequisites to the Ph.D. program that contains additional fundamental coursework that would normally be satisfied while pursuing an MSCE degree. This Ph.D. program would normally require about four years of total graduate work. All students take a 36-unit core program, comprising class sequences in statistical analyses, biological sciences, environmental chemistry, and environmental health. An additional 30 units are also taken specializing in a specific health, water, air, or solid waste field, such as stormwater management, epidemiology, toxicology, wastewater treatment, air quality, or solid and hazardous wastes management. These specialized sequences will provide more advanced background in important environmental health topics and will well prepare the students for their dissertation research that will focus on environmental health engineering. The program also includes other closely related tracks such as by-product utilization, industrial ecology, and other health or safety related studies. Passing qualifying, comprehensive, and defense examinations are required for successful completion of the degree. For more detailed information, contact Dr. Robert E. Pitt, Program Coordinator for the Ph.D. in Environmental Health Engineering, UAB Department of Civil and Environmental Engineering (telephone 205-934-8434).

UAB also cooperates in programs leading to the Ph.D. in civil engineering awarded by the University of Alabama (Tuscaloosa) or by the University of Alabama in Huntsville. The student's advisory committee will be composed of faculty from the UAB graduate program in civil engineering, together with graduate faculty from the cooperating institution. In determining the student's program, the advisory committee will consider the student's academic objectives and background. Coursework may be taken at UAB and at the cooperating institution.

Government and Public Service

Program Information

Program Objective
The Master of Public Administration program prepares individuals for positions of leadership in public and nonprofit sectors of the economy. It is a professional graduate degree for both pre-career students and in-service administrators. The program is designed to develop the insights and skills needed to plan and help formulate policy, and to organize, manage, and implement programs and operations. Graduates tend to cluster in three general areas: managers, analysts, and policy specialists. The MPA curriculum is designed to ensure that students: (1) understand the political, economic, legal, and social context of public administration; (2) achieve substantial

competence in management or organization theory and behavior, and administrative procedures; and (3) gain experience in the application of statistical and economic analyses of public policy issues. To accomplish these objectives, students complete a seven-course core curriculum that provides a foundation for more specialized course work.

Degree Requirements
Students in the MPA program must complete a total of 53 hours or the equivalent, with an overall grade average of at least B. Six of those hours are earned in an internship placement, although that requirement may be waived for students who have full-time paid work experience in public or nonprofit agencies. Previous graduate work at UAB or another institution may be credited toward the degree, if it is directly applicable. Students may select the thesis option or the non-thesis option. For students who are interested in both public administration and the delivery of public health services, a coordinated MPA-MPH degree program is offered. For students who are interested in administrative careers in law, a coordinated MPA-J.D. degree program is offered with Cumberland School of Law.

Admission Requirements
Because of the multidisciplinary nature of the program, persons from all undergraduate majors are considered for admission to the program. Applicants are expected to have achieved an undergraduate grade point average of 3.0 or better. Applicants are also expected to have achieved an average score of 500 or better on each of the three sections (verbal, quantitative, and analytic) of the GRE or a score of 500 on the GMAT. Letters of reference are also required to enter the program. Persons failing to meet these admission standards may be considered for admission on probation. Application for admission should be made to the UAB Graduate School 1400 University Blvd., Room 511, Birmingham, Alabama 35294-1150; telephone (205) 934-8227. Admission will be made each quarter.

Internships and Placements
Students may apply for internship placement at any time following completion of MPA 659. Several paying opportunities exit, although the majority of internships are nonpaying. Typical placements are in city and county government, planning departments, public health agencies, social service agencies, state government agencies, and various nonprofit organizations. The Department has placed several students in the prestigious Presidential Management Internship Program, which provides an excellent opportunity for eventual employment with the federal government.

Curriculum

Core Courses
All students are required to take the following seven courses:

MPA 659 Scope of Public Administration: National and Subnational
MPA 660 The Public Policy-Making Process
MPA 661 Administrative Theory and Behavior
MPA 664 Public Personnel Administration
MPA 666 Public and Nonprofit Budgeting

MPA 686 Research Design and Introduction to Statistics
MPA 687 Statistical Analysis

In addition to the core courses, students must complete four courses in one of the following specializations, plus four electives.

Specializations
Students should select a specialization based upon their career goals and interests. The specializations that are available are Organizational Management, Urban Planning and Management, Public Policy Analysis, Public Finance/ Economic Development, and Gerontology. Students may also obtain a generalist MPA by taking two different courses from each of three of the specializations.

Organizational Management
This is the broadest of the specializations. The majority of students who choose this area are mid-career and wish to improve their management skills. Students may select two different sub-specializations: general organizational management and nonprofit management. The first sub-specialization is designed for those interested in general management, human resources, and organizational development. The second sub-specialization is designed for those interested in nonprofit management.

Students must take three of the following four courses:

MPA 663 Organizational Behavior and Change
MPA 667 Public and Administrative Law
MPA 675 Administrative Ethics
MPA 676 Financial Management in the Public Sector

Plus one course from either of the following groups:

General Organizational Management
MPA 665 Management Science
MPA 668 Intergovernmental Relations
MPA 677 Managing Information in the Public and Nonprofit Sector
MPA 685 Special Topics in Public Administration

Nonprofit Management
MPA 672 Agency Administration
MPA 673 Community Planning and Organization
MPA 678 Strategic Planning for Public/Private Action Nonprofit Management
MPA 690 Seminar in Public Service Issues

Urban Planning and Management
Students interested in city management or planning should select this specialization. Relevant positions include policy development and implementation, budget development, public works management, and economic and community development.

Students must select four of the following courses:

MPA 662 Urban Administration
MPA 668 Intergovernmental Relations
MPA 673 Community Planning and Organization
MPA 677 Managing Information in the Public and Nonprofit Sector
MPA 678 Strategic Planning for Public and Private Action
MPA 680 Urban Development and Planning
MPA 681 Local Government Planning

Other courses in planning or urban politics may also substitute in this track.

Public Policy Analysis
This specialization should be chosen by those who plan to work as management, budget or research analyst. Other relevant professions include program planning and development, productivity enhancement, and program evaluation.

Students must select four of the following courses:

PSC 503 Politics of Aging
MPA 665 Management Science
MPA 669 Democracy, Policy, and Power
MPA 670 Environmental Disasters
MPA 677 Managing Information in the Public and Nonprofit Sector
MPA 683 Microeconomic Applications to Policy Analysis
MPA 684 Welfare Policy
MPA 685 Special Topics in Public Administration: Geographic Information Systems
MPA 688 Applied Statistical Analysis
MPA 689 Program Evaluation

Public Finance and Economic Development
Students interested in economic development, budgeting, fundraising, and financial management should select this specialization. Relevant positions include economic and community development, budget analyst, and financial officer.

Students must select four of the following courses:

MPA 671 Special Topics in Public Finance
MPA 676 Financial Management in the Public Sector
MPA 680 Urban Development and Planning
MPA 683 Microeconomic Applications to Policy Analysis
MPA 685 Special Topics in Public Administration: Geographic Information Systems
MPA 690 Seminar in Public Service Issues: Fund-Raising
MPA 691 Economic Development

Gerontology students wishing to receive a Certificate of Gerontology in conjunction with their MPA degree may complete the gerontology curriculum outlined elsewhere in this catalog. Students must complete at least 15 semester hours of graduate work in gerontology or geriatrics in addition to their core MPA courses. The gerontology curriculum consists of an overview seminar, three electives chosen from a roster of courses approved by the Committee on Undergraduate and Graduate Education in Gerontology, and an internship or relevant research project. The three credit hour gerontology internship may substitute for three hours of MPA internship. For additional information on the Gerontology certificate, contact Dr. Patricia S. Baker, UAB Gerontology Education Program, Center for Aging, Room 201-E1, 933 19th Street South, Birmingham, AL 35294-2041.

Comprehensive Examination
During, or in the quarter preceding, the last term of study, students must successfully complete a comprehensive examination. Such an exam will require the student to synthesize material learned over the course of the program.

Master of Business Administration
The Masters of Business Administration Program is accredited by AACSB-The International Association for Management Education. The objectives of the program are to provide professional, graduate-level education and to maintain continuing relationship with the business community through service activities. The MBA Program is designed to provide competency in management and to acquaint the student with all aspects of business activity. The program is decision-oriented, focusing on key aspects of modern administration, and it seeks to prepare graduates for leadership roles in business, industry, government, or social services. In order to deal effectively with increasingly complex problems of organizations, managers require training in sophisticated analytical techniques, an appreciation for the behavioral facets of management, and an ability to anticipate and adapt to changes in the organizational environment.

Requests for application forms and information concerning admission procedures should be directed to the Graduate School of Management office. Applicants must be holders of baccalaureate degrees from regionally accredited institutions and must present evidence including, but not limited to, GMAT (Graduate Management Admission Test) scores and undergraduate records. The minimum acceptable GMAT score is 450. In addition, foreign student applications require a minimum score of 550 on the TOEFL. Admission to the programs is competitive.

If an applicant has not completed a business calculus course within five years of admission with at least a C average, the applicant will be required to remove this deficiency through completion of UAB's Math 109 with a C average or better, through successful completion of the Graduate School of Management's Boot Camp, or by passing a proficiency exam.

Program Requirements
The MBA Program is suitable not only for students with baccalaureate degrees in business but also for those who have degrees in engineering, science, or other liberal arts.

The MBA degree requires a minimum of 36 hours and a maximum of 54 hours, of which at least 24 hours must be beyond the common body of knowledge and be open exclusively to graduate students as specified by the AACSB accrediting organization. Students may pursue the MBA degree as full-time or part-time students. Students with prior coursework in business may be exempted from up to 18 credit hours of the 54 required for the degree. Waivers and exemptions are determined upon admission by the graduate advisor. In order to waive a course, students must have completed equivalent coursework at the undergraduate level with a B average.

Admission is competitive and is based on an estimate of the ability of the applicant to complete the degree program successfully and on the appropriateness of the program to the applicant's career goals. The Graduate School and its programs accept the most qualified students who apply. Most programs can accommodate only a limited number of students; therefore, some qualified applicants may be denied admission.

University of Alabama in Huntsville

This section of the report identifies transportation-related programs offered at the University of Alabama in Huntsville. Courses and programs in transportation and related fields offered at UAH are identified below. They consist of:

MSE program in Civil and Environmental Engineering
MSE in Engineering Management
MS in Materials Science

The following majors and minors are recognized: Air Pollution Control, Environmental Management, Geographic Information Systems, Materials Science, Mechanics of Solids, Public Policy, Structures, Systems Engineering, and Transportation Planning

Admission Requirements

In addition to the general Graduate School admission requirements, requirements for admission to the program leading to the Master of Science in Civil Engineering degree include the following criteria:

1. The Department reviews each applicant on and individual basis in view of multiple factors including, but not limited to: grades, grade point average, prior academic experience, references, independent and supervised research, and test scores.

2. The GRE exam is normally required of all students; international students are required to take the TOEFL exam.

MSE Program Requirements

The basic program of study, common to both plans, contains a minimum of 24 semester hours of graduate-level course work that must include:

1. 12 hours of graduate courses in an engineering major including supporting engineering courses
2. First minor of six hours of courses in an approved area of specialization

3. Second minor of six hours of courses in Mathematics or Statistics

Up to 12 hours of 500 level courses may be taken in fulfillment of these requirements.

Appendix B
UA System Transportation-Related Graduate Course Offerings

In this appendix, the relevant graduate course offerings currently offered by the three UA System campuses are reviewed in detail.

University of Alabama

Civil Engineering

CE 450 Highway Design and Construction. Introduction to highway geometric design, drainage, traffic-control devices, pavements, economic analysis, and construction.

CE 451 Geometric Design of Roadways. Application of principles of geometric design.

CE 452 Traffic Safety. Introduction to traffic safety techniques: overall safety programs, site identification, data gathering and analysis, accident reconstruction, safety treatment selection, resource prioritization, and design projects.

CE 455 Preparation and Design of Airport Facilities. A design and planning course that includes the air transportation system, airport facilities planning, and airport facilities design.

CE 457 Pavement Design and Construction. The thickness design of base, sub-base, asphalt, and concrete layers for highway pavements, including both design and construction aspects.

CE 458 Traffic Engineering. Vehicle operating characteristics, traffic flow, geometric design of roads and intersections, and methods of traffic control.

CE 467 Construction Methods and Estimation. Applications to mass earthwork, utilities, foundations, building construction, roadways, dams, and heavy-steel and concrete structures.

CE 545 Bituminous Materials and Mixtures. Consideration of major types of bituminous materials – asphalt cements, cutback asphalts, asphalt emulsions – leading to current practice for designing optimum pavement mixtures.

CE 550 Highway Design and Construction. Introduction to highways and transportation systems: geometric design, drainage, traffic control devices, pavements, economic analysis, and construction. Includes rail, air, and water modes. Writing proficiency is required for a passing grade in this course.

CE 551 Geometric Design of Roadways. Application of the principles of geometric design; alignment, vertical control, drainage, traffic control, interchanges and intersections. Design projects are prepared to illustrate standard techniques.

CE 552 Traffic Safety. Introduction to traffic safety techniques: overall safety programs, site identification, data gathering and analysis, accident reconstruction, safety treatment selection, resource prioritization, and design projects.

CE 555 Preparation and Design of Airport Facilities. A design and planning course that includes the air transportation system, airport facilities planning, and airport facilities design.

CE 557 Pavement Design and Construction. The thickness design of base, sub-base, asphalt, and concrete layers for highway pavements, including both design and construction aspects.

CE 558 Traffic Engineering. Vehicle operating characteristics, traffic flow, geometric design of roads and intersections, and methods of traffic control.

CE 559 Pavement Rehabilitation. Covers two areas concerning care of existing highway asphalt and concrete pavements. Major maintenance includes overlay design, additional drainage, recycling, and slab repair. Routine maintenance includes distress surveys, pothole repair, and crack and joint sealing.

CE 591A Intelligent Transportation Systems (ITS). Introduces the concept of ITS, and discusses the research and development going on in the field.

CE 591B Transportation Planning. The role of transportation in urban planning, and planning studies.

CE 591C Construction Project Management. Applications to mass earthwork, utilities, foundations, building construction, roadways, dams, and heavy-steel and concrete structures.

CE 653 Traffic Planning. The role of transportation and traffic in urban planning; the relationship of traffic facilities to land use, zoning, and planning studies.

Geography

GY 430 Geographical Information Systems. Two lectures and one laboratory period. Analysis of the topological relationships of multivariate geographical data using concepts and techniques of geographic information systems.

GY 465 Regional Planning and Analysis. Principles and processes of regional planning and the analytical methods appropriate for solving regional planning problems. Case studies and the role of the planner in the regional planning process are discussed.

GY 530 Geographic Information Systems. Introduces the basic concepts of geographic information systems (GIS), including definition and components of GIS, spatial data structures, data sources, data input, manipulation and analysis, applications of GIS, and managing GIS.

GY 565 Regional Planning and Analysis. Principles and processes of regional planning and the analytical methods appropriate for solving regional planning problems.

Management Science

MGS 310 Introduction to Management Science. Concepts of management science and their application in decision making. Topics include linear programming, transportation models, integer programming, dynamic programming, queuing theory, decision theory, and network methods.

MGS 400 Management Science I. Deterministic models in decision-making process. Attention is given to the assumptions, development, and administrative implications of mathematical programming models and network models.

MGS 401 Management Science II. Probabilistic models in decision-making process. Attention is given to the assumptions, development, and administrative implications of queuing, reliability, game theory, Markov, and decision models.

MGS 420 Computer Simulation. Development and use systems models to simulate administrative decision-making processes.

MGS 440 Decision Support Systems. This course accesses information requirements to support the various types of decisions in an organization. Students develop the specifications for each of the components of a model-based information system designed to support effective managerial decision-making.

Mathematics

MATH 303 Contemporary Applied Mathematics. This course is primarily concerned with mathematical models of real-world situations in the physical and social sciences and the professions. It provides excellent background material for middle-school and secondary-school mathematics teachers.

Industrial Engineering

IE 417 Project Management. This is an engineering management course designed to introduce students to the functions of project engineers and managers. It details the process of planning and controlling project scope, time, and cost.

IE 431 Systems Simulation. Simulation methodology, emphasizing discrete, computer-simulation modeling.

IE 517 Project Management. This is an engineering management course designed to introduce students to the functions of project engineers and managers. It details the process of planning and controlling project scope, time, and cost.
IE 561 Systems Simulation. Simulation methodology, emphasizing discrete, computer-simulation modeling.

Statistics

ST 250 Statistical Methods I. Introduction to use of basic statistical concepts in business applications. Descriptive statistics, index numbers, measures of central tendency and variation, probability, random variables, discrete and continuous probability distributions, sampling distributions, and point and interval estimation are covered. Computer software applications are utilized.

ST 251 Statistical methods II. Testing of hypotheses, analysis of variance, regression and correlation, time series, index numbers.

ST 450 Statistical Methods in Research I. . Development of fundamental concepts of organizing, exploring, and summarizing data; probability, common probability distributions; sampling and sampling distributions; estimation and hypothesis testing for means, proportions, and variances using parametric and nonparametric procedures; power analysis; goodness of fit; contingency tables. Statistical software packages are used extensively to facilitate valid analysis and interpretation of results. Emphasis is on methods and on selecting proper statistical techniques for analyzing real situations.

ST 451 Statistical Methods in Research II. Analysis of variance and design of experiments, including randomization, replication, and blocking; multiple comparisons; correlation; simple and multiple regression techniques including variable selection, detection of outliers, and model diagnostics. Statistical software packages are used extensively to facilitate valid analysis and interpretation of results. Emphasis is on methods and on selecting proper statistical techniques for analyzing real situations.

ST 550 Statistical Methods for Applied Research I. Development of fundamental concepts of organizing, exploring, and summarizing data; probability, common probability distributions; sampling and sampling distributions; estimation and hypothesis testing for means, proportions, and variances using parametric and nonparametric procedures; power analysis; goodness of fit; contingency tables. Statistical software packages are used extensively to facilitate valid analysis and interpretation of results. Emphasis is on methods and on selecting proper statistical techniques for analyzing real situations.

ST 551 Statistical Methods for Applied Research II. Analysis of variance and design of experiments, including randomization, replication, and blocking; multiple comparisons; correlation; simple and multiple regression techniques including variable selection, detection of outliers, and model diagnostics. Statistical software packages are used extensively to facilitate valid analysis and interpretation of results. Emphasis is on methods and on selecting proper statistical techniques for analyzing real situations.

University of Alabama at Birmingham

Unless otherwise noted, all courses are for three semester hours of credit. Course numbers preceded with an asterisk indicate courses that can be repeated for credit, with stated stipulations.

Civil Engineering

Environmental Engineering

602. Environmental Management. Concepts for managing environmental problems; control mechanisms of environmental practitioners; environmental impact statements and regulatory methods.

631, 731. Environmental Law. Law as it applies to the environmental engineer. New and emerging regulations.

632, 732. Industrial Water and Wastewater Treatment. Boiler feed waters, cooling waters, wastewaters from various industries. Assessment of treatability, system design, and equipment selection. Prerequisite: CE 335.

633. Solid and Hazardous Wastes. Engineering principles and management issues of generation, storage, collection, transfer, transport, processing, recovery, and disposal of wastes.

634, 734. Air Quality Modeling and Monitoring. Atmospheric pollutants; effects, reactions, and sources. Air pollution meteorology and dispersion modeling. Ambient monitoring.

635. Environmental Engineering. Air and water pollution, solid waste. Quality of environment. Environmental health. Regulation, legal considerations. Prerequisite: CE 335.

636, 736. Urban Stormwater Water Pollution Management. Quality and quantity of urban stormwater. Receiving water problems and sources of pollutants. Runoff quality and quantity characterizations. Selection and design of controls; regulations. Prerequisite: CE 585.

637, 737. Environmental Experimental Design and Field Sampling. Experimental design, sensitivity analyses, water sampling, and flow monitoring. Receiving water chemical reactions. Field investigations. Lecture and laboratory. Prerequisite: CE 334.

638, 738. Chemical Processes and Pollutant Impacts in Water. Aquatic chemistry. Chemical behavior of pollutants in receiving waters. Fate of common pollutants. Chemical kinetics in natural waters. Photochemical reactions. Computer modeling of wastewater discharges. Prerequisite: CE graduate student.

639, 739. Sediment Sources and Controls. Erosion and sediment transport in urban areas; design of common erosion control practices. Prerequisite: CE 485.

640, 740.. Biological Processes and Pollutant Impacts in Water. Biological monitoring, pollutant effects on aquatic ecosystems, biological effects on pollutant behavior. Computer modeling of effects on streams. Field assignments. Saturday labs to supplement classes. Prerequisite: CE graduate student. Four hours.

641, 741. Environmental Engineering and Water Resources Seminar. Seminar focusing on student research and guest presentations of various topics of interest to environmental engineering students. Mandatory continuous enrollment for all environmental engineering students. One hour.

681. Environmental Chemistry. Chemical equilibrium, acid/base, chemical concepts in pollutant behavior. Chemical kinetics, redox system, hydrolysis; pesticides, chemical wastes. Prerequisite: CE 638 or PHE 500.

682, 782. Unit Processes in Water and Wastewater Treatment. Water and wastewater characteristics and how they affect treatment processes. Grit removal; filtration; clarification, dissolved air flotation, gas transfer, disinfection, water softening, ion exchange, activate sludge, sludge dewatering, and sludge disposal. Growth kinetics of microorganisms and photosynthetic processes. Prerequisite: CE 335.

683, 783. Water and Wastewater Treatment Unit Processes Laboratory. Construction and evaluation of bench-scale treatment processes. Treatability of water and wastewater. Coagulation of sedimentation, settleability of biological sludges, aerobic biological treatment, chemical treatment, water softening toxicity, disinfection; and sludge treatment processes. Prerequisite: CE 682.

684. Hydraulic Engineering Systems. Fundamentals of hydraulics including properties of water, hydrostatic forces, flow in piping systems, flow in open channels, hydraulic structures, elements of hydrology. Prerequisite: CE 333 or PHE 545.

685. Engineering Hydrology. Hydrologic principles: hydrologic cycle, precipitation data, stream flow measurements. Applications to engineering problems: stream flow analysis, watershed management. Prerequisite: CE 333 or PHE 545.

686, 786. Engineering Hydrogeology. Groundwater movement, natural quality, contamination, and restoration. Well hydraulics and flow net analysis. Prevention of groundwater contamination. Prerequisite: CE 485.

687, 787. Stormwater Detention Pond Design. Design of detention ponds for stormwater management. Water quality and hydrology concepts. Prerequisite: CE 485.

Structural Engineering/Structural Mechanics

612, 712. Theory of Elasticity. Equations of linear reduction to plane stress, plane strain, and generalized plane strain. Airy and Love stress functions in solution of problems. Prerequisite: CE 220.

615, 715. Theory of Elastic Stability. Static stability of bars, beams, trusses, and rigid frames. Dynamic stability of bars. Energy method applied to buckling problems. General theory of elastic stability. Prerequisite: CE 220.

616, 716. Mechanical Vibrations. Free and forced single-degree-of-freedom systems. Multiple-degree-of-freedom systems. Damped, forced two-degree-of-freedom systems. Simple continuous systems. Prerequisites: CE 215 and CE 220.

617, 717. Theory of Plates and Shells. Linear theory and solutions of plates of various shapes. Large deflection theory and solutions of rectangular and circular plates. Membrane and bending theories of shells. Solutions of problems in conical, cylindrical, and spherical shells. Prerequisite: CE 612.

620, 720. Advanced Mechanics. Variation of stress at a point, principal and maximum shear stress. Problems of symmetrical deformation; thick-wall cylinders, sphere, rotating disk. Noncircular torsion sections. Curved beams. Failure theories. Unsymmetrical bending, shear center. Prerequisites: CE 220 and CE 221.

626, 726. Foundation Engineering. Application of principles of soil mechanics to determine bearing capacity and settlement of spread footings, mats, single piles and pile groups; site investigation, evaluate data from field and laboratory tests; estimate stresses in soil masses; lateral resistance of piles and pile group; retaining walls, sheetpiles and coffer-dams. Prerequisite: CE 332.

650, 750. Advanced Structural Steel Design. Beams, columns, tension members, and connections; current research. Prerequisite: CE 450.

655, 755. Advanced Reinforced Concrete. Beam, column, and slab actions; current research. Prerequisite: CE 455.

656, 756. Prestressed Concrete Design. Principles and concepts of design in prestressed concrete including elastic and ultimate strength analyses for flexural, shear, bond, and deflection. Principles of concordancy and linear transformation for indeterminate prestressed structures. Prerequisite: CE 455.

660, 760. Structural Mechanics. Elastic beam deflections, beam columns, lateral torsional buckling, column stability, plastic design, plate bending, yield line theory. Prerequisite: CE 360.

661, 761. Introduction to the Finite Element Method. Concepts and applications of the finite element method. Development and applications of basic finite elements. Software use. Prerequisite: Permission of instructor.

662. Advanced Structural Analysis. Analysis of indeterminate structures using classical and matrix methods. Use of large-scale computer programs. Prerequisite: CE 360.

663, 763. Finite Element Methods. Theory and applications in structural mechanics. Plane stress, plane strain, axisymmetric problems, solids, plates, shells, nonlinear systems. Prerequisite: CE 461.

664, 764. Structural Dynamics. Dynamic analysis of single and multiple degree-of-freedom systems. Lumped and consistent mass methods. Approximate design methods. Matrix methods of solution emphasizing earthquake design. Prerequisites: CE 215 and 360.

667, 767. Wind and Seismic Loads. Loads on structures caused by extreme winds and earthquakes. Calculations of wind and earthquake loads according to theory and codes.

668, 768. Bridge Engineering. Bridge loads, steel beam bridges, composite beam bridges, bridge bearings, reinforced and prestressed concrete slab and T-beam bridges, bridge evaluations and ratings, upgrade methodologies, computer applications. Prerequisites: CE 450 and CE 455.

Transportation, Materials, and Supporting Courses

611. Facilities Engineering. General engineering project planning, applying codes and standards, preliminary design, economic forecasting, environmental planning and reports, site selection, population displacement, spare cash flow, specifications and plans.

642. Highway Materials and Construction. Properties of materials used in highway construction. Construction methods and management. Prerequisite: CE 345

643. Pavement Design and Construction. Analysis of stresses and strains in pavement systems. Design of flexible and rigid pavements, base courses, and subgrades. Effects of loading on pavement life. Prerequisites: CE 222, 332, and 345.

647. Engineering Optimization and Modeling. Mathematical techniques associated with analysis of systems. Project scheduling, optimization, and simulation as applied to civil engineering system analysis. Use of pre-programmed computer solutions in system analysis. Prerequisites: EE 130 and CE 360.

649. Engineering Liability. Laws related to liability for engineering design in context of products liability and construction projects; roles and liabilities between various parties involved in construction projects; ways to liability. Three hours.

657. Concrete Technology. Properties of concrete in relation to specifying, purchasing, and evaluating concrete materials. Fresh and hardened concrete properties. Concrete mix design

procedures. Effects of finishing, curing, weather conditions, and various construction procedures. Ready mix concrete production and field placement techniques. Specification writing to ensure good quality concrete and field inspection procedures. Case studies of problems in concrete construction. Prerequisite: CE 221.

658. Engineering Management. Management techniques for practicing engineer.

Government and Public Service

659. Scope of Public Administration. National and sub-national: Major theories, concepts, and techniques in American public administration. Special emphasis on public administration at state and local levels.

660. The Public Policy-Making Process. Public policy making as decision-making process. Examines stages of process with applied references.

661. Administrative Theory and Behavior. Theories of organization, management, and administration as applied to public, private, and nonprofit agencies.

662. Urban Administration. Issues and problems and methods related to the governance and operational management of metropolitan areas.

663. Organizational Development. Behavior of Individuals and groups within organizations.

664. Human Resources Management. Recruitment, selection, classification, and development of organizational personnel in the public sector.

665. Management Science. Analytic approaches to administrative decision making in the public sector; emphasis on allocating resources and achieving objectives.

666. Public and Nonprofit Budgeting. Budget development and analysis using techniques such as cost-benefit and variance analysis, spreadsheet, and other microcomputer tools.

667. Public and Administrative Law. Explanation of law in society and legal setting of public administration.

668. Intergovernmental Relations. Relationships among national, state, and local governments in U.S. system.

669. Democracy, Policy and Power. Explores the connection between democratic theory, the public policy process, and the practice of public administration.

670. Environmental Disasters. Examines the worldwide problem of chemical and nuclear accidents, with a particular focus on understanding the community impacts, human service implications, and related public policy issues.

671. Special Topics in Public Finance. Seminar focused on specific topics in public finance including economics, revenue projection, capital budgeting, project evaluation, and debt management for public and nonprofit agencies.

672. Agency Administration. Challenges faced by managers of nonprofit agencies; balancing competing values such as efficiency, effectiveness, and equity.

673. Community Planning and Organization. Formation and strengthening of networks among social service administrators to aid delivery of human services.

675. Administrative Ethics. Ethical components of administrative activities in public and nonprofit agencies.

676. Financial Management in the Public Sector. Revenue sources and projection, capital budgeting, project evaluation, and debt management.

677. Managing Information in the Public and Nonprofit Sector. Theory and applications of information management in the public and nonprofit sectors.

678. Strategic Planning for Public and Private Action. Theoretical and practical application of planning models for solving public problems.

680. Urban Development and Planning. Evolution of urban planning as related to growth and change of cities.

681. Local Government Planning. Theories, methodologies, and political aspects of municipal planning.

683. Microeconomic Applications to Policy Analysis. Application of production and consumption theory, market structure, theories of market failure and regulation, and collective choice to policy analysis.

684. Welfare Policy. History, development, and operation of welfare policy at the national, state, and local levels.

685. Special Topics in Public Administration. Seminar based on research and substantive interests of MPA faculty and students.

686. Research Design and Introduction to Statistics. Research design, descriptive statistics, probability distributions, hypothesis testing, and confidence intervals. Four hours.

687. Statistical Analysis. Association, contingency table analysis, simple linear regression, ANOVA, and multiple regression. Four hours.

688. Applied Statistical Analysis. Application of advanced statistical tools and designs to problems in public affairs. Tools include factor analysis, ARIMA, Probit, and Logit. Prerequisite: MPA 687.

689. Program Evaluation. Analytic tools for evaluating public and nonprofit programs and services. Prerequisite: MPA 687.

690. Seminar in Public Service Issues. Seminar based on contemporary issues that arise in public and/or nonprofit management.

691. Economic Development. Develops an understanding of the impact of market and noneconomic forces on local and regional economic development.

692. Independent Study in Public Administration. Individual reading and research in public administration. Prerequisite: Permission of program director.

693. Internship in Public Administration. Directed work experience in public or nonprofit agency; analytical report of activities required.

695. Microcomputer Applications. Preparation for microcomputer usage in MPA courses.

699. Thesis Research. Prerequisite: Admission to candidacy. One-six hours.

Master of Business Administration (MBA)

609. Accounting for Management. Role of accounting in external and internal reporting; planning, control, and decision making from point of view of user of accounting information.

610. Cost and Control. Determination and use of cost data for decision making, control and evaluation of performance, and formulation of goals and budgets. Prerequisites: MBA 609, 640.

611. Management Information Systems. Applications of information and management sciences to design and use of decision-oriented systems.

620. Corporate Finance. Introduction to financial management of non-financial corporations. Topics include time value of money, bond and stock valuation, cost of capital, capital budgeting, capital structure and dividend policy. Cases may be used. Prerequisites: MBA 609, 640, and 660.

630. Social, Ethical, and Legal Environment. Social, ethical, and legal environment in which business enterprise operates domestically and internationally.

631. Administrative Theory and Practice. Advanced theories of organization and management with emphasis on applications.

632. Organizational Behavior. Elements of organizational behavior and their dynamic interaction. Emphasis on individual and small group behavior in organizations. Prerequisite: MBA 631.

633. Production and Operations Management. Introduction to management planning and control techniques applicable to operations portion of various enterprises.

634. Business Policies and Simulation. Integration of management, finance, accounting, marketing, economics, production, and decision-making concepts through study of business policy and business simulation. Prerequisite: Last quarter in MBA program.

635. International Business Analysis. Problems and strategic considerations of firms engaged in international business. Prerequisites: MBA 609, 620, 631, 640, 650, and 660.

640. Applied Microeconomic Analysis. Application of economic theory and methodology to decision making: theoretical and empirical analysis of demand, production, costs, and pricing behavior.

641. Macroeconomic Analysis and Decision Making. Macroeconomic analysis; modern theory of aggregate demand and supply; forecasting and link between business firm and microenvironment. Prerequisites: 640, 660.

650. Modern Marketing Concepts. Analytical approach to business systems directing flow of goods and services from product conception and production to consumption from a marketing manager's point of view.

651. Seminar in Marketing Policy. Problems of marketing managers; planning, implementing, evaluating, and controlling marketing activities. Prerequisite: MBA 650.

660. Quantitative Methods I. Selected statistical techniques, including statistical inference, regression, and decision theory. Application to business problems.

661. Quantitative Methods II. Introduction to topics in operations research. Prerequisite: MBA 660.

614. Taxation for Management. Tax issues affecting business management and decision making. Fundamentals of taxation introduced with emphasis on economic significance of taxes. Prerequisite: MBA 609.

621. Topics in Corporate Finance. An advanced course in finance with emphasis on special topics such as financial planning, working capital management, leasing, hybrid financing, international capital budgeting, etc. Case studies are used. Prerequisite: MBA 620 and 660.

622. Investments. Theoretical and practical aspects of investments and portfolio management. Prerequisites: MBA 620, 660.

623. Finance Seminar. In-depth examination, study, and analysis of current issues and problems in selected areas of finance. Prerequisites: MBA 620 and 660, or permission of instructor.

624. International Financial Management. Financial analysis and decision making in international context. Prerequisites: MBA 620.

636. Human Resource Management. Critical management theory as applied to human resource problems such as employment, employee education and training, labor-management, health and safety, compensation and human resources research. Prerequisite: MBA 631.

639. Seminar in Management. Current issues and problems in selected areas of management. Prerequisite: MBA 631, 632, or permission of instructor.

653. Services Marketing. An examination of the generic differences between goods and services, with appropriate marketing strategies for services developed. Prerequisite: MBA 650.

654. International Marketing. Examination of international marketing activities, including environmental issues, marketing strategy, and tactical considerations in entering foreign markets. Prerequisite: MBA 650.

669. Foundations of Total Quality Management. Reviews essential elements of TQM and emphasizes their interrelatedness. What thought processes of management must be changed, why, and how is discussed with application to manufacturing and service sectors. Prerequisites: MBA 660 and MBA 631, which may be taken concurrently, or permission of instructor.

673. Product Planning, Development and Management. Introduction of the process of new product development, managing existing products and product deletion decisions. Prerequisite: MBA 650 or HA 671.

698. Directed Study (Non-thesis Research). Prerequisite: Approval of Graduate School of Management.

Students may choose only two courses (six hours) from the following list of 500 level electives or, if an undergraduate accounting major, from the list of 500-level accounting electives.

EC 520. Applied Forecasting. Practical use of various forecasting techniques on business and economic data; dynamic regression models, exponential smoothing, moving averages, seasonality, univariate Box Jenkins ARIMA modeling. Prerequisite: MBA 660.

MG 507. Management of the Information Resources. Managerial aspects of management information systems; planning and controlling information resources, organizing information resource function, computer hardware, and environment of computer industry. Prerequisite: MBA 611.

MG 518. Quality Control. Concepts, techniques, and organizational requirements to ensure that quality is provided to consumer; breadth of quality efforts, statistical quality control methods,

quality circle principles, and quality assurance activities in various enterprises. Prerequisite: MBA 633.

MG 521. Entrepreneurship. Analytical and critical examination of functions and environments where new organizational development takes place. Role of entrepreneurship in creation and development of new economic entities. Prerequisite: MBA 635.

MK 520. Sales Management. Management of personal selling function. Nature of selling task; recruiting, selecting, training, compensating, and evaluating sales personnel. Prerequisite: MBA 650.

MK 540. Small Business Consulting and Research. Applied field work integrating all of the functional business fields. Prerequisites: MBA 620, MBA 631, MBA 650, and permission of instructor.

QM 525. Applied Regression Analysis. Simple, multilinear, and polynomial regression analysis. Model selection, inferential procedures, and application with computer. Prerequisite: QM 214, MBA 660.

University of Alabama in Huntsville

Civil Engineering

503 Reinforced Concrete Design Three hrs.
Design of reinforced concrete structures with emphasis on the ultimate strength method. Aspects of prestressed concrete design: computer applications. Prerequisite: CE 381 or consent of instructor. (Same as CE 403.)

504 Structural Design Three hrs.
Principles of the design of steel structures using ASD methods. Analysis and design of structural elements including beams, columns, connection details. Prerequisite: CE 371 or consent of instructor. (Same as CE 404.)

511 Introduction to Geographical Information Systems Three hrs.
Introduces vector, raster and tabular concepts, emphasizing the vector approach. Topics include: spatial relationships, map features, attributes, relational database, layers of data, data ingesting, digitizing from maps, projections, output, applications, and availability of public data sets. Prerequisites: Senior standing or instructor's approval. (Same as CE 411,ES 411/511, ATS 411/511.)

520 Urban Transportation Planning
Planning of highway systems and terminals as part of a complete planning approach, public transportation, transportation planning studies, projection analysis, plan formulation, and programming. Prerequisite: CE321

522 Traffic Engineering
Driver, pedestrian and vehicle characteristics. Principles of traffic flow for improved highway traffic service and safety. Examines freeways, rural roads, urban streets, traffic signals, signs, channelization, and other traffic control measures. Prerequisite: CE321

530 Concrete Mix Proportioning Three hrs.
Classification of concrete aggregates and their effects on concrete properties. Mixing, placing, and testing of normal weight, high strength, and lightweight concretes. Proportioning according to ACI methods. Laboratory included. (Same as CE 430.)

541 Open Channel Hydraulics Three hrs.
Design and analysis of erodible and non-erodible channels. Uniform flow, channel roughness, gradually and spatially varied flow, rapidly varied flow, hydraulic jumps, gradually varied unsteady flow, flood routing, flow measurements, channel models, channel and culvert design. Prerequisite: CE 472.

549 Introduction to Environmental Engineering Three hrs.
Engineering aspects of air, water, and thermal pollution. Hydrologic cycle, water sources and uses; industrial and other sources of primary and secondary pollutants. Transport process in environmental problems and in their control. Prerequisite: MAE/CHE 352 or parallel. (Same as CE 449 and CHE 449/549.)

550 Environmental Control Three hrs.
Engineering design and synthesis of environmental control systems. Control of multi-phase systems with application to air and water pollution control. Prerequisite: MAE/CHE 442. (Same as CHE 550.)

552 Industrial Waste Treatment Three hrs.
Advanced topics in the area of hazardous waste management and water quality control. Emphasis on industrial waste, including hazardous waste management. Topics include: generation, storage, collection, transfer, disposal, recycling, economic, environmental, and regulatory considerations. Prerequisite: CE 549.

557 Hydrology Three hrs.
Occurrence and movement of water over the earth's surface for engineering planning and design. Relationship of precipitation to stream-flow with frequency analysis, flood routing, and unit hydrograph theory. Prerequisite: MAE/CHE 352. (Same as CE 457.)

558 Environmental Engineering Design Three hrs.
Engineering design and project management of environmental quality/restoration systems. Students will complete a design project focusing on one of the following systems: sanitary landfill, municipal incinerator, or groundwater/site remediation. Lectures will address skills for technical presentations and proposal writing, as well as process design and decision making. Prerequisite: CE 449. (Same as CE 458.)

574 Applied Mechanics of Solids Three hrs.
Stresses and strains at a point, theories of failures, stress concentration factors, thick-walled cylinders, torsion of noncircular members, curved beams, unsymmetrical bending, and shear center. Prerequisite: CE 370. (Same as CE 474 and MAE 474/574.)

581 Advanced Soil Mechanics Three hrs.
Continuum mechanics applied to soil behavior. Theoretical approaches to consolidation, shear strength, slope stability and soil stabilization. Prerequisite: CE 372. (Same as CE 481.)

582 Soil Dynamics, Three hrs.
Behavior of soils under dynamic, earthquake and blast loading. Analysis of foundation vibration and isolation. Prerequisite: CE 372. (Same as CE 482.)

585 Foundation Engineering, Three hrs.
Design of foundations with emphasis on reinforced concrete, footings, caissons, piles, retaining walls, and mat foundations. Effect of bearing pressure on foundations. Prerequisites: CE 372 and 403. (Same as CE 485.)

646 Erosion and Sedimentation, Three hrs.
River morphology and river response, incipient erosion and its prediction, bed form and roughness, degradation, aggradation, and local scour in alluvial rivers. Design of stable channels, computation of bed load. Prerequisites: CE 472, 554.

650 Environmental Impact Analysis, Three hrs.
National environmental policy act and its implementation. Environmental impact process. Writing an environmental impact statement. Prerequisite: CE 549.

652 Introduction to Air Pollution, Three hrs.
Technology of air pollution dealing with air pollutants, effects, sources, combustion processes, and abatement and control technology. Engineering contributions to both the problems and their solutions. Nature of air pollution problem and fundamental technological approaches to its solution. Prerequisite: graduate standing. Offered upon demand. (Same as CHE 652.)

654 Environmental Transport, Three hrs.
Fundamental principles of mass transport, chemical partitioning/transformations in environmental systems. Practical transport examples for surface water, ground water, and atmospheric systems will be presented and mathematical modeling will be utilized for solutions. Prerequisite: CE/CHE 549.

655 Hazardous Waste Management, Three hrs.
Topics include definition of hazardous waste, regulatory considerations, risk assessments, and categories of waste. Current and emerging treatment and disposal technologies will be explored. Prerequisite: CE 549.

671 Continuum Mechanics, Three hrs.
Kinematics and kinetics, various coordinate systems, constitutive equations for continuous media: applications to solids, liquids, and gases. Prerequisites: MAE/CHE 352, CE 370. (Same as MAE 671.)

675 Rock Mechanics, Four hrs.
Principles of continuum mechanics applied to the design of structures in rock; tunnels, underground structures and foundations. Joint behavior; stresses; analysis of rock slopes; instrumentation. Prerequisite: CE 372.

Industrial & Systems Engineering (ISE)

523 Statistical Quality Control, Three hrs.
Statistical theory and techniques to control quality of manufactured products. Prerequisite or parallel: ISE 391 or ISE 690. (Same as ISE 423.)

524 Ergonomics and Methods Analysis, Three hrs.
Introduces basic principles of methods analysis and ergonomics. Methods analysis topics include: work measurement, work measurement tools, work sampling, job analysis, job evaluation, and development and use of flow and activity charts for methods improvement. Ergonomics topics include: anthropometric data, workplace design, design of the physical environment, work organization, and display and control design. Includes term project and laboratory exercises. Prerequisite: ISE 391 or 690. (Same as ISE 424.)

547 Introduction to Systems Simulation, Three hrs.
Philosophy and elements of digital discrete-event simulation. Emphasis on modeling and analysis of stochastic systems, including probabilistic models, output analysis, and use of simulation software. Prerequisites: CPE/EE 197, ISE 391 or 690. (Same as ISE 447.)

627 Introduction to Systems Engineering, Three hrs.
Overview of engineering analytic methods applied to design of operational, procedural, and hardware systems. The systems engineering process, the system life cycle concept, parametric analysis, cost-benefit and tradeoff analysis. Use of engineering models of components, logic, signals, and organization in systems analysis and design optimization from a total system and life cycle perspective. Prerequisite: ISE 690.

635 Linear Programming, Three hrs.
Application of linear programming to complex allocation problems. Methods for determining maximum or minimum of objective functions whose variables are subject to constraints. Simplex methods, degeneracy, modified simplex, transportation problems, network flows, goal programming, and sensitivity analysis. Prerequisite: ISE 626.

638 Engineering Reliability, Three hrs.
Methodology of reliability prediction including application of discrete and continuous distribution models. Reliability estimation, reliability logic diagrams, life testing, and reliability demonstrations. Prerequisite: ISE 690.

641 Advanced Quality Control, Three hrs.
Advanced topics in statistical quality control including: short-run SPC techniques, autocorrelated data, multi-variate quality control charts, process capability analysis, and the use of evolutionary operations (EVOP) to improve and control process quality. Prerequisite: ISE 523.

647 Advanced System Simulation, Three hrs.
Methods and procedures for simulation of large and complex systems. Discrete increment, continuous time and combined models. Comparison of discrete-event simulation languages. Model verification and validation. Statistical inference. Input data collection and analysis, output analysis, and comparison of alternatives. Prerequisite: ISE 547, 690.

670 Integrated Product and Process Design, Three hrs.
Introduces the concepts and tools that support integrated products and process design. Particular attention is devoted to multifunctional teams and their value in promoting the concept of life-cycle engineering. Provides experience with tools and technologies that support the IPPD philosophy. Prerequisite: Graduate standing.

690 Statistical Methods for Engineers, Three hrs.
Application of probability and statistics useful in research work. Descriptive statistics, theoretical distribution functions, point and interval estimates, tests of hypotheses, linear regression, and analysis of variance. Prerequisite: MA 201.

697 Master's Project for Plan II, Three hrs.
The master's project (Plan II) paper must demonstrate competence in the major discipline of the student's program of study. The paper must meet departmental standards and must be defended before a faculty committee during an oral examination. Must be taken at the end of the student's program of study. May be repeated. Maximum three hours credit toward degree. Required each semester student is working and receiving direction on a Plan II project.

699 Master's Thesis, Three, six, or nine hrs.
Required each semester student is working and receiving direction on a master's thesis. Minimum of two semesters and six hours required for MSE students. A maximum of nine hours of credit is awarded upon successful completion of master's thesis.

723 Engineering Economic Analysis, Three hrs.
Mathematical models for expenditure analysis under uncertainty. Relationship between investment decision criteria and microeconomic theory. Capital planning and budgeting. Decisions involving expansion, acquisitions, replacement, and disinvestment. Prerequisite: ISE 390 or 690, ISE 321 or instructor approval.

726 Systems Modeling, Three hrs.
Philosophy and methodology for modeling probabilistic systems. Includes Markov processes, queueing theory, and inventory theory. Team project required. Prerequisites: ISE 390 or 690, ISE 626 or 627.

730 Multi-criteria Decision Analysis, Three hrs.
Methods for analysis of management-decision problems involving multiple goals and constraints. Linear and nonlinear goal programming; risk programming and decision making in fuzzy environments. Prerequisite: ISE 635.

732 Industrial Forecasting and Analysis I, Three hrs.
Industrial forecasting methods. Simple forecasting models, multivariate regression, correlation, and spectral analysis, exponential smoothing, and Box-Jenkins forecasting. Prerequisite: ISE 690.

734 Value and Decision Theory, Three hrs.
Mathematical development of decision-making process. Statistical decision theory and game theory applied to decision making under risk and uncertainty. Consideration of utility, benefit functions, opportunity loss and value of additional information. Prerequisite: ISE 690.

738 Reliability, Availability, and Maintainability, Three hrs.
In-depth application of decision theory and MIL-HDBK-217, and maintenance engineering techniques in order to achieve targeted reliability, availability and maintainability design goals. Prerequisite: ISE 638.

790 Advanced Statistical Applications, Three hrs.
Continuation of ISE 690 with extension to nonparametric methods, multivariate analysis, and clustering techniques. Prerequisite: ISE 690.

Engineering Management (EM)

660 Engineering Management Theory, Three hrs.
Comparison of classical management principles and theory with the environment, goals, and practices of high technology, research and development, and other scientific-engineering organizations. Cases used to illustrate contemporary problems and environments. Prerequisite: Graduate standing.

661 Strategic Engineering Management, Three hrs.
Analysis of industries; generic, market share, vertical integration, and life-cycle strategies as applied to technology-based organizations. Relationship between buyers and suppliers. Environment and competitor analysis in a global marketplace. Prerequisite: EM 660.

662 Foundations of Total Quality Management, Three hrs.
Basic understanding of TQM in context of fundamental building blocks of effective management; measurement, problem solving, continuous improvement, teamwork, customer focus, and supportive culture. Prerequisite: EM 660 or permission of instructor.

665 Financial Methods for Engineers, Three hrs.
Financial and managerial accounting for the engineering manager; accounting

fundamentals, transaction recording, understanding financial statements, and management applications including costing, budgeting, performance evaluation and control, and ratio analysis. Prerequisite: Graduate standing.

666 Engineering Project Management, Three hrs.
Management and control of multifaceted engineering and technological projects. Coordination and interactions between client and various service organizations. Project manager selection. Typical problems associated with various phases of project life cycle. Case studies illustrate theories and concepts. Prerequisite: Graduate standing.

667 Labor Relations, Three hrs.
Negotiation and administration of labor agreements. Survey of historical, legal, and structural environments that influence collective bargaining process. Simulation of collective bargaining. Prerequisite: Graduate standing.

697 Engineering Management Project I, Three hrs.
Application-oriented student project designed to show competence in engineering management.

698 Engineering Management Project II, Three hrs.
Application-oriented student project designed to show competence in engineering management. Continuation of EM 697.

761 Evolving Theory of Engineering Management, Three hrs.
Development of applicable engineering management theory using classical concepts, contemporary studies and practices at successful technology-based organizations. Prerequisite: EM 760.

766 Implementation of Technology, Three hrs.
Challenges to implementing advanced technology equipment, systems, and methods in engineering organizations. Justifying technology, assimilating change, changing management roles, personnel practices and organizational structure, and dealing with impact of new technologies on business policies and strategic planning. Prerequisite: EM 666 or permission of instructor.

767 Contemporary Applications in Engineering, Three hrs.
Application of key qualitative and quantitative principles of engineering management to real-world case problems. Students work both as teams and as individuals to solve multidimensional management/organizational problems that require an integrative point of view. Prerequisites: EM 666, 760, 766.

Materials Science (MTS)

MTS 501 Structure, Composition and Properties of Materials I, Three hrs.
How structure and composition determine a material's mechanical properties and performance. Topics covered include bonding and crystal structure, disorder, defects, phase diagrams, phase transitions, diffusion and other kinetic processes, deformation, fraction mechanics, strengthening

processes as applied to metals, ceramics, semiconductors, polymers and composites. Prerequisite: CH 341 or permission of instructor.

Chemical and Materials Engineering (CME)

CME 541 Chemical Kinetics and Reaction Design, Three hrs.
Fundamental principles of chemical kinetics and chemical reactor engineering along with the design of both thermal and catalytic reactors. Prerequisites: CHE 344, 443.

CME 649 Transport Phenomenon, Three hrs.
Mass, energy, and momentum transport in steady and transient motions in real and rheological substances. Prerequisite: CHE 442. (Same as MAE 649).

Mechanical Engineering (MAE)

542 Internal Combustion Engines, Three hrs.
Application of principles of thermodynamics, heat transfer, and fluid mechanics to combustion engines and turbines. Basic engine types, engine components, idealized cycles, combustion, fuels, engine variables, testing, exhaust gas analysis, and air pollution as related to spark-ignition, compression-ignition, and turbine engines. Prerequisites: MAE 342, 454, MAE/CHE 442.

546 Solar Energy Systems, Three hrs.
Components for solar-energy systems (collectors, heat exchangers, thermal storage).Numerical simulation of solar energy systems, and solar energy system design. Residential and commercial space heating, process heating, and hybrid system applications. Prerequisites: MAE 446, 544; MAE 454 recommended.

547 Energy Conversion and Power Generation I, Three hrs.
Application of principles of thermodynamics and fluid mechanics and economics to analysis and design of conventional hydro and steam power plants. Energy sources and end uses, fossil fuels, combustion equipment, steam generators, and pollution control devices. Hydro, steam and wind turbines. Prerequisites: MAE/CHE 352, MAE 442, 454; MAE 446 recommended.

548 Energy Conversion and Power Generation II, Three hrs.
Application of principles of thermodynamics, heat transfer, and fluid mechanics to combustion engines and turbines. Basic engine types, engine components, idealized cycles, combustion, fuels, engine variables, testing, exhaust gas analysis, and air pollution as related to spark-ignition, compression-ignition, and turbine engines. Prerequisites: MAE 342, 454, MAE/CHE 442.

574 Applied Mechanics of Solids, Three hrs.
Stresses and strains at a point, theories of failures, stress concentration factors, thick-walled cylinders, torsion of noncircular members, curved beams, unsymmetrical bending, and shear center. Prerequisite: MAE 370. (Same as MAE 474 and CE 474/574.)

577 Experimental Techniques in Solid Mechanics, Three hrs.
Experimental methods to determine stress, strain, displacement, velocity, and acceleration in various media. Theory and laboratory applications of electrical resistance strain gages, brittle coatings, and photoelasticity. Application of transducers and experimental analysis of engineering systems. Prerequisites: MAE 370 and junior standing. (Same as MAE 477 and CE 477/577.)

578 Matrix Methods in Structural Mechanics, Three hrs.
Matrix application to formulation and solution of linear problems in structural mechanics. Applications to trusses, beams, and frames. Prerequisites: MAE 370, 442. (Same as MAE 478 and CE 478/578.)

585 Numerical Methods and Computation II, Three hrs.
Advanced topics in numerical methods and computation including Gaussian quadrature; interpolation, integration and differentiation using cubic splines; eigenvalue and eigenvector analysis of large systems; round-off error analysis; stability and convergence analysis of iterative methods. Prerequisite: MAE 396. (Same as MAE 485.)

586 Numerical Engineering Analysis, Three hrs.
Finite elements and finite differences in solving various engineering problems. Numerical applications to fluid mechanics, heat transfer, structural mechanics, and machine design. Prerequisite: MAE 396. (Same as MAE 486.)

589 Computer-Aided Engineering, Four hrs.
Application of computer methods in the analysis and design of structural, thermal, and dynamical systems. Use of state-of-the-art finite element and finite difference computer programs. Practical guidelines for discrete modeling; analysis of modeling errors. Comparison of exact and approximate solutions to boundary value problems. Use of microcomputers in engineering design and analysis. Prerequisite: MAE 396. (Same as MAE 489.)

644 Information Retrieval in Remote Sensing, Three hrs.
Methods for extracting engineering and scientific information content from indirect sensing measurements. Multi-spectral sensing and spectral pattern recognition. Linear and nonlinear inversion methods. Application to remote sensing from space. Prerequisite: permission of instructor.

649 Transport Phenomena, Three hrs.
Mass, energy, and momentum transport in steady and transient motions in real and rheological substances. Prerequisite: MAE 442. (Same as CHE 649.)

660 Structural Dynamics, Three hrs.
Application of the theory of vibrations to discrete and continuous models of structures. Numerical methods of analysis for both spatial and temporal variables. Modal synthesis and step-by-step time integration methods. Finite element applications; substructuring techniques. Prerequisite: MAE 561. (Same as CE 660.)

674 Finite Element Analysis I, Three hrs.
Finite element theory, variational methods, weighted residuals; applications to linearpartial differential equations in continuous media; solution of boundary-value and initial-value problems. Prerequisite: MAE 671. (Same as CE 674.)

677 Optical Techniques in Solid Mechanics, Three hrs.
Overview of conventional methods for experimental stress analysis. Introduction to applied optics with emphasis on non-destructive, laser-based testing methods, fiber optic recording systems, photoelectronic-numerical data acquisition, and computer aided analysis. Prerequisite: MAE 477/577 or consent of instructor. (Same as CE 677.)

678 Mechanics of Composite Materials, Three hrs.
Introduction to composite materials, micro- and macro-mechanical behavior of laminae; bending, buckling and vibration of laminated plates. Prerequisites: MAE 671, 672. (Same as CE 678.)

692 Graduate Engineering Analysis I, Three hrs.
Ordinary differential equations (ODEs), Green's functions, linear algebra, simultaneous differential equations, application of ODEs to mechanical systems, Fourier series and integrals, Laplace transformations, vectors, and tensors. Prerequisite: MA 324.

693 Graduate Engineering Analysis II, Three hrs.
Partial differential equations (PDEs) and boundary-value problems, Bessel functions, Legend polynomials, vector analysis and integral theorems, introduction to tensor analysis, calculus of variations, analytical functions of a complex variable, Taylor and Lauren expansions, the residue theorem, and stability criteria. Prerequisites: MA 324, MAE 692 or permission of instructor.

749 Mass Transport, Three hrs.
Mass transfer in solid and fluid systems under steady and transient conditions. Integration of momentum, heat and mass transfer equations with application to reactive, rheological and multicomponent systems. Prerequisites: MAE 643, 651. (Same as CHE 749.)

765 Random Vibration of Elastic Systems, Three hrs.
Dynamic analysis of elastic systems including the response of complex structures to random excitations. Typical excitations include random wind, thermal, earthquake, aerodynamic, and ocean wave phenomena. Probabilistic mechanics methods. Concepts of reliability. Stationary and ergodic processes. Prerequisite: MAE 561. (Same as CE 765.)

772 Theory of Structural Stability, Three hrs.
Energy criterion for stability of elastic structure under conservative loading. Stability concept for general continuous systems. Rigorous and approximate methods of analysis. Buckling of structural elements under impulsive and nonconservative loading. Postbuckling behavior. Prerequisite: MAE 671. Offered upon demand. (Same as CE 772.)

773 Theory of Shells, Three hrs.
Analysis of thin plates and shells including higher order approximation theories and transverse-shear deformations. Illustration of theories by selected problems. Prerequisite: MAE 671. (Same as CE 773.)

774 Finite Element Analysis II, Three hrs.
Advanced topics in finite element analysis; application to nonlinear partial differential equations in continuum mechanics; theoretical studies of convergence and stability of solutions. Prerequisite: MAE 674. (Same as CE 774.)

778 Fracture Mechanics, Three hrs.
Theory of crack propagation, stress intensity factors, series expansion, asymptotic approximations, field singularities, integral transforms, numerical solutions. Prerequisites: MAE 671, 672. (Same as CE 778.)

Management (MGT)

504 Negotiation Techniques, Three hrs.
Develops principles, skills, and techniques for effective negotiation and conflict resolution. Describes common mistakes in negotiation and provides a framework to prepare students for business or personal negotiation sessions. Lab Fee: $20. Prerequisite: None.

623 Organizational Theory, Three hrs.
Theories of organizations and their structures. Organizations from the perspectives of management, psychology, sociology, political science, and economics. Organizations as groups of people and as systems in multiple environments. Goals, resources, effectiveness, equilibrium, and change relating to organizations. Administration's relationships with organization with emphasis on research and assessment. Lab Fee: $10. Prerequisite: MGT 600 or equivalent.

631 Strategic Human Resource Management in a Technological Environment, Three hrs.
Examines the major functions of human resource management—planning, staffing, compliance with laws regulating employment relations, training and development, compensation, employee relations, and union-management relations—from a strategic perspective. Particular attention is given to special challenges faced by high technology firms and organizations experiencing technological change. Lab Fee: $10. Prerequisite: MGT 600 or equivalent. Spring.

640 Principles of Project Management, Three hrs.
Conceptual foundation and organization of project management. The project life cycle, lanning, control, marketing, utilization of human resources, and financial management. Lab Fee: $10. Prerequisite: None.

698 Strategic Management, Three hrs.
Graduate Courses in Management Information Systems (MIS)

500 Decision Support Systems and Expert Systems, Three hrs.
Analysis of information system components and technologies which aid the manager in the decision making process. Concepts supported by use of current DSS/ES software. Lab Fee: $30. Prerequisites: MIS 301 or equivalent and 15 hours in the MSM program.

Political Science (PSC)

500 The American Polity, Three hrs.
Comprehensive and intensive review of the foundations, institutions, and dynamics of the American polity and the relationship of these forces to the making of public policy.

501 The Public Policy Process, Three hrs.
Economic, political, social, and institutional factors which influence the policymaking process and the impact of policy decisions made by the national, state, and local levels of government. Examination of the steps in policymaking analysis.

605 Public Policy Seminar, Three hrs.
Focuses on specific policy areas of the national government such as foreign policy, science policy, or national security policy.

611 Public Personnel Administration, Three hrs.
Purposes, functions, and processes of personnel management at the national, state, and local levels.

612 Budgetary Process, Three hrs.
Governmental revenue and expenditure policies. Budget as a method of administrative and fiscal control.

615 Special Topics in Public Administration, Three hrs.
Selected current issues in public administration.

620 Intergovernmental Relations, Three hrs.
Intergovernmental relations in the U.S. Specific government programs are discussed in terms of funding arrangements, policy decisions, and program administration.

630 Public Values and Public Policy, Three hrs.
Critical examination of the normative aspect of public policy-making. Focuses on the value assumptions of social theoretical paradigms that influence the design of public policy and on the ethical and moral implications of those designs. Major themes include ideological biases of empirical analyses and evaluations in the policy sciences, ethics of social policy formation, and moral problems of economic distribution, and redistribution.

635 Methodological Issues and Public Policy, Three hrs.

Emphasis upon application of advanced quantitative techniques to public policy issues. Prerequisite: AHS 300.

637 Development of Management and Policy, Three hrs.
Evolution of modern American business management and government policy. (Same as HY 637.)

651 Public Policy and the Law, Three hrs.
Judicial influences on the development and application of public policy in the United States. Role of the judiciary as a political actor.

Atmospheric Science (ATS)

501 Survey of Atmospheric Science, Three hrs.
General survey of the field of atmospheric science. Quantitative examination of atmospheric physical properties including atmospheric composition, structure and dynamics. Detailed inspection of evolving atmospheric structures using real-time data systems. General topics include atmospheric thermodynamics, atmospheric dynamics, cloud physics, atmospheric radiation, and related topics in atmospheric remote sensing. Prerequisites: MA 172 and PH 112 or consent of instructor. (Same as ES 501.)

511 Introduction to Geographical Information Systems, Three hrs.
Introduces vector, raster and tabular concepts, emphasizing the vector approach. Topics include: spatial relationships, map features, attributes, relational database, layers of data, data ingesting, digitizing from maps, projections, output, applications and availability of public data sets. (Same as ES 511.) Fall.

513 Geographical Information Systems and Remote Sensing, Three hrs.
Hands-on approach to GIS and satellite remote sensing. Popular satellite data sets such as LANDSAT and AVHRR is coupled with GIS data sets to increase understanding of the earth system. Topics include satellite sensors, basic radiative transfer, orbits, raster formats, atmospheric correction, distortion, image corrections, rotations and mapping, spatial resolution, image interpretation, radiometric and geometric enhancement, multispectral transformations, and classifications. Prerequisites: ATS 511. (Same as ES 513.) Spring.

514 Scale and Landscape in GIS, Three hrs.
Relationship of scale processes in the interpretation of remote sensing and GIS applications. Topics include those associated with multiple representations of remote sensing data, analysis techniques for integrating multiple sets of remote sensing and auxiliary data at different scales, and geostatistics. Prerequisites: ATS 511, 513. (Same as ES 514.) Fall.

515 Advanced Topics in GIS, Three hrs.
Advanced special topics: visualization of GIS and remote sensing data, landscape characterization (pattern vs. process), multitemporal analysis, aggregation of data types, developing an integrated GIS environment for performing complex space-time modeling

analyses, and land-atmosphere interactions. Prerequisites: ATS 511, 513. (Same as ES 515.) Spring.

522 Air Pollution: Meteorology Concepts and Modeling, Three hrs.
Meteorological factors affecting air pollution concentrations, including boundary layer turbulence, mixing height and wind statistics. Development of Gaussian models, plume rise models, and stability classifications. Operational models for regulatory applications. Pollutant exposure. Air pollution climatology and empirical modeling. Chemical transformations and photochemical modeling. Prerequisites: ATS 501 or consent of instructor. (Same as ES 522.) Fall, even years.

551 Atmospheric Fluid Dynamics I, Three hrs.
Fluid dynamics in the atmosphere. Coriolis acceleration, scale analysis and appropriate approximations of the complete governing equations. Numerical analysis and interpretation of weather phenomena. Prerequisites: MA 324 and PH 112. (Same as ES 551.)

570 Satellite Remote Sensing I, Three hrs.
Covers a broad range of topics concerning digital image processing applied to the remote sensing of atmospheric, cloud and surface properties. Topics include image interpretation, radiometric and geometric enhancement of satellite imagery, supervised and unsupervised classification techniques, image transformations, textures, atmospheric correction, calibration and navigation of satellite imagery. Prerequisites: MA 324, PH 112. Fall, odd years.

670 Satellite Remote Sensing II, Three hrs.
Analysis and interpretation of satellite data: AVHRR, GOES, SSM/I, ERBE and LANDSAT. Topics include retrieval and analysis of earth radiation budget, cloud liquid water, land and ocean temperatures, vegetation characteristics, cloud optical properties, biomass burning fire patterns, smoke and dust aerosols, and advanced cloud classification techniques and applications to NASA's Mission to Planet Earth. Prerequisite: ATS 570. Spring, even years.

Chemistry (CH)

525 Environmental Chemistry, Three hrs.
Principles of quantitative analyses related to minor components of a sample. Applications selected from principal analyses necessary to maintain environmental quality of air, water, and soil. Selection of conditions for collecting reliable samples, concentration of components with techniques for increasing concentration of selected component, relationships between physical and chemical changes in sample and signal output of predominant transducers, and translation of chemical analysis into meaningful specifications. Lecture only. Prerequisites: CH 521 or 223; EE 311, 342. (Same as ES 525.)

549 Spectroscopy and Molecular Structure, Three hrs.
Intermediate level treatment of principles of spectroscopy and their application to determination of molecular structure. Prerequisite: CH 343.

Environmental Science (ES)

525 Environmental Chemistry, Three hrs.
Principles of quantitative analyses related to minor components of a sample. Applications selected from principal analyses necessary to maintain environmental quality of air, water, and soil. Selection of conditions for collecting reliable samples, concentration of components with techniques for increasing concentration of selected component, relationships between physical and chemical changes in sample and signal output of predominant transducers, and translation of chemical analysis into meaningful specifications. Lecture only. Prerequisite: CH 521 or 223; EE 311, 342. (Same as CH 525.)

590 Environmental Laws and Regulations, Two or three hrs.
Air pollution control laws and water pollution control laws including air and water pollution standards and variances, congressional and judicial developments in control laws, economic and technological difficulties encountered in meeting standards, relation to state and federal agencies in the enforcement of pollution control laws, and methods of monitoring violations and legal penalties. (Offered through Continuing Education.)

591 Environmental Quality Planning, Two or three hrs.
Provides field planners with in-depth understanding of the Water Resource Council's Principles and Guidelines and the Environmental Quality Evaluation Procedures Manual; their relationship to environmental planning and evaluation; and their application to water resources set forth in P&G planning, including incremental analyses for justification of mitigation measures being recommended. Pays particular attention to the needs of the environmental member of a plan formulation team in planning and scheduling the geophysical, ecological, cultural and aesthetic investigations. Covers the location and use of available environmental information, the integration of new studies, the appraisal of environmental elements of alternative plans (determining significance for both non-monetary and monetary values), trade-off considerations, the environmental basis for selecting a recommended plan, and the presentation of net environmental quality effects for decision making. (Offered through Continuing Education.)

594 Cultural Resources, Two or three hrs.
Provides field personnel with an in-depth working knowledge of current policies, procedures, and acceptable methods for assessment, inventory, and evaluation of the impact water resources projects may have on cultural resources, historic and prehistoric properties. Covers the statutory base for historic preservation, with emphasis on the National Historic Preservation Act (NHPA), the Archaeological Resources Protection Act, and the Reservoir Salvage Act. Procedures for complying with Section 106 of NHPA and for nominating properties for inclusion in the National Register of Historic Places. Not less than four hours of lecture are provided to cover social impact assessment and the relation of cultural heritage and historic (and prehistoric) properties to present-day communication construction and cohesion. (Offered through Continuing Education.)

595 Aesthetic Resources, Two or three hrs.

Provides field personnel with in-depth working knowledge of current policies, procedures, and acceptable methods for assessment and evaluation of the impact water resources projects may have on the aesthetic quality of urban and rural environments. Stresses visual impacts, but covers other perceptual impacts. Considers the definition of the study area as described in the Principles and Guidelines. Not less than four hours of lecture are given on the description of present land use in the study area and methods for predicting future land use for both the with-project and the without-project conditions. (Offered through Continuing Education.)

597 Environmental Impact Assessment of Projects, Two or three hrs.
Detailed consideration is given to factors involved in evaluating the effects of proposed projects upon the environment. Data and information required for environmental evaluation of major federal projects are examined. Particular emphasis is placed on physical and chemical factors that can impact biological and cultural resources. Procedures to be followed in complying with the National Environmental Protection Act (NEPA) and with the Procedures and Guidelines for Water Resources Implementation Studies (P&G) are analyzed to assist in the preparation and critiquing of an assessment. Coordination with other agencies, public involvement, and points to be considered in legal challenges are examined. (Offered through Continuing Education.)

Appendix C
Review of Competing Programs in the Southeast

In this appendix, the relevant programs and graduate course offerings currently offered by competing institutions throughout the Southeast are reviewed in detail.

Programs

This section addresses which colleges and universities in the Southeastern United States offer a transportation specialty in their Civil Engineering Master's Program.

An extensive search was performed on the Internet to find candidates that offer a Master's in Transportation Engineering. By using only the Internet, 14 colleges and universities were found that were located in the Southeast. They are listed below:

Table C-1. Southeastern Schools with Transportation Graduate Programs

School	Transportation Masters	Course Listings
Auburn University	Yes	No
Clemson	Yes	Yes
Florida State University	Yes	Yes (crude)
Georgia Inst. Of Tech	Yes	Yes
Mississippi State University	Yes	No
National Technological University	Yes	Yes
North Carolina A&T State	Yes	Yes
University of Arkansas Fayetteville	Yes	Yes
University of Florida	Yes	Yes
University of Kentucky	Yes	Yes
University of Memphis	Yes	Yes
University of Mississippi	Yes	Yes
University of Tennessee Knoxville	Yes	Yes

Auburn University

Auburn University offers a Master's Degree in Civil Engineering. The web page did not specifically state which specialty areas are available for the Civil Engineering Master's Degree. It stated that Transportation Engineering was a specialty area of Civil Engineering in general. By viewing the course offerings on the web page for Spring 1999, Fall 1999, and Winter 2000, many advanced level transportation classes were offered:

Table C-2. Auburn University Transportation Courses

Call Number	Course Name
Civil 550	Traffic Engineering Analysis
Civil 551	Traffic Control Systems
Civil 558	Railway Engineering
Civil 587	Pavement Design
Civil 589	Pavement Construction
Civil 682	Pavement Materials Characterization
Civil 684	Pavement Management Systems
Civil 686	Advanced Structural Pavement Design

There were no course descriptions found on the website.

Clemson University

Clemson offers a Master's Degree in Transportation Engineering through their Department of Civil Engineering. Civil Engineering has been taught at Clemson since 1889, so the program is well established. The most recent class schedule available was from the Fall of 1999, and at the time it was posted on the web page, it was tentative. Only two advanced transportation classes were listed:

Table C-3. Clemson University Transportation Courses

Call Number	Course Name
CE 610	Traffic Engineering Operations
CE 612	Urban Transportation Planning

There were no course descriptions found on the website.

Florida State University

Florida State University does not specify that it offers a Civil Engineering Master's with a concentration in Transportation Engineering, but from reviewing the offering of classes posted on their web page, there are several upper level transportation classes offered:

Table C-4. Florida State University Transportation Courses

Call Number	Course Name
TTE 4804	Highway Geometric Design
TTE 4201	Traffic Engineering
TTE 4250	Traffic Operations
TTE 5127	Highway Pavement Design

There were no course descriptions found on the website.

Georgia Institute of Technology

Georgia Institute of Technology (Georgia Tech) offers a Transportation Engineering specialty in their Master's of Civil Engineering program.

Mississippi State University

Mississippi State University specifically states that they offer an undergraduate degree in Civil Engineering with a concentration in Transportation Engineering. The University's web page does not show any information regarding Master's Degrees offered in Civil Engineering, but there is a page dedicated to admissions to the Graduate School of Civil Engineering.

Mississippi State's Civil Engineering web page also has a link to the Transportation Research Center, a research facility that is funded by the Mississippi DOT and MSU. There were no course offerings listed on their web page.

The National Technological University

The National Technological University is a university that is dedicated to the advanced education of the technological and engineering fields through distance learning. The university offers a Master's of Science Degree Program in Transportation Systems Engineering. A sample course listing was found on their website showing the elective courses needed to fulfill the Transportation Degree.

Table C-5. The National Technological University Transportation Courses

Call Number	Course Name
TE 710	Bituminous Materials and Mixtures
TE 711	Highway Geometric Design
TE 712	Pavement Design
TE 718	Pavement Performance and Management
TE 727	Economic Analysis of Transportation Investments
TE 530	Highway Safety
TE 731	Traffic Engineering

There were no course descriptions found on the website.

North Carolina A&T State University

North Carolina A&T State University offers an extensive Master's Program in Transportation Engineering.

The University of Arkansas

The University of Arkansas in Fayetteville has a large Civil Engineering Department. The University offers a Master's Degree in Civil Engineering with a concentration in Transportation Engineering. A list of the available courses is below.

Table C-6. The University of Arkansas Transportation Courses

Call Number	Course Name
CVEG 4003	Computer Methods in Transportation
CVEG 4403	Public Transportation
CVEG 4413	Pavement Evaluation and Rehabilitation
CVEG 4423	Highway Geometric Design
CVEG 4433	Transportation Pavement and Materials
CVEG 5143	Transportation Soils Engineering
CVEG 5343	Highway Bridges
CVEG 5413	Transportation and Land Development
CVEG 5423	Structural Design of Pavement Systems
CVEG 5433	Traffic Engineering
CVEG 5443	Transportation Planning Methods
CVEG 5453	Asphalt Mix Design and Construction
CVEG 5463	Transportation Network Modeling
CVEG 5473	Transportation Systems Characteristics
CVEG 5483	Transportation Management Systems
CVEG 5493	Engineering Intermodal Transportation

There were no course descriptions found on the website.

The University of Florida

The University of Florida offers an extensive Graduate Program in Civil Engineering with a concentration in Transportation Engineering. The course offerings can be seen below.

Table C-7. The University of Florida Transportation Courses

Call Number	Course Name
TTE 5006	Transportation Systems Planning
TTE 5255	Basic Traffic Signal Operations
TTE 5258	Urban Intersection Operations
TTE 5256	Traffic Engineering
TTE 5805	Geometric Design of Transportation Facilities
TTE 5835	Pavement Design
TTE 5837	Pavement Management Systems
TTE 6257	Traffic Control Systems
TTE 6315	Highway Safety Analysis
TTE 6526	Airport Planning and Operations
TTE 6606	Urban Transportation Models
TTE 6815	Freeway Design and Operations

There were no course descriptions found on the website.

University of Kentucky

University of Kentucky offers eight broad areas of graduate study and research in the Civil Engineering Department. A Master's Degree with a concentration in Civil Engineering is certainly included in the eight areas. A list of the courses offered at the graduate level is below.

Table C-8. University of Kentucky Transportation Courses

Call Number	Course Name
CE 531	Transportation Systems Operations
CE 533	Railroad Facilities Design and Analysis
CE 534	Pavement Design, Construction, and Management
CE 539	Transportation Systems Design
CE 633	Air Transport Engineering
CE 634	Traffic Characteristics

There were no course descriptions found on the website.

The University of Memphis
The University of Memphis offers a Master's of Science in Civil Engineering with a concentration in Transportation Engineering. The website gives a full description of all courses offered.

The University of Memphis
The University of Mississippi offers a Master's of Science in Civil Engineering with a concentration in Transportation Engineering. The website gives a full description of all courses offered.

The University of Tennessee
The University of Tennessee at Knoxville offers a Master's of Science in Civil Engineering with a concentration in Transportation Engineering. The website gives a full description of all courses offered.

Categories and Courses

The courses in transportation and related fields offered by other universities in the Southeast are listed in the tables below. Courses are grouped into categories of design, materials, analysis/economics/statistics, planning, airports and railways, applications, and other.

Table C-9. Design Courses

Highway Geometric Design	Arkansas
Highway Bridges	Arkansas
Structural Design of Pavement Systems	Arkansas
Pavement Design	Auburn
Advanced Structural Pavement Design	Auburn
Geometric Design of Transportation Systems	Florida
Pavement Design	Florida
Freeway Design and Operations	Florida
Highway Pavement Design	FSU
Highway Geometric Design	FSU
Design of Highways and Transit Facilities	Georgia Tech
Transportation Systems Design	Kentucky
Transportation Facilities Design and Operations	Kentucky
Route Location and Design	Memphis
Geometric Design of Transportation Systems	Memphis
Design of Highway and Airport Pavements	Memphis
Pavement Design	Miss. State
Geometric Design of Highways	N.C. A&T
Pavement Design	N.C. A&T
Highway Geometric Design	National Technological University
Pavement Design	National Technological University
Pavement Design and Management	S.W. Louisiana
Highway Engineering (Design)	Tennessee
Geometric Design and Layout of Roadways and Community Facilities	Tennessee
Pavement Design	Univ. of Louisville

Table C-10. Materials Courses

Pavement Evaluation and Rehabilitation	Arkansas
Transportation Pavement and Materials	Arkansas
Transportation Soils Engineering	Arkansas
Asphalt Mix Design and Construction	Arkansas
Pavement Construction	Auburn
Pavement Materials Characterization	Auburn
Pavement Management Systems	Auburn
Pavement Management Systems	Florida
Pavement Design, Construction and Management	Kentucky
Bituminous Materials and Mixtures	LSU
Transportation Engineering Materials	LSU
Pavement Materials Characterization	LSU
Pavement Management Systems	LSU
Pavement Maintenance and Rehabilitation	LSU
Bituminous Materials and Mixtures	National Technological University
Pavement Performance and Management	National Technological University
Pavement Management Systems	Ole Miss
Highway Pavements	Ole Miss

Table C-11. Analysis/Economics/Statistics Courses

Transportation Network Modeling	Arkansas
Traffic Engineering Analysis	Auburn
Advanced Traffic Flow Analysis	FSU
Traffic Engineering	Georgia Tech
Economic and Financial Aspects of Public Works Planning	Georgia Tech
Transportation Engineering Data Collection Methods	LSU
Transportation Demand Analysis	LSU
Systems Analysis in Transportation	LSU
Air Transportation Economics	LSU
Transportation Systems Evaluation	Memphis
Modeling of Transportation Systems	N.C. A&T
Economic Analysis of Transportation Investments	National Technological University
Traffic Flow Theory and Control	S.W. Louisiana
Analysis Techniques for Transportation Systems I	Tennessee
Analysis Techniques for Transportation Systems II	Tennessee
Advanced Traffic Operations	Univ. of Louisville

Table C-12. Planning Courses

Computer Methods in Transportation	Arkansas
Public Transportation	Arkansas
Transportation and Land Development	Arkansas
Traffic Engineering	Arkansas
Transportation Planning Methods	Arkansas
Transportation System Characteristics	Arkansas
Transportation Management Systems	Arkansas
Engineering Intermodal Transportation	Arkansas
Traffic Control Systems	Auburn
Traffic Engineering Operations	Clemson
Urban Transportation Planning	Clemson
Transportation Planning Systems	Florida
Basic Traffic Signal Operations	Florida
Urban Intersection Operations	Florida
Traffic Engineering	Florida
Traffic Control Systems	Florida
Urban Transportation Models	Florida
Traffic Engineering	FSU
Traffic Operations	FSU
Transportation Engineering II	Georgia Tech
Advanced Transportation Planning	Georgia Tech
Mass Transit Planning	Georgia Tech
Advanced Traffic Operations	Georgia Tech
Traffic Flow Theory	Georgia Tech
Urban Transportation Planning	Georgia Tech
Transportation Administration	Georgia Tech
Transportation Systems Operations	Kentucky
Traffic Characteristics	Kentucky
Traffic Engineering Operations and Controls	LSU
Mass Transit Systems	LSU
Urban Transportation Policy and Planning	LSU
Traffic Engineering	Memphis
Urban Transportation Engineering	Memphis
Traffic Engineering Operations	Memphis
Mass Transit Systems	Memphis
Traffic Engineering	Miss. State
Traffic Engineering	Miss. State
Urban Transportation Planning	N.C. A&T
Traffic Engineering	N.C. A&T
Public Transportation Systems	N.C. A&T
Traffic Engineering	National Technological University
Infrastructure Management	Ole Miss
Transportation Engineering II	Ole Miss
Transit System Planning and Design	S.W. Louisiana
Traffic Engineering	Tennessee
Urban Transportation Planning	Tennessee
Public Transit Planning	Tennessee
Transportation Planning w/ Micro Computer Applications	Tennessee
Planning and Transportation	Tennessee
Transportation Planning and Urban Development	Univ. of Louisville

Table C-13. Airport and Railway Courses

Railway Engineering	Auburn
Airport Planning and Operations	Florida
Airport Planning and Design	FSU
Airport Planning and Design	Georgia Tech
Air Transport Engineering	Kentucky
Railroad Facilities Design and Analysis	Kentucky
Railroad Facilities Design and Analysis	Kentucky
Airport Planning and Design	Memphis
Airport/Railroad Planning and Design	Tennessee
Airport Planning and Design	Univ. of Louisville

Table C-14. Applications Courses

Computerized Traffic Surveillance and Control	Georgia Tech
Advanced Technology Applications in Transportation	Georgia Tech
Computer Simulation in Transportation	Georgia Tech
GIS Applications in Transportation	Georgia Tech
Urban Transportation Planning Models	LSU

Table C-15. Other Courses

Intelligent Transportation Systems	FSU
Environmental Impacts of Transportation	Georgia Tech
Highway Safety	Kentucky
Transportation on Inland Waterways	Memphis
Highway Operations and Safety	N.C. A&T
Highway Safety	National Technological University
Traffic Accident Reconstruction	Tennessee
Environmental Analysis of Transportation Systems	Univ. of Louisville

Appendix D
Review of Competing Programs in the U.S.

The figures on the following pages show transportation specialties and courses offered by institutions of higher education in the Northwest, Mid-Atlantic, Ohio Valley, Mid-West, Mid-West South, Northwest, Southwest, and Western Region, respectively.

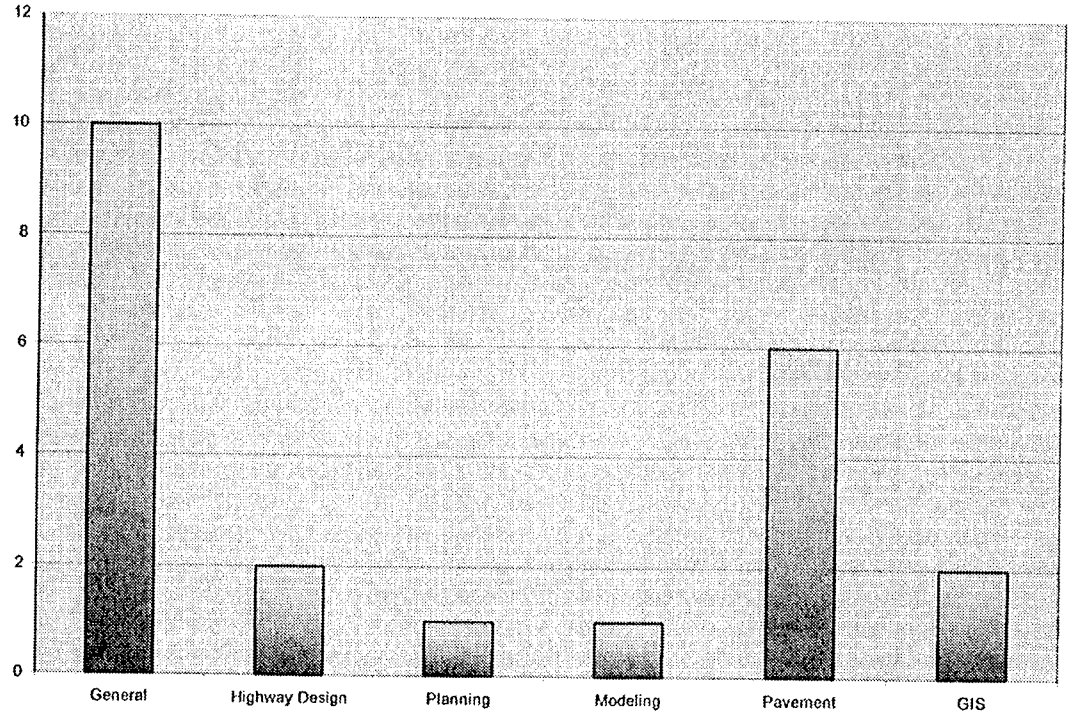

Figure D-1. Transportation Specialties Offered in the Northeast

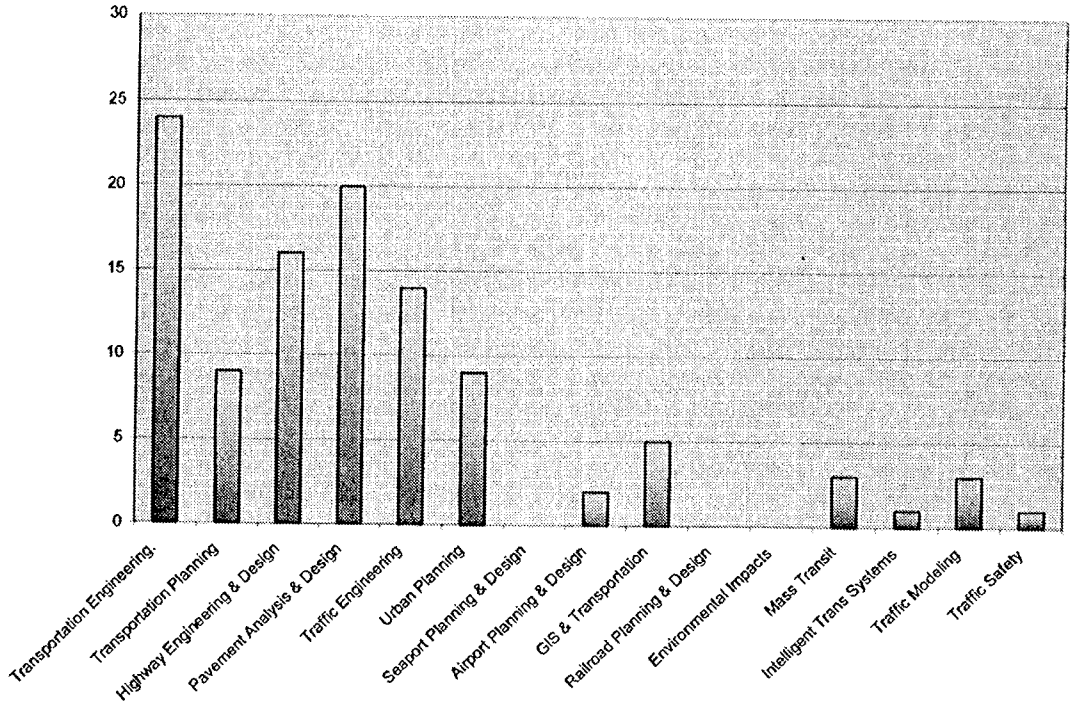

Figure D-2. Transportation Courses Offered in the Northeast

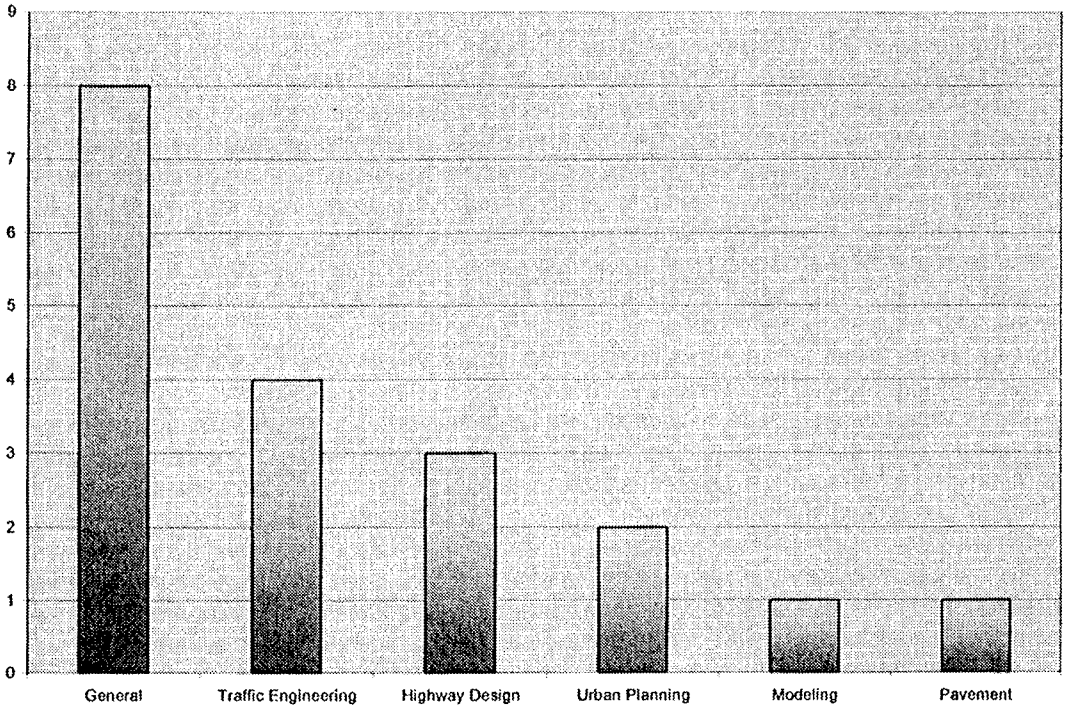

Figure D-3. Transportation Specialties Offered in the Mid-Atlantic

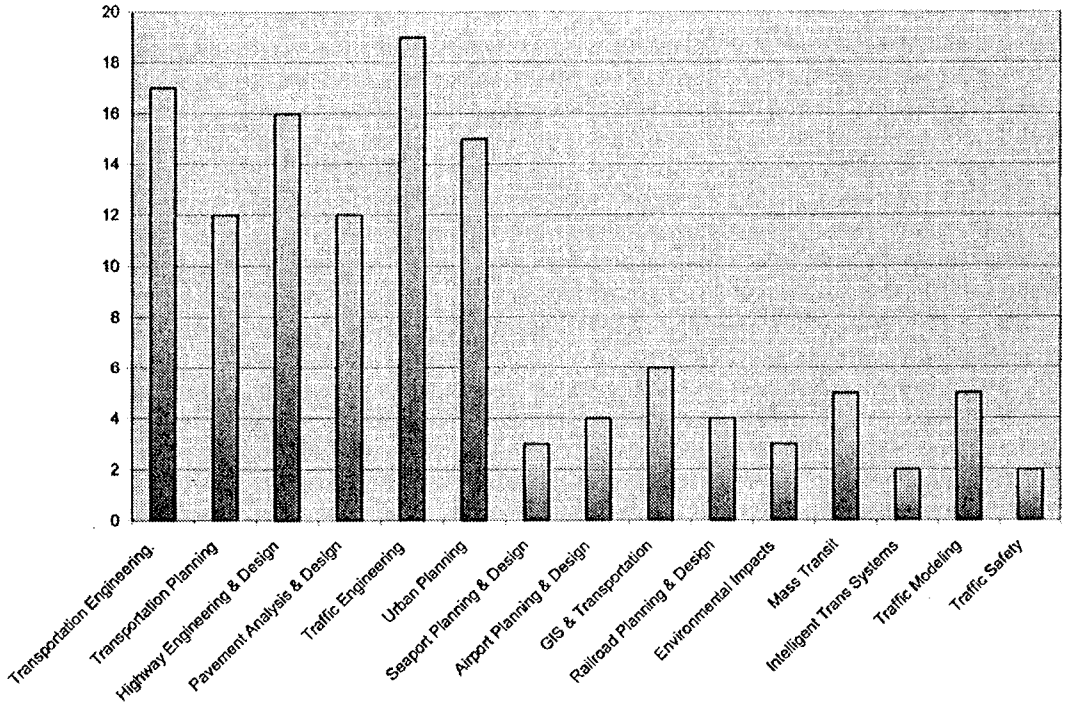

Figure D-4. Transportation Courses Offered in the Mid-Atlantic

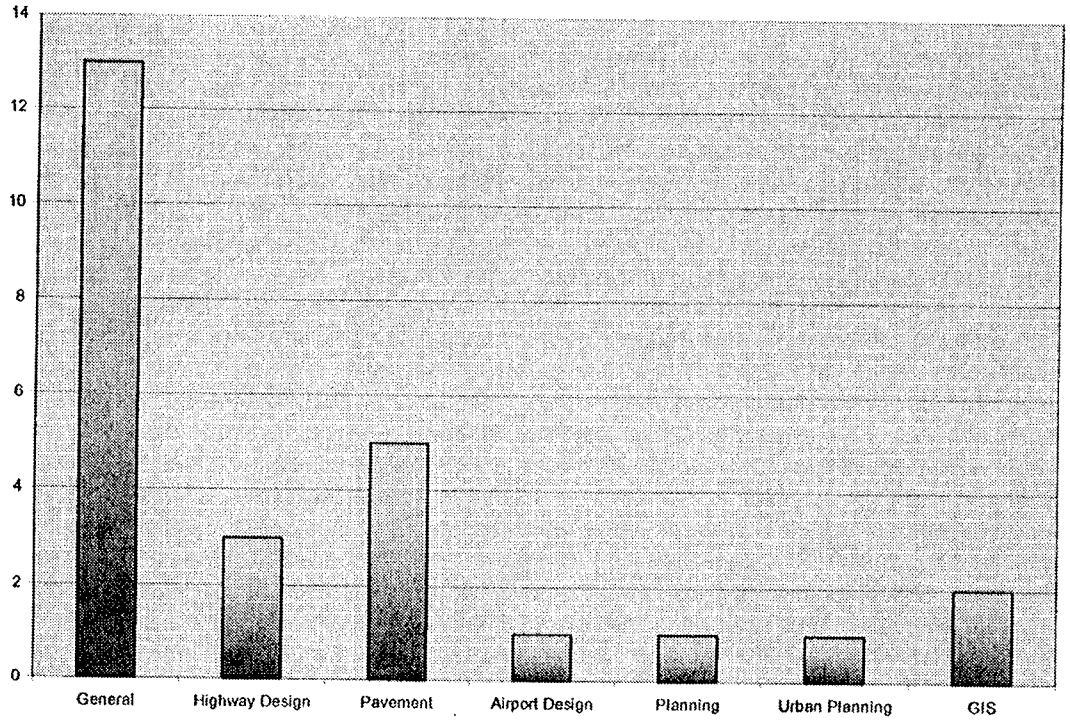

Figure D-5. Transportation Specialties Offered in the Ohio Valley

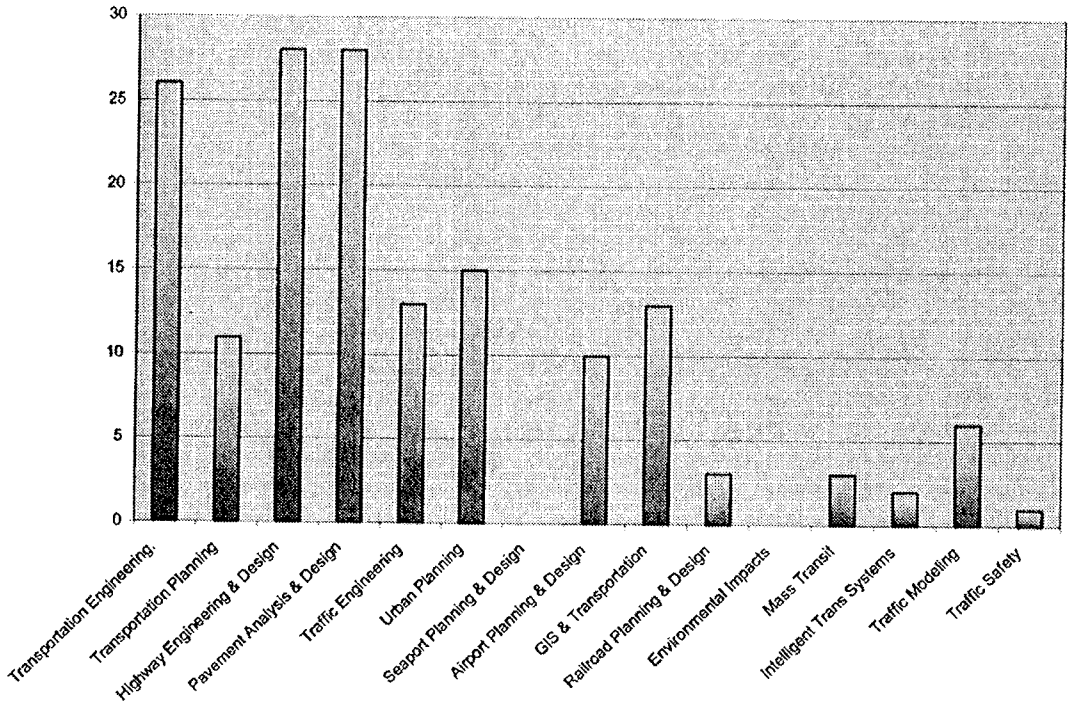

Figure D-6. Transportation Courses Offered in the Ohio Valley

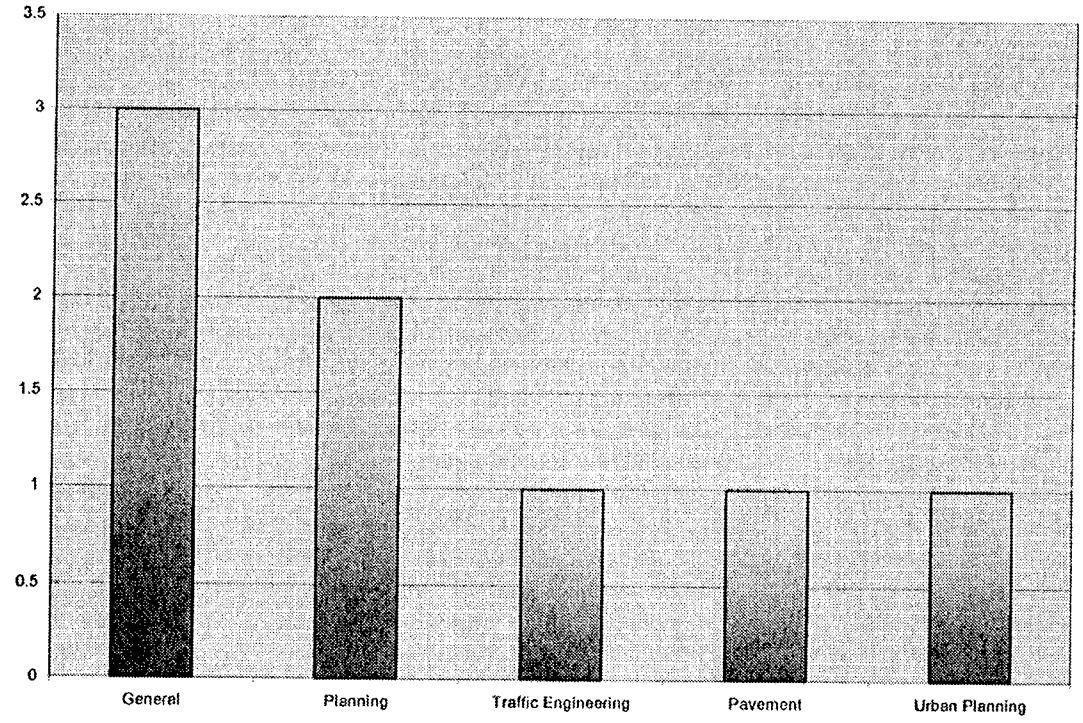

Figure D-7. Transportation Specialties Offered in the Mid-West

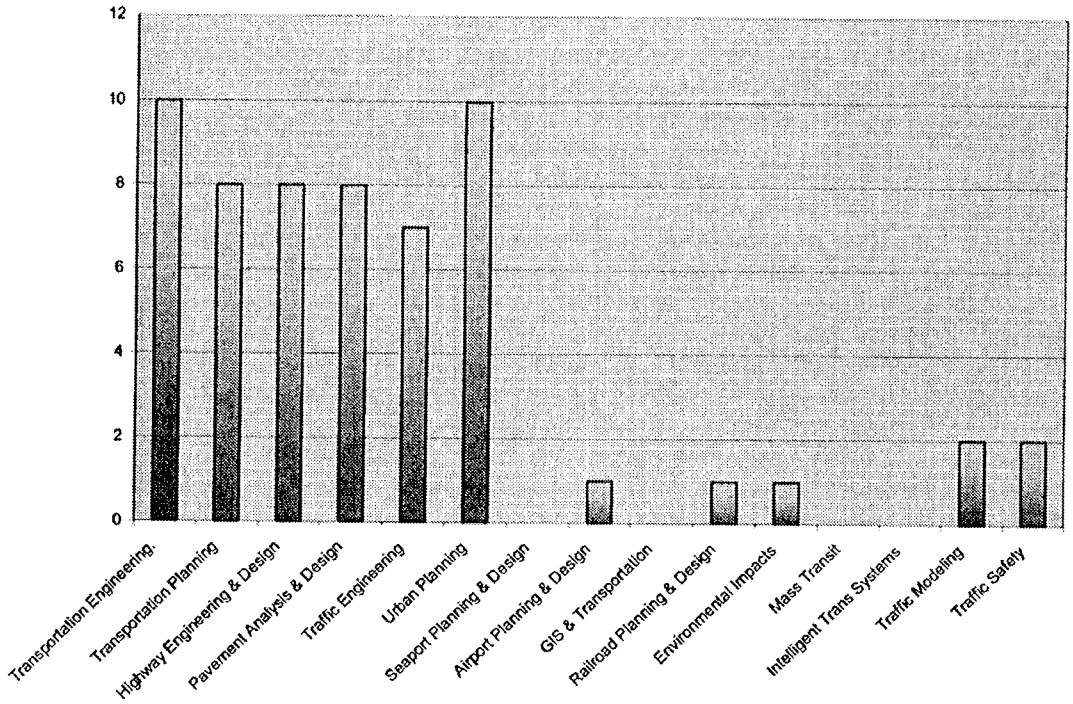

Figure D-8. Transportation Courses Offered in the Mid-West

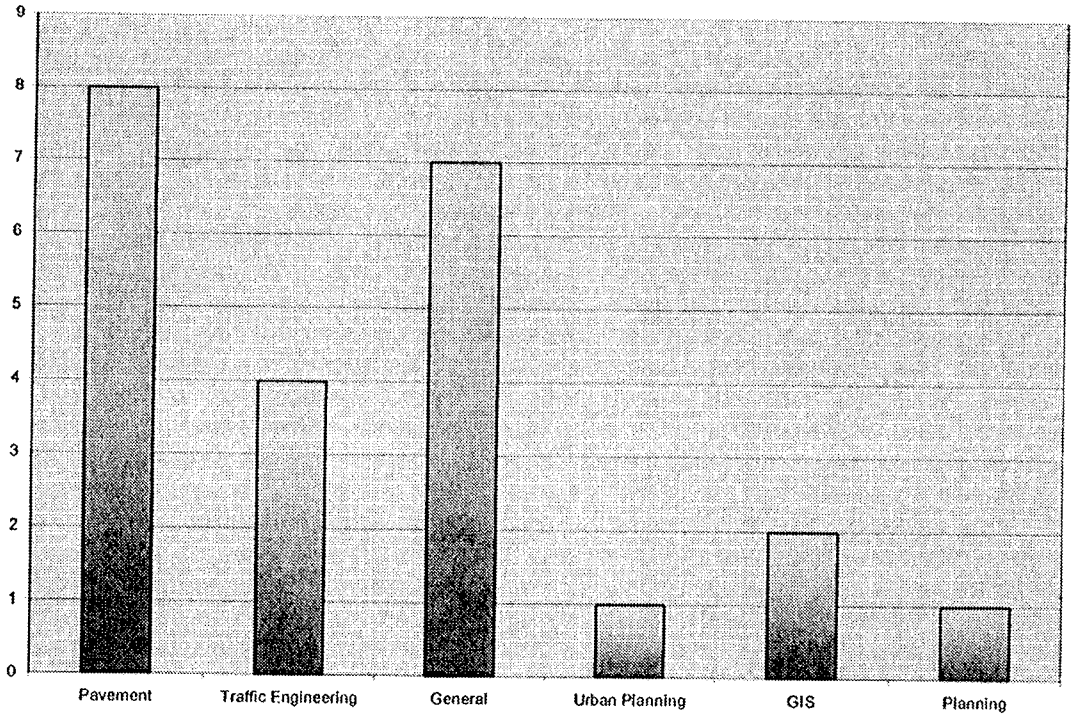

Figure D-9. Transportation Specialties Offered in the Mid-West South

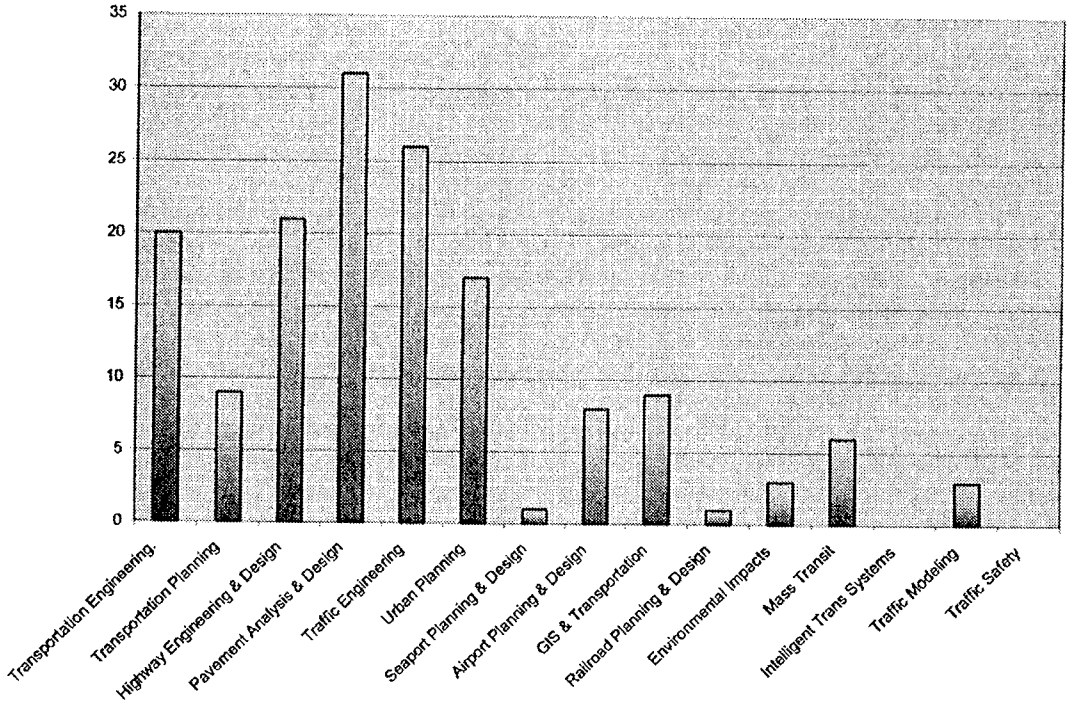

Figure D-10. Transportation Courses Offered in the Mid-West South

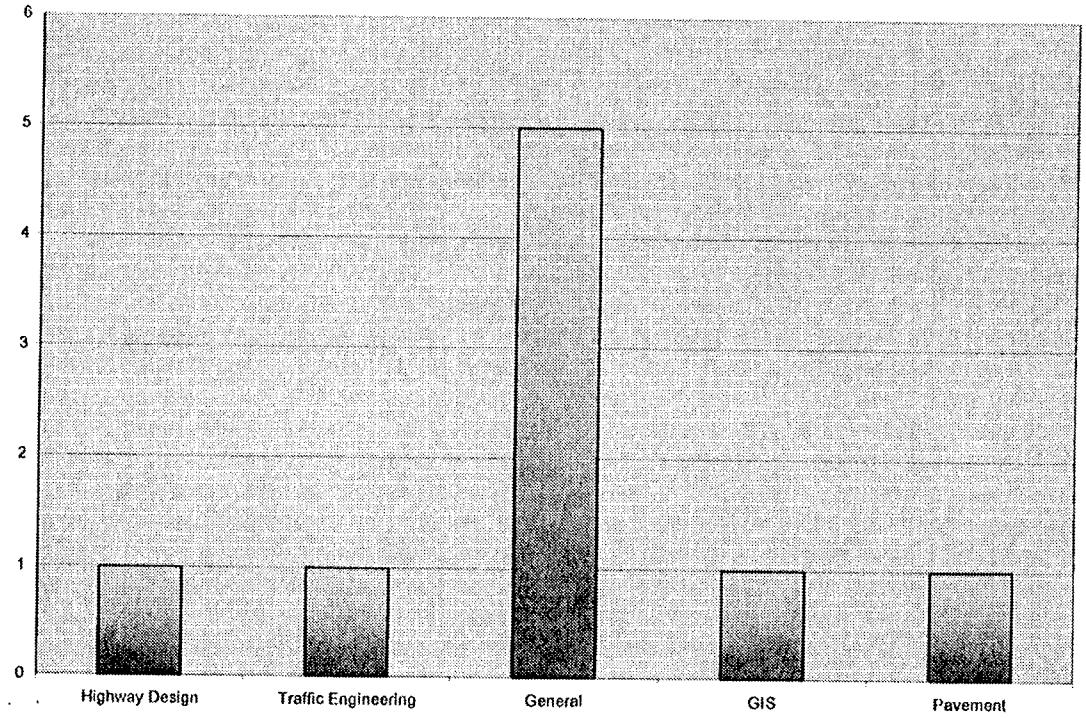

Figure D-11. Transportation Specialties Offered in the Northwest

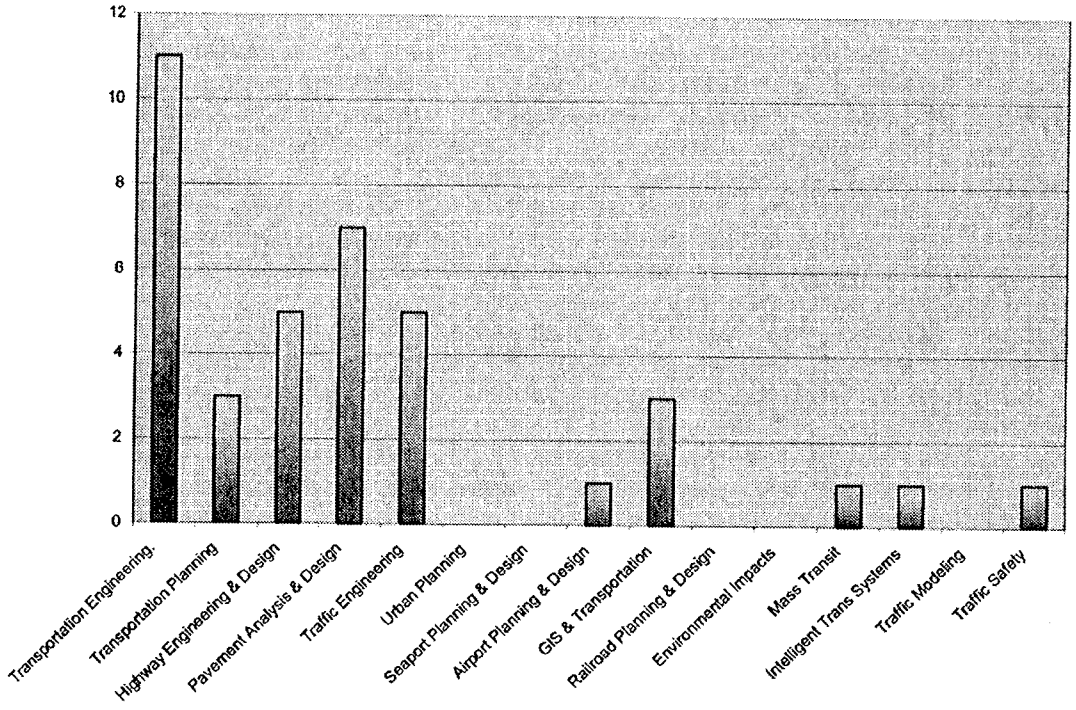

Figure D-12. Transportation Courses Offered in the Northwest

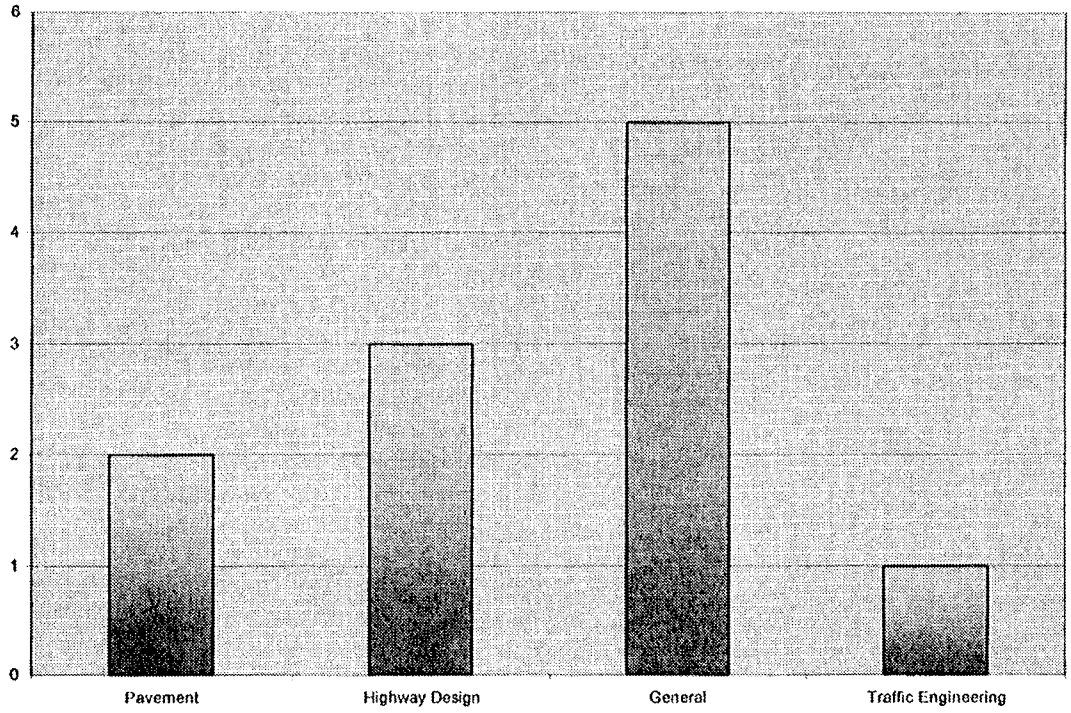

Figure D-13. Transportation Specialties Offered in the Southwest

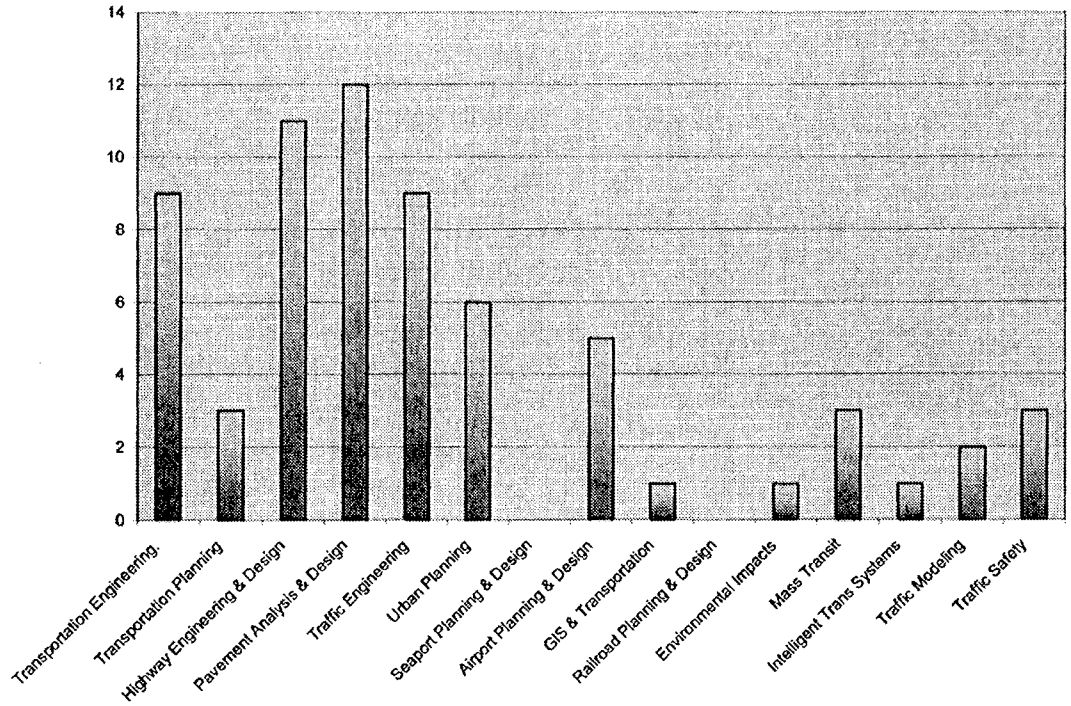

Figure D-14. Transportation Courses Offered in the Southwest

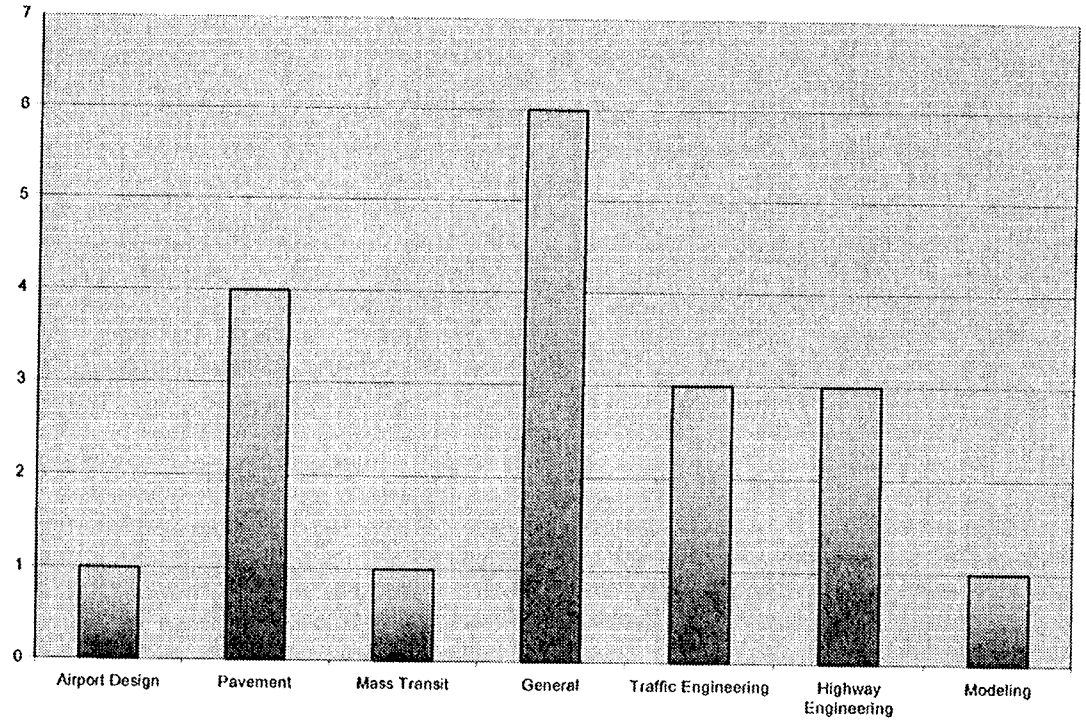

Figure D-15. Transportation Specialties Offered in the Western Region

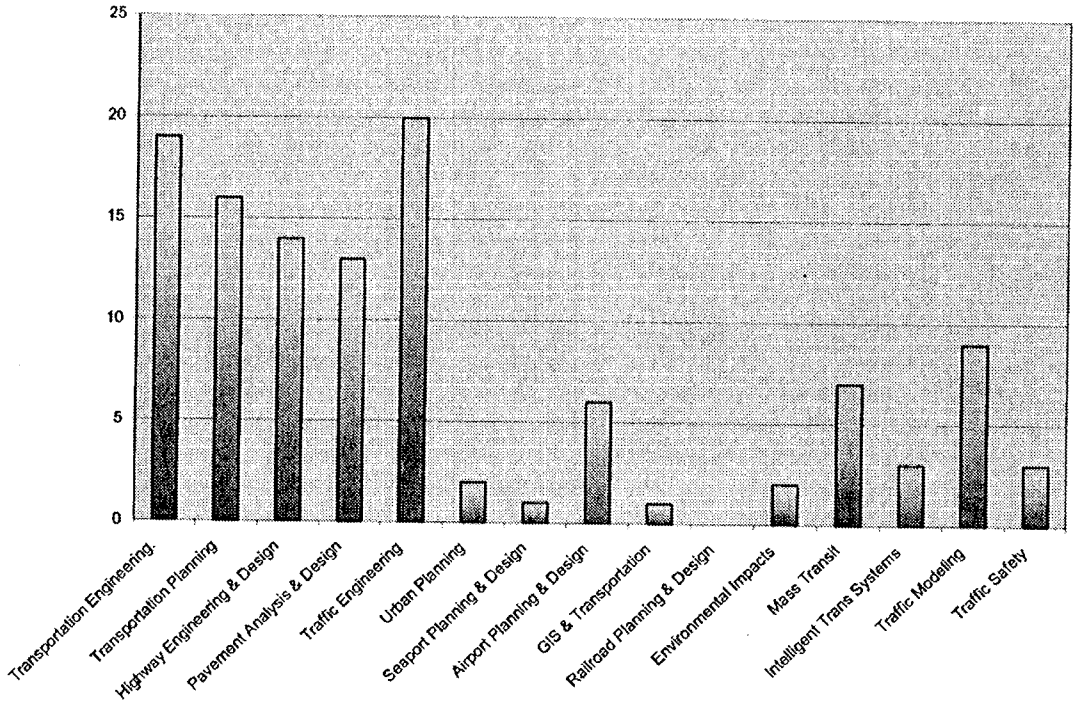

Figure D-16. Transportation Courses Offered in the Western Region

University Transportation Center for Alabama

CONTACT INFORMATION
University Transportation Center for Alabama
271 H M Comer Mineral Industries Building
PO Box 870205
University of Alabama
Tuscaloosa, AL 35487-0205
(205) 348-9925
(205) 348-0783 fax
utca@coe.eng.ua.edu
http://bama.ua.edu/~utca/

University Transportation Center for Alabama

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University Transportation Center for Alabama
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PO Box 870205
University of Alabama
Tuscaloosa, AL 35487-0205
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utca@coe.eng.ua.edu
http://bama.ua.edu/~utca/