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AN OUTLOOK AT THE FUTURE OF THE AIRLINE AVIONICS INDUSTRY

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ABSTRACT

The aviation industry is slowly but surely changing its character. As airlines restructure, what they ask of, and how they relate to their suppliers (including avionics manufacturers) will greatly change as well. The avionics industry is currently facing many challenges as a result of the reluctance of airlines to invest in new technologies and the possibility that airframe manufacturers will take over this industry. This paper analyzes the changes and performance of the avionics industry. It provides an overview of the evolution of avionics technologies and explores the impact of airline deregulation on the avionics industry. It also provides a perspective on the future outlook of the industry with implications to marketing strategies of avionics manufacturers.

HISTORICAL PERSPECTIVE

Despite substantial research assessing the effects of deregulation on airline market structure and performance, little has been done to measure similar impacts on the avionics industry. The commercial air transport avionics industry is changing with simultaneous effects of advanced technology and airline deregulation causing shifts in airline priorities for avionics equipment.

The term avionics is derived from AVIation electrONICS. It describes an increasingly broad spectrum of aircraft equipment and functions. Avionics refers to aircraft electronic equipment that serves the primary functions of communications, navigation and automatic flight control. Many aircraft functions that were performed in the past by mechanical, hydraulic or electrical systems now are conducted as electronic systems. Aircraft electronic systems are those characterized by relatively small operating voltages, small current levels, and

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typically solid-state circuitry. Aircraft electrical systems are characterized by high voltages and current levels, such as those associated with primary electrical power systems. Once an aircraft system becomes electronic, it is often regarded as an avionics system.

Following World War II, the U.S. airline industry blossomed, carrying passengers, freight and mail. In the mid-1940s, the Aeronautical Radio, Inc. (ARINC) (a not-for-profit corporation owned by airlines) was created.[1] ARINC committees and sub-committees were formed by airline personnel and ARINC dministrative support staff to develop technical standards for the avionics industry.[2] Because commercial airframe business was dominated by the United States, ARINC standards also were applied equally to foreign airlines.

From the 1940s to the mid-1980s the avionics industry was dominated almost totally by two U.S. firms, Collins Avionics and Bendix Avionics, which supplied complete lines of communication and navigation equipment to virtually all the world's airlines.[3] Foreign avionics firms, mostly in Western Europe, addressed primarily the avionics needs of their militaries.[4] Other U.S. firms served niches in the commercial marketplace. Formation of the Airbus consortium in Europe led ultimately to entry of European avionics firms into the commercial market (beginning with the introduction of the A300B in 1972. By the mid-1980s, European avionics firms began to make their first advances into the U.S. commercial avionics market. These attempts were, however, met with limited success.

EVOLUTION OF THE AVIONICS TECHNOLOGY

Technological advances in commercial aviation from the late 1940s to the late 1960s focused almost exclusively on airframes (aerodynamics, structures and materials), and propulsion (the transition from propeller to jet thrust and fuel efficiency). The period from the late 1960s to the late 1970s witnessed significant developments in the avionics field. Research and development costs were high, while the size of the market remained relatively unchanged. The selling price of avionics systems multiplied. Prices were camouflaged by the significant economies brought to airlines by phenomenal advancements in airframe and propulsion technology. In addition, the pricing policies of the Civil Aeronautics Board (CAB) allowed airlines to set up airfares to recover the costs of acquiring these sophisticated systems.[5]

The period from the late 1970s to the present has seen the introduction of a truly astounding level of avionics technology. Flight management systems contain entire flight plans in software, along with airplane configuration and performance databases. Flight plan progress and information is displayed graphically and in real-time on CRT (Cathode Ray Tube) and LCD (Liquid Crystal Display) display systems. Primary flight instrument display systems integrate numerous flight and air data instrument indications on a single display. Distance measuring equipment (DMEs), which previously displayed a simple slant-range to a selected ground station, now can scan multiple stations, select optimum stations on the basis of positional geometry and signal quality, and supply the resultant data to the flight management system for navigational support.

Weather radar systems, which in the past only displayed areas of detectable precipitation, now can annunciate several levels of precipitation (digitally calibrated to more than 300 NM), display turbulence in precipitation and automatically eliminate ground clutter from the display. Windshear detection systems annunciate the presence of low-level atmospheric windshear. Autopilot systems routinely perform fully automatic climb, enroute, descent, landing and rollout operations. Collision avoidance systems display surrounding aircraft, calculate, predict and annunciate conflicting flight paths. Satellite-based communication and navigation systems provide worldwide data link and telephone quality voice contact, and highly accurate four-dimensional position data. On-board maintenance computer systems continually diagnose the condition of networked avionics, identify faults and downlink maintenance requirements to the destination station.[6]

Advances in avionics have brought significant improvements in safety to airline operations. Flight management systems have reduced pilot workload, allowing for improved alertness and concentration in handling abnormal procedures. Integrated display systems have reduced the instrument scan. New weather radar features have made it possible for flight crews to avoid precipitation-related turbulence and to interpret the radar display more accurately. Autoland systems allow airplanes to land in poor visibility with far greater accuracy and reliability than is possible with human control. Collision avoidance and windshear detection systems have successfully addressed two of the leading and most insidious hazards in aviation.

Among the most significant contributions to airline economics brought about by modern avionics is elimination of the third flightcrew member (the flight engineer. This was possible as a result of automated data acquisition and display systems such as the B767's engine indicating and crew alerting system (EICAS). Improved fuel economy also was possible due to, in conjunction with improved airframe designs, introduction of electronic engine controls (EEC) and the full authority digital engine control (FADEC) system. Working in combination with advanced aerodynamics and engine design, precise engine control made available by avionics EEC systems has resulted in substantially improved engine reliability and specific fuel consumption (SFC). As a result, some modern airplanes can move the same number of passengers over comparable flight profiles for less than half the fuel required by earlier models. Automatic maintenance downlinks have made significant improvements to airline on-time operating performance.

AIRLINE DEREGULATION AND THE AVIONICS INDUSTRY

Over the past few decades, avionics manufacturers and airframe manufacturers have worked hand-in-hand from one airplane project to the next. Some products grew from military research and development (R&D) as technologies were declassified. When airframe manufacturers announced the cost of a new airplane, airlines simply lined up to pay the price. This was possible in a regulated environment.

Following airline deregulation in 1978, the U.S. domestic airline industry has witnessed much more drastic changes than could have been predicted by analysts. Deregulation resulted in concentration of the airline industry into a small number of large carriers operating under cost-control pressures. Smaller carriers survived only when they followed the most efficient and low-cost operating measures. In this radically new environment, airlines had to lower their costs to be competitive. This operating philosophy has been the cornerstone of many strategic decisions on reducing manpower, negotiating new labor contracts and outsourcing many functions to outside contractors. Costs associated with airplane acquisition and operations also had to be reduced. Many avionics manufacturers had to reorient their thinking from being technology-driven to market-driven. The new marketing strategy was to focus on essential avionics functions to reduce the costs to the users.[7]

The following example demonstrates how the new cost-cutting philosophy of airlines has affected the avionics industry. The development of satellite communications (SATCOM) systems is expected to make available to passengers such services as oceanic telephones, fax machines, computer modem hook-ups, television and others. Despite the many years spent in developing these systems, they are now being met with caution from airlines reluctant to incur their substantial cost (about $500,000 per shipset).[8]

Another example is Boeing's attempt to introduce an electronic library system on the new B777 airplane. The system would provide hyper-linked graphical presentations of aircraft maintenance manuals, diagnostic procedures, wiring diagrams, minimum equipment lists and instrument approach charts, and memory to operate advanced graphical cabin entertainment systems as well as a host of additional features and benefits. Because of the high cost of the system (some $1 million per shipset), it is not likely to be installed on any aircraft soon.[9]

Finally, the ultimate technical advance for low-visibility approach operations (enhanced or synthetic vision systems for operations at runways not certificated for Category III operations (remain completely outside airlines' budgets and financial plans. Systems of this type would make diversions virtually obsolete, while saving billions of dollars in airport infrastructure improvements. Yet, airlines have demonstrated very little interest in these systems because of their prohibitive costs.

Throughout the early 1990s, airlines pushed back deliveries of most new airplanes on order, and canceled others.[10] Avionics manufacturers, who often rely on sales related directly to purchase of new airframes for as much as 80 percent of their business, have experienced serious economic downturns as a result of delayed deliveries. Airlines also have begun delaying the purchase of capital items not required for basic operations, and have set new standards for selection of aircraft equipment, including avionics. It appears that airlines will invest in avionics equipment only if it will help fly passengers more safely, faster, on time, and, at the same time, is cost-effective.

On the other hand, the cost-cutting strategies of airlines can offer some new opportunities for avionics manufacturers to provide maintenance service. Assuming an airline elects to maintain B767 avionics systems (for example, up to twenty airplanes), an additional investment of $2 million is required for test equipment, $3 million for a service parts inventory and additional funds are needed for training technical personnel.[11] Given the high reliability of modern avionics equipment expressed in mean time between failures (MTBF), it appears more advantageous for airlines to contract this service to avionics suppliers. Amortization of high capital costs associated with acquisition of test equipment and parts is poor. And, airline technicians are generally unable to maintain technical competency on units they see only rarely; so the costs of training increase while the productivity that results from good training remains low.

THE CHANGING MARKET STRUCTURE OF THE AVIONICS INDUSTRY

Just as profit-starved airlines sought shelter through a strategy of buy-outs and mergers, avionics manufacturers, who have found themselves without adequate capital to advance their product lines, have followed the same path. In 1973, the North American Rockwell conglomerate purchased the Collins Avionics Company, and became Rockwell International. Collins retained its identity as the Collins Avionics Division of Rockwell International. The acquisition at that time supplied Collins with the capital needed to enter the highly competitive airframe systems/seller furnished equipment (SFE) market.

Allied Chemical purchased Bendix in 1982 and in 1984, Allied-Bendix purchased the King Radio Company. AlliedSignal was formed as a result of a merger with Signal Corporation in 1985.[12] In 1992 Bendix formed a team with Dassault of France, in which Dassault offered a high gain SATCOM antenna subsystem and Bendix, not a SATCOM supplier, primarily offered domestic U.S. marketing contacts. The Bendix name officially disappeared in 1993.

Throughout the late 1980s and early 1990s, Collins, with 70 percent market share, struggled with a bleak financial outlook, due to a projected downturn in new airplane orders. Collins teamed with Ball Aerospace to provide the directional antenna, a key element in its traffic alert and collision avoidance product (TCAS). Later, Collins again teamed with Ball Aerospace to provide high-gain and low-gain antenna subsystems, and a Class A high-power amplifier for its SATCOM system.

In the 1970s, Sperry Flight Systems purchased the division of RCA that manufactured air transport weather radar systems. Honeywell purchased Sperry Flight Systems in 1986 and, in 1992, Westinghouse, looking for market opportunities and applications for its military avionics products, teamed with Honeywell to jointly offer a commercial version of the Westinghouse military weather radar system, modified to perform the predictive windshear detection function. Alliances and teaming arrangements of this type were intended to save investment dollars by combining areas of complementary expertise among manufacturers. On balance, these arrangements have not worked due primarily to a lack of control and coordination among the participants. Different program priorities have produced schedule interruptions and occasional failure to meet airline schedule requirements. Different levels of funding and commitment have often led to inconsistent after-sale support.

In the meantime, dominance of the avionics industry by U.S. firms started to lessen. The success of the Airbus consortium led inevitably to European public support for avionics system development. A consortium of European avionics firms, which previously addressed only military needs, organized to produce supplier-furnished equipment (SFE) for the Airbus line of airplanes. These firms included Thompson CSF, Sfena, EAS, and Crouzet. They merged to form Sextant Avionique and placed 50 percent of their shares with Aerospatiale. Sextant began producing buyer-furnished equipment (BFE) for the avionics markets in the mid-1980s, and is expected to increase its market share in the late 1990s. In 1993, Northwest Airlines announced a joint development program with Sextant to develop an integrated optical system for low visibility approaches. If such a program achieved even moderate success, the entire Northwest fleet would be outfitted with these advanced European avionics.

AN OUTLOOK OF THE AVIONICS INDUSTRY

Reductions in military R&D budgets, combined with cost-cutting strategies of airlines will likely impact the technological development and innovations in avionics. Products may be somewhat more mundane, and new technologies will be implemented at a much slower pace. New operating systems such as the Future Air Navigation System (FANS), Communication-Navigation-Surveillance/Air Traffic Management (CNS/ATM), Automatic Dependent Surveillance-Broadcast (ADS-B), and Free Flight are not being implemented smoothly, activation estimates varying from one period to the next. Future developments in avionics technology include low-visibility approaches to replace existing instrument landing system; satellite-based area navigation (point-to-point) systems to replace existing enroute navigation facilities; and reducing oceanic lane dimensions to increase the availability of economical routings in oceanic regions, particularly the North Atlantic.[13] The U.S. Global Positioning System (GPS) and the Russian GLONASS satellite constellations offer broad foundations for these systems. The Global Navigation Satellite Systems (GNSS) provide the geometry for four-dimensional navigation: position (latitude and longitude), altitude, and speed. GNSS provides extremely accurate area navigation over land or water. Airborne receivers are becoming available at prices that are kept low by aggressive competition, while multi-mode receivers (MMRs) are being installed to accommodate both gradual implementation of GPS domestically, and European-specific landing systems (MLS) simultaneously.

GNSS also is potentially accurate enough for uses in instrument approaches.[14] Potential accuracy refers to codes that once were available only to the military and now are being made available for commercial use, as well as "differential" geometry applications GNSS, combined with autoland and an enhanced or synthetic vision system (e.g., multi-modal radar), could be the all-weather landing system of the future. It also would reduce or eliminate the need for extremely expensive capital investments in airport infrastructure, obviating the need to build Category III runways and higher quality ground-based radio beacon systems. Finally, GNSS accuracy can allow linking back satellite coordinates via SATCOM data to coastal air traffic control facilities, where the information can be displayed on pseudo-radar (a display system based on vector coordinates derived from GPS position). This will result in reducing oceanic lane dimensions from the current 60 nautical miles to five miles horizontally and from 2,000 feet to 1,000 feet vertically. These requirements are manifest in new standards for Required Navigation Performance (RNP) and Reduced Vertical Separation Minima (RVSM).

In the area of communications, it is expected that much routine voice traffic between air traffic control and air transport flight crews will be replaced by digital data link messages generated by ground-side and on-board airborne computers. Canned messages will be uplinked to the airplane or downlinked from the airplane in the data link service, processed on the receiving side and displayed to the recipient. It is as yet undecided whether this technology will be in the L-band or conventional VHF range.

All new technologies will have to be introduced in a cost-effective manner. No matter how critical or desirable a new capability may appear, it will not be accepted by airlines unless the price of acquiring it is justified by cost-savings. It is estimated that the investment needed to continue and complete the technology applications described above could exceed $1 billion. Avionics manufacturers do not have the capital available, and do not expect to in the near future.

One conjecture foresees the takeover of avionics firms by airframe manufacturers, which may draw little objection from the antitrust community. Should it occur, it would constitute one of the most significant changes ever to take place in the U.S. commercial aviation industry. Freedom of choice of avionics, a long established and coveted principle among airlines, will likely disappear. More highly integrated systems may be produced by airframe manufacturers at a lower cost than today's more discrete units. ARINC standards probably will cease to exist under such an arrangement, as an airframe manufacturer will design avionics with less concern for interchangeability with a competitor's airplane.

The first sign that the industry is moving in this direction already has appeared in the form of the Boeing 777's AIMS Cabinet architecture developed by Boeing. Taking advantage of continued component-level miniaturization and circuit-level integration, the B777 avionics systems architecture is built around an avionics integrated management system: AIMS Cabinet. It contains a number of avionics functions in the form of plug-in modules; previously these were built as individual boxes. These functions include the flight management system (FMS), display generation, airline communications addressing and reporting system (ACARS—a VHF data link system), the central maintenance computer (CMC), the thrust management computer (TMC), and the data acquisition functions performed by the digital flight data acquisition unit (DFDAU). Airlines who purchase the B777 are acquiring plug-in modules instead of discrete units as spares for these systems.

This architecture signals a dramatic change in the way avionics maintenance will be performed at the line and depot levels. It raises new questions regarding how such units are to be certified, updated and configuration-controlled. As avionics functions become less discrete and are represented more by generic modules plugged into a cabinet designed as SFE hardware, avionics will become commodity-like in the marketplace. As barriers to entry are lowered, traditional avionics suppliers may have to continue downsizing, or, as suggested earlier, may become targets for acquisition by the airframe manufacturers. This may signal the end of an industry dominated by the United States throughout the history of aviation.

CONCLUSIONS

The aviation industry is slowly but surely changing its character. As airlines restructure, what they ask of, and how they relate to their suppliers (including avionics manufacturers) will greatly change as well. In particular, the avionics industry is facing many challenges as a result of airlines' reluctance to invest in new technologies and the possibility that airframe manufacturers will take over this industry. To survive and thrive, avionics manufacturers will need (1) a comprehensive understanding of their customers (especially their economics and underlying needs), (2) an objective capability assessment-measured against the emerging set of customer requirements, and (3) a thorough appraisal of partnerships and alliances to assess their impacts on cost and non-economic factors like quality and flexibility. A careful assessment of risk and overall strategic ramifications is also essential.[15]

In order to survive in the 1990s and beyond, avionics firms will have to develop innovative marketing strategies. They will need a complete understanding of how each airline customer operates (e.g., customer's priorities, desires and requirements.) AlliedSignal, for example, has developed a new custom display development system which supports fast and cost-effective design of primary (EFIS) flight displays customized to customer requirements.[16] Avionics firms will need to provide complete service packages to airlines, including spares leasing and contract maintenance. They also can exploit the new market opportunities for technically upgraded retrofit equipment to extend the lives of older airplanes for several more years. An example is Northwest Airlines program to modernize its DC-9 fleet by retrofitting Stage III noise kits, FAA-required aging aircraft modifications, new interiors, and updated avionics systems.

Avionics manufacturers also can seek and develop meaningful strategic alliances with other U.S. and foreign firms. Manufacturers must base strategic alliances on what they bring to the market, not solely on what they bring to each participating firm. These emerging trends will change the business environment of the avionics industry from a strongly autonomous operation to one of complex interdependence.

GLOSSARY OF ACRONYMS

AVIONICS	Aviation electronics
ARINC	Aeronautical Radio, Inc.
CRT	Cathode Ray Tube
LCD	Liquid Crystal Display
CAB	Civil Aeronautics Board
FAA	Federal Aviation Administration
DME	Distance Measuring Equipment
FMS	Flight Management System
NM	Nautical Miles
EICAS	Engine Indication and Crew Alerting System
EEC	Electronic Engine Control
FADEC	Fuel Authority Digital Engine Control
SFC	Specific Fuel Consumption
R&D	Research and Development
IFR	Instrument Flight Rules
SATCOM	Satellite Communications
MTBF	Mean Time Between Failure
SFE	Seller Furnished Equipment
TCAS	Traffic Alert and Collision Avoidance System
ACARS	ARINC Communications Addressing and Reporting System
DFDAMU	Digital Flight Data Acquisition and Management Unit
BFE	Buyer Furnished Equipment
GPS	Global Positioning System (U.S.)
GLONASS	Global Navigation Satellite System (Russian)
GNSS	Global Navigation Satellite System (Generic)
AIMS	Avionics Integrated Management System
CMC	Central Maintenance Computer
TMC	Thrust Management Computer
DFDAU	Digital Flight Data Acquisition Unit
EFIS	Electronic Flight Instrument System

ENDNOTES

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