

FAA'S DESIGN APPROACH TO A GLOBAL DATA LINK SYSTEM

Ephraim Shochet, Ph.D

Federal Aviation Administration Technical Center
Atlantic City International Airport, NJ 08405

ABSTRACT

This paper describes three key features of the design approach that the FAA has chosen to achieve the vision for a global Data Link system. Although the FAA's overall system design is committed to change and evolution, there are, nevertheless, certain features of the approach which are relatively fixed. We have called this the structure of FAA's design approach. These relatively fixed features are (1) evolutionary Data Link improvement, (2) extensive use of end-to-end, high fidelity simulation, and (3) a coherently integrated system design.

THE END STATE

Data Link system planners have envisioned that by the early part of the 21st century digital air/ground Data Link will have become the primary medium for routine communications among users of the National Airspace System (NAS). Within the context of this vision, air traffic clearances and instructions will be transferred and negotiated by Data Link, and when accepted by the pilot, directly fed into the aircraft's flight management system. In addition, Data Link will support the introduction of advanced air traffic control (ATC) automation by creating a channel for direct two-way communication of complex information between the ATC ground computers and the aircraft's

flight management system. When used to support a global position monitoring capability, Data Link, it is thought, will be the basis for an ATC system that provides consistent and homogeneous services across oceanic and domestic airspace.

Beyond its role as a direct means of communication between controllers and pilots, it is envisioned that Data Link technology will enable future ATC automation systems, such as the Advanced Automation System (AAS), the Automated En Route Air Traffic Control (AERA) System and the future Air Traffic Management System (ATMS), to provide their full potential for increasing safety and efficiency of the NAS.

The key issue is this: How is it possible to subject all these systems and factors to prediction and control in order to achieve the ultimate objective, which is to improve the safety and efficiency of the future air traffic system? Clearly this is an immense demand. There is an extraordinary complexity involved which will require unparalleled degrees of effective planning and control.

EVOLUTIONARY DATA LINK IMPROVEMENT

The FAA approach to the design, development, and implementation of a global Data Link system is based on the principle of evolutionary Data

Link improvement. For example, the FAA Data Link Applications Program Plan includes the following examples of Data Link applications that will yield incremental benefits: (1) two way Data Link that will support ATC communications in the Oceanic, En Route, and Terminal Airspace; (2) advanced air traffic management applications that will extend the basic two-way Data Link capability to include the exchange of trajectory information; (3) enhanced tower Data Link services that will automate additional routine communications; and (4) weather oriented flight information services.

Evolutionary Data Link improvement is fundamentally different than either the "giant-step" approach or "piecemeal" approach to system design. In the giant-step approach, the complete system is designed from the specification, and a detailed implementation plan is developed. The system procedures are also defined, and the total system is then deployed. The drawbacks of this approach are (1) the immediate and large capital investments, (2) simultaneous integration of the system into existing operations, and (3) the likely disruption of existing operations caused by problems in training, definition of procedures, and possible equipment problems.[1]

At the other extreme is the piecemeal approach. In this case, specific parts of the system which are closely connected are independently designed, and put into operation one at a time. The "system" that would eventually result would be a conglomeration of fragmented individual designs. The coherent integration of the individual parts into the whole would be very unlikely. Thus, significant redesign and patching of the system would be needed in order to achieve an integrated, effectively functioning system. As one writer put it, "The biggest problem with the piecemeal approach is the one that can only be seen over the longest time

perspective. You simply cannot take a complex high technology system and change it weak link by weak link. The separate fixes do not, in the aggregate add up to a modern efficient system, but to a patchwork quilt."[2]

Between these two extremes of design methodology is the FAA's evolutionary approach. Using this approach, the FAA plans to implement Data Link equipment and procedures, step by step, in successive and realistic stages. As a result, investment in Data Link technology will be gradual. New airborne and ATC Data Link functionality will be deployed in an incremental manner, thus causing no serious disruptions to system operations, safety, and efficiency of the NAS, while at the same time continually improving the total system effectiveness. The training of ATC personnel in Data Link technology and procedures will be carefully timed to help ensure a smooth transition. Thus, the approach is to introduce new Data Link hardware, software, and procedures in an accelerated but orderly evolutionary manner. The portions of the Data Link system that are implemented at any one stage must be critically examined to insure the smooth integration of Data Link functionality into the NAS.

Perhaps most important is the fact that the FAA's evolutionary approach to Data Link development and implementation allows for the changing needs and specifications of the total system. While it is undeniable that, as portions of the Data Link system design are implemented, certain firm commitments in the system design do occur. However, the evolutionary approach implies that the rest of the system design must continue to adapt itself to changes in Data Link requirements, technological capability, and the availability of new equipment.

In the evolutionary approach, the objectives of the Data Link system are continually re-

inspected from the point of view of emerging new requirements, procedures, budgetary limitations, etc. The continual re-examination of the Data Link requirements in the light of new technology and equipment available to meet them should help to ensure an integrated Data Link system design. It is fully recognized that a changing NAS environment, the progressive advancement of equipment capability, and changing national economic conditions, will impact and transform the role of the Data Link system over the years. At the same time, commitment to a certain system design and equipment configuration certainly imposes some practical limitations such as the need to freeze system specifications. Nevertheless, the evolutionary nature of the Data Link system should be considered at every stage of the system design and implementation.

EXTENSIVE USE OF END-TO-END, HIGH FIDELITY SIMULATION

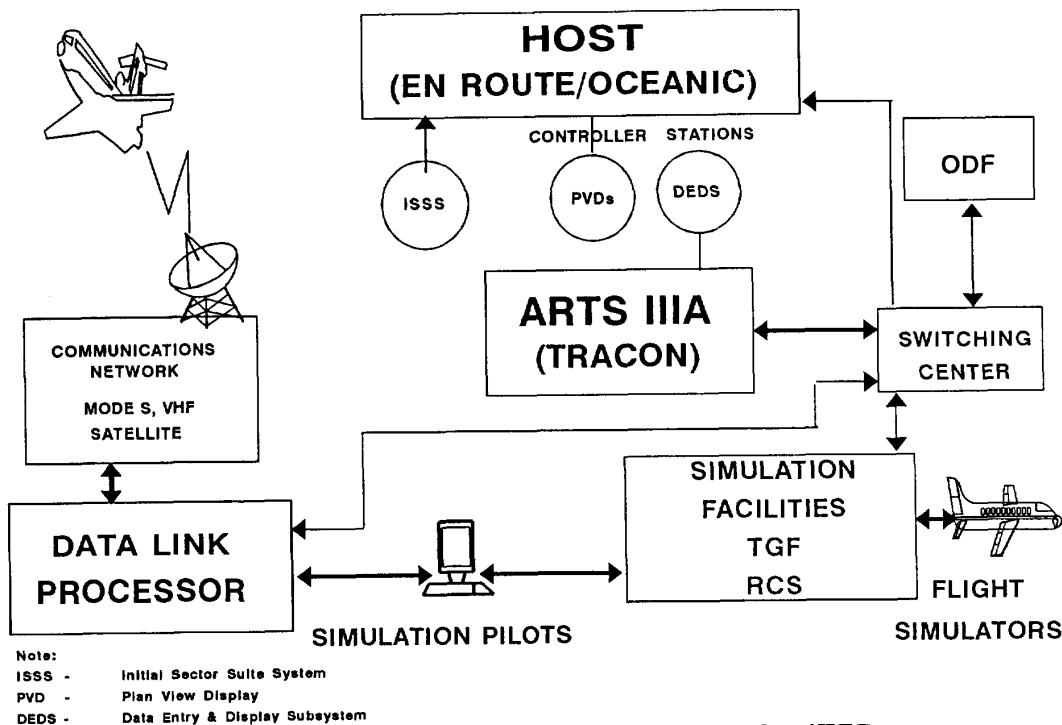
Another key feature of the FAA approach to the design of global Data Link system is the extensive use of end-to-end, high fidelity simulation. This methodology represents the most comprehensive preoperational test of systems in an experimental environment. Furthermore, simulation has gained credibility in the FAA as a technique which can provide realistic answers to system performance and acceptability questions in a form that has face validity for FAA operational personnel. Real time simulation provides designers with a cost effective method to test overall system performance early in the design phase. Additionally, it provides a method for controllers, pilots, government, and industry representatives and other subject matter experts to evaluate system designs prior to operational implementation.

Therefore, the primary methodology for answering Data Link research questions will be

through the use of high fidelity, controller and pilot in-the-loop simulation. End-to-end simulation of Data Link will allow the evaluation of controller and pilot interaction on operational NAS systems. The simulations will investigate controller/flightdeck integration issues using candidate hardware and software configurations. Tests will incorporate the use of flight simulators to accurately evaluate controller/flightdeck integration and to assess system acceptance, workload, and performance. The evaluations will use professional controllers and airline pilots.

Much of the Data Link research will be conducted in the Data Link test bed at the FAA Technical Center using realistic ATC scenarios. The Data Link test bed is a laboratory facility which uses actual NAS equipment and simulation computers to create a system which is able to realistically exercise Data Link applications in an end-to-end fashion. As shown in figure 1, the test bed is composed of the NAS En Route Laboratory, the Automated Radar Terminal System (ARTS) IIIA Laboratory, the Target Generation Facility (TGF), the Data Link Laboratory, the Reconfigurable Cockpit System (RCS), and the Oceanic Development Facility (ODF). As systems are developed for the terminal, en route and oceanic environments, interfacility simulations will be conducted to test questions associated with the transfer of aircraft between airspace.

Human factors research will target those issues associated with the integration of airborne and ground-based functions, and on testing Data Link applications in terms of their impact on controllers, flight crew, and the safety and efficiency of the air traffic system. This research will iteratively test and develop candidate pilot and controller interfaces and communication procedures for Data Link applications.



**FIGURE 1. FAA TECHNICAL CENTER
DATA LINK TEST BED**

Research into the psychophysical limitations of pilots and controllers must determine the phases of flight and ATC operational environments where specific Data Link applications provide enhancements in terms of safety and efficiency, as well as situations where Data Link could threaten safe operations or detract from the expeditious flow of traffic. Such research will be conducted in high fidelity simulation, during which pilots and controllers can experience and react to the flow of events that occur on the ground and in the air as Data Link applications are exercised. These evaluations will assess the impact of the test packages on pilot and controller performance and workload as well as an overall system performance.

COHERENTLY INTEGRATED SYSTEM DESIGN

The success of the Data Link system as an integrated whole is the primary objective. Thus, the third feature of FAA's design approach repeatedly emphasizes the necessity for coherent system integration. Since aircraft need communications wherever they go, Data Link applications must be developed to efficiently function across national boundaries, over the ocean, and across all ATC environments. This will require a large scale compatible Data Link communications system for international ATC. To accomplish this, the FAA must participate with the international aviation community, insuring compatible two-way Data Link

applications and integrated flight deck avionics. Therefore, a primary research and development task is to complete the development of a homogeneous or "seamless" two-way Data Link capability across all boundaries.

Since there are significant operational differences between the Data Link services required for tower, terminal, en route and ocean environments, the objective is to effectively accommodate all of these differences and yet build a global capability which appears seamless across all environments and boundaries, and which can be utilized by a single system of Data Link avionics. Accordingly, Data Link functionality will be integrated into the Host/PVD, ARTS IIIA, Tower Data Link System (TDLS), and the oceanic environment, and into the emerging elements of the AAS-ISSS, Terminal Advanced Automation System (TAAS), and Tower Control Computer Complex (TCCC).

As pointed out in the FAA Data Link Applications Program Plan, Data Link applications must accommodate a wide range of user needs, including those associated with air traffic management, flight information services, communications/navigation/surveillance, cockpit display of traffic information, automatic dependent surveillance, etc. In addition, there are a number of automation programs that have significant Data Link requirements such as Airport Surface Traffic Automation (ASTA)/Airport Movement Area Safety Systems (AMASS), Terminal ATC Automation (TATCA), AERA, Oceanic, Flight Operations and Air Traffic Management Integration (FTMI), etc. Therefore, the FAA plan is to develop Data Link applications that are compatible with other Data Link implementations across the NAS.[3]

The technical complexity of this task is increased by the fact that excessive integration of parts and

functions of the system can destroy the independent redundancy needed to prevent dangerous situations from occurring. As pointed out by Braverman, in many situations the required level of safety will dictate that not only should two parts of the system not use common equipment but that they should use different techniques and be in different locations under different environmental conditions.[4]

CONCLUSION

It is not possible to predict the events which might alter the vision for Data Link by the 21st century. Therefore, a flexible but controlled approach to the future is favored, where the design objectives are sensitive to the variable nature of exceedingly complex open systems such as Data Link. The FAA's approach to Data Link system design is, therefore, committed to a definite course of action with the end state clearly in mind, yet open to adjustment and change.

REFERENCES

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