
Air Traffic Control Development at Lincoln Laboratory

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■ Lincoln Laboratory—developed air traffic control technologies, which were described in the Fall 1989 issue of this journal, are now in operational use. These technologies include the Mode-Select beacon system, the Traffic Alert and Collision Avoidance System, the Precision Runway Monitor system, the Terminal Doppler Weather Radar, and the Moving Target Detector signal processor used in the current generation of Airport Surveillance Radars. Our newest efforts focus on utilization of the Global Positioning System for both navigation and surveillance, and on the development of automation aids for air traffic control and management.

SINCE THE PUBLICATION of the first *Lincoln Laboratory Journal* special issue on Air Traffic Control in 1989, several systems developed by Lincoln Laboratory have come into operational use. The Traffic Alert and Collision Avoidance System (TCAS) described in William Harman's 1989 article is now installed on all scheduled passenger airliners that carry over twenty-nine passengers in the United States. Several "saves" (avoided near misses or collisions) have been credited to TCAS by pilots. The problem of the interaction between the automatically generated maneuver advisories and the normal air traffic control process was underestimated, but this problem has been mitigated by providing more training for the air traffic controllers affected, and it will eventually be solved by automatic display of resolution advisories to the controllers. A version of TCAS for smaller airliners is now being deployed. A more advanced TCAS, which will support horizontal as well as vertical avoidance maneuvers and which will use a GPS-based form of Automatic Dependent Surveillance rather than aircraft-based interrogation, is now under development. This advanced TCAS is discussed in the article by Douglas Burgess in this issue.

The Mode S beacon system described in Vincent Orlando's 1989 article is now in active deployment

with eight interrogator sites fully commissioned out of a total of 148. All of the large airliners in the United States now have Mode S transponders as a consequence of the installation of TCAS equipment. The article by Steven Bussolari in this issue describes how Lincoln Laboratory is working with UNISYS to exploit the data-link capability of the Mode S system to provide automated information services to the pilots of general-aviation aircraft. Vincent Orlando's article on the Global Positioning System (GPS) Squitter shows how the Mode S transponders will be used (exploiting a concept first promulgated by Paul Drouilhet, Jr.) in conjunction with GPS to provide Automatic Dependent Surveillance.

The primary radar technology described in the 1989 article by Melvin Stone and John Anderson is now widely deployed in the Airport Surveillance Radar 9 (ASR-9) built by Westinghouse Electric Corporation. James Pieronek's article in this issue describes an upgrade to the ASR-9 that incorporates more recent technology and algorithms into the radar by using a cleverly engineered replacement of circuit boards. The new processing capability improves the traffic-handling and fixed-clutter-rejection capability of the ASR-9 and provides a means of dealing more effectively with a changing clutter environment (e.g.,

highway traffic, anomalous propagation, and birds).

The Parallel Runway Monitor (PRM) work described by Raymond LaFrey in 1989 has resulted in a reduction from 4300 feet to 3400 feet of required runway separation for independent simultaneous operation of parallel runways in bad weather. The article by Eric Shank in this issue shows how this reduction in separation can be done safely by using better monitor sensors and displays and an automated alarm system. The PRM design was recently put into service at the new Denver International Airport to support triple-runway simultaneous IFR approaches.

The Terminal Doppler Weather Radar (TDWR) built by Raytheon and now commencing to provide wind-shear protection at forty-five airports in the United States incorporates the Lincoln Laboratory-developed clutter-detection and microburst-detection algorithms described in the 1989 special issue of the *Journal*. The article on TDWR by James Evans and David Bernella in this issue describes subsequent field demonstrations to validate the Raytheon design and examine performance in additional meteorological regimes; the article also describes assistance in site adaptation for the operational TDWRs.

The principal current focus for terminal aviation weather research at Lincoln Laboratory is the reduction of delays caused by weather and the prediction of hazardous weather phenomena by integrating data from various terminal-area sensors (e.g., Doppler weather radars, surface sensors, aircraft measurements, and lightning data). An overview article by James Evans and Elizabeth Ducot describes the motivation for and design of the Integrated Terminal Weather System (ITWS) as well as the results of initial ITWS operational testing at major airports. Additional articles by Marilyn Wolfson, Edward Chornoboy, and Rodney Cole describe the ITWS algorithms for predicting microbursts, tracking storm cells, and determining the winds aloft throughout the terminal area. Tests using the Lincoln Laboratory ITWS prototypes have conclusively demonstrated that a significant reduction in delays caused by thunderstorms can be achieved at major airports.

Prevention of collisions involving aircraft on the airport surface is the subject of three articles in this issue, one by James Eggert and two by Harald Wil-

helmsen. Some of the algorithms developed for the Lincoln Laboratory demonstration of the Runway Status Light System at Logan International Airport in Boston have been licensed to Raytheon for incorporation into a system currently being installed in India.

The aviation infrastructure in the United States is undergoing a major transition characterized by the use of automated systems to increase capacity, reduce delay, and improve equipment maintenance. Automated advisories to pilots from the TCAS system are now in use; automated alarms are part of the PRM and the Surface Traffic Automation programs that are now being installed. The restructuring of the en route air space—the “free flight” concept—will be supported by an automated system to detect and resolve conflicts between aircraft. An early simulation effort, described in the article by Martin Eby, shows that an en route “free flight” environment does not require frequent course changes to ensure safe separation. The major difficulties to be overcome are the maintenance of system safety and the devising of workable transitions to the restructured operations. A development program to provide automation aids for runway assignment and aircraft sequencing to terminal air traffic controllers is discussed in the article by Herman Vandevenne. The application of machine-intelligence techniques developed for the maintenance of military communications systems to the air traffic control radar and communications infrastructure is discussed in the article by Harold Heggstad.

The work reported in this issue was sponsored by the Federal Aviation Administration. There are two hundred people in the three groups that comprise the Lincoln Laboratory effort in Air Traffic Control. We appreciate the opportunity to work on such interesting and important technical problems.

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