Air Traffic Control at Lincoln Laboratory

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It is perhaps fitting that I write the foreword to this issue of the *Lincoln Laboratory Journal* as I wait in an airport lounge, my flight through Chicago delayed by a fast-moving winter storm. From my seat near the window, I can see a long line of aircraft waiting to be de-iced before entering the runway complex. On top of the air traffic control tower, the rotodome of the Airport Surface Detection Equipment (ASDE) skin track radar is spinning, and I imagine that the controllers inside are paying particular attention to their surface traffic displays as the visibility deteriorates. Although the intensifying snow blocks my view of it, the ASR-9 airport surveillance radar is providing the terminal air traffic controllers with the location, identity, and altitude of arriving and departing aircraft. Along with the ASR-9, the Terminal Doppler Weather Radar (TDWR) and Next Generation Weather Radar (NEXRAD) are providing reflectivity and Doppler information to the forecast algorithms in the Integrated Terminal Weather System (ITWS) and Corridor Integrated Weather System (CIWS) to help air traffic managers make traffic routing decisions.

The surveillance and weather technology in these operational systems reflects the success of thirty-five years of work in Air Traffic Control at Lincoln Laboratory. Yet the fact that my flight has been delayed ninety minutes is a reminder of how far we have yet to go. The articles in this issue describe recent developments in surveillance and weather technology that have significantly improved the safety and efficiency of air transportation and provide a look ahead to the development of a safer and more delay-resistant air traffic control system.

The basis of our nation's air traffic control system is an accurate and timely picture of the airspace, including the precise location and identification of aircraft and the current and future weather phenomena that affect their flight. Three articles focus on this topic. In the article entitled "Surveillance Accuracy Requirements in Support of Separation Services," Steven Thompson and James Flavin present an approach to determine the fundamental aircraft surveillance requirements for aircraft separation and show how the improvements in beacon radar technology developed at the Laboratory can significantly increase airspace capacity. In the article entitled "Advances in Operational Weather Radar Technology," Mark Weber describes adaptive scan strategies and algorithms that take advantage of increased processing power to improve the weather detection performance of the TDWR and NEXRAD radars, particularly in the presence of complex storm environments. Advanced techniques for forecasting hazardous weather on multi-hour time scales are the subject of the article entitled "Advanced Aviation Weather Forecasts," by Marilyn Wolfson and David Clark.

It is easy to see how the traffic concentration at airports causes delay, particularly in the presence of hazardous weather. However, our operational experience with ITWS prototypes showed that delays were present even when that weather was far from the airport terminal area. In the article entitled "Corridor Integrated Weather System," James Evans and Elizabeth Ducot describe how the ITWS concept was expanded as a large-scale integrated system of sensors, forecast algorithms, and user displays to address these en route delays. The CIWS has been deployed in the nation's busiest air traffic corridor, where it serves as a prototype of the integrated sensing and decision support that will be required to manage air traffic more efficiently. Our operational experience with the CIWS prototype has taught us about the need for integration of weather forecasts with air traffic management, particularly as the latter becomes more automated. This topic is examined in the article entitled "Integrating Advanced Weather Forecast Technologies into Air Traffic Management Decision Support," by James Evans, Mark Weber, and William Moser.

The Laboratory's work in air traffic surveillance has long focused on the airport surface. With the increase in air traffic, runway incursions have become a significant safety concern. The article entitled "Operational Evaluation of Runway Status Lights," by James Eggert, Brad Howes, Maria Kuffner, Harald Wilhelmsen, and Jonathan Bernays, describes a system of lights on the airport surface, operated automatically with data from airport surface surveillance, which provides pilots with the situational awareness required to prevent dangerous runway incursions. The authors describe their experience with the operational use of the Runway Status Light System (RWSL) prototype at Dallas/Fort Worth International Airport.

The Departments of Transportation, Commerce, and Defense and NASA have formed the Joint Program Development Office to define the air traffic control system of 2025. That system is designed to accommodate a tripling of air traffic over the next ten to fifteen years while improving safety and reducing weather delays. As I wait for my delayed flight, that vision seems far off. At this moment, however, at airline dispatch centers and at Federal Aviation Administration facilities from the control tower to the System Command Center, traffic managers are using information from sensors and forecast systems developed at Lincoln Laboratory to decide when my flight might be released for departure. The work presented in this issue of the *Lincoln Laboratory Journal* provides the first steps toward that future system.

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