Looking Back

Conceiving Collision Avoidance

Lincoln Lab proved that unfeasible was not the same as impossible

When Congress held hearings in June 1979 on how to prevent midair aircraft collisions, the Federal Aviation Administration indicated that transponder-based surveillance was not technically feasible. At that time, Lincoln Laboratory was completing a new FAA air traffic control surveillance system designed to replace old technology. We understood transponder surveillance, and we took that testimony as a call to action.

A DC-9 collision with a Marine jet in California in 1971, which killed 50 people, heightened the urgency for a collision avoidance system using air-to-air surveillance. Airline prototypes with top-mounted antennas to minimize terrain multipath interference effects, new frequencies to avoid interference, and modern waveforms for timing accuracy worked, but were impractical because all existing planes would need expensive new equipment before the new system could detect them.

Aircraft orientation and airframe shielding cause independent variations in effective antenna gain that increase the effective transponder variance and help separate otherwise identical transponders. William Harman saw another important benefit: variable interrogation power would help filter out lower-power multipath reflections by causing transponders to reply only to interrogations near receiver threshold.

We encouraged the FAA to test this idea. In flight trials, they varied interrogation power with an RF attenuator that used a power diode with a digitally controlled bias voltage. But Laboratory engineers Ray LaFrey and Joe DiBartolo realized that such an attenuator would never be stable enough for the job. Indeed, problems with the attenuator’s resolution, instability, and speed caused the trials to fail—hence the pessimistic report to Congress.

That failure inspired Ray and Joe to develop a better attenuator. In 1980, DiBartolo worked with a commercial vendor to build a more stable unit that replaced the diode with an array of switched attenuators. With Dave Spencer, Dennis Callahan, and Bill Petrovick, they built a prototype that we could fly. Harman and Loren Wood used it over the next several years to refine the algorithms for tracking replies in the face of multipath and garble. The result was the Traffic Alert and Collision Avoidance System (TCAS), which has had remarkable success in preventing mid-air collisions.

—JERRY D. WELCH

Welch, a senior staff member at Lincoln Laboratory, led the Laboratory’s program to develop TCAS.