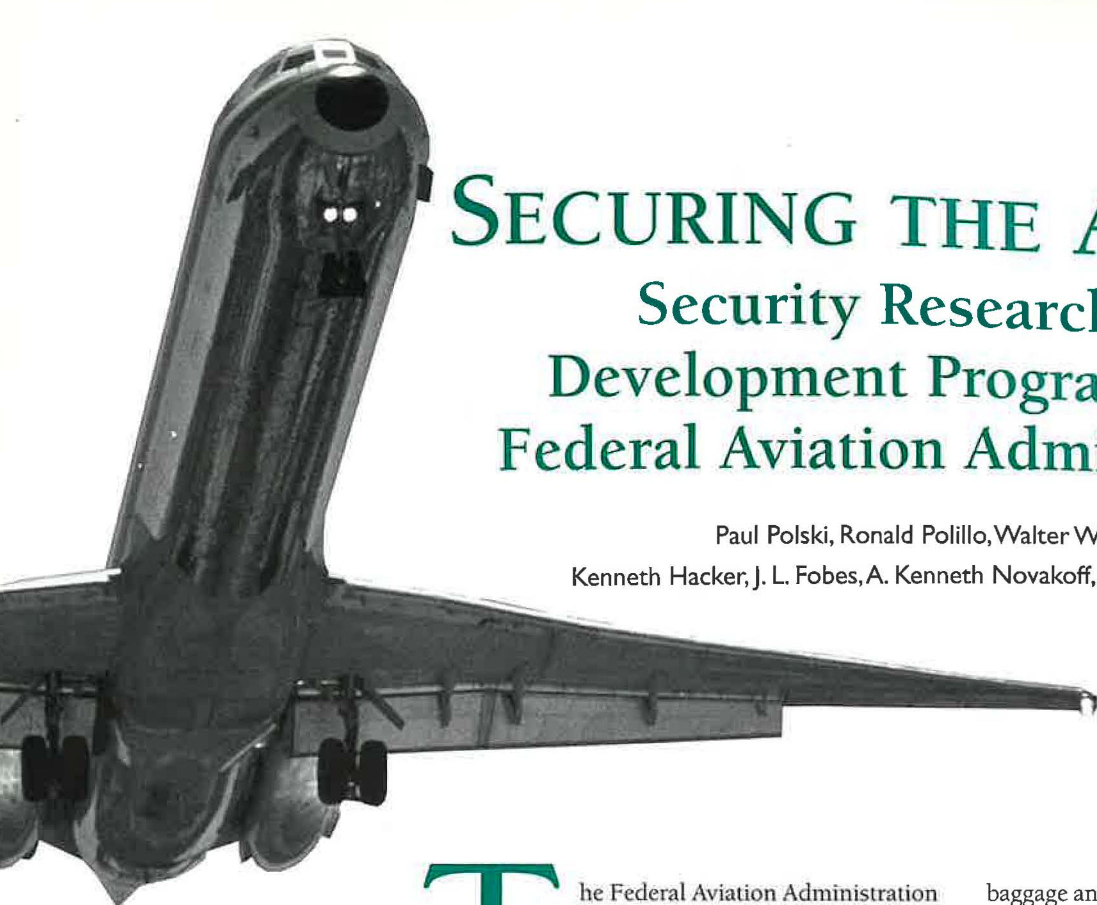

Securing the Airways

Security Research and Development Program of the Federal Aviation Administration

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The Federal Aviation Administration has been conducting aviation security research and development for the past 30 years. In the late 1970s these efforts focused on countering the hijacking threat, and included the development of weapon detection technologies and equipment. After a series of hijacking incidents in the 1960s and early 1970s, public and congressional interest in aviation security increased. In 1974 Congress passed the Antihijacking Act, which essentially established the FAA's responsibility for research, engineering, and development in the area of aviation security to counter the terrorist threat. The 1988 Undetectable Firearms Act fostered agency research and development for equipment to detect smaller nonmetallic weapons. Today the FAA serves as the lead agency for all U.S. government research in explosive and weapon detection.

As a result of the Pan American Flight 103 tragedy at Lockerbie, Scotland, in December 1988, the President's Commission on Aviation Security and Terrorism recommended that the FAA pursue a rigorous program in aviation security research, development, and deployment to counter the terrorist threat to the civil aviation system. The commission suggested more research and experimentation be performed on aircraft structures designed to minimize airframe damage caused by explosive devices that might escape detection and arrive on board the aircraft. A broad range of additional research areas was suggested, including the development of stronger security measures for controlling checked baggage and access to aircraft, the testing of security systems, the further development of explosive detection systems, the exploration of ways to maximize human performance, and the formulation of cooperative arrangements with other government agencies. The subsequent Aviation Security Improvement Act of 1990 confirmed this mandate by providing new authority for the FAA to strengthen aviation security through accelerated research and development. The agency intensified its research and development efforts accordingly, and in 1992 opened a new aviation security research laboratory at its William J. Hughes Technical Center in New Jersey.

The FAA's aviation security system has proven effective in meeting its original objective of countering the hijacking threat. It is recognized, however, that the nature of this threat is constantly changing, and that terrorists have grown increasingly sophisticated. Moreover, what was once primarily a foreign threat has now become a domestic threat as well, as evidenced by the Oklahoma City and World Trade Center bombings. Although the downing of TWA Flight 800 in August 1996 has not been shown to have resulted from a terrorist act, this incident further increased public awareness of terrorism, and caused both the White House and the FAA to reflect on the current threat and the best means of deterrence.

Shortly after the TWA tragedy, President Clinton created a White House Commission on Aviation Safety and Security, chaired by Vice President Gore. The president tasked the group to develop a strategy for improving aviation safety and security both domestically and internationally. In February 1997 the commission released its final report (*1*,p.3), stating:

> In the area of security, the Commission believes that the threat against civil aviation is changing and growing, and that the federal government must lead the fight against it. The Commission recommends that the federal government commit greater resources to improving aviation security, and work more cooperatively with the private sector and local authorities in carrying out security responsibilities.

The commission's recommendations (*1*,pp.25–27) on how to improve civil aviation security included the following:

- The federal government should consider aviation security as a national security issue, and provide substantial funding for capital improvements;
- The FAA should establish federally mandated standards for security enhancements;
- The FAA should implement a comprehensive plan to address the threat of explosives and other threat objects in cargo and work with industry to develop new initiatives in this area;
- The FAA should establish a security system that will provide a high level of protection for all aviation information systems;
- The FAA should work with airlines and airport consortia to ensure that all passengers are positively identified and subjected to security procedures before they board aircraft;
- The FAA should work with industry to develop a national program to increase the professionalism of the aviation security workforce, including screening personnel; and
- Access to airport controlled areas and physical security of aircraft must be ensured.

The commission made it clear that recent criminal acts against civil aviation have demonstrated an increasing level of knowledge among terrorists with regard to the design and deployment of improved explosive devices.

To meet this growing challenge, the FAA has created an aggressive security research and development program to develop technology and standards that can defeat the threat of terrorism and criminal acts targeting aviation. This program includes research, development, and test and evaluation activities in the areas of explosive/weapon detection, human factors, aircraft protection, and airport security technology integration.

Explosive/Weapon Detection

The FAA initiated its explosive/weapon detection program to improve the systems used in airports for screening checked and carry-on baggage, air cargo, mail, and passengers during the boarding process. The current systems are intrusive and labor-intensive. Therefore, the agency is working with industry to design computer-assisted systems that will be faster and more effective and provide uniform high performance. The challenge is greater than merely detecting a weapon or explosive; the challenge is to be able to distinguish weapons or explosives from the many items travelers pack in their luggage, and to do so quickly and efficiently and with a manageable level of nuisance alarms.

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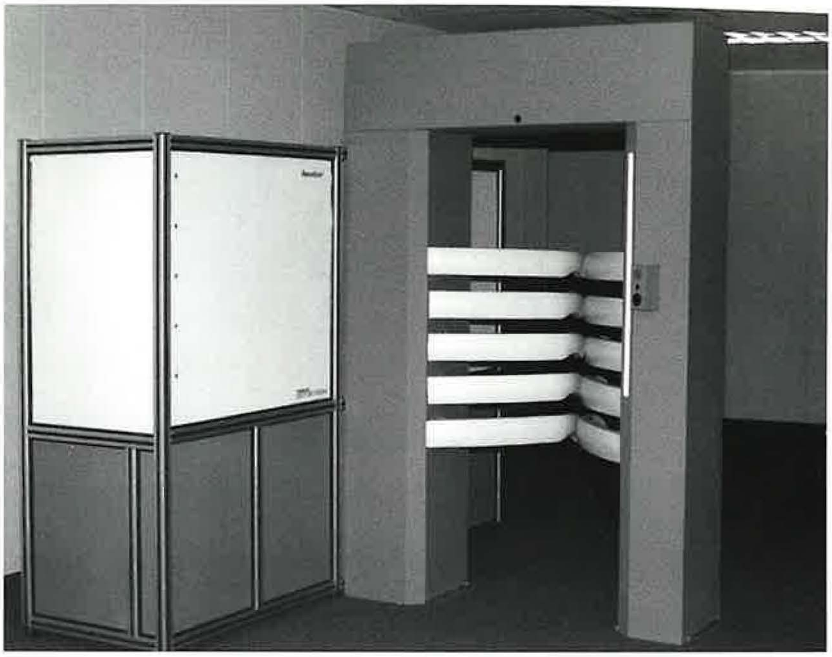
To achieve this goal, the FAA is pursuing the development of promising weapon/explosive detection systems and other aviation security technologies. New developments will also provide innovative techniques for improved use of existing detection systems. Currently the agency is investigating nuclear, X-ray, electromagnetic, mass spectrometry, chemiluminescence, and ion-based trace weapon/explosive detection technologies, among others.

An example of these efforts that demonstrates cost-saving technology transfer is the adaptation of computed tomographic X-ray imaging technology, first employed in the medical field, for use at airports. In 1994 the FAA certified the first explosive detection system (EDS) to meet its extensive criteria for inspecting checked baggage. Developed by InVision Technologies, Inc., of Foster City, California, under contract to the FAA, the CTX-5000 system initially uses transmission X-ray data to acquire an overall map of objects in baggage. It then uses strategic computed tomography from a revolving gantry X-ray to identify objects that could be explosives. A program for airport demonstration of the CTX-5000 EDS technology at San Francisco, Atlanta, and Manila has been under way for almost a year.



New trace detection portal for detection of weapons and explosives in passenger baggage under development by the Federal Aviation Administration at its William J. Hughes Technical Center, Atlantic City, New Jersey.

In September 1996 the White House Commission on Aviation Safety and Security recommended that the federal government purchase significant numbers of computed tomography detection devices, automated X-ray machinery, and other innovative weapon/explosive detection devices to be placed in airports. Congress subsequently approved the president's budget amendment of $144.2 million for the purchase and installation of state-of-the-art baggage-screening equipment and other aviation security improvements at major U.S. airports.

In October 1996 the secretary of transportation announced that the FAA had established a Security Equipment Integrated Product Team to carry out the mandate of acquiring advanced security equipment.[1] This is the first of the FAA's integrated product teams to include members from the airlines and airport authorities that will ultimately own and operate the equipment to be acquired. The team has awarded three contracts to date. In December 1996 it awarded a $52.2 million contract for 54 FAA-certified computed tomography explosive detection systems, the InVision CTX-5000-SP. In May 1997 the team purchased $12.2 million worth of trace detection security equipment from Thermedics Detection, Inc. of Chelmsford, Massachusetts; Barringer Instruments, Inc. of New Providence, New Jersey; and Ion Track Instruments of Wilmington, Massachusetts. In August 1997 the FAA announced the purchase of $7.3 million worth of explosive detection equipment for screening checked baggage from Vivid Technologies of Woburn, Massachusetts, and EG&G Astrophysics of Long Beach, California. In addition, two systems engineering and integration service contracts were awarded to Raytheon Service Company and Lockheed Martin C^2 Integration Systems Division to provide planning, installation, training, and testing for the equipment purchased by the team.

By March 1998 the integrated product team expects to award up to five additional contracts for trace weapon/explosive detection devices, three contracts for automated X-ray devices, and two contracts for quadrupole resonance systems. Trace detection equipment installation began in December 1996, and the first CTX-5000 machines were installed at John F. Kennedy International Airport in New York and O'Hare Airport in Chicago in January 1997. Final equipment deliveries under the InVision contract will be made by December 1997.

Human Factors

Placing weapon/explosive detection equipment at airports is an important step, but it is also necessary to ensure that the personnel who operate that equipment are properly trained and qualified. To improve the selection, training, and performance monitoring of airport security screeners, the FAA has developed the Screener Proficiency Evaluation and Reporting System. This system can help select applicants likely to be successful, provide computer-based training (CBT), and maintain screener proficiency by projecting images of dangerous articles and determining whether the screener correctly detects the threats. The FAA is testing the system at 19 major U.S. airports to determine its cost-effectiveness under operational conditions at major airports. In addition, to optimize the contributions of checkpoint screeners to overall security system effectiveness, the FAA recently awarded grants to nine U.S. air carriers for the

[1] The FAA's integrated product teams bring together representatives from a variety of functional disciplines, such as research specialists, airway facilities and logistics personnel, testing and contract personnel, system and specialty engineers, lawyers, and others, to focus exclusively on delivering products. The teams have life-cycle responsibility for their products. This responsibility extends from applied research through acquisition and beyond, to the point of ensuring that products are up and working properly after they have been delivered and installed in the field.

purchase and operational evaluation of both CBT and threat image projection software.

A CBT system is being developed to train airport preboard screeners in all of their job responsibilities, with an emphasis on detection of improvised devices using conventional X-ray equipment.[2] The FAA has also funded the development of a separate CBT system to train screeners in the use of the CTX-5000 explosive detection system to scan checked luggage for improvised explosive devices. The potential benefits of CBT are self-paced learning, enhanced opportunities for realistic practice, reduced overall training time, combined training and performance testing, and consistency of instruction.

Threat image projection software provides the capability to insert fictional threat images into X-ray and CTX image displays of actual passenger bags. It exposes screeners to threat images on a selected or random basis, in part to train them to become more adept at detecting threats. Most important, the unpredictable insertion of fictional threats throughout a duty cycle enhances screener vigilance, which is essential since actual bombs are relatively rare. The threat image projection software also provides screener assessment reports and records and maintains operations history.

Another major challenge to enhancing domestic aviation security stems from the seemingly overwhelming number of passengers and flights. Applying to all passengers security procedures beyond those now in place will be difficult because of cost, logistics, and system availability. However, a significant increase in security can be quickly obtained if the number of passengers needing special additional security treatment can be reduced to a small percentage of those traveling. Passenger profiling systems are one potential means of screening the vast majority of air travelers, and the FAA has been working closely with Northwest Airlines to conduct research and development on such systems.

The profiling system planned by the FAA and currently under development is passive in that the information considered is not obtained directly from passengers. The FAA's approach focuses on passenger data associated with airline reservation systems. Northwest Airlines is finalizing a Computer Assisted Passenger Screening (CAPS) system on the WorldSpan computerized reservation system. The process will be made as generic as possible, and the airline will support the modification of CAPS to run on other airlines' computerized reservation systems.

Aircraft Protection

The FAA initiated its aircraft hardening program in 1990 in response to directives of the President's Commission on Aviation Security and Terrorism and mandates set forth in the Aviation Security Improvement Act of 1990. The overall objective of the program is to protect commercial aircraft from catastrophic structural or critical system failure due to an in-flight explosion. Secondary objectives are to investigate vulnerability to interference with the aircraft electronic systems from spurious electromagnetic or high-energy signals and to assess the threat posed by manually operated, highly mobile surface-to-air missiles.

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To accomplish these objectives, researchers are working to determine the minimum size of explosive that would result in aircraft loss. They are also studying ways of decreasing vulnerability to explosive effects, as well as threats from electromagnetic interference, projected energy, and surface-to-air missiles, that can be applied to the current and future fleet of commercial aircraft. To obtain the best information possible, the FAA is working with experts in the fields of engineering and explosive research from the Department of Defense and private industry, as well as civil aviation authorities in Great Britain and France.

The vulnerability effort initially required an extensive collection of data that, although related to DOD survivability research, was unique. Aircraft structure and system response to internal blasts had never been thoroughly assessed. For this reason, a complementary research effort to collect the necessary data was undertaken, using Navy expertise on internal blasts aboard ships and Air Force expertise on aircraft survivability. The FAA entered into interagency agreements with the Naval Surface Warfare

[2] An improvised explosive device is a fictional threat image prestored on the system during screening operations. The screener has no way of distinguishing the fictional threat image from a resistant real bag image. This program provides a means to maintain vigilance, as well as an accurate index of individual screener performance.

Center, Carderock Division, and the Air Force Wright Laboratory to help in this research effort. Methods of modeling blasts and respective damage also had to be developed. Using blast and damage characteristics, material failure mechanisms, and modeling approaches supplied by the Navy, the Air Force developed a vulnerability methodology that specifically examined blast effects on structure, aircraft systems, flight controls, and aerodynamics. The test data were also used to develop and validate computer models designed to forecast damage to other, more current types of aircraft. In addition, the Air Force conducted numerous wind tunnel tests to determine the aerodynamic effects of an aircraft flying with extensive structural (and possible flight control) damage.

Working with aircraft manufacturers, the FAA conducted a vulnerability assessment to determine blast effects on the current and future fleet of commercial aircraft. The mechanism used for this effort was an FAA research grant to the National Institute for Aerospace Studies and Services (NIASS), with airframe manufacturing support from McDonnell Douglas, Boeing, and Lockheed. NIASS used many of the test data and modeling techniques developed by DOD to determine the specific vulnerability of aircraft currently in use. NIASS also identified additional data needed to make viable decisions, and DOD in turn planned further explosive tests to acquire this information.

As the vulnerability assessment effort evolved, ideas for mitigating blasts by either retrofitting the current fleet or instituting new design techniques and materials were identified by both DOD and NIASS. Although the specific effort with NIASS has been completed, additional work is being planned with the manufacturers. A reusable test asset is being designed by New Mexico Institute of Mining and Technology and McDonnell Douglas Corporation for use in analyzing and validating new hardening design concepts and materials.

To validate the results of the analytical vulnerability assessments, the FAA, together with the Civil Aviation Authority of the United Kingdom, purchased a scrapped 747-100 airframe. The explosive test conducted on this airframe, coupled with some structural assessments on two other scrapped fuselage segments, should provide the data needed for this purpose.

The FAA is also working to develop blast-resistant luggage containers for use by the carriers on wide-body commercial aircraft. Current luggage containers are made primarily from aluminum and other lightweight materials. New containers being designed and fabricated use lightweight but blast-resistant composite materials. Several prototypes have been built and are currently being tested. For example, JAYCOR, Inc., under contract to the FAA, has developed a hardened LD-3 container (the most common container used on wide-body aircraft) weighing less than 300 pounds, yet providing a 10- to 20-fold increase in explosive resistance as compared with typical existing containers.

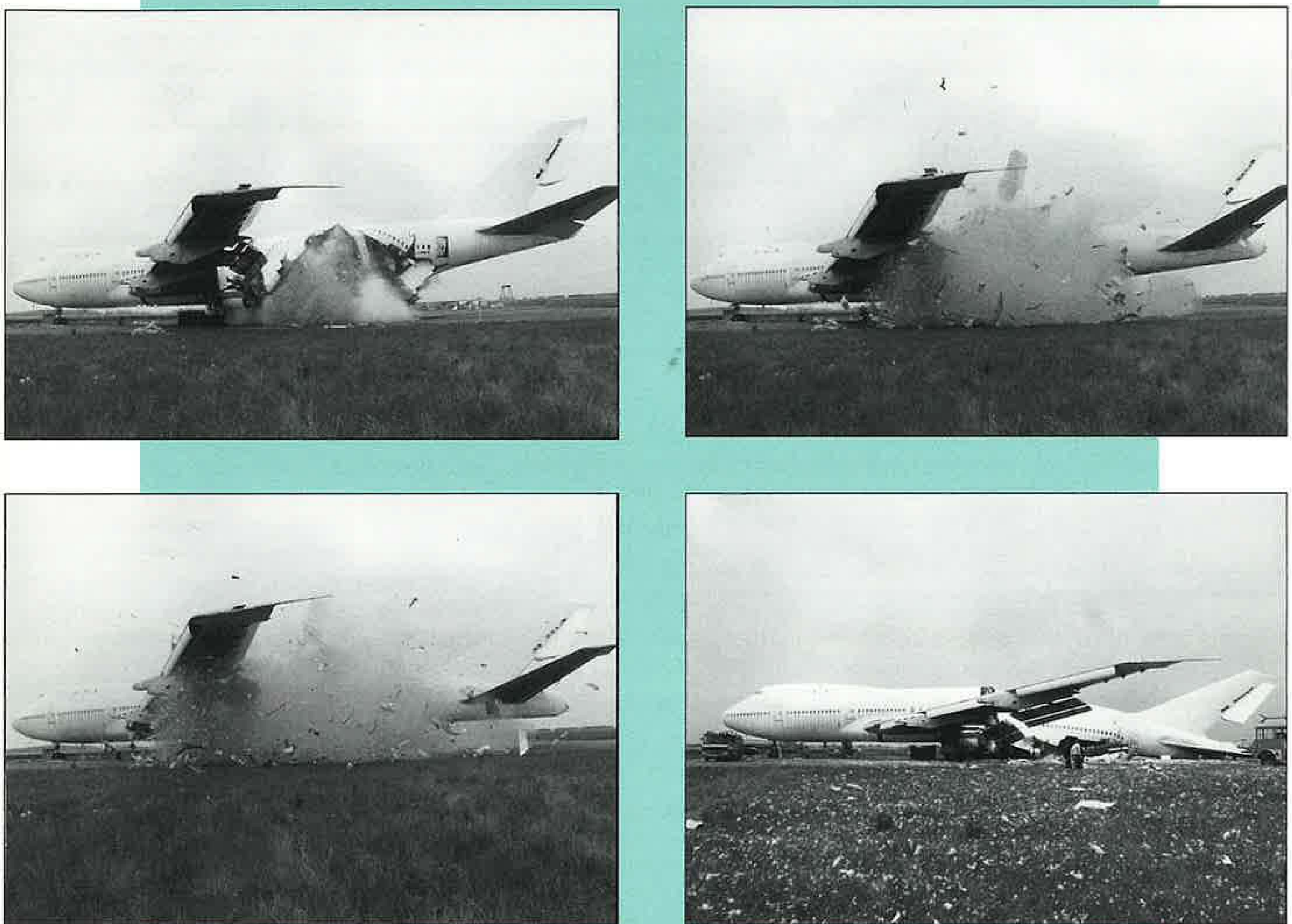
Working directly with the airlines through container certification experts from the Air Transport Association (ATA), the Society of Automotive Engineers (SAE), and the International Air Transport Association (IATA), the FAA has developed a draft specification for hardened containers. This technical description provides potential container manufacturers with the specifications required for a hardened container, although the FAA has not yet taken regulatory action in this area. The agency is also acquiring for use by the airlines a number of prototype devices representing a variety of design concepts and materials. Operational tests of these devices will focus on utility, durability, total cost of ownership, and repair requirements and methods, as well as continued explosive resistance. ATA is assisting in the assignment and tracking of these devices, and inputs from the carriers will be included in the overall research assessment.

In addition, the FAA is conducting analyses of the impact of electromagnetic interference and man portable air defense systems (MANPADS) on commercial aircraft. These research efforts are primarily investigative in nature and involve assessing the potential vulnerability of aircraft to these threats. The research efforts will be closely coordinated with current intelligence forecasts to determine actual alternative courses of action.

The electromagnetic effort complements the FAA's High Energy Radio Frequency (HERF) research program: whereas the electromagnetic effort is attempting to determine whether a potential terrorist could initiate damaging electronic interference, the HERF program focuses on interference from all sources, including unintentional interference from items such as personal computers, telephones, and calculators. Possible countermeasures are being coordinated between the two efforts.

The FAA is using expertise from the DOD community to assist in assessing threats from projected energy sources and MANPADS. DOD has already addressed vulnerability, lethality, and countermeasures for these threats with regard to military aircraft. The FAA is working with the Joint Technical Coordinating Group on Aircraft Survivability, comprising experts from the Air Force, Navy, Army, and Office of the Secretary of Defense, to convert and modify DOD data for the study of commercial aircraft.

FAA Study of Blast Effects on Commercial Wide-Body Aircraft



In 1996 the FAA's Aviation Security Research and Development Division and the United Kingdom's Civil Aviation Authority collaborated to study blast effects on commercial wide-body aircraft and potential mitigation methods by exploding a pressurized 747-100 at Bruntingthorpe Airfield, Leicestershire, England (about 70 miles outside of London). This effort was part of the FAA's ongoing aircraft hardening program to address measures that could protect civil aircraft from explosions in luggage. During the test, researchers simultaneously exploded four bombs in the aircraft. Three of the explosions tested aircraft hardening methods. The fourth, against an unprotected part of the aircraft, was designed to cause catastrophic structural failure by blowing a large hole in the airframe so that potential blast mitigation methods could be investigated.

Airport Security Technology Integration

In airport security there is often a fine line between protecting the safety of passengers and restricting their smooth flow through various security checkpoints. With more than a million passengers entering U.S. airports daily, the task of checking passengers without impeding their flow through the airport is not easy. The FAA faces the challenge of providing advanced security systems that can protect the general public in a very open environment.

The FAA's airport security technology integration program takes a broad view of the various elements that comprise airport security. The researchers' basic assumption is that security is a concern for everyone from airline and airport employees to the flying public, not just for law enforcement officials and baggage screeners. The focus of the research includes not only equipment, but also people, the methods used to train and motivate them, the procedures used to operate the equipment, and the procedures used to respond to a threat.

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Researchers are seeking new methods of securing the airport environment against potential threats. Unlike other agency security research and development programs, this effort goes beyond the physical boundaries of any given airport to include all elements of the national airspace system, such as air traffic control, communications, airway facilities, airport access routes, and the physical design of airports. To accomplish an effort of such broad scope, the agency is developing modeling tools that will provide long-term analysis capability through the application of operations research and computer modeling to the development, design, and management of the civil aviation security system. These tools will enable better use of security system technologies and procedures, resulting in reduced development costs and increased operational effectiveness and overall system security. Modeling will also provide for early validation of requirements, identification of potential problems, development of solutions to those problems, and a system simulation capability. These analytical tools will support improvements in system design, airport installation configurations, and investment decisions. They will quickly and accurately validate requirements for system design and for weapon/explosive detection configurations and procedures. The focus is on developing an integrated system technology approach.

The Future Challenge

Realizing that civil aviation exists in a dynamic environment, the FAA is developing a security system that will optimize the strengths of a broad range of technologies. The goal is to create an integrated aviation security system that will be highly effective against a variety of threats, be highly reliable, have a minimal negative operational and economic impact on civil aviation, be responsive to specific means of attack, and anticipate future risk to the civil aviation environment. In this system, less reliance will be placed on the labor-intensive human element for the performance of high-volume, routine functions. Instead, aviation security will continue to evolve toward a system that will enable security professionals to perform with maximum effectiveness, relying to the extent possible on automated detection technologies that are constantly vigilant and not subject to fatigue or distractions as are human screeners.

The FAA's security research and development efforts currently involve identifying and refining new technologies for the prevention and mitigation of threats. Security is already being enhanced by combining several different aviation security technologies into a single system. By 2010, systems able to perform functions such as passenger screening will be combined into an integrated system that will constitute the aviation security system of the future.

Reference

1. White House Commission on Aviation Safety and Security. *Final Report to President Clinton*, February 12, 1997.