Appendixes

Appendix A
The FAA Aviation Security R&D Program

Introduction and History

The most applied, mission-specific, and largest research and development program in the area of counterterrorism technology, and certainly the one most in the public's eye, is the FAA Aviation Security R&D program, conducted by the FAA Technical Center in Atlantic City, NJ. This program has been the focus of considerable attention, being reviewed by the President's Commission,[1] the National Academy of Sciences,[2] and by the FAA itself.[3]

This program suffers from its placement within the overall structure of the FAA, as well as its connection to the FAA Aviation Security program. The Technical Center Director reports to the Executive Director for Systems Development (within the overall FAA organization), who reports directly to the Administrator. Within the Technical Center, the Aviation Security Branch, which conducted the program, was until recently[4] a part of the Airports Division in the Engineering and Development Service. Thus, it was three administrative levels removed from the Director of the Technical Center. Last year, in response to both external and internal criticisms, the Aviation Security R&D program was elevated to the service level. Prior to the above change, the branch was staffed by only 13 personnel. The Technical Center, and, consequently, the Aviation Security R&D program, still has no direct line relationship with the Assistant Administrator for Civil Aviation Security (CAS). Figure A-1 shows an organization chart for the FAA as of August 1990.

The FAA's research and development programs started in the early 1970s to provide means of countering the perceived hijacking threat, Early research and development work was primarily in the area of metal detectors, resulting in the successful suppression of this threat. The September 1975 bombing at LaGuardia Airport first focused attention on the problem of detecting explosives, which has been the central focus of the R&D program ever since. In 1976, the R&D budget of the branch was about $1.5 million. The first proposal to investigate the use of thermal neutron analysis (TNA) to detect explosives was originated by Westinghouse in 1977. Over the next decade, two primary research areas grew to the prototype-hardware stage: vapor detection by chemiluminescent detectors and fast chromatography, and the TNA program. In 1984, Thermedics, Inc., of Waltham, MA, a subsidiary of Thermo-Electron Corp., became the primary contractor for the development of the vapor detection system and in 1985, Science Applications International Corp. (SAIC) and Westinghouse were chosen to demonstrate the TNA concept (in 1987, the Westinghouse funding was terminated). In the eighties, the FAA's R&D budget grew from $7 million to over $9 million per year, augmented by the procurement of six prototype TNA units (monitored by the Technical Center but funded out of the Office of Civil Aviation Security). In fiscal year 1990, the R&D budget was over $16 million; the budget for fiscal year 1991 was about $30 million. It is a rapidly growing program in a period of retrenchment in Federal budgets. Table A-1 shows funding levels for FAA Aviation Security R&D.

The main area of emphasis of the FAA Aviation Security R&D program is explosives detection. This is still by far the dominant effort in the program. A second area of investigation that has been pursued over the past several years has been a systems analysis of the airport security problem. The analysis includes system components such as training, procedures, technologies, and controlling access to guard all the ways and physical paths that threats (e.g., hijackers, weapons, explosives) may take to the aircraft. This program has been conducted by the Sandia Laboratory of the Department of Energy (DOE) under contract from the FAA Technical Center. One new area of emphasis is aircraft hardening against explosives and another new field of effort involves the study of the application of human factors to aviation security.

In response to the several intense reviews and criticism (particularly by the Presidential Commission) of the overall R&D program, dramatic and rapid changes are currently being implemented in its staffing, organization, funding, and outlook. The comments made in this report are primarily aimed at the situation that existed until very recently; many of the identified problems are well on their way to being corrected. However, some other problems discussed

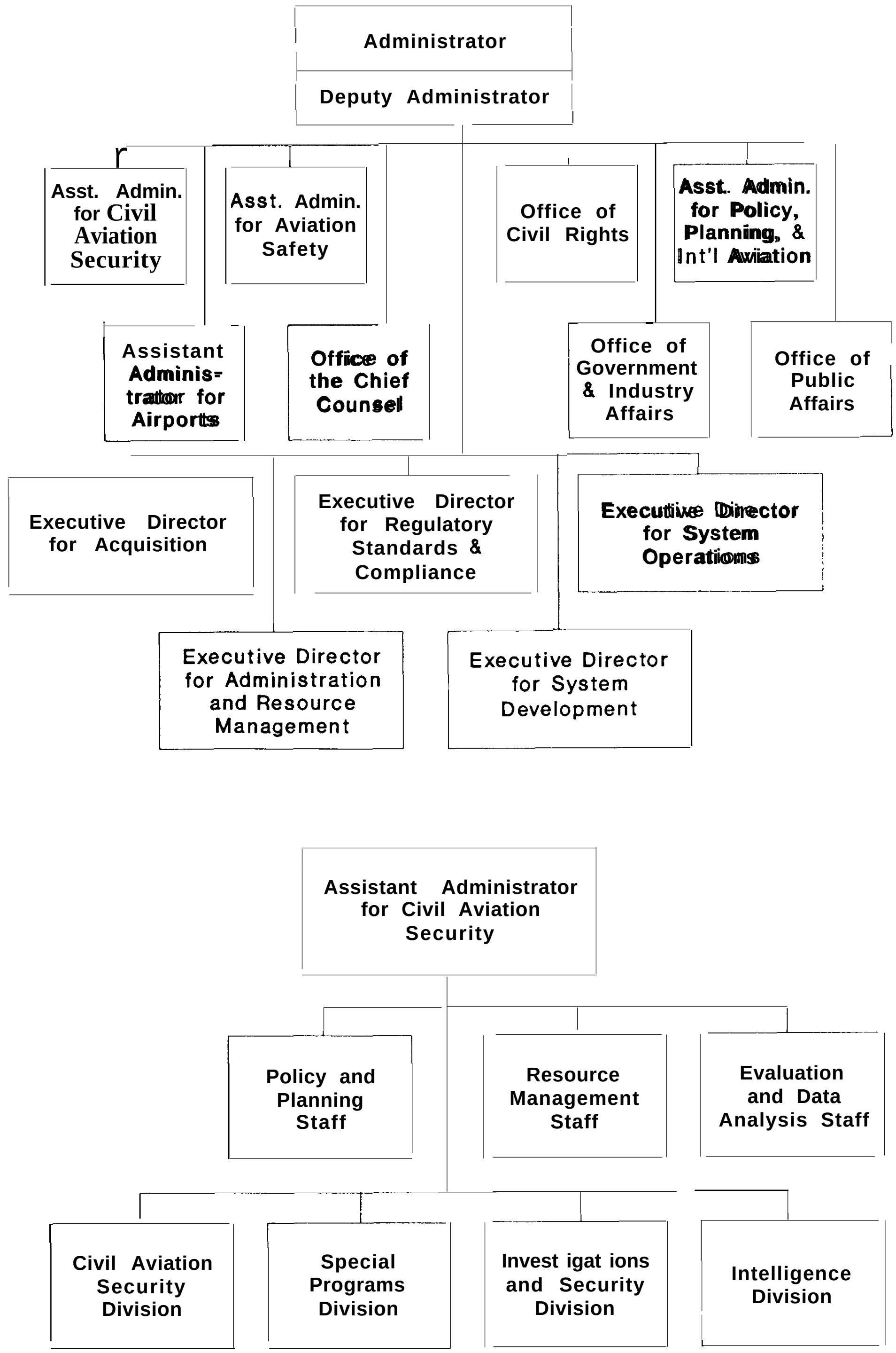
[1] The White House, *Report of the president's Commission on Aviation Security and Terrorism* (Washington, DC: May 15, 1990).

[2] Committee on Aviation Security, National Materials Advisory Board, National Research Council, "Reducing the Risk of Explosives on Commercial Aircraft," Publication NMAB-463 (Washington, DC: National Academy Press, 1990).

[3] U.S. Department of Transportation, Federal Aviation Administration, "Blueprint for Change: A New Security Organization," Report by the Office of the Deputy Associate Administrator for Appraisals, No. 90-2, Aug. 14, 1990.

[4] In response to the President's Commission on Aviation Security and Terrorism, the program was elevated to a "Service" level, the highest technical level in the Technical Center, reporting directly to the Center Director, and its staffing increased significantly (to 37 slots) as approved by the Administrator in July 1990.

Figure A-l—Organization of the FAA



SOURCE: U.S. Department of Transportation, Federal Aviation Administration, "Blueprint for Change: A New Security Organization," Report by the Office of the Deputy Associate Administrator for Appraisals, No. 90-2, Aug. 14, 1990, p. 3, figure 1a.

Table A-l—FAA R&D Funding Levels for Aviation Security

Fiscal year	Funding (in $ million)
1985	$7.4
1986	12.0
1987	14.4
1988	9.5
1989	9.9
1990	16.9
1991	30.3

SOURCE: Federal Aviation Administration, 1991.

hercin are still unsolved program and require further attention.

Current FAA Technical Center Research and Development Program

During fiscal year 1990, the FAA Technical Center security research and development program became involved in some controversial issues, notably the question of TNA testing and deployment, It has since undergone a complete reorganization and change of personnel. During these major diversions, the program has continued to function and is operating at ever higher funding levels, partially due to the infusion of new congressionally appropriated money, which was motivated by the report of the Presidential Commission.

The fiscal year 1990 program emphasized a continuation of research that had been ongoing since the previous year, with a few new starts made possible at the end of the year by the new money. A major innovation was the issuance of a Broad Agency Announcement (BAA) in November 1989,[5] a new way of inviting industry and academia to propose new ideas to the FAA for exploratory funding. The announcement specified the areas of FAA interest as follows:

- explosives detection-with a great deal of detail given about interest in various technologies of bulk and vapor detection of explosives,
- weapons detection,
- airport security,
- security systems integration, and
- aircraft hardening and blast/fragmentation containment.

During the year, the FAA received over 300 inquiries, over 80 white papers, and 68 actual proposals under this BAA. However, only five of these proposals were actually funded by the end of fiscal year 1990. Many of the industry groups that submitted formal proposals to the FAA under this BAA felt that the responses that they received were neither prompt not satisfactory. Of course, those that received no funding would naturally complain. However, a principal complaint was rather that no responses at all were provided for a long time. The apparent logjam in dealing with the BAA was likely due, in large measure, to the massive self-examination and reorganization that the FAA security program and the security part of the Technical Center were undergoing at the time.

In the bulk explosives detection area, the program was driven primarily by the conflict surrounding the SAIC/TNA. Testing programs were elaborated to allay criticisms of earlier tests of the system, TNA enhancements were funded to improve its performance, and, finally, other concepts were investigated, such as coupling TNA to other sensors to achieve better performance than achieved by the current XENIS (i.e., the TNA coupled to a conventional x-ray) system. A major program to develop a gamma ray resonance absorption explosives detection system under a joint program of Soreq Nuclear Center of the Israel Atomic Energy Commission and Los Alamos National Laboratory of the DOE was restarted. It had begun in 1987 as exploratory work, but had stalled when the program had matured into a more focused effort. However, the complexity of creating such a joint program delayed the start of actual new work on this program until well into fiscal year 1991. An upgraded program of research into the puked fast-neutron detection scheme was also initiated. Some new work was also started in NMR/NQR and on advanced x-ray systems, as well as on a positron emission spectroscopy scheme.

Another major funding area of the Technical Center has been the technology of vapor detection of explosives. A number of the past programs in this area were continued and several new ones started, including several basic technology investigations of the underlying science of vapor detection.

A third effort, the systems category, has been continuing. A major part of it, the integrated security system study at Baltimore/Washington International Airport, is moving from the conceptual stage to the hardware demonstration phase. A new program on aircraft hardening was also initiated under this element, initially looking at container hardening. This program element also includes the work at the National Academy of Sciences in support of the FAA program (both the overall evaluation resulting in the NAS report as well as support of the test program), Architectural and Engineering work on a new FAA explosives testing laboratory, and some miscellaneous expenditures.

The approximate program expenditures by element for fiscal year 1990 are listed in table A-2.

[5] U.S. Department of Transportation, Federal Aviation Administration, Technical Center, Aviation Security Branch, Broad Agency Announcement (BAA), TCBAA-90-001, ACD-120, November 1989.

Table A-2—Program Elements for Aviation Security R&D—Fiscal Year 1990 (figures in thousands of $)

Element T 1801A—TNA and other bulk explosives detection systems:	
TNA assessment support	$ 561
TNA enhancements	681
Other bulk detectors/dual sensor modifications	551
	$1,793
Element T 1801B-Vapor systems:	
Chemiluminescent detectors	$ 500
(Work at Sandia)	300
Mass spectrometers	1,065
Systems support	700
Research support	100
	$2,665
Element T 1801C—New technology:	
Gamma ray resonance absorption	$ 1,035
Pulsed fast neutron technology	1,300
Advanced x-ray technology	200
Biotechnological detection	257
Vapor systems research	1,233
Bulk technology R& D.	1,080
National Academy of Sciences support	588
	$5,693
Element 1801C—Concourse access and miscellaneous:	
Millimeter wave technology	$ 465
BWI demonstration	3,000
Aircraft hardening	338
New laboratory-A&E study	500
Academic fellows program.	200
Miscellaneous.	600
	$5,103
Total	$15,254

SOURCE: Federal Aviation Administration, 1990.

Because of the FAA'S contracting procedures, in particular the late-in-the-fiscal-year commitments, much of the above work was scheduled to start in fiscal year 1991 and consequently could only be done in that year.

Current Problems

According to several studies, the FAA Aviation Security R&D Service suffers from a number of difficulties. There are some technical problems, including a thin staff of experienced technical managers; a lack of systematic planning, particularly with respect to scope and requirements; problematic administrative support (insufficient number of contracting specialists) for timely contracting, and insufficient outside scientific advice and guidance. Further, there are a number of institutional problems, primarily due to the place of the Service in the FAA organizational hierarchy. There is a lack of coordination with the decisionmaking and operational groups in the FAA This R&D activity, in particular, requires strong coupling to the R&D work to the Civil Aviation Security operations groups. Some of these problems have been discussed in the report of the Presidential Commission, some in the National Academy of Sciences report, and some are enumerated in the FAA report on changing its security organization.[6]

Critique by the President's Commission

The FAA has not met the challenge of developing effective detection technology to meet the progressively more sophisticated threat of terrorists.

> The agency has not planned for the future but has reacted to past events. . . specifications were at best, of doubtful utility for terrorists have used plastic bombs at least since 1982 that are lighter than the weight specification for detection of plastic explosives by an EDS [explosives detection system] machine. . . today's TNA machines cannot, without an unacceptably high rate of positive false alarms, detect the amount of Semtex widely believed to have blown up Pan Am 103. . . . The TNA machine . . . although never scientifically tested, was approved by the Administrator of the FAA for use as meeting the specifications for detection of plastic explosives. . . without approval of the Technical Center that the TNA met the EDS standards. . . . The FAA needs to bridge the gap between what can destroy aircraft and what can be reliably detected. . . . Can steps be taken to modify airframes to minimize the damage? . . . The FAA for years did not have a continuing scientific and engineering advisory committee of independent, acknowledged experts to advise on its research programs. . . . The FAA must give higher priority and allocate more federal funds to R&D.[7]

The commission made recommendations generally in line with these comments.

Critique by the National Academy of Sciences[8]

The National Academy of Sciences, National Materials Advisory Board, has probably performed the most detailed study of the FAA Aviation Security R&D program to date. A committee of 10 (primarily academic) experts with expertise in analytical instrumentation, forensic analysis, explosives chemistry, and nuclear sciences met 8 times between January 1989 and May 1990. The committee was briefed by the FAA officials and program managers and contractors, as well as by groups whose concepts were not currently funded. Committee members also visited specific laboratories to get briefings in more depth on some developments. A limited-attendance workshop was held to solicit new

6 U.S. Department of Transportation, Federal Aviation Administration oP. cit., footnote 3.

7 The White House, op. cit., footnote 1, pp. 63-66.

8 Committee on Aviation Security, op. cit., footnote 2.

ideas from knowledgeable scientists with innovative concepts of how to attack the problem.

An important conclusion of the NAS study was that it is unlikely that any single technological means will significantly reduce our vulnerability to a sophisticated terrorist threat. Consequently it is clear that a succession of screening techniques or stages will be appropriate and explosives detection must be looked at from a systems or integrated point of view. Further, there are various costs involved in the implementation of any screening procedure: the direct costs of the equipment and the personnel required as well as the indirect costs of the delays or changed operational procedures that are demanded of the airlines. Consequently, any choice for security improvement is necessarily a compromise between the degree of security achieved and the costs imposed. This furnishes an argument for a well-thought-out systems approach to the specification of security requirements.

The National Research Council report came up with a specific set of nine recommendations and some program priority recommendations, which are summarized below:

a. Define a search strategy to optimize the mix of technologies that are available. No single detection technology is currently capable of providing the needed sensitivity and specificity required to provide security; a combination of currently available devices may well provide significantly better security than is now provided.

b. Implement low technology and human-factors-type improvements. Assure positive passenger/baggage matching on all aircraft, eliminate curbside luggage check-in, give specific consideration to passengers and baggage that disembark at intermediate stops, implement risk profiling of passengers, and bring about improvements in training, motivation, and monitoring of security personnel.

c. **Define performance criteria of detection systems. A minimum detectable-explosive quantity and a minimum vapor-detection sensitivity of 1 to 100x 10^{-15} gram was recommended. The quantity was in disagreement with the higher explosives quantities used currently by the FAA**

d. **Explore reinforcing aircraft baggage containers. Investigate the possibility of relatively simple inexpensive modifications that could increase the capability of the aircraft to withstand small explosions to the point where detection is made easier.**

e. **Establish standardized operational test procedures and testing facilities for explosives detection systems. A government operated (e.g., FAA) or supervised, yet completely neutral, test facility should be established to conduct standard tests and acceptance procedures on any detection hardware available. Field tests under realistic airport conditions were recommended.**

f. **In testing bulk or vapor explosives detectors, develop standard positive controls for routine checks of sensitivity of instruments and for blind checks of the system and observers.**

g. **Take advantage of systems integration opportunities for vapor detectors. Combine the best stages of various commercial instruments to create a more effective total system.**

h. **Explore the tagging of explosives and detonators to make them easily detectable. It has been suggested that the addition of small amounts of materials added to explosives and detonators could make them easily observable by inexpensive means.**[9]

i. **Continue the support of the exploration and the development of new methods that maybe applicable to explosives detection. The committee could not identify any approaches that were neither monitored nor funded by the FAA and recommended that the FAA continue its R&D program to keep abreast of the state of the art. This constituted an endorsement of a good part of the FAA R&D program.**

J. **Program priorities:**
- **Establish an explosives detection systems analysis and architecture group.**
- **Demonstrate passenger/luggage correlation schemes.**
- **Solicit and fund proposals for aircraft hardening analysis.**
- **Establish an operational testing facility.**
- **Solicit and fund proposals for developing positive controls for bulk and vapor phase systems.**
- **Select a prime contractor or systems architect to optimize vapor phase systems.**
- **Solicit and fund proposals to demonstrate explosives tagging schemes.**
- **Solicit and fund exploratory research proposals for new methods of explosive detection.**

k. **Funding recommendations:**

Major funding areas
- **airport-based nuclear accelerator**
- **improved x-ray explosives detection**
- **nuclear resonance absorption (NRA)**
- thermal **neutron activation (TNA)**
- **x-ray computerized tomography (CT)**
- **x-ray methods for bomb detection**

[9] OTA disagrees with this recommendation, as regards explosives: see U.S. Congress, Office of Technology Assessment, *Technology Against Terrorism: The Federal Effort,* OTA-ISC-481 (Washington DC: U.S. Government Printing Office, July 1991), p. 51. OTA concluded that this proposal ignores the problem of the large amounts of plastic explosives currently available to terrorists as well as the fact tbat some plastic explosives can be manufactured by terrorist groups or can be obtained from state sponsors.

Moderate funding areas

- chemiluninescent vapor detection systems
- fast-neutron activation associated particle
- glow discharge ionization tandem mass spectrometer system
- ion mobility vapor phase system
- nuclear quadruple resonance (NQR)
- pulsed fast-neutron activation (PFNA)

Modest funding areas

- fast-neutron activation (FNA)
- nuclear magnetic resonance (NMR)
- vapor phase component technologies

Critique by the FAA Report[10]

"The office of Civil Aviation Security (CAS) has not provided adequate direction and oversight in defining and documenting adequate research requirements and has not set program priorities. . . . The Center currently works under a 1986 memorandum for explosive detector requirements. . . . There is no current comprehensive security R&D plan which delineates requirements for R&D projects and lists goals. . . . Communications between the CAS and the Technology Center have not been adequate. . . . There has not been continuous dialogue between CAS and the Technology Center. . . . The security R&D program does not contain the same operational test and evaluation or independent test and evaluation procedures that other agency R&D programs currently use to evaluate new technologies . . . the program has focused narrowly on technological solutions rather than thinking of aviation security as a system. "

OTA Comments on Concentration and Priorities

In any R&D program, concentration and priorities are a matter of judgment. However, several of the previously cited critiques point out, and OTA concurs, that the technical center program has been too narrowly focused, decoupled from the real world with respect to requirements, and devoid of an overall plan with goals and schedules.

As an example of the narrow focus, the vapor detection program, although doing excellent work in this detection technology, focused on the concept of a personnel inspection booth using vapor detection equipment. The program should have asked the broader question: what is the basic capability of the equipment and how could such equipment be utilized in an aviation security system? Vapor detection capabilities are very scenario-dependent; the same equipment that may function well in one particular use may be useless in another mode.

There is strong evidence that some vapor detectors are able to detect plastic explosives. This case has been made by the Department of State as well as by several foreign governments and appears to be confirmed by some recent FAA tests. The issue is to devise a viable scenario for applying this ability to the aviation security problem. Several tests have recently been run to determine the capability of commercial vapor detection equipment in searching for explosives in electronic equipment as identified from x-ray images.[11]

A similar criticism applies to the FAA approach with respect to their evaluation of the SAIC/TNA. The TNA was pursued as an all-encompassing first and final inspection system. When its performance fell short for that application, both at the higher explosives quantities set by the FAA and at the lower value widely believed more appropriate, the FAA looked for supplemental measurements that could be used to fix its shortcomings. A more effective approach would ask what functions TNA can perform; possibly it could function as the high-cost, low-throughput device at the end of a chain of other systems that only inspects a few questionable items left indeterminate after other screening. Such an approach would run counter to the FAA'S earlier attempt to implement TNA as its chosen EDS.[12]

The R&D program also needs to make a clear decision on to what level of development a concept should be taken: should the FAA take technology all the way to a fully developed commercial prototype (as it is doing in the case of the SAIC/TNA) or is it the FAA'S responsibility to demonstrate the feasibility of a technology and to certify that it has demonstrated requisite performance levels? This issue touches on the definition of requirements for instrumentation developed by the R&D program. For example, the inclusion of a probably unnecessary throughput requirement that makes R&D difficult and expensive (see ch. 4). For long-term projects (on the order of 3 years or more), the R&D program should spend its effort on demonstrating sufficient measurement accuracy to satisfy the FAA performance requirements for sensitivity and specificity at given threshold quantity levels (which may be kept classified to protect information on the vulnerability of a future security system). From there on, the vendors and the airline (or airport authority) could negotiate the specific technologies they wish to implement to meet the FAA specifications,

[10] U.S. Department of Transportation Federal Aviation Administration op. cit., footnote 3, ch. 1.

[11] The FAA recently conducted an assessment of four commercial vapor detection systems for checking carry-on baggage in combination with other sensors (x-ray screeners), with some encouraging results that have not been released to date. Further, the Massachusetts Port Authority at Logan Airport, Boston, recently also conducted a series of tests utilizing Thermedics equipment.

[12] See 54 Federal *Register 36938* (Sept. 5, 1989).

subject to operational testing of the commercial products for compliance.

A related question is the issue of how much help the FAA should give: a single source can achieve a favored commercial position through significant government support. In lieu of being able to afford multiple approaches, which would be the fairest and best procedure, it may be preferable for the FAA not to fund one competitor all the way to a production prototype, but rather to restrict Federal funding to demonstrating the required measurement ability. The FAA should insist on proper and timely documentation of the results and the distribution of data gathered under federally funded programs to all interested competitors to the degree legally permitted. An exception to this strategy maybe in order in the case of an urgent need to field equipment as soon as possible, such as might have arisen during the Gulf War, because of an increased terrorist threat. In such cases, rapid funding to prototype of a single project would probably be the most efficient path.

The issue of a properly designed and implemented qualification test program for any and all detection systems was highlighted in the first OTA report.[13] As discussed in that report, the interpretation and use of test results was the root of much of the controversy for the SAIC/TNA. In particular, there was lack of agreement about the meaning of test results between the Technical Center and FAA officials responsible for regulations. The FAA Technical Center has taken a large number of constructive steps in the direction of developing proper protocols for such tests and for carrying them out.[14] The design and conduct of testing is another area where the utilization of a broadly based scientific advisory group, as recommended by several of the investigations, would be very constructive.

OTA Comments on R&D Program Requirements

The lack (or obsolescence) of realistic technical requirements for the Technical Center research program has been identified as a serious problem by several of the investigations. The setting of these requirements is an area where much better and closer cooperation is required between the Technical Center and the Assistant Administrator for Aviation Security. Inherent in the proper use of requirements to guide the research program is the need for the operational part of the organization to be in full agreement with these requirements, to coordinate with the Technical Center in their implementation and rulemaking process, and to be consistent in the interpretation of the test results regarding certification.

The issue of the proper mass of explosives that a detection system must be able to detect has been much discussed. Although it is true that some secrecy on the topic is a good idea, this does not obviate the need to set this requirement from a proper empirical and analytical base and to provide justification for the choice (even if the details are classified). There are ample data in various U.S. Government agencies, such as the FBI, as well as with foreign governments and agencies, to guide this choice. FAA is currently collaborating with a number of agencies and with airframe manufacturers to derive a justifiable quantitative analysis of this problem.

Aside from the primary issue of the weight of explosives to be used as the threshold, there is also some confusion about the type of explosives that should be specified. When a performance value is quoted for TNA testing, it is usually given as a weighted average of five commonly used explosives, including Semtex and TNT. Different threshold values are used for each explosive in an effort to account for the differences in the explosive power of the various products. Consequently, when a specific threshold is quoted, that value is an average and not necessarily applicable to all explosives.

One serious omission was propagated in this averaging process, with regard to testing the TNA system: the omission of a particular explosive that, in fact, has been a favorite of airline bombers for nearly 10 years. This omission has been redressed in recent independent tests at Gatwick.

A similar but less discussed issue is the FAA-specified requirement for throughput for a candidate detection system. This standard (currently set at 6 seconds per bag or 10 bags per minute for luggage checking) has been used in the past to decide that some concepts are not acceptable or are too Slow.[15] Though apparently straightforward, this standard is actually vague and performance with respect to this parameter is not well known, even for the much-tested SAIC/TNA. In fact, throughput performance is very application-specific. First, there has been no clear determination of the throughput requirement, which is location-specific—it can differ by over an order of magnitude between locations. The best work in this area is probably the recent report by the University of California at Berkeley done for the Air Transport

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13 U.S. Congress, Office of Technology Assessment, op. cit., footnote 9.

14 The National Academy of Sciences has been asked to follow its previous study with a test protocol design for bulk detectors; Sandia Laboratories has conducted some studies of a test protocol; a group of four outside consultants setup a test protocol for and carried out a set of tests performed at Kennedy airport in April 1990 and at Gatwick in June 1991; Idaho National Engineering Laboratory has been tasked with developing protocols for testing vapor detectors and with carrying out some evaluations.

15 See also discussion in ch. 4.

Association (ATA).[16] This work defines the required throughput in terms of bags per hour required to eliminate or minimize queuing of luggage to practical levels. However, to relate this work to a given machine presents further problems since the specific use must be defined.

This work also discusses the interpretation of the throughput of the TNA system. The current TNA machine has a belt speed of 30 feet per minute, which gives it the theoretical ability to pass 10 bags per minute, if they are spaced with 36 inches between bag center lines. In that sense it meets the FAA EDS specification. However, at this spacing, the three radiation trap doors that contain the radiation would not be able to close, and consequently the machine would present a radiation hazard (according to Bureau of Radiological Health standards). In order to allow the doors to close, the spacing between bag centers needs to be about 52 to 60 inches, slowing the maximum rate to 6 to 7 bags per minute. This is the real maximum rate that a stand-alone TNA system with an automatic decision algorithm and a mechanism that can handle and remove the rejected bags.

If the system is coupled to another sensor, such as in the XENIS option, the correlation time of the two observations can become another rate-determining step. 'Throughput" lacks a simple definition and depends almost entirely on the specific operational use. Consequently the use of throughput in a certification protocol is probably misguided; throughput should be a consideration for the user to choose so as to meet the FAA's (and its own) operational requirements at a given location in the most effective and economic manner.

There is no reason why a comparatively slow (e.g., 1 to 2 bags per minute) system, with a high confidence (detection probability) and a high specificity (low false alarm rate), could not be a very attractive system when used in combination with other devices. In fact, it is quite probable that in a chain of different detectors, such as is likely to be used in overall detection systems, a slow, high-cost, final-stage filter will find a niche.[17] The throughput should not be an FAA-specified parameter, particularly at the R&D stage, but rather should be machine-performance information that needs to be considered in the selection of the specific role in which a detector is utilized.

In the area of vapor detection systems, current requirements are equally soft. It is difficult to specify the minimum amount of explosives that a device should be able to detect and to account for first-order countermeasures (e.g., wrapping explosives to trap the vapor). Again, the throughput is entirely dependent on the application scenario. The setting of specifications and standards is also a problem for current x-ray systems, since being able to differentiate the density steps of a test wedge, the currently used standard, is not very meaningful when x-ray systems are employed to attempt to detect explosives.

Finally, the issue of automation as stated in the requirements for an EDS needs to be clarified. The FAA EDS specification calls for an "automated" system. However, automation should be utilized so as to minimize the use of the human operator, yet should retain for the final decision process the powerful ability of the human to discriminate between many unknown items. In currently proposed systems, there is an operator that performs the final clearance of the automatically rejected bags, either from a careful study of a high-resolution sensor (usually an x-ray image) or, in the last resort, by a hand search. This level of automation may serve the requirement of relieving the boredom of human operators, which is generally cited as the primary reason for automation, except for extremely low false alarm levels. Of course, FAA officials are aware of this. A precise definition is, however, required to clarify the use of the term "automation" in the certification process.

The FAA Technical Center is currently developing a program plan to address, among other things, the setting of realistic technical requirements for security hardware. As part of this plan, possible future threats, such as new explosives or incendiaries, will also be covered. This effort is intended to resolve many of the problems noted above.

OTA Comments on Technical and Administrative Support

The technical staff available to manage the FAA Aviation Security R&D program has been limited in numbers; however this problem is apparently well on its way to being corrected.[18] One area where the lack of technical staff was very evident was in the responses offered to the BAA respondents. OTA heard many complaints of lack of FAA response from contractors that had submitted inquiries, white papers, and proposals under this BAA. Five contracts were issued under this request, specifically for:

- testing a competing TNA system at GammaMetrics;
- vapor detection work at CPAD, Canada;
- aircraft container hardening work at Jaycor;
- automation of the AS&E Z-Scan system; and

[16] Geoffrey D. Gosling and Mark M. Hansen, "Practicability of Screening International Checked Baggage for U.S. Airlines," Institute of Transportation Studies, University of California at Berkeley, UCB-ITS-RR=90-14, July 1990.

[17] This topic is discussed in greater detail inch. 4.

[18] Under the reorganization of the program into a Technical Center Service, the number of personnel Wetted to the program has been increased from 13 to 37.

. SAIC work in vapor detection.

OTA draws several conclusions. First, five awards do not constitute a sufficient number to encourage innovation and diversity; second, at least two of these awards were for work that was proceeding at the companies at the time; work that was well known to and even desired by the FAA-therefore, these contracts were not really the "innovation" thrust of the BAA, which was aimed at producing new ideas and concepts;[19] third, not all respondents in such a request received notifications of the evaluation and disposition of their submittals in reasonable time-they should have; and finally, all respondents should be informed of the actions taken and contracts issued so that confidence is built up in the community that BAA requests are a worthwhile place for industry to present their new ideas. The staff time to prepare these responses is a good investment in future relations with sources of innovation.

It also appears that the contract administration support given to the research and development program at the Technical Center was not very effective. Research and development organizations have a very difficult time with contracts that start and stop on a yearly basis. When the release of most of a fiscal year's funds are delayed until the last few months of that year, as has repeatedly happened in this program, great difficulties face those groups that have continuous programs. It also appears that the FAA has frequently taken an inordinate length of time from decision to signed contract.

Outside Scientific Advice

Some of the previously cited reviews of the FAA R&D program have recommended that the program make greater use of outside experts for advice and guidance in scientific and other technical matters. Suggestions have ranged from direct involvement of outside consultants in the program management to scientific advisory committees to give the program greater validity and "clout." OTA agrees with both of these suggestions and believes that liberal use of outside ''experts' could be very beneficial to the program. FAA is moving in this direction, following the requirement of the Aviation Security Improvement Act of 1990, which mandated the establishment of a scientific advisory panel as a subcommittee of FAA's Research, Engineering, and Advisory Committee.[20]

The FAA Technical Center program has used several university personnel as expert consultants with considerable success. Expansion of this type of use is highly recommended. The FAA R&D program is very broadly based, utilizing a wide variety of technologies, from nuclear physics to sophisticated electronics, from state-of-the-art artificial intelligence to physical optics and spectroscopy. Each of these areas has many experts who could be very helpful in giving advice in their areas. It is very easy for a generalist program manager to be "snowed" in some specialty area and either miss some obvious error or be trapped into "re-inventing the wheel." Outside experts are usually familiar with the technical leaders in their area of knowledge. These people, even if not knowledgeable about the FAA program, could make significant contributions to progress of the FAA program by relating the program to current research. Liberal use of outside consultants can also be very effective in assisting evaluation of new programs.

Institutional Problems

A research and development program can only be useful to an organization if it is properly connected to the overall management of the organization and to the fulfillment of the organization's mission. In the case of R&D into aviation security technologies, institutional disconnect has been a major problem. Not only was the program conducted by a minor part of the FAA Technical Center (as noted, this has recently been changed) but it has been decoupled from the functions of the former Office of Civil Aviation Security, now the Assistant Administrator for Civil Aviation Security. The latter situation manifested itself in improper and outmoded requirements (e.g., the amount of explosives to be detected), a lack of overall planning, and a variety of inconsistent interpretations of data and results, often by personnel far removed from the technology programs. The presence of these problems has not allowed the R&D program to serve FAA management well in its decision processes.

As mentioned earlier in this appendix, the FAA Technical Center reports to the FAA Administrator through the Executive Director for Systems Development. The Assistant Administrator for Civil Aviation Security also reports to the Administrator. Such an arrangement can only work if great care is taken in assuring the coordination between all pertinent functions, and if specific agreements exist covering the jurisdiction of the various groups. This has not been the case in the past.

Several groups have been directly involved with various aspects of the R&D program and with the applications of the results and data of that program. The R&D program is primarily located at the Technical Center. However, human factors as used in screening or profiling of passengers, was the concern of the Intelligence Division within the Office of Civil Aviation

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[19] This may have been due, in part, to a natural tendency on the part of the contractors to present modifications of ideas that were funded in the pint, rather tban to be very innovative.

[20] Aviation Security Improvement Act of 1990, Public Law 101-604, sec. 107.

Security. For years there was, within the Office of Civil Aviation Security, only one individual assigned to monitoring the R&D program. For the FAA in general, regulatory standards are produced under an Executive Director for Standards; however, for aviation security, this function was subsumed under the Office of Civil Aviation Security (now under the Assistant Administrator for Civil Aviation Security). Thus, this function was removed from both other standards-setting functions and from the FAA Technical Center's expertise. The issue of aircraft vulnerability or hardening was pursued by the Investigations and Security Division. The relations between that program and the Technical Center were not at all clear; the Technical Center has only recently asserted leadership in this area. It is not surprising that aircraft hardening and human-factors consideration did not enter the Technical Center R&D program planning until very recently.

The notoriety and public attention given to certain aspects of the R&D program by congressional hearings, the President's Commission, and the publicity in the aftermath of the Pan Am 103 tragedy have also created difficulties for the R&D program. The threat (via the FAA rulemaking process[21]) to require a new-technology explosives detection system at many airports created the potential of major business for a confused explosives detection equipment industry. Seeking guidance in order to plan the allocation of their resources, industry sought out interviews with all levels of the FAA and also with congressional members, both those directly involved with the FAA security issue and those who represented home districts. It was not uncommon to hear of visits to all levels of FAA management, right up to the Administrator, by contractors wishing to either sell or emphasize the virtue of their devices. This environment is not conducive to conducting a balanced R&D program.

The Technical Center's R&D program should be open and responsive to the needs of those responsible for planning and supervising aviation security operations. However, a R&D program should be conducted in an atmosphere of responsibility and understanding by the people who are actually doing the R&D. Personnel responsible for security operations should not also be responsible for the R&D. However, they should and must play an important role in the planning and setting of the desired requirements as well as priorities, with R&D decisions left to R&D management. As has been suggested by FAA officials, this could be accomplished by developing a memorandum of understanding (MOU) between the representatives of the Assistant Administrator for Civil Aviation Security and the Director of the Technical Center.[22] Such an MOU was signed by the Assistant Administrator and the Director of the Technical Center on March 19, 1991. This is a very positive step.

Ideally, in this coordination, the CAS representative should speak for all aspects of the security operation, including rulemaking and intelligence functions, and the Technical Center for all R&D, including human factors. Further, CAS should insure that the data and results obtained in the R&D program will be used only as agreed to and warranted by the R&D personnel. The Technical Center, in turn, should be responsive to the needs of the CAS in setting their research goals and requirements. Following the achievement of the MOU, a coordinating committee for security research and development should be formed to meet on a regular basis and provide the feedback and assurance that coordination is accomplished on a timely basis.

Certain aspects of the proposed new FAA organization are in accord with these suggestions. Under CAS, a R&D staff is suggested. This is the proper place to focus all the coordination functions within the CAS and for the primary interface with the Technical Center. The new organization of the Technical Center, with its elevation of the aviation security program to the highest operational level, should place the responsibility for coordination properly with the Director of the Aviation Security Research and Development Service.

The Future-Beyond Fiscal Year 1991

As a result of the attention showered on the FAA Security R&D program an opportunity to make significant progress has developed. There has been a major reorganization of the Technical Center aviation security R&D program and the organization has been elevated in status to the highest level. A new Director of the Service has been appointed and a radical change in technical and program management personnel has occurred.

It is not known to what degree past institutional problems have been resolved. There may still be questions concerning the relationship of the Assistant Administrator for Aviation Security with the Technical Center program. Will the Technical Center be allowed to run its own R&D program? How will the planning and requirements effort be coordinated with the operational side (CAS)? Most important, how will the technical results be protected from misinterpretation by the operational personnel charged with implementing the new technology through standards and rulemaking?

With a budget of $30 million for fiscal year 1991, a significant increase in effort (from $16 million in 1990) occurred. Many projects compete for these increased funds. Further, there is strong pressure to produce new

21See FAA rules FR 5436938 and 28985, dated Sept. 5, 1989, and July 10, 1989 respectively.

22Department of Transportation, Federal Aviation Administration, Op. Cit., footnote 3.

prototype detection systems that will provide answers to the airport security problem in a short time. This trend must be balanced against a carefully laid out program to provide the basic foundations of detection-technology.

There will be pressures to jump to demonstration prototypes of systems that are still in the research stage, resulting in large long-term commitments that may interfere with a more deliberately planned and balanced approach. The role of the FAA aviation security R&D program should be carefully assessed: is it desirable to bring completed prototypes to the field-testing phase, resulting in commercial advantages gained by groups that perform the development contracts, or should the role of the FAA be to demonstrate the ability of a given technology to make the measurements required for its purposes to the specificity and selectivity required, but leave the prototype development to the competitive market? The latter lends itself much better to a broad attack on a problem where there is no single, simple answer and where a group of technologies must be established that, in various combinations, can provide the needed increment in security. The former maybe favored if there is urgent need to deploy equipment as soon as possible.

OTA'S Comments on Specific Technologies

A number of detection technologies in the near-prototype stage are at the point where they should be able to make a contribution to improving security within the next 18 months. With the experience gained from four field units, the capabilities of the SAIC/TNA should be well understood and its optimum role could be determined. This role may not necessarily be as the primary detector that handles all the checked luggage. The Imatron Computerized Tomography X-Ray Scanner may find its niche in the coming year. A key need there is to determine the length of time required for the system to discriminate bombs, possibly when guided by simpler x-ray scanners. The x-ray technique for looking at bomb components may prove valuable, if its performance can be properly defined. Further, the role of pattern recognition in x-ray technologies should be further evaluated.

If there are competing TNA systems under commercial development, the companies should be encouraged to bring these systems to the test phase where their capabilities and performance can be assessed. The creation of a test facility and an independent testing group, complete with impartial and well accepted test protocols and standards, should be a priority. Standards for testing new bomb detection devices should include a large set of passenger baggage (probably obtained from airlines' unclaimed luggage), reflecting a diversity of locations and seasons. The approach to the testing and certification effort must be broadly based so that all types of detectors can be brought into this program and evaluated on an equal basis.

The development, or at least the evaluation, of the accelerator technology required by all the nuclear bulk detection methods, specifically for their use in public installations as required by the airport security program, should also be a prime objective. Without the requisite accelerator technology, most of the nuclear detector techniques will fall by the wayside due to practical considerations. The nuclear resonance absorption (NRA) concept is such a candidate: without a viable proton accelerator it is just an idea; with one, it may be a very competitive scheme. It appears premature to define a prototype for the NRA system at this time. An aggressive program to obtain the key answers to questions such as accelerator feasibility, detection threshold, detector scheme, and data requirement for discrimination, should lead to the knowledge base that is needed to define the optimum use of this technique. Such a sequential program will require considerable time, probably 3 years at least. An aggressive program directed at one of the other nuclear techniques (possibly pulsed fast neutrons or associated particle production) that measures both elemental and spatial distributions may also be promising. Which technique should best be pursued may well rest on the comparative ease with which the required accelerators can be developed.

Apart from detection devices, there are several areas that may bear fruit in the coming year. Increased attention to human assessment of the threat, the so-called profiling of travelers by skilled security personnel, is desirable. Positive passenger/luggage matching at the entry to the aircraft is another need. The role of the FAA Aviation Security R&D Service could be to bring the technologies together to develop an integrated system, since many of the technical pieces already exist commercially. It is a matter of giving the operators the best data and help so they can make the right compromises among cost, operational complexity, and effectiveness.

The work being conducted by the FAA Technical Center at the Baltimore/Washington International Airport, supported by Sandia National Laboratory, to implement a totally integrated airport security system is also of prime importance. This effort should operate with input from other groups, including FAA operations, airport operators, airlines, and those involved in the other technology R&D programs.

The final high-priority area for the future is aircraft hardening, discussed by both the President's Commission and the NAS study. In June 1990, the FAA Technical Center convened a meeting of government employees active in explosives and structural research and related topics to discuss and conceive such a program. This group developed and published a program plan that has served the purpose of guiding this activity since that time.[23] Although it is a comprehensive and broad-based approach to the issue and recommends a combined analytical and empirical approach with frequent cross-checks, this report does not seem sufficiently technically based to provide the required guidance to the program. Since that report, more technically oriented efforts are taking place both within FAA and in cooperation with the Department of Defense.

[23] FAA Technical Center Plan, "Aviation Security Research and Development Plan for Aircraft Hardening," August 1990.