U.S. Department of Transportation
Federal Aviation Administration

Report to Congress

Aviation Security Aircraft Hardening Program

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Report of the Federal Aviation Administration to the House and Senate Committees on Appropriations pursuant to Senate Report 102-351 on the Department of Transportation FY 1993 Appropriations Act

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I. EXECUTIVE SUMMARY

This report is submitted in response to language in Senate Report 102-351 accompanying the Department of Transportation Appropriations Act for Fiscal Year 1993. The Federal Aviation Administration (FAA) was asked to study different types of technology designed to protect aircraft against certain explosives and to report to the Appropriations Committees on its findings. The FAA was also asked to consider investment and operating costs, acceptable safety margins, passenger convenience, and any other relevant factors. Interim reports were submitted to the Appropriations Committees in September 1994 and March 1996.

This report provides a current assessment and review of the research work completed to date regarding one such technology, hardened containers.

II. PROGRAM BACKGROUND

The aircraft hardening program was initiated in 1991 in response to recommendations of the President's Commission on Aviation Security and Terrorism and in compliance with direction set forth in the Aviation Security Improvement Act of 1990. The goal of the program is to protect commercial aircraft from catastrophic structural damage or critical system failure due to in-flight explosions.

Aircraft hardening analysis generally consists of two distinct elements: susceptibility and vulnerability. Susceptibility is the probability that explosives of a particular nature and amount can be successfully placed on board an aircraft. Vulnerability is the conditional probability that an aircraft will be destroyed or suffer some specific level of damage if an explosion takes place on board. This latter probability is a function of the characteristics of the explosive charge (e.g., weight, type, and placement) and the design capacity of the aircraft to withstand the explosive forces and resulting consequences. The aircraft hardening program addresses the vulnerability aspects of aircraft security by determining the vulnerability of aircraft and their occupants to onboard explosions and the methods of reducing this vulnerability through modifications to aircraft structures and/or components, such as luggage containers.

To accomplish the program objectives, tasks were designed to determine and identify: (1) the minimum amount of explosives that will result in aircraft loss; and (2) the methods and techniques that can be applied to the current and future fleets of commercial aircraft to decrease their vulnerability to explosive effects. The program is divided into two separate projects to address the objectives and requirements: explosive vulnerability and mitigation techniques.

The program draws on experts in the fields of engineering and explosives research from Government agencies within the Departments of Defense and Energy; from private industry such as aircraft manufacturers, luggage container manufacturers, and advanced materials experts; and from other governments/international organizations, such as the

United Kingdom's Civil Aviation Authority, the French Direction Generale De L' Aviation Civile in France, and the Government of Israel.

The focus of potential mitigation techniques has been the development of blast-resistant airline luggage containers. The hardening of aircraft luggage containers offers an attractive option as a blast-mitigating technique because a performance-based specification already exists for aircraft luggage containers. A draft appendix to the specification that specifies the FAA's requirements for blast-mitigating containers has been developed. The development of the hardened container specification also allows for the transition of hardened container technology to private industry. However, even with the development of a viable hardened luggage container, research into other mitigation techniques still will be required, because only wide-body aircraft currently use containers. In addition, the possibility exists that other hardening and explosives detection techniques can be developed that could make container hardening unnecessary. Finally, it is critical to determine the effects of blast and possible solutions across the spectrum of aircraft designs as a means of maintaining a technological advantage over future advances in criminal/terrorist explosives technology. The hardened container, however, provides the best opportunity for a near-term solution.

III. CONTAINER HARDENING

The objectives of this project are to assess the structural and functional readiness of selected hardened luggage container designs and to investigate the operational effectiveness and cost effectiveness of such designs. Ideally, the hardened container would need to have a life-cycle cost that approaches the life-cycle costs of containers currently used by airlines. For example, increases in acquisition and maintenance costs should be balanced by the extended container lifetime of the hardened container.

Hardened containers could be introduced into the airline industry through rulemaking or other regulatory means. Since current luggage containers are replaced on an average of every 2 to 5 years, the introduction of hardened containers into the market might be accomplished through attrition over some agreed-upon period of time.

A. Blast Resistance of Existing Baggage Containers

In order to determine the blast resistance of containers currently in use, tests were conducted on containers of the LD-3 classification, beginning with low charge weights and then increasing charge weights until failure took place. Pressure and strain measurements were taken for each test, along with high-speed film for post-test analysis of the explosive event. The test results indicated that the blast loading on the LD-3 structure was dependent on the density of the luggage that contained the explosive, the location of the explosive in the container, and the arrangement of the luggage surrounding the test article. Final analysis revealed that the current generation of LD-3 containers had very little inherent blast resistance capability.

B. Potential Container-Hardening Techniques

Eight different techniques to harden luggage containers were studied initially. These techniques consisted of both blast containment and blast management concepts. A blast containment design completely suppresses the effects of an explosion within a container. The blast containment concept offers the best alternative for suppressing the potentially catastrophic effects of post-blast fires. In addition, the blast containment container is considered an independent element within the cargo bay environment and requires no special handling procedures for placement and positioning on aircraft on the part of an airline. Conversely, a blast management design considers the container as part of a system within the aircraft cargo bay. In general, the blast management container is designed to allow a controlled failure of the container during the blast, while venting the detonation products (overpressure, fragmentation) into an adjacent container. The disadvantage of the blast management technique is that it requires special handling on the part of an airline. In addition, the blast management concept does not fully address the potentially catastrophic effects of a post-blast fire within a container and container/aircraft structural interaction. Based on the hardening techniques investigated in this study, the results indicated that an explosion could be mitigated best within a blast containment container constructed of high-strength composite materials.

C. Hardened Container Development Program

Proof of Concept: Under an FAA research project conducted from 1991-1994, several prototype blast-hardened containers were manufactured using a lightweight, high-strength composite material. This material also was chosen for its fragment-penetration resistance and fire-retardant characteristics. The prototypes were of the LD-3 classification, which is the most common type of container used by wide-bodied passenger airlines.

Initial, full-scale tests were performed in January 1992 on two prototype containers to demonstrate the feasibility of the hardened container. In each test, the prototype containers were packed with representative luggage and a plastic explosive charge was placed in a piece of baggage in a controlled location. The containers were instrumented with pressure and strain gages and the blast events were recorded with both normal and high-speed movie cameras. Although the preliminary results were good in terms of the blast containment properties of the hardened containers, the container door on the first test article failed before the maximum resistive capacity of the new design could be determined. Consequently, the door of the container was redesigned. A second test series was performed in April 1992. In the first two tests of the container with the new composite door, the blast was successfully contained. In the third test at a considerably higher charge level, partial venting occurred as the capacity of the container-door connection was exceeded. All charge weights used were considerably higher than those withstood by current containers.

Using the data obtained from the earlier tests, another prototype container was designed incorporating design refinements from the previous tests. The container weighed 392 pounds, which is within the bounds of current container tare weights. Tested in November 1992 in the same manner as were the previous two designs, the container withstood an explosive charge size that closely approximates the current explosives detection system standard.

Two additional LD-3 prototypes were designed to exhibit an improved strength-to-weight ratio based on insight gained in the testing performed to date. The containers were constructed at a decreased tare weight over previous designs, making them more attractive to the airline industry while they maintained their blast-resistant properties. From 1993-1994, each of the prototypes was tested. The final prototype was successfully tested at an explosive charge size that was equivalent to the existing detection standard with a tare weight of 284 pounds.

Development of Hardened Container Technical Specifications: The Society of Automotive Engineers, developer of the current baggage container specifications, has assisted the FAA in the development of a performance-based appendix to its specification for cargo unit load devices (ULD) that applies to LD-3 class blast-resistant airline baggage containers. This draft specification is dated January 1996. In addition to delineating the required design criteria for a blast-resistant container, the specification also covers the airworthiness and operational requirements with which hardened container designers would need to comply to have their containers certified for use. The explosive size that is required to be contained by the specification exceeds the charge size specified in the Criteria for Certification of Explosives Detection Systems (published in September 1993) to provide a margin of safety.

Development of Hardened Containers Meeting Specifications: The FAA solicited potential developers for hardened container design proposals to meet the FAA-established requirements for blast resistance. The designs were also evaluated for their ability to meet existing FAA airworthiness requirements and conform to airline operational requirements. The solicitation was conducted in two phases. During the first phase (1995-1996), four potential container designs were chosen from a field of 12 respondents. Of the four vendors selected, none of the container concepts tested was able to meet the FAA's requirements for blast resistance.

As a result of the respondents' failure to meet the requirements of the first solicitation, a phase II solicitation was conducted in 1997. As with phase I, vendor's designs submitted under phase II were evaluated based on the blast resistance capability of their designs in addition to airworthiness and airline operational requirements. Two vendors were selected from a field of eight respondents. The two designs selected were tested for compliance to FAA blast-resistance requirements and conformance to FAA airworthiness certification requirements. In March 1998, blast validation testing was conducted on both designs. Of the two designs tested, one container fully met the FAA's blast requirements. The tare weight for the successful container was 340 pounds. The successful container design was submitted to the FAA certification office for airworthiness approval. In

July 1998, the design was granted an FAA design letter of approval. Based on available funding, current plans call for the construction of 11 units of the certified container design. The 11 units are scheduled to be delivered by January 1999. Concurrent with this effort, in January 1999, the FAA plans to blast test two more hardened container designs for potential in-service evaluation. Pending airline participation for the operational evaluation phase, it is estimated that enough operational data can be collected to assess the operational viability of blast-mitigating airline baggage containers as outlined in the following section.

In addition, a study of container composite materials manufacturing and repair considerations is underway to obtain an assessment of factors, such as practical and acceptable weight, manufacturing processes, operability, repair and maintenance capability, and associated costs. Work began in the last quarter of fiscal year 1998 and will continue through fiscal year 2000. Those designs that are deemed the most viable will be candidates for study under this activity.

D. Air Carrier Operational Demonstration

The purpose of this task is to determine the economic and operational impacts of hardened luggage containers. It will address the explosive resistance and viability of each container, the container tare weight, the manufacturing cost and repair capability of the container, and issues relating to operability. These issues must be addressed before recommendations for rulemaking can be made to ensure that the specifications for hardened containers can be met at a reasonable cost.

As previously mentioned, 11 units of the hardened container meeting the FAA's requirements for blast resistance are scheduled to be delivered by January 1999. These units have been offered by the FAA to Air Transport Association (ATA) member U.S. air carriers for operation on regularly scheduled flights for the purpose of collecting operational, cost, and repair data on hardened containers. With the exception of Northwest Airlines, the ATA member air carriers will not accept these units based on anticipated operational problems because of the container door location and operation. The container currently is being redesigned to address air carrier operational concerns. However, it is anticipated that several design iterations will be necessary, because blast validation is required for each significant design change. ATA member carriers have agreed to have handling personnel evaluate units for operation of the door mechanisms in winter conditions. This will occur in February 1999.

Tower Air (which operates out of John F. Kennedy International Airport), Northwest Airlines, and the Government of Israel have agreed to employ operationally the units. Tower Air will receive four units, and Northwest Airlines and the Government of Israel will each receive one unit in February 1999. During this deployment, data regarding the functionality, durability of both the panel material and the closure mechanisms, and repair and maintenance will be evaluated. Additionally, units will be destructively tested at established intervals to ensure that degradation of the containers' blast resistance capability has not occurred. The remaining five units will be held in reserve to replace those that are destructively tested.

The cost of the 11 units that currently are being constructed is $38,000 each. If the units are purchased in quantities of more than 1,000 units, the price per unit is estimated to be between $16,000 and $24,000. The price of each aluminum unit used by the airline industry ranges from $1,000 to $2,000, depending on the design and manufacturer.

IV. SUMMARY

The feasibility of blast-resistant baggage containers has been demonstrated under the prototype effort and subsequent FAA solicitation resulting in the successful testing and certification of a unit developed by private industry. This unit is capable of mitigating an explosive threat in excess of the current explosives detection system certification criteria. The development of hardened container design criteria has been completed, resulting in a draft specification for LD-3-type hardened baggage containers. This draft specification provides a vehicle by which the FAA could mandate the use of hardened containers if they are proven to be operationally viable and ensure that these containers will meet or exceed required blast resistance and airworthiness requirements.

Prototype containers will continue to be developed and tested in order to refine existing design requirements and address airline operational issues. Analysis of the operational considerations is being initiated. This includes assessing those factors with which the airlines are most concerned; i.e., container cost, tare weight, repair, operability, and maintainability. This analysis will ensure that specifications for a hardened container can meet a reasonable life-cycle cost. Further work with industry will help ensure that the existing specification is appropriate.

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