A PROGRAMMATIC OVERVIEW OF THE LARGE AIRCRAFT SURVIVABILITY INITIATIVE (LASI)

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Abstract

The recent events in Mombassa, Kenya and in Iraq have highlighted the need for better understanding of commercial aircraft survivability to man portable air defense systems (MANPADS) and methods to counter this threat to aviation.

The Large Aircraft Survivability Initiative (LASI) is an U.S. Air Force (46th Test Wing) initiative to bring together the full capabilities of the federal government and industry with the common purpose of improving large aircraft survivability through collaborative efforts. The LASI objectives are to assess, by demonstration and analysis, the survivability of large aircraft and investigate the viability of survivability enhancement technologies to aid in the selection of appropriate countermeasures to protect commercial aircraft.

The LASI consortium began coordinated planning in 2003 and began testing in 2004. Infrared signature measurements to support modeling and simulation of MANPADS engagements are part of the initial collaborative program. Over the course of the next several years, the consortium plans to acquire representative large aircraft components and conduct a multi-faceted evaluation to include controlled vulnerability testing on components and sub-systems to understand and ultimately improve the survivability of large aircraft.

Introduction

LASI is an U.S. Air Force-led (46th Test Wing) initiative to bring together the full capabilities and resources of the federal government and industry with the common purpose of improving large aircraft survivability through collaborative efforts. Active members of the LASI consortium include the U.S. Air Force, U.S. Navy, Transportation Security Administration (TSA), Joint Aircraft Survivability Program Office, and NASA. LASI also enjoys interested participation from the U.S. Department of Homeland Security (DHS), Federal Aviation Administration (FAA), General Electric Aircraft Engines, Pratt-Whitney Aircraft Engines, United Airlines, and others.

The LASI core objectives are to assess, by demonstration and analysis, the survivability of large aircraft and investigate the viability of survivability enhancement technologies to aid in the selection of appropriate countermeasures to protect commercial aircraft. LASI has organized several technical working groups to address specific

survivability issues in the following topic areas: Infrared Signature Measurement, Vulnerability Modeling & Simulation, Aircraft Structures, Fire Protection, and Susceptibility Reduction. LASI holds periodic workshops where working groups can plan their respective research activities and exchange technical information.

Survivability verification testing and other forms of research are occurring at several facilities throughout the U.S. that are ideally suited for aircraft survivability investigations. IR signature measurements were conducted earlier this year at Eglin AFB in Florida and Edwards AFB in California. Test article acquisition is underway to prepare for component vulnerability testing at Wright-Patterson AFB and Eglin AFB.

Background

MANPADS are widely proliferated throughout the world, available to almost anyone and are relatively inexpensive to buy. They can be handled by a single individual and can be concealed until just seconds before its use. With minimal training, a single terrorist and a MANPADS can be a formidable threat. For these reasons, MANPADS are the weapons of choice for terrorists against aircraft. As we have seen in the recent MANPADS attacks in Kenya and Iraq, terrorists have the will and intent to attack large aircraft with MANPADS. These attacks lend credibility to the assertion that MANPADS pose a serious threat to large aircraft interests around the world.

The potential loss of large aircraft to the MANPADS threat spans the spectrum of interests that utilize them in their operations. Commercial, large aircraft derivatives are being used extensively to satisfy a wider variety of mission roles throughout the world. The U.S. military increasingly relies on the commercial aircraft fleet to augment military transports to support an overwhelming operational tempo. While most military transport aircraft were designed to be somewhat survivable to combat damage, the commercial aircraft are not. Also, the potentially long-reach of terrorists and the threat they pose to the flying public is another reason for concern. Whether the issue of the MANPADS threat is addressed by public safety mandate (i.e., DHS, TSA), mission security (DoD), or economics (industry), LASI is a forum where individual resources can be combined for the larger good of large aircraft survivability.

The issue of large aircraft survivability has not been fully addressed. LASI researchers feel this is largely due to two factors: 1) Lack of any reason before now to improve the survivability of large aircraft; and 2) Voids in empirical data that show how combat damage can affect the survivability of large aircraft. Through LASI, researchers are intent on remedying these deficiencies through the scope of work presented in this paper.

Scope

The task of assessing the survivability of large aircraft against any threat whether it causes physical damage or induces onboard system failures must be broken down to the following areas: susceptibility, vulnerability, and mitigating survivability enhancements.

LASI researchers are conducting susceptibility investigations that will help minimize the probability of large aircraft encountering or being damaged by MANPADS threats. These investigations will begin by understanding how and where MANPADS will usually attack the aircraft. LASI researchers will accomplish this through the use of modeling tools and hardware-in-the-loop (HITL) simulated missile engagements against a projected IR-image of a target aircraft. Using this technique, a statistical hit-point database can be generated, and hit-point concentrations can be mapped onto the aircraft. Knowing how and where the aircraft is likely to be hit will focus efforts on potential vulnerabilities, and may even suggest ways of reducing the aircraft's susceptibilities. Collecting the IR signature of an aircraft is the first step in this process, and LASI researchers have already measured the signatures of selected aircraft in all modes of flight.

LASI researchers are also interested in conducting investigations that will improve the understanding of vulnerabilities that exist in the aircraft's structural, propulsion, flight control, fuel, and crew systems. These areas of uncertainty will be explored through a series of component vulnerability tests. Since MANPADS are already known to track the IR signature of the engines, initial emphasis will be focused on engine and wing vulnerabilities. Engine vulnerability testing will be done using a build-up approach. The first step will be to understand the damage effects due to mass-on-mass kinematics, and then add warhead effects. The last test series will look at cascading effects of a MANPADS hit against a running engine in an airflow field. The collateral damage to the surrounding wing structure and the potential for fires will be investigated as well.

LASI researchers hope that the overriding outcome of their work will result in new system design features, improved manufacturing processes, and add-on equipment that will mitigate existing survivability deficiencies. Hopefully, these large aircraft survivability enhancements will deny the aircraft as a target given a threat encounter through improved susceptibility or, failing that, harden the vulnerable places on the aircraft.

In summary, LASI researchers will conduct a variety of susceptibility and vulnerability investigations over the course of the next several years that will improve the overall survivability of large aircraft.

Initial Focus Aircraft

LASI has selected the Boeing 747 as its initial focus aircraft. The 747 has numerous features that superbly represent the rest of the commercial, large aircraft fleet making it an ideal technical candidate. The LASI researchers believe that any susceptibilities, vulnerabilities, or mitigations discovered on the 747 should be generally scalable to other large aircraft in the class. Technical reasons notwithstanding, 747s are heavily used to transport personnel and cargo throughout the world making it a strong candidate in practical terms as well.

Proposed Products

LASI is still in the early stages of planning, however, a few products have been named as threshold products for the consortium's work. They are:

1. Measuring the IR signatures of a cross section of aircraft which will be used to create a set of high-fidelity signature models that will support susceptibility and vulnerability reduction studies.

2. Do a high-fidelity survivability assessment of the initial study aircraft, the 747. In doing so, the LASI researchers hope to gain baseline information of how and where MANPADS will attack, how the materials and components will react, what the resultant aircraft dynamics are, and gain a better understanding of system vulnerabilities. Further work in these areas will support engineering design trade studies leading to improved survivability.

3. The knowledge gained by this work will be used by decision makers to minimize the risks to the aircraft as given a MANPADS encounter. Based on the specific mission needs, decision makers will have a wider selection of mitigation options such as countermeasures, explosion and fire protection, and damage adaptive flight controls to choose from.

Summary

LASI researchers are taking an analysis-driven approach to answering large aircraft survivability questions. The first task is to characterize a representative cross-section of large aircraft types and use these models to conduct simulated MANPADS engagements using hardware-in-the-loop techniques. The outcomes of numerous simulated MANPADS attacks can be used to focus in on selected areas of the aircraft, averting the need to do full-up system level testing, and instead do smarter component-level tests. These component tests will be done using a gradual degradation approach so that researchers will be able to clearly understand how the MANPADS damage mechanisms

can add up to catastrophic system failures. This approach also maximizes the use of limited test articles.

LASI's coordinated comprehensive approach will go a long way to solve critical deficiencies in understanding the issue of large aircraft survivability against a MANPADS attack. The initiative will draw from the multi-disciplined expertise of many researchers and will make optimal use of limited resources. LASI's legacy will be a standard set of tools and data that can be used to improve the aircraft survivability in large aircraft.