

Designing for

Emerging and existing survivability technologies focus on reducing the susceptibility and vulnerability of our air systems

Military aircraft have always had to contend with an enemy who is trying to shoot them down. However, today civilian aircraft also operate in a man-made hostile environment, because of the increased activities of terrorists. As a consequence, survivability for both military and civilian aircraft has become an issue of paramount importance to many governments, commercial airlines, and aircraft companies.

What is survivability?

Aircraft survivability has been defined as “the capability of an aircraft to avoid or withstand a hostile environment.” That environment can be natural, as in the case of severe air turbulence, lightning, midair collisions, and crashes; or man-made, comprising elements such as enemy air defenses or terrorist weapons. When the environment is man-made, the field is referred to as the combat survivability discipline.

To some, survivability in the man-made hostile environment is achieved by flying high, or fast, or at a long range, out of the reach of the enemy’s weapons. To others, it is achieved by stealth, and many believe that survivability and electronic warfare (EW) are synonymous. Still others believe a survivable aircraft is one that can take a hit and continue to fly.

These opinions are too exclusive. In the systems engineering approach, survivability is achieved by designing, equipping, and operating an aircraft so that it can avoid the hostile environment, if possible, or withstand the environment, if necessary. In the vernacular of the combat survivability discipline, avoiding the hostile environment is referred to as reducing the susceptibility of the aircraft—the probability that it will be hit by one or more damage mechanisms, such as the blast and fragments from a warhead detonation.

Susceptibility reduction for civil aircraft in-



In this F-14 MANPADS test, conducted under the Joint Live Fire program, the objective was to determine the vulnerability of the F-14 to the threat. The aircraft was placed on a platform and was not operating. First-order effects of the threat were determined, as was the method of firing the threat at a stationary target.

survivability

cludes searching baggage and passengers for weapons as they board a flight, policing the area around an airport to prevent a terrorist from taking a shot at a departing or approaching aircraft, developing flight paths that minimize the exposure time to a threat weapon, and using on-board infrared countermeasure equipment to defeat IR surface-to-air missiles such as a man-portable air defense system (MANPADS).

Designing an aircraft to withstand a hostile environment is referred to as reducing its vulnerability—the probability it will be killed when hit by damage mechanisms. Examples of vulnerability reduction for civil aircraft include the use of hardened luggage containers that can withstand an internal detonation, the physical separation of redundant hydraulic power systems so that a single hit or detonation will not cause the loss of all hydraulic power, the use of on-board inert gas generators (OBIGGs) to prevent fires and explosions inside fuel tanks, and

nacelles that can contain the debris from a damaged engine. Note that the last three features also reduce the probability of a mishap due to a bird strike or fuel tank spark, and consequently also increase the safety of the aircraft.

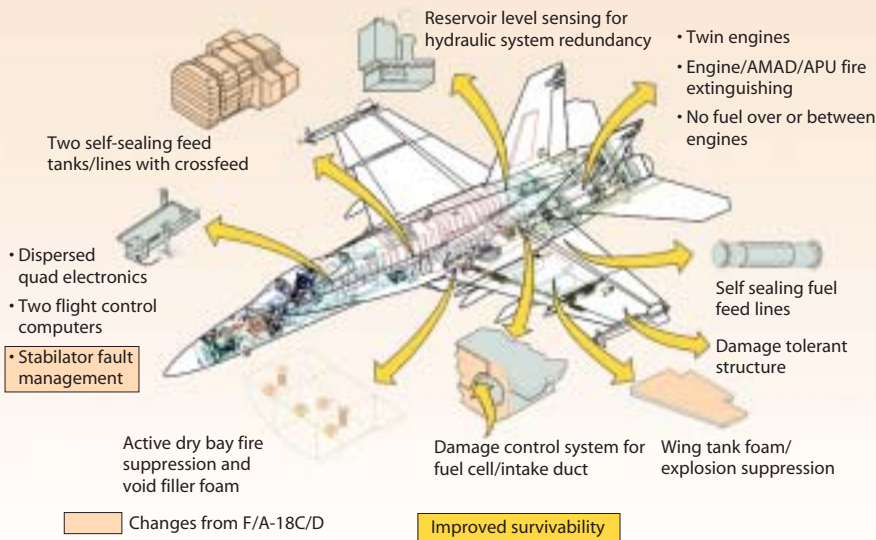
Survivability features on U.S. military aircraft

Combat survivability began its evolution as a formal design discipline for military aircraft about 30 years ago, mainly as a result of the loss of approximately 5,000 U.S. military aircraft to enemy fire during the 1962-1973 war in Vietnam. Today, the U.S. DOD develops and procures survivable aircraft.

For example, because approximately 2,500 helicopters were downed in the Vietnam conflict, both the AH-64A Apache and UH-60A Black Hawk were designed to take a single hit by an armor-piercing incendiary round anywhere on the helicopter and continue to fly safely for 30

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F/A-18E/F VULNERABILITY REDUCTION THROUGH DESIGN



minutes. This design requirement paid off when approximately three dozen of the U.S. Army's 101st Airborne Division Apaches on a mission against the Republican Guard near Karbala early in Desert Storm II were heavily damaged by small arms fire. Only one of the Apaches was killed in the battle, a testament to the low vulnerability of the design.

In the A-10 Thunderbolt II, vulnerability was a major consideration during design because of its close-air support mission.

Stealth and electronic countermeasures are important contributors to the survivability of the F-117 Nighthawk, B-2 Spirit, and F/A-22 Raptor, and survivability was one of the four design pillars of the Joint Strike Fighter program. The F/A-18A Hornet was the first Navy aircraft with significant consideration of survivability. The latest version, the F/A-18E/F Super Hornet, has been designed to reduce its radar signatures and is equipped with state-of-the-art defensive electronic countermeasures. More-

over, several vulnerability reduction features have also been added to the already rugged design of this C/D variant.

The V-22 Osprey had significant survivability requirements during design. According to Mike Mikel, the former V-22 survivability IPT leader, the Osprey was designed to a rigorous set of 'Not to Exceed' requirements for a wide range of threats, from small arms to anti-aircraft artillery. The design philosophy was to provide state-of-the-art survivability to the most cost-effective levels commensurate with mission effectiveness.

MANPADS countermeasure programs

In the late 1990s, the Air Force began a program known as the Large Aircraft Infrared Countermeasures program, or LAIRCM, to reduce the susceptibility of large, slow-flying tanker and transport aircraft such as the C-17 and C-130 to modern shoulder-launched infrared MANPADS (man-portable air defense systems) missiles. In 2001, Northrop Grumman's Electronic Systems won the contract to develop and produce the LAIRCM system. It is a laser-based variation of the company's lamp-based directional IR countermeasures system.

The Science and Technology Div. of the Dept. of Homeland Security established the Counter-MANPADS Office to help determine the viability, economic costs, and effectiveness of adapting existing technology from military to commercial aviation use. In early October 2003, a call for proposals was issued to address the IR MANPADS threat.

On January 6, 2004, three contractor teams, BAE Systems, Northrop Grumman, and United Airlines, were awarded Phase I six-month contracts to provide a detailed design and an analysis of the economic, manufacturing, and maintenance issues and solutions needed to support a system that will be effective in the commercial aviation environment.

In August of that year, BAE Systems and Northrop Grumman were selected to proceed to Phase II, which will include the development, test, and evaluation of prototype systems using existing military or commercial technology. Phase II will last approximately 18 months, and will be followed by a recommendation to the administration and Congress for the most viable solution to defend against shoulder-fired missiles.

On March 30, 2004, bipartisan legislation

Survivability and system safety

The system safety discipline attempts to minimize those conditions known as hazards that can lead to a mishap resulting in material damage and personal death or injury in environments that are not made hostile by man. The hazards considered by the system safety discipline can be due to internal system failures or features or to outside influences, such as environmental factors or operator errors. Thus, together, the system safety and survivability disciplines attempt to maintain safe operation and maximize survival of an aircraft and its occupants in all environments, in both peacetime and wartime. An example of the cooperation between the disciplines is the introduction of fuel system fire/explosion protection technology developed for military aircraft into civilian airliners following the loss of TWA 800.

SURVIAC

The DOD center of technical and analytic excellence for nonnuclear survivability and vulnerability data, information, methodologies, models, and analyses relating to U.S. and foreign aeronautical and surface systems is the Survivability/Vulnerability Information Analysis Center (<http://iac.dtic.mil/surviac/>). SURVIAC collects and maintains combat damage data from most major conflicts, including the South-east Asia conflict and Desert Storm I. Models developed by the JASPO Survivability Assessment Subgroup are maintained and disseminated by SURVIAC. A Model Guide that describes each of the survivability and lethality models is available from the SURVIAC Central Office.

to provide additional interim protections for commercial aircraft from shoulder-fired missiles was introduced in the House of Representatives (H.R. 4056). The Commercial Aviation MANPADS Defense Act of 2004, or CAMDA, includes both long- and short-term solutions, as well as domestic and international efforts.

The act is intended to make it clear that while the Dept. of Homeland Security (DHS) is conducting R&D of missile defense equipment for commercial aircraft, interim solutions to the threat posed by MANPADS should be taken. Major provisions include:

- Encouraging the president to pursue international diplomatic and cooperative efforts, including multilateral and bilateral treaties, to limit the availability, transfer, and proliferation of MANPADS and to seek the destruction of excess, obsolete, and illicit systems.

- Requiring the FAA to, when appropriate, expedite airworthiness certification of missile defense systems for commercial aircraft and avoid duplicating the efforts taken by DHS during the missile defense system R&D program.

- Encouraging the president to continue programs to reduce the number of MANPADS worldwide.

- Requiring DHS to report to the Congress, within one year, on the vulnerability assessment reports they are conducting at U.S. airports and any ground-based defense policies or procedures recommended through that process.

A new version of the bill (HR 2905) was introduced in July of this year and referred to the House aviation subcommittee.

Survivability infrastructure and resources

DOD acquisition policy requires a thorough and systematic survivability program to ensure that it is adequately considered throughout the aircraft design process. This is accomplished in different ways by each of the three departments within DOD.

The principal agencies responsible for Army aviation survivability include the Army Research Laboratory's Survivability and Lethality Analysis Directorate and the Joint Project Office for Aircraft Survivability Equipment and Advanced

Threat Infrared Countermeasures/Common Missile Warning System. The Naval Air System Command's Survivability & Threat Lethality Division is the lead agency for the survivability of Navy and Marine aircraft. A major survivability agency within the Air Force is Aerospace Survivability and Safety Flight.

The primary DOD joint service office responsible for aircraft survivability is the Joint Aircraft Survivability Program Office (JASPO), chartered by the Joint Aeronautical Commanders Group. It was formed in January 2003 by combining the Joint Technical Coordinating Group on Aircraft Survivability with several related activities to increase overall effectiveness.

The combined group has a long and dedicated history of developing survivability technology and getting it applied to aircraft through the Vulnerability Reduction and Susceptibility Reduction Subgroups. An example of the technology promoted by the Vulnerability Reduction Subgroup is the OBIGGs. This subgroup played



NAVAIR China Lake's Survivability Division conducted a vulnerability test of a C-130 aircraft by firing a live Stinger missile at it.

a major role in the development of OBIGGs a number of years ago. Since that time OBIGGs has gone on the C-17, F/A-22, V-22, F-35, AH-64, AH-1Z, UH-1Y, MH-60K, and recently the MH-47E. The subgroup has recently moved into new fire and explosion technology areas with the potential for large payoffs. Its current passive fire protection work is an example. The enhanced powder panels for fire protection in dry bays and ionomer self-sealing technologies have shown promise and are lightweight enough for unmanned air vehicles.

The Susceptibility Reduction Subgroup continues to develop leading-edge aircraft countermeasures technology, and its products have consistently been applied to new EW systems as

they are developed. Aerogel is an example of a promising new technology that was promoted by this subgroup as a retrofitable material for thermal and IR emission suppression in and around aircraft engines. Although many application problems had to be worked out, the material was successfully applied in specific locations to shield aircraft hot spots, greatly reducing the IR signature. This technology demonstrated tremendous potential to reduce the susceptibility of current U.S. aircraft to IR-seeking missiles—the Kiowa program manager selected it for a Kiowa upgrade program, and the Apache program is now doing the same.

The tools, models, and simulations needed to design, analyze, test, and evaluate the survivability of U.S. systems are developed and organized within the Survivability Assessment Subgroup. One of their focus areas is survivability model and simulation (M&S) credibility.

The JASPO established the Joint Accreditation Support Activity (JASA) several years ago to assess, improve, and document the credibility of approved survivability models that are provided through the DOD Survivability/Vulnerability Information Analysis Center (SURVIAC). JASA

developed a cost-effective verification, validation, and accreditation (VV&A) process that allows programs to tailor their VV&A programs to fit their needs and thus reduce costs. JASA supports acquisition programs and other activities with M&S accreditation support services.

The Joint Combat Assessment Team (JCAT) within the JASPO focuses on collecting combat damage and loss data and showing warfighters what happens when tactics and countermeasures are not fully successful and their aircraft takes a hit. The JCAT is the JASPO's tie to the warfighter. Its primary mission is to deploy combat data collection teams to conduct inspections and forensic analysis of combat-damaged aircraft and incident sites and to interview aircrew, intelligence, weapons and tactics, and logistics personnel.



Survivability is a critical system characteristic that has evolved into a distinct and important design discipline. Viable, cost-effective technologies for reducing the susceptibility and vulnerability of our air systems exist today and are continuing to emerge. ▲

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