Joint Aircraft Survivability Program (JASP)

In FY24, the Joint Aircraft Survivability Program (JASP) continued advancing tools, processes, infrastructure, and workforce to demonstrate progress towards transforming the OT&E and LFT&E of aircraft survivability. JASP also continued to deliver new techniques and technologies, demonstrating the potential to enhance the survivability of U.S. aircraft in contested, multi-domain operations.

JASP advanced aircraft survivability T&E capabilities by validating and releasing new modeling and simulation (M&S) capabilities, enabling enhanced evaluations of red threat engagements against blue rotary-wing aircraft in the low-altitude battlespace. In addition, JASP: (1) released defensive cyber analysis capabilities for OT&E and LFT&E in support of aircraft survivability evaluations and completed the first cyber LFT&E demonstration on a full-up operational aircraft, (2) completed design and development of advanced electro-optical (EO)/ infrared (IR) guided missile hardware-in-the-loop simulators and a new 2-Color Infrared (2CIR) missile warning system stimulator for IR countermeasures T&E, (3) significantly expanded the test dataset characterizing dry bay fire ignition on aircraft from kinetic threats (fragments and bullets) for development of version 2.0 of the Next Generation Fire Model (NGFM) beginning in FY25, (4) continued maturing and testing future concept of operations (CONOPS) that enable aircraft combat damage incident reporting in anti-access/area denial environments, (5) increased aircraft threat detection and countermeasure capabilities by completing an assessment of Directed Infrared Countermeasure escort protection capabilities and limitations, and by demonstrating new electronic attack (EA) techniques and analytical tools to counter advanced radar threats, and (6) improved aircraft and personnel protection by maturing a flammable fluid mist control additive through testing to characterize fire prevention performance, qualify the additive for use in avionics cooling systems, and demonstrate low-rate production with a path to scale up manufacturing.

PROGRAM OVERVIEW

The Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS) was chartered in 1971, in response to high aircraft loss rates experienced during the Vietnam War. The JTCG/AS initially focused on aircraft susceptibility reduction (design characteristics that make an aircraft harder to detect) and aircraft vulnerability reduction (design characteristics that give an aircraft the ability to withstand a hit). The JTCG/AS focus later grew to include M&S and establishing aircraft survivability as a design discipline through the development of a formal curriculum at the Naval Postgraduate School.

In 1985, the oversight responsibility of the JTCG/AS was assigned to the newly established Joint Aeronautical Commanders Group. Funding for the JTCG/AS was consolidated under what is now the DOT&E.

In January 2003, the Joint Aeronautical Commanders Group signed a new charter establishing JASP to replace the JTCG/AS, while expanding the JTCG/AS charter to include the Joint Combat Assessment Team (JCAT).

In 2005, the Service aviation systems commands (U.S. Army Aviation and Missile Command, U.S. Air Force Life Cycle Management Center, and Naval Air Systems Command [NAVAIR]) chartered JASP as it is known today.

MISSION

JASP develops cross-Service aircraft survivability solutions and evaluation methods needed to dominate the air domain and mitigate U.S. aircraft losses in combat. Specifically, JASP:

- Advances the capability and credibility of joint aircraft combat effectiveness tools used in combat mission planning, training, and weapon schools to support the development of air combat tactics, techniques, and procedures.
- Develops and manages enterprise-level digital tools required to support comprehensive evaluation of aircraft effectiveness and survivability, with confidence.
- Collects and analyzes U.S. aircraft combat damage and losses via the JCAT, to develop the requirements for joint aircraft survivability solutions that provide force protection and remedy operational shortfalls.
- Leverages advances in science and technology to develop innovative aircraft survivability enhancement features.

FY24 KEY ACTIVITIES

» ADVANCING THE CAPABILITY AND CREDIBILITY OF JOINT AIRCRAFT COMBAT EFFECTIVENESS TOOLS

Acquisition Community, Combat Mission Planning, Training, and Weapon Schools

JASP's Survivability and Lethality of Aircraft in Tactical Environments (SLATE) provides a two-sided combat simulation with "First Look," "First Shot," "First Kill" capability over the survival/kill chain. SLATE supports two-sided combat from one-on-one to several-on-several. The SLATE user selects which players (i.e., shooters, weapons, and targets) to include in the engagement simulation. The user defines events that cue shooter and target reactions. All inflight aircraft and weapons players are based on high-fidelity simulations.

Early in FY24, SLATE version 1.1.1 was released by the Defense Systems Information Analysis Center as a controlled unclassified information and classified application. During FY24, the SLATE development team worked several long lead tasks, as shown in the SLATE Operational View 1 in Figure 1. These tasks supported medium/high and low altitude, multi-domain, and two-sided air combat analysis capabilities. FY24 activities included:

- Radio frequency (RF) propagation losses
- Naval surface-to-air missile (SAM) simulations
- Electronic Warfare (EW) countermeasures
- Rotary-wing/tilt-rotor simulations
- Air defense artillery (ADA) sites

The SLATE user interface/user experience includes interactive, virtual range, and constructive batch capabilities. SLATE supports importing multiple types of terrain that are used for advanced displays and simulation effects. Figure 2 shows the SLATE user interface/user experience geographical displays for rotary- and fixed-wing aircraft with terrain imagery.

SLATE leverages the Hybrid Integration and Visualization Engine and the Agile Combat Effects Library (ACEL) to enable multi-domain two-sided air combat analyses with a growing suite of capabilities and data. This integration

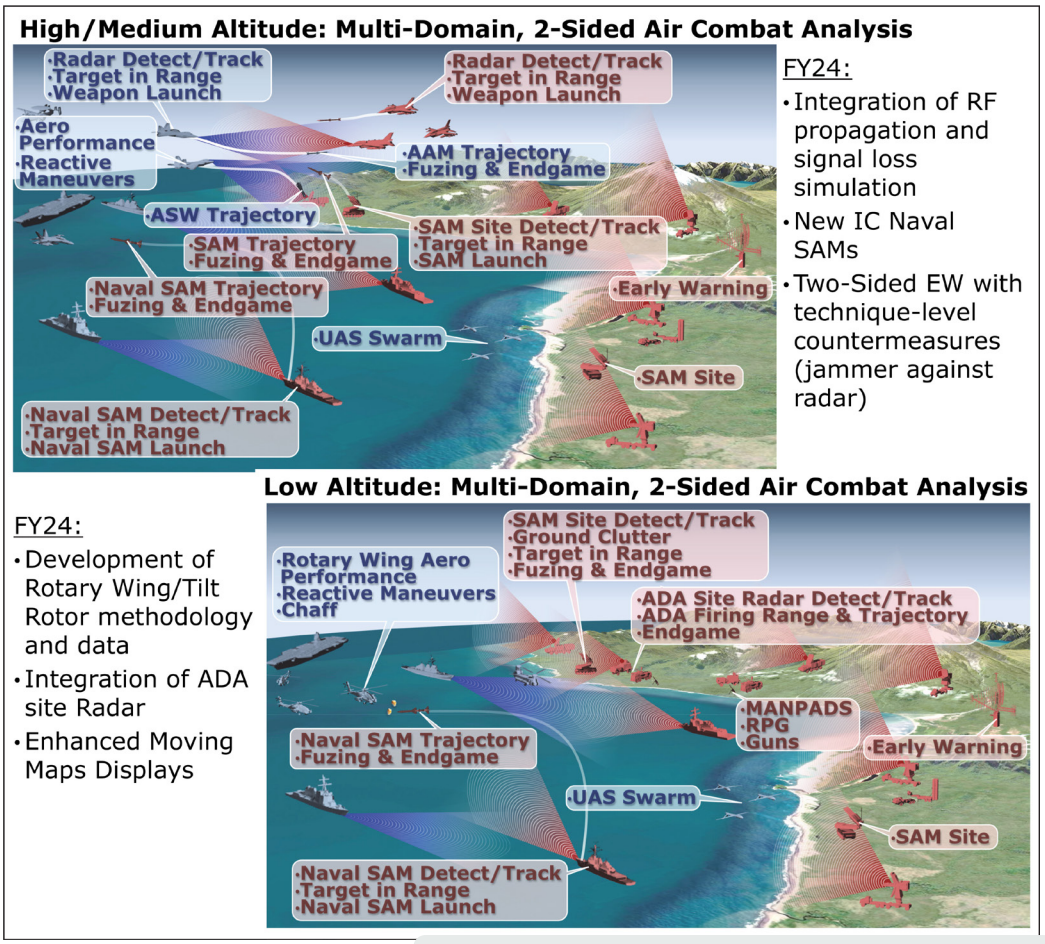

Figure 1. SLATE Operational View 1 (OV-1)

AAM – Air-to-Air Missile; ADA – Air Defense Artillery; ASW – Anti-Submarine Warfare; EW – Electronic Warfare; IC – Intelligence Center; MANPADS – Man-Portable Air Defense System; RF – Radio Frequency; RPG – Rocket-Propelled Grenade; SAM – Surface-to-Air Missile; UAS – Unmanned Aerial System

Figure 2. SLATE Rotary- and Fixed-Wing Aircraft Graphical Displays with Terrain Imagery

architecture enables fast implementation of supplier authoritative simulations and data (e.g., the intelligence community, system program office).

As SLATE evolves, it will become suitable for future LFT&E evaluations, provide a more complete evaluation with less time and cost, and provide a streamlined path for implementing blue system simulation and data into ACEL. ACEL is a major component of the Joint Technical Coordinating Group for Munitions Effectiveness Joint Anti-Air Model application. Leveraging this architecture enables sharing between the acquisition (SLATE) and operational warfighter (Joint Anti-Air Model) simulations.

In FY24, JASP completed long-lead development of the aero performance (BlueMax) rotary-wing capability. It was released by the Defense Systems Information Analysis Center as a controlled unclassified information application. BlueMax version 7.2 is included within SLATE and is accessible via the ACEL Application Programming Interface (API) and ACEL Micro API.

ACEL Micro APIs provide specific simulation capabilities that can be leveraged by external simulation frameworks. Current development is enabling the ACEL aero performance simulation and library of aero data to be reused as a "plug-in" into the Advanced Framework Simulation framework. Additional reuse with other frameworks (Joint Simulation Environment and Integrated Threat Analysis Simulation Environment) are being assessed. The reuse of the ACEL simulations and data through the Micro APIs provide authoritative and consistent results across the DoD.

JASP advanced SLATE and ACEL through integration of authoritative intelligence center EW red (hostile) players. SLATE simulates the interaction of the red (hostile) radars with blue jammers, using the pulse descriptor word interface, enabling two-sided EW with technique-level countermeasures. SLATE version 1.2 release is scheduled for November 2024.

» DEVELOPING AND MANAGING ENTERPRISE-LEVEL DIGITAL TOOLS

Supporting Comprehensive Evaluation of Aircraft Effectiveness and Survivability, With Confidence

Through tri-Service configuration control boards, JASP continues the management of major M&S tools used to estimate air combat effectiveness and survivability against an array of operationally representative kinetic threats. The toolsets include the air-to-air combat simulation Brawler, the surface-to-air engagement model Enhanced Surface-to-Air Missile Simulation (ESAMS), multiple domain two-sided air combat simulation SLATE, and the vulnerability analysis code Computation of Vulnerable Area Tool, along with its supporting penetration and fire prediction codes Projectile Penetration, Fast Air Target Encounter Penetration, and the NGFM.

In FY24, JASP continued the effort to develop tools for cyber and high-energy-laser (HEL) non-kinetic threats. JASP continued to add cyber survivability evaluation capability to the Cyber Operations and Lethality Effectiveness tool. A new risk assessment module calculates the likelihood and mission impact of a potential threat against critical system components, informing decision authorities for determinations on risk tolerance/acceptance. New data flow modeling enables characterization and assessment of the impact to critical data from potential threats. Automated system characterization and data ingestion techniques improved the efficiency of assessing aircraft systems. New tools were added to semi-automatically perform standardized, repeatable cyber survivability assessments to

quantify a mission system's ability to detect and recover from cyber events. This effort, in collaboration with the Air Force, Army, and Navy aviation cyber survivability communities, provides M&S capability and data standardization to develop and evaluate aircraft survivability in contested cyberspace.

JASP initiated a two-year effort to achieve interoperability of HEL-relevant M&S toolsets for practical HEL survivability analysis by 2025, with associated processes, metrics, and supporting test data. The effort will also identify data voids, M&S capability limitations, and other factors limiting platform-level survivability analysis.

Collect and Analyze U.S. Aircraft Combat Damage and Losses Using the JCAT

In FY24, JASP continued to enable aircraft combat damage incident reporting through the JCAT. The JCAT is heavily engaged with U.S. Indo-Pacific and European Commands supporting operational commanders with combat data collections while also leveraging operational exercises. They continued development of a new CONOPS utilizing Title 50 (i.e., intelligence) tools to enable the near real time forensics of aircraft combat damage in anti-access/area denial theaters of operation.

JCAT launched a third phase of aircraft combat damage assessment training with two objectives: (1) to impart to students a situational knowledge of naval aviation missions, capabilities, and tactics as well as present and potential threats; and (2) to offer practical training, including a hands-on exercise, in the use of National Technical Means tools. By completing this course, assessors learned to effectively characterize incidents, perform threat analysis, and develop aircraft combat damage reports that will inform combatant commanders rapidly and provide the DoD critical data to address aircraft survivability gaps.

To mature the JCAT CONOPS and further solidify the command-to-command relationships, the JCAT took advantage of previous large-scale exercise observations of the 692 ISR Group (DGS-5) and the 8th Intelligence Squadron Air Domain Awareness Cell. Moreover, the JCAT expanded observation and growth to additional sites for mission execution during Valiant Shield 2024. JCAT assessors executed daily operations for 15 consecutive days in support of JCAT CONOPS maturation, training and development of toolsets and procedures, and building working relationships with active component commands. The team also leveraged established DGS-5 and 8th Intelligence Squadron Air Domain Awareness Cell best practices and explored new tools, processes, and functional teams to support CONOPS maturation and refinement from prior years. The team focused on developing an assessment product that is viable and supports timely and relevant transfer of information to the respective operational commanders.

» DELIVERING INNOVATIVE SURVIVABILITY ENHANCEMENT FEATURES

Threat Detection and Countermeasures Technologies

In collaboration with OSD and Service organizations, JASP matured threat detection and countermeasure technologies needed to defeat advanced EO/IR and RF-guided threat systems. JASP's adaptability allows it to adjust its portfolio to quickly fill critical gaps in technologies required by Service programs while maintaining its core efforts of developing and testing self-protection countermeasure techniques. The Naval Research Laboratory (NRL) completed the Directed Infrared Countermeasure Escort Protection Concept project quantifying

Figure 3. 2CIR missile warning simulator hardware and primary beam improvement

countermeasure system performance in formation flight against several EO/IR guided threat classes.

NRL completed development and testing of a threat launch simulator for testing 2CIR missile warning systems. The new simulator reproduces missile launch features used by 2CIR missile warning systems while significantly reducing the recovery time between engagements. The simulator, shown in Figure 3, will transition to the Center for Countermeasures to support OSD and Service IR countermeasures T&E.

The Naval Surface Warfare Center Crane Division continued work on Reconfigurable Signal Injection Missile Simulation, using hardware-in-the-loop simulation of advanced threats. These hardware-in-the-loop simulators, for multiple reticle-based IR missiles utilizing actual missile seeker tracking and guidance hardware, support development and evaluation of aircraft threat countermeasure techniques and technologies, improving the efficiency and speed of delivering survivability effectiveness to the fleet.

NRL completed the Manipulative Geo-Indicator Countermeasures project to develop and validate analytical tools to develop EA techniques to counter advanced passive RF threat systems. In FY24, NRL validated Manipulative Geo-Indicator Countermeasures with testing at the Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland.

NRL continued work with NAVAIR's Advanced Tactical Aircraft Protection Systems Program Office (PMA-272) to develop firmware and software to support their next generation Digital Radio Frequency Memory system for countermeasure effectiveness development and training. The new user interface architecture and design will enable the development and test of new EA techniques to counter advanced RF-guided threat systems.

Aircraft Force Protection

In FY24, JASP matured a low-weight, retrofittable mist control additive to significantly reduce the ignition of flammable avionics cooling fluids from warhead fragmentation. The U.S. Army Combat Capabilities Development Command completed fragment threat testing of treated fluids, quantifying the probability of ignition reduction. The Army Research Laboratory conducted MIL-PRF-27252C testing to qualify the additivized cooling fluid for use in electronic applications, and Army Research Laboratory / California Institute of Technology worked with fluid efficiency to demonstrate low-rate production and develop a path to scale up production.

The NAVAIR's Naval Aviation Red Team (AIR-RT) performed a deep-dive cyber vulnerability assessment on the P-8A Poseidon, a U.S. Navy weapons system essential to the mission of hunting submarines. AIR-RT's evaluation identified novel cyber threat vectors to the Navy's program leadership and validated the remediation of previously identified cyber deficiencies. The effort also demonstrated a repeatable process and methodology for performing cyber LFT&E and full spectrum survivability evaluations. AIR-RT, in concert with its partners, took existing test approaches and techniques to new heights through this evaluation, which culminated with on-aircraft testing.

AIR-RT also partnered with industry to develop digital twins and models of P-8A avionics components (in this case, software and real-time operating systems rehosted on emulated hardware) to provide an accurate representation of the mission systems for cyber-attack tool development. The digital twins and models rehosted mission systems avionics software on emulated hardware, enabling cyber vulnerability research to be performed with increased efficiency. Partnering the cyber with the kinetic threat survivability community through this endeavor helped merge two worlds, and two separate lexicons, into one integrated test team. In developing a process for performing cyber LFT&E, this initiative paved the way for the joint Services to undertake similar efforts.

Aircraft Survivability T&E

JASP made notable progress in delivering validated models of red radar systems that can acquire and track blue rotorcraft in low-altitude RF environments. This initiative, termed Joint Aircraft Threat Model Simulation Validation, focused on signal propagation and processing, rotary-wing flight dynamics, and countermeasure effectiveness to simulate radar

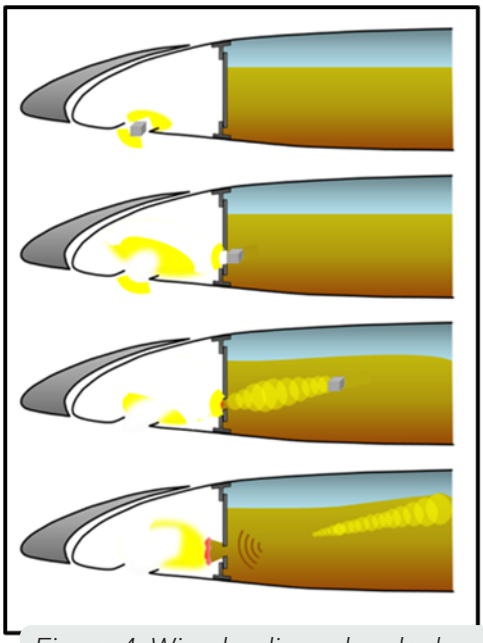

Figure 4. Wing leading edge dry bay fire ignition process

phenomena such as rotor blade flash, chaff dispense, and environmental clutter.

The team conducted open-air tests to validate and assess the accuracy of the BlueMax, ESAMS, and SLATE M&S capabilities using the MV-22B platform. These validated models will help evaluate the effectiveness of Blue-Sky chaff dispensing and rotorcraft detectability in cluttered environments against RF threats. The project's final deliverables will include the integration of updated ESAMS features into SLATE, reflecting new systems and capabilities.

Ballistically initiated fire presents the largest vulnerability for fixed-wing aircraft. The U.S. Air Force 704th Test Group Aerospace Survivability and Safety Office, Air Force Life Cycle Management Center, and U.S. Army Combat Capabilities Development Command Analysis Center conducted fragment and armor piercing incendiary testing to support development of NGFM version 2.0. This model, by credibly predicting dry bay fire ignition from kinetic threat impacts, will improve the capability to develop, test, and evaluate the survivability of aircraft from fire initiated by enemy weapon impacts. Figure 4 shows the wing leading edge dry bay fire ignition process; a fragment flash from hitting the leading edge, interacts with fuel spurting from the wing integral fuel tank to ignite a fire in the dry bay.

The team conducted hundreds of tests that significantly expanded the relevant dataset establishing statistical confidence in the prediction algorithms. To extract test data from high-speed video more effectively, the team is also looking into machine learning and artificial intelligence. Moreover, they are exploring the use of the Arbitrary Lagrangian Eulerian Three-Dimensional high-fidelity physics-based model to supplement the experimental data with variations in test configurations, such as tank sizes, ullage volumes, and shotline placement. This data, along with other test data, will be used to develop NGFM version 2.0 with a planned release in the 4QFY25.