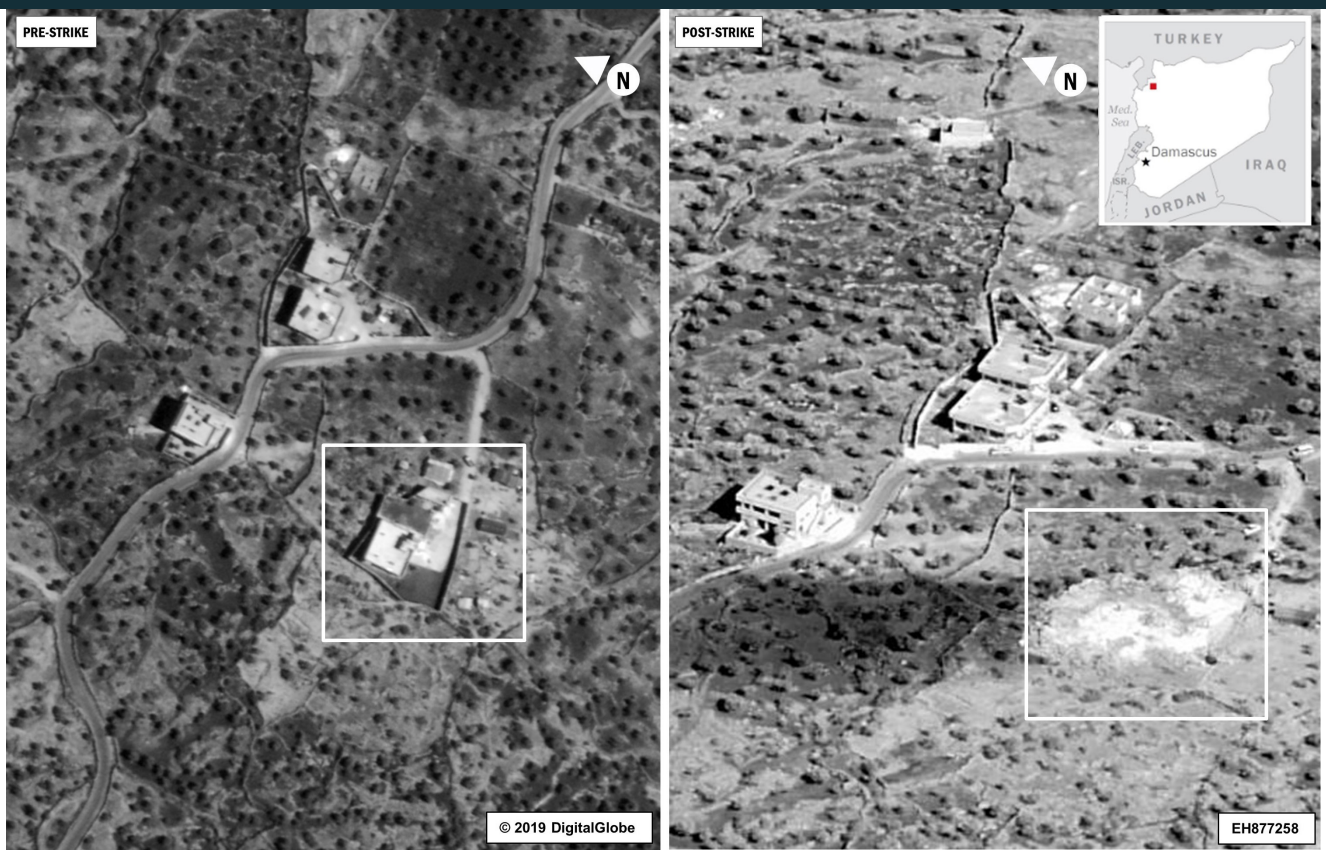
Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME) Program



In FY23, the Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME) program utilized modern software development methods to demonstrate the ability to increase the capability, user interface, experience, and integration of weaponeering tools more effectively and efficiently. JTCG/ME uses target vulnerability data, standards, methodologies, and processes to advance the weaponeering capabilities and accuracy of lethality effects and collateral damage estimates (CDE) against kinetic, maritime, cyber, electromagnetic spectrum (EMS), and directed energy targets. In FY23, the JTCG/ME program used automated data collection to collect over 90,000 strike products to analyze strikes, inform reach-back support, and support weaponeering tool verification and validation, training, and expenditure analysis. In FY23, JTCG/ME generated 13 reach-back packages for weaponeering, CDE, and munition effectiveness assessment in support of current operations. In coordination with the Joint Live Fire (JLF) program, JTCG/ME also continued to collect data to underpin the methodology required to advance full-spectrum survivability and lethality methods and tools applicable to operations planners and OT&E and LFT&E of DoD systems and services.

PROGRAM OVERVIEW

The JTCG/ME program was chartered in 1968 to serve as the DoD's focal point for munitions effectiveness information. It started by delivering Joint Munitions Effectiveness Manuals (JMEMs) – the sole source for all non-nuclear weapons effectiveness data and methodology for the DoD. The JMEMs have been the "how to" manuals for determining the type and number of ordnance on target. Today, JMEMs have transitioned to kinetic and non-kinetic tools used in operational weaponeering, and CDE in direct support of multi-domain operations, mission planning, and training. These tools are used by joint and Service planners in force-on-force effect estimations, mission area analysis, requirements studies, and weapon procurement planning. These tools are also used by the Service acquisition community in performance assessments, analyses of alternatives, and survivability enhancement studies, and include:

- The Digital Imagery Exploitation Engine (DIEE), a tool that enables users to plan and execute kinetic strikes by seamlessly performing the following Advanced Target Development steps: (1) geographically locate and characterize the target; (2) weaponeer the target using JMEM Weaponeering System (JWS); (3) perform target coordinate mensuration; (4) determine CDE using the Digital Precision Strike Suite Collateral Damage Estimation (DCiDE) tool; and (5) produce and output graphics to the appropriate databases.
- Weaponeering tools capable of estimating lethal effects for directed energy weapons (DEW), cyber, maritime targets, and EMS fires.
- The Joint Anti-Air Combat Effectiveness (J-ACE) tool used in combat mission planning, training, and in weapon schools to support the development of air combat tactics, techniques, and procedures (TTP). The J-ACE tool's main module is the Joint Anti-Air Model (JAAM), which is discussed in the Joint Aircraft Survivability Program (JASP) section of this Annual Report.

The JTCG/ME program also manages the JLF program. The JLF program is focused on the development of adequate full-spectrum survivability and lethality tools, methods, and infrastructure required for both; advancement and accreditation of weaponeering tools; and support of OT&E and LFT&E of DoD systems and services.

MISSION

The JTCG/ME program develops, advances, and sustains weaponeering tools. These tools, frequently referred to as JMEM products, are used by the combatant commands (CCMDs) to estimate and optimize the type and number of U.S. offensive kinetic and non-kinetic capabilities required to achieve the desired lethal effect. These products support assessment against a range of kinetic and non-kinetic strategic or tactical targets, while mitigating risk for collateral damage including civilian casualties. JTCG/ME leverages the JLF program to develop and enhance full-spectrum survivability and lethality digital tools; improve survivability and lethality T&E methods and processes; and enable live data collection to support rigorous verification, validation, and accreditation (VV&A) of survivability and lethality digital tools.

FY23 KEY ACTIVITIES

» DELIVERING CREDIBLE WEAPONEERING TOOLS TO CCMD STRIKE AUTHORITIES

JMEMs are used daily by warfighters worldwide in direct support of operations, mission planning, and training. The user base includes approximately 26,000 personnel, spanning the following entities:

- DoD Service members
- Joint Staff/CCMDs
- Multiple coalition partners
- Acquisition community, T&E enterprise, Intelligence Community, and National Laboratories

In FY23, JTCG/ME fielded updates to DIEE to improve product accuracy and efficiency in support of operational warfighters. Specifically:

- In collaboration with Office of the Under Secretary of Defense for Intelligence and Security (OUSD(I&S)) and the Joint Staff Directorate for Intelligence (J-2), JTCG/ME has been improving the efficiency and effectiveness of the Joint Targeting Intelligence process by developing, standardizing, and integrating the Advanced Target Development workflow and tools. As part of this process, operational users will be able to link desired effects to tactical tasks outlined in operational plans, which will increase the probability of meeting the commander's objective via enhanced integration and connectivity across the targeting enterprise to enable targeting at scale.
- JTCG/ME has been applying modern software development methods including development, security, and operations (DevSecOps) to enable continuous and incremental improvement in capability, user interface, and experience of JWS tools. JTCG/ME also added new weapon and weapon trajectory data to its scene-based weaponeering products, allowing the strike authorities to account for enhanced technologies and capabilities in their calculations of target defeat. To maintain consistency with the latest National Geospatial-Intelligence Agency mensuration methods, JTCG/ME updated calculation tools for both Mensuration Services Program and Common Geopositioning Services.
- JTCG/ME completed updates to collateral effects radii tables, reducing their error margins. It advanced the friendly force collateral effects library mitigation tool to increase the efficiency of collateral effects analysis and enhance risk estimate distance calculations used by DCiDE. Using the JLF program, JTCG/ME continued the collaboration with the University of Virginia on the development of Traumatic Brain Injury (TBI) risk functions. Based on Joint Trauma Analysis and Prevention of Injury in Combat Program (JTAPIC) combat data, available military blast models/methodologies testing from the Enhanced Weaponeering Integrated Product Team, JLF developed a conservative approach to update TBI blast risk estimates for inclusion in Risk Estimate Distances (REDs).
- JTCG/ME generated 13 reach-back packages for weaponeering, CDE, and munition effectiveness assessment in support of current operations.
- JTCG/ME facilitated 28 training classes/events for over 300 students at 22 locations. Training of integrated product capabilities (DIEE/JWS) continues to enable the operational community to successfully employ munitions while minimizing collateral damage.

» ADVANCING THE CAPABILITY, EFFICIENCY, AND ACCURACY OF TARGET DEVELOPMENT TOOLS

JTCG/ME continued to advance the capabilities efficiency and accuracy of target development tools to respond to CCMD needs in an increasingly complex and dynamic multi-domain operational environment. JTCG/ME upgraded existing weaponeering capabilities to increase the effectiveness of kinetic strikes and developed new capabilities to enable deliberate and dynamic engagements using cyber, EMS, and DEW capabilities.

Advanced Target Development

The DIEE is a vital software program for the targeting enterprise at the global level. The DIEE provides digital solutions to the essential Joint Targeting Cycle functions for both the U.S. and coalition partners.

The DIEE software turns current workflow inefficiencies into automated and integrated solutions within one ecosystem. DIEE's essential targeting functions apply across the targeting spectrum and address Basic, Intermediate, and Advanced Target Development. Key functions include Target Coordinate Mensuration, weaponeering methodologies using JWS, CDE effects using the DCiDE tool, targeting graphics production, and combat assessment.

FY23 accomplishments include the release of DIEE v2.3.2 to address critical issues with hardware dependencies. In addition, developing DIEE v3.0 with native 3D viewing capabilities without hardware dependencies (as shown in Figure 1), integration of JWS and Capability

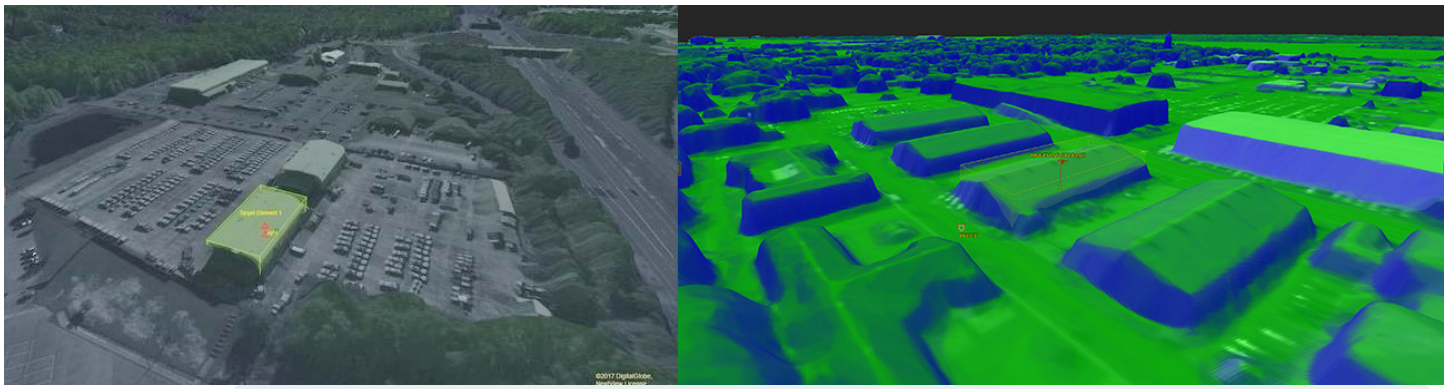


Figure 1. Examples of native 3D viewing capability no longer requiring additional hardware

Solutions Package beta versions, and critical integration with third-party libraries and tools.

As part of the OUSD(I&S) and J-2 Joint Target Intelligence Modernization (JTIM) initiative, JTCG/ME initiated the development of a federated workflow management (WFM) tool streamlining the targeting enterprise production, tracking process while reducing costs. The WFM is a standalone web application and will be fully integrated through DIEE. DIEE and all other JTIM associated programs as well as leadership throughout the Joint Targeting Community will all have a dashboard and associated notifications using this tool.

Weaponeering

The JWS combines a series of weapon system characteristics, delivery accuracy, and target vulnerability data needed to estimate the final aimpoint, delivery conditions, and number of weapons on target necessary to achieve combatant commanders desired lethal effects. In FY23, JWS v2.4.1 continued sustainment efforts with the next planned release in early 2024 to support urgent operational needs. Capabilities of future versions of JWS include auxiliary tools and equipment fragility modeling to include structural target components and surface mobile targets. The next generation JWS product line continued the development of weaponeering capabilities including structural targets, interior and exterior personnel, and materiel targets, and integration with DIEE.

CDE

In FY23, JTCG/ME made significant progress toward improving the ability of the DoD and coalition partners to accurately characterize the CDE associated with lethal effects of U.S. weapons. Specifically, JTCG/ME leveraged the multi-year Enhanced Weaponeering and CDE test program to quantify the collateral effects resulting from munitions detonating either in the ground or beneath structures. Data sets from the Enhanced Weaponeering and CDE test program were used to improve, verify, and validate high fidelity digital tools used to predict building debris mass and velocity distributions from multiple structure types, along with crater ejecta, ground shock, and blast pressure for various soil types and munition burial configurations. The uncertainty in these predictions must be minimized, as they are the foundation for fast-running engineering models used by the DCiDE tool and JWS to estimate weapon collateral damage and lethality. In FY23, JTCG/ME conducted several tests, depicted in Figures 2 through 4, to further the understanding of munition burial and building debris effects on personnel and nearby structures. These live data supported the evaluation of the combined effects of a kinetic impact and subsequent below-ground detonation, along with the mitigation of blast and fragmentation effects and the hazards from secondary debris enhancing the validation of the weaponeering and CDE tools.

Battle Damage Assessment (BDA)

JTCG/ME continued the multi-year effort to verify, validate, and advance the effectiveness of JMEM

Figure 2. Kinetic impact test conducted in partnership with the U.S. Army Engineer Research and Development Center's Mobile Ballistic Research System at Fort Polk, Louisiana

Figure 3. Follow-on test with buried ordnance at Aberdeen Proving Ground, Maryland

Figure 4. Two-story over-burial building debris test at Aberdeen Proving Ground, Maryland

weaponeering tools by capturing otherwise perishable combat assessment data for future analysis. The goal of the BDA program is to enable credible post-strike analysis to ensure commander's intent has been achieved while capturing strike details (as directed by the Civilian Harm Mitigation Response – Action Plan) for future reference and use by the targeting enterprise. To meet this intent, JTCG/ME continued to collect BDA data, not only to analyze strikes and inform reach-back support, but also to support weaponeering tool verification and validation, training, and expenditure analysis.

In FY23, JTCG/ME used automated data collection to collect over 90,000 strike products in the U.S. Central Command, the U.S. Africa Command, and the U.S. European Command areas of responsibility. An Optical Character Recognition tool was developed to quickly and efficiently assist in the process of identifying and databasing strike products. These strike products are stored in the Joint Battle Damage Analysis Repository (JBAR), via an Army cloud environment (c-Army), with an interactive web mapping dashboard for use by the joint community.

An application programming interface is in development that will allow DIEE to directly connect to, and expedite storage of, newly produced strike products. This direct connection will facilitate accurate strike product archival for future use through the JBAR web mapping interface.

Lethal Effect Estimates

JTCG/ME continues to leverage the Advanced Warhead Characterization (AWC) project to improve the fidelity of weapons' lethal effect data. In FY23, the program initiated the Validated Munitions

Effectiveness Model (VMEM) series, which includes high-fidelity modeling and simulation (M&S), advanced test diagnostics, data analysis, and munition model validation. Advanced test diagnostics tools (e.g., computed tomography, digital image correlation, X-ray, photon Doppler velocimetry, pressure measurements, and optical fragment tracking, as shown in Figure 5) support efficient data collection and high-fidelity model validation for munitions.

The AWC project is continuing to build, refine, and document the techniques, processes, and procedures, which will be provided to the JTCG/ME Systems Characteristics Working Group for use in approved warhead characterization procedures. VV&A of the munition model is the goal of the VMEM process.

In FY23, JTCG/ME also leveraged the small-scale blast test program initiated by the JLF program to provide a tailorable scale target model that will be used to efficiently collect larger volume and higher fidelity lethality data as compared to current models and processes. The JLF program also continued to execute the Multiphase Blast Explosive (MBX) program with the purpose of increasing the ability of weaponeering tools to estimate MBX lethal effects used in low-collateral damage munitions.

Lethal Effect Estimates - Hypersonic Weapons

In FY23, JTCG/ME continued addressing the shortfalls related to the evaluation of lethality and associated weaponeering tool capabilities for hypersonic weapons. JTCG/ME initiated the live data collection program to support the advancement and accreditation of high-fidelity digital tools intended to estimate hypersonic weapons lethal effects. Near-term efforts will account for weapon characterization, including terminal effects and delivery accuracy. This hypersonic initiative will address longer-term hypersonic T&E improvements for broad-ocean-area tests, enabling weapon accreditation with greater granularity at reduced costs and with simplified logistics. The JLF program continues to make progress in luminescent technology development and testing, which will enable optical characterization

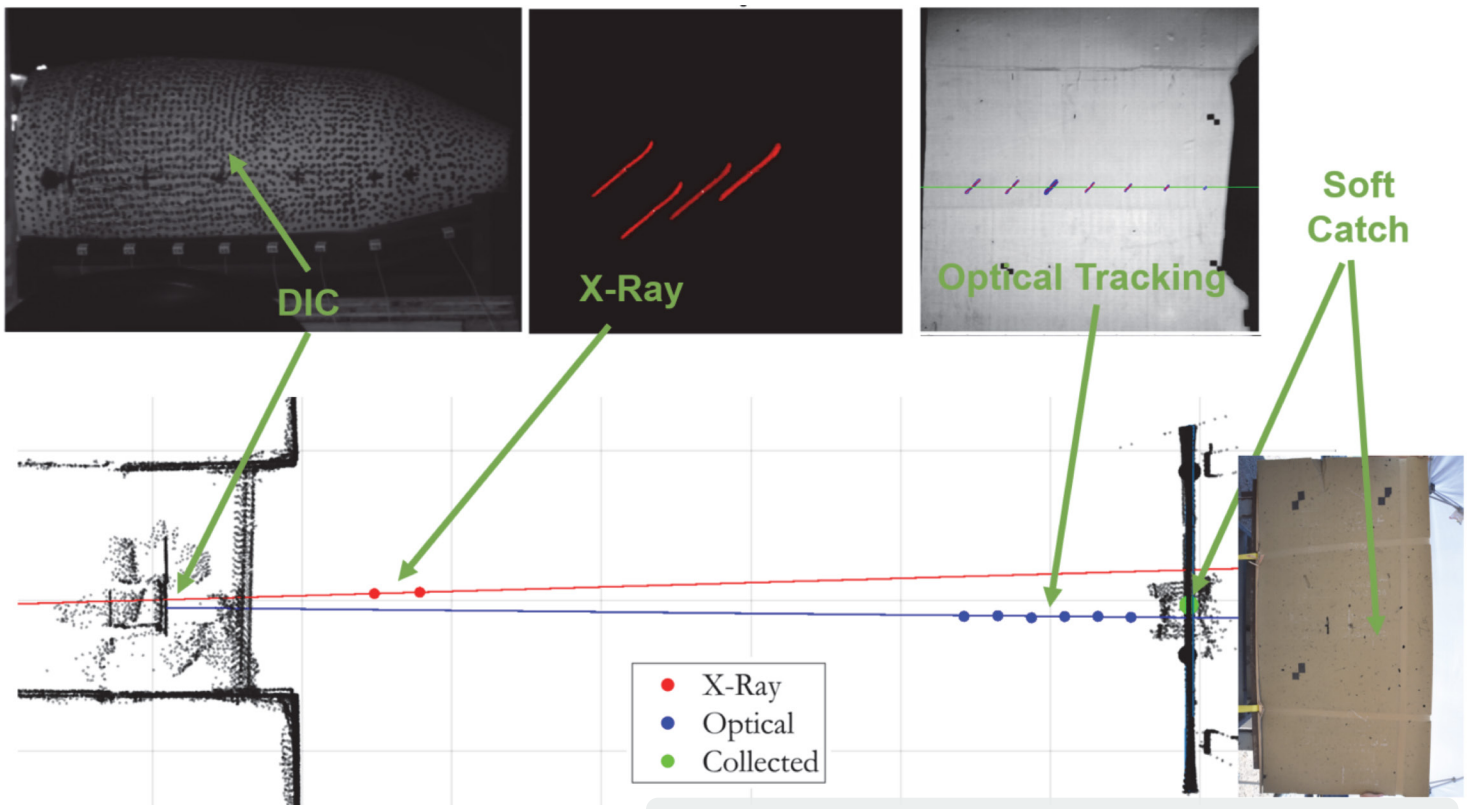


Figure 5. The use of a compilation of multiple advanced test diagnostics as part of the munition model validation process

of fragment dispersion in flight tests to adequately evaluate emerging hypersonic weapons.

Lethal Effect Estimates - Maritime Targets

In FY23, JTCG/ME continued the effort to enhance the ability of weaponeering tools to support the warfighter with credible and timely lethal effects estimates against adversary maritime (surface and subsurface) targets. Within this effort, JTCG/ME has developed weaponeering guides for several maritime targets not currently in JTCG/ME inventory. JTCG/ME also developed and delivered version 1.0 of the Target Damage Cards software, shown in Figure 6, for integration and fielding in DIEE, enabling new maritime weaponeering analysis tool for surface and ultimately subsurface targets.

JTCG/ME continues to execute a collaborative test program that procures data to close knowledge gaps, improve current analytical tools and methods, and develop advanced digital tools (e.g., the Next Generation Enterprise Maritime Lethality Tool) required to support the delivery and fielding of weaponeering tools against such targets. Other digital tools that will be advanced as part of this initiative include the Submarine Vulnerable Effects Model, Navy Enhanced Sierra Mechanics, and Dynamic System Mechanics Advanced Simulation. This effort increases weapons systems' lethality against foreign maritime threat platforms and will also support more effective and efficient survivability evaluation of U.S. ships and submarines in support of LFT&E objectives. Figure 7 shows the progression of the fidelity of models needed.

M&S VV&A

JTCG/ME continued the critical VV&A and uncertainty quantification (UQ) efforts in coordination with the U.S. Army, U.S. Air Force, U.S. Navy, and Lawrence Livermore National Laboratory representatives to develop standards of VV&A/UQ practices across the JTCG/ME product lines. VV&A experts

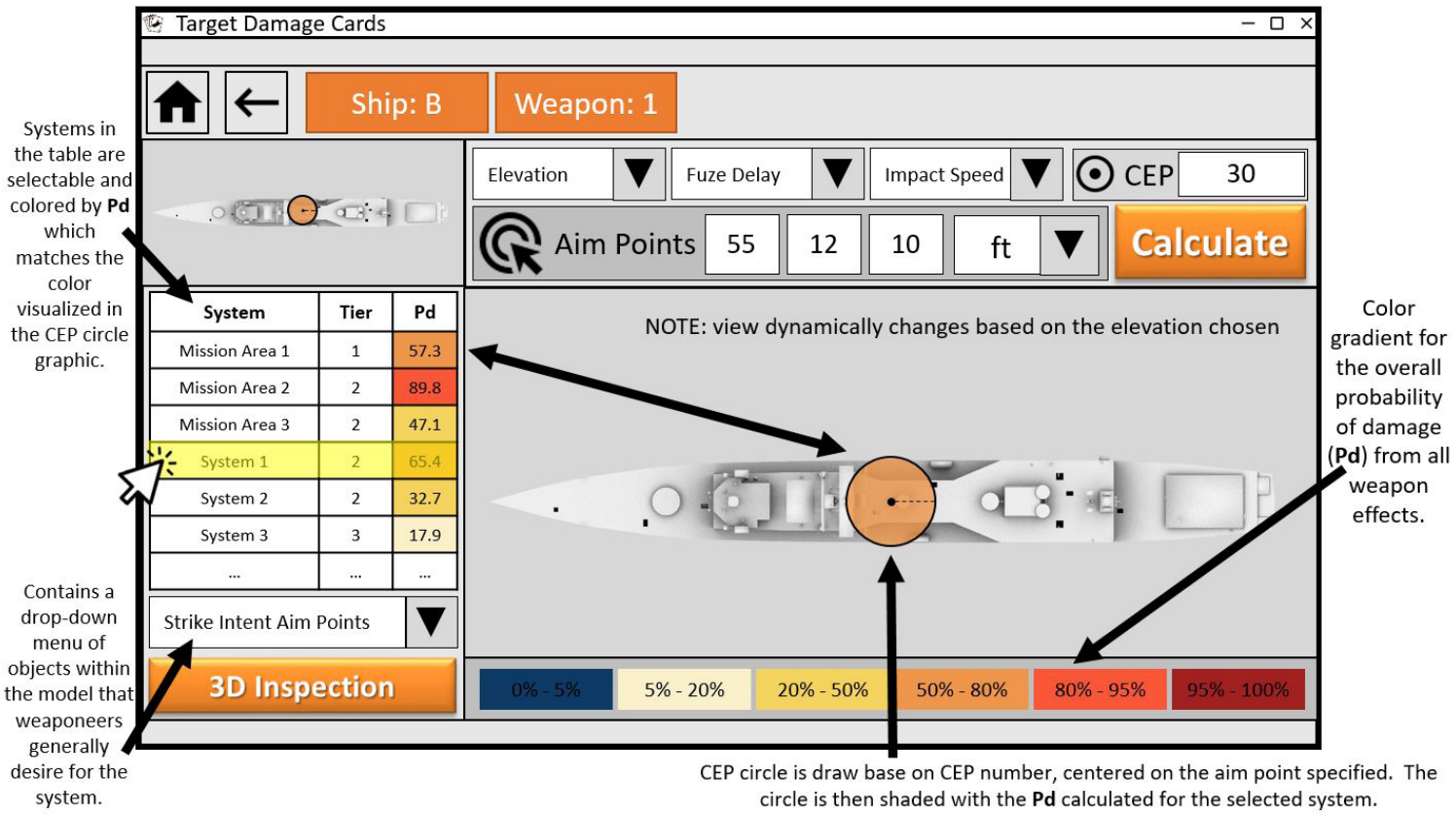


Figure 6. Maritime Target Damage Card visualization tool

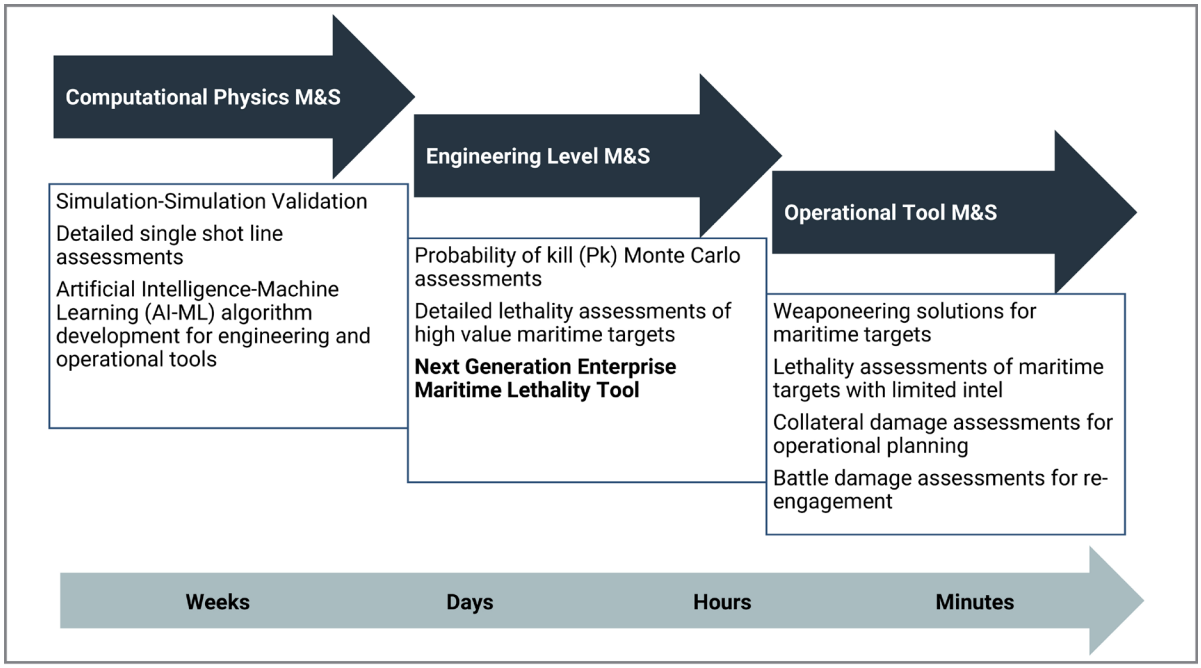


Figure 7. A Pipeline of federated models gives the fleet the most accurate data to support operational planning

presented current techniques, efforts, challenge areas, data gaps, and future development areas to foster potential areas for cross-organizational collaboration, which could improve practices and reduce uncertainty in JTCG/ME, OT&E and LFT&E tools. JTCG/ME developed standardized documents to expand on the VV&A/UQ activities for next generation of JWS, Joint High-Power Microwave (HPM) Applied Weaponeering Knowledge Software (JHAWKS), Joint Laser Weaponeering Software (JLaWS), and document JTCG/ME's VV&A practices.

Data Management

To support the implementation of the DoD Data Management Strategy in FY23, JTCG/ME expanded the repositories for archival, review, approval, and access of lethality and vulnerability data, methodology, and documentation. The three following repositories serve multiple user communities with corresponding features and capabilities:

- For data, the Joint Analysis Repository and Visual Interface System (JARVIS) is a web-accessible repository with the authoritative data to support JTCG/ME's portfolio of warfighter applications. A critical requirement is to facilitate the data development and joint-Service review and approval processes. This repository also serves the T&E and acquisition community by providing JTCG/ME approved target vulnerability packages. In FY23, JTCG/ME deployed several updated versions of JARVIS that provided significant enhancements including data management capabilities for weapon characteristics and pre-generated weaponeering results.
- For methodology standards and practices, JTCG/ME created the Joint Effects Library (JEL), shown in Figure 8, as the official repository for all implemented methodology and supporting functions that are approved by JTCG/ME and use in weapon effects applications. Not only does it serve as an archive for all JTCG/ME approved modules, but it also enables the incorporation of standard acceptance workflow and supporting material. The intent is to improve quality, increase reusability and reliability, and finally reduce time to integrate modules into weaponeering applications. In FY23, JTCG/ME incorporated several additional modules into the JEL to support penetration

effects, cratering, material targets, and blast effects.

- For documentation, the Bugle is a wiki-style website built on Defense Technical Information Center's (DTIC's) DoDTechipedia platform. Hosting on DTIC makes JTCG/ME's technical reports, data requests, and model documentation accessible to the DoD community. In FY23, additional content was added to share information and collaborate on JTCG/ME products, models, and methodologies. In addition, JTCG/ME improved the site navigation and the overall user experience.

Joint Effects Library

Effects Methodology	Common Properties	Common Utilities	Functional Methods	Supplemental Materials
• Penetration • Blast • Fragmentation • Fire/Flood • Obstruction • Etc.	• Materials • Terrain • Atmosphere • Etc.	• Model Generators • Import/Export • Scenario Setup • Weapon Delivery • Etc.	• Equipment • Personnel • Probability of kill • Etc.	• Documentation • Test cases/ scenarios • Test Results • V&V Reports • Approval Memos • Etc.

Figure 8. JEL Repository of JTCG/ME-accredited methodologies and documentation

These three repositories work in conjunction to provide joint-Service approved munition effectiveness data, methodology, and documentation within JTCG/ME and throughout the DoD.

In parallel, the JLF program continued to make progress towards establishing a framework capable of consolidating available and future LFT&E data in support of data mining and data analytics intended to effectively inform requirements, performance evaluations, and development of full-spectrum survivability and lethality tools. The U.S. Army Combat Capabilities Development Command Analysis Center is leveraging JARVIS to store tri-Service-developed and -approved target vulnerability data. Initial efforts focused on database structure development, user access controls, process flow and approval structure. This enhanced repository will be used to establish connections between Service-developed targets and the JTCG/ME products to enable access and sharing of more targets for the warfighter while facilitating military service data maintenance and control.

» ENABLING MULTI-DOMAIN SUPERIORITY WITH DEW, CYBER, INFLUENCE OPERATIONS, AND EMS FIRE WEAPONEERING TOOLS

JTCG/ME has made significant progress and worked in partnership with the Services, Department of Energy's National Laboratories (e.g., Sandia, Lawrence Livermore, Idaho), academia (e.g., Georgia Tech, Johns Hopkins Applied Physics Laboratory), and DOT&E field activities (e.g., Center for Countermeasures, JASP, Test and Evaluation Threat Resource Activity) to support the warfighter with weaponeering tools intended to integrate kinetic and non-kinetic fires for optimized mission and lethal effects, while mitigating collateral effects to noncombatants, infrastructure, facilities, and equipment. While JTCG/ME has focused on the development and fielding of separate weaponeering tools that can account for DEW, cyberattacks, and EMS fires, it has also initiated the plans to provide an architecture for a single JWS capable of estimating the appropriate number and type of either kinetic or non-kinetic weapons, and their combined effects, required to achieve superiority in a multi-domain operational environment.

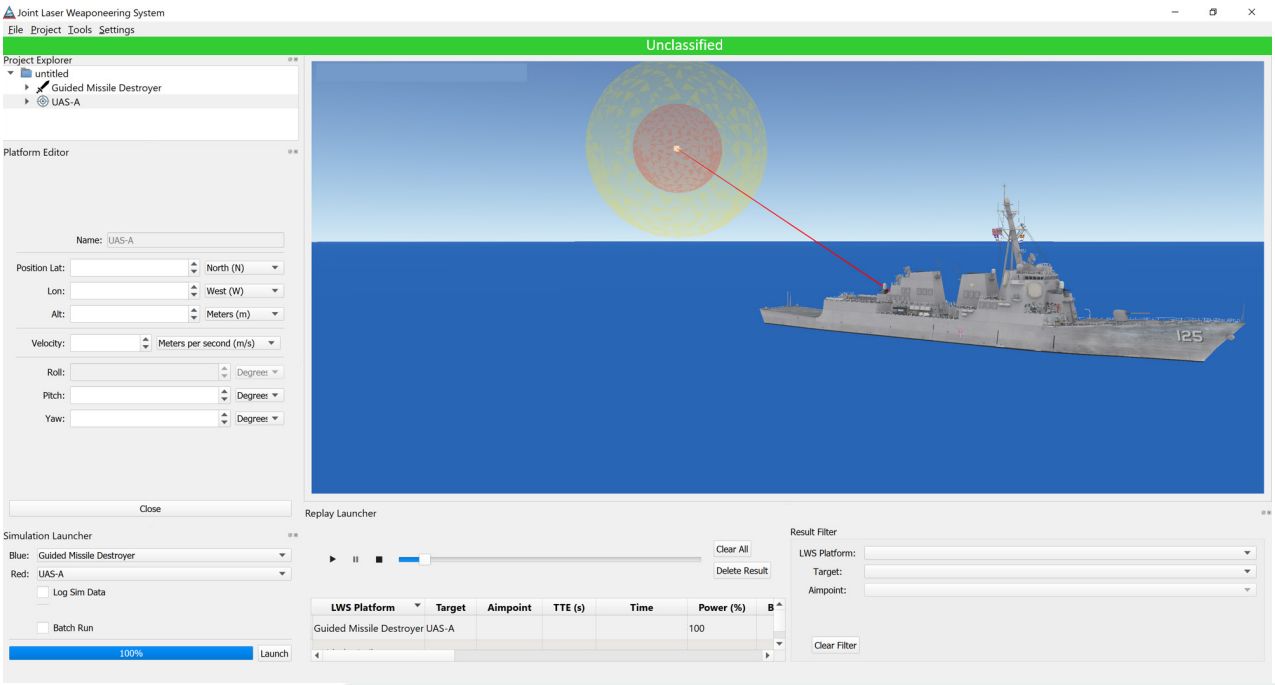


Figure 9. JLaWS simulation with HELRAT laser radiation hazard zones

DEW

In FY23, JTCG/ME continued to develop and validate DEW weaponeering tools – JLaWS and JHAWKS– to enable the CCMDs to estimate lethal effects using high energy lasers (HEL) and HPM.

JLaWS

JLaWS uses target data, weather effects, and optical risk characteristics to output associated vulnerability result and time to effect for solid state laser weapon systems. JLaWS considers the effect of weather on laser propagation by automatically downloading weather files from established services to account for location dependent weather conditions. JLaWS allows the user to calculate optical risk in the event of HEL reflections from targets using the High Energy Laser Risk Assessment Tool (HELRAT). HELRAT graphically portrays the risk distances around a target that contains reflected laser radiation levels that could cause ocular hazards to friendly forces in the area. Figure 9 shows a JLaWS graphical rendering of a ship-based Laser Weapon System (LWS) engagement with an unmanned aerial vehicle (UAV) target and the spherical zones around the target, as calculated by HELRAT, in which ocular hazards exist.

demonstrated JLaWS to multiple HEL LWS operational users to obtain operational feedback. As

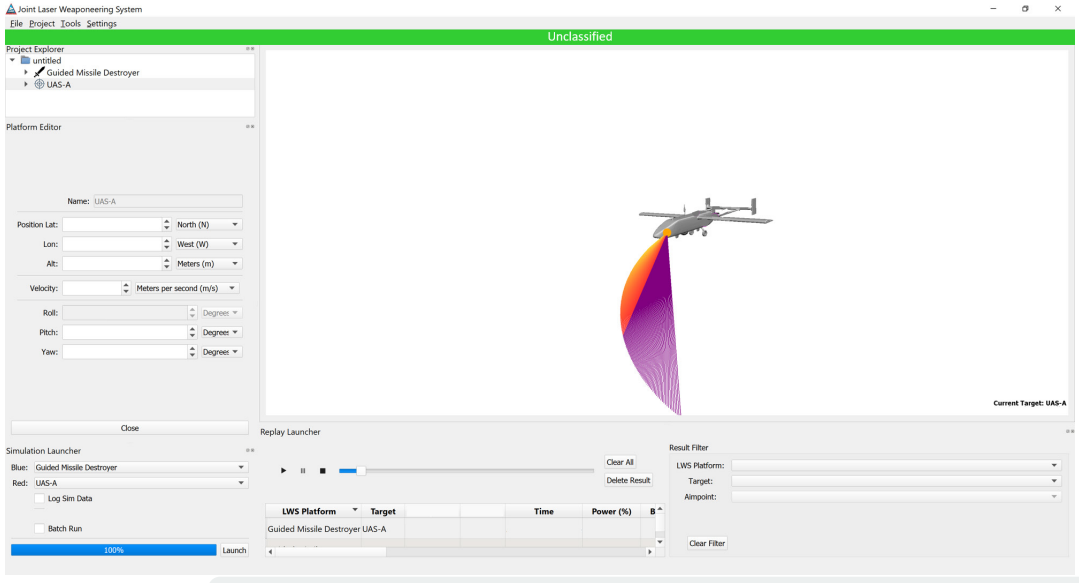


Figure 10. JLaWS Vulnerability Explorer and examples of shot lines

a result, JTCG/ME supplied operational users with JLaWS-developed target cards that displays optimal aimpoints on a target. Figure 10 shows an example JLaWS output for a UAV target. In FY23, JTCG/ME accredited HELRAT for use in functional domains, such as DoD exercises, training scenarios, and weapon system demonstrations.

JHAWKS

To advance the development and fielding of HPM weapon systems (HPMWS), JTCG/ME conducted several lethality tests against service-specific targets identified to fill data gaps. JTCG/ME conducted vulnerability and failure mode analyses to support M&S tool development and verification for both engagement level models and weaponeering tools. JTCG/ME identified and further developed an initial architecture for JHAWKS using the model-based systems engineering construct shown to the right of Figure 11. JTCG/ME continued further development of a tool for estimating collateral damage effects during HPMWS engagements and developed courses of action to integrate JLaWS and JHAWKS capabilities into DIEE.

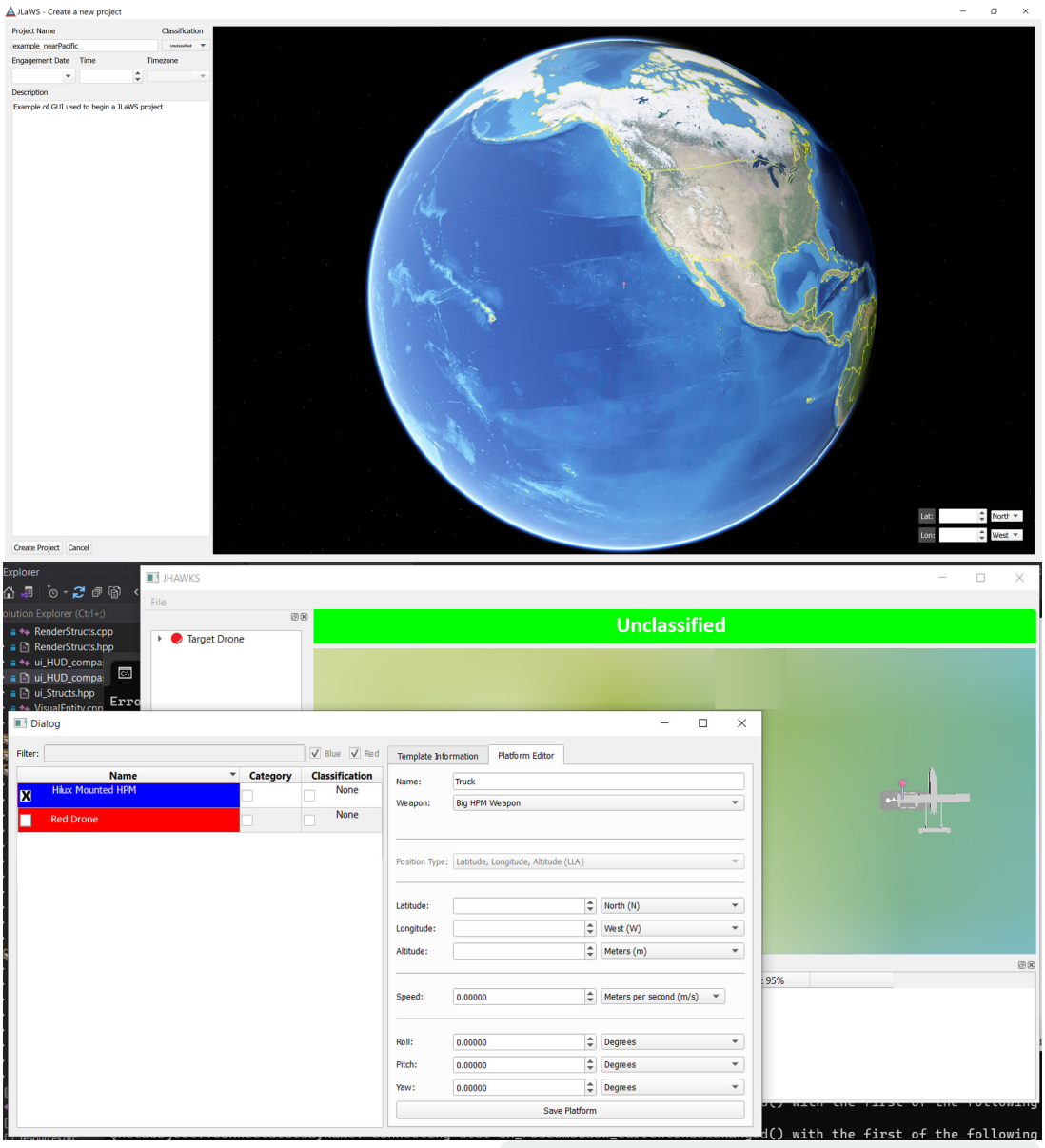


Figure 11. JHAWKS initialization windows

Cyber Operations Lethality and Effectiveness (COLE)

In FY23, JTCG/ME continued the development and fielding of cyber JMEM capabilities for the warfighter. The COLE tool is the foundational product, which enables commander operations decisions through advanced analytics used to adequately visualize, plan, evaluate, and assess the full spectrum of cyberspace activities. The COLE gateway delivers the DoD user with a comprehensive cyber effectiveness analysis capability for development, testing, and operational engagement.

JTCG/ME deploying v3.0 of the COLE tool on both classified and unclassified networks. COLE v3.0 enables mission planning allowing users to model cyber networks, characterize properties and associated uncertainties of network components, and model the effects of cyber capabilities against those networks. COLE's network characterization function allows users to create, manipulate, and share portrayals of network topologies for use in

planning cyber operations. COLE's mission planning function enables planners to devise attack options and routes through an adversary's network.

Major COLE improvements over the last year include continued development of the state and initial development of the functional model capabilities that allow planners to consider the dynamic state of the target network over time as well as considering access, and operational impact. These new features allow users to simulate and examine cascading effects within a network as multiple courses of action and different weapon-target pairings.

JTCG/ME also continued focus on user engagement with multiple Operational User Working Group and technical engagement sessions.

JTCG/ME continues to team with the JASP on the Machine Assisted Exploitability Simulation and Testing for Resilient Operations (MAESTRO) effort to further develop COLE's ability to assess cyber vulnerabilities of U.S. platforms. COLE for T&E provides a framework of models and tools to aid in examining aircraft cybersecurity.

In association with the JLF Cyber Automated Threat Discovery and Vulnerability Evaluation Reinforcement (CADAVER) program, the JNKE program continued its expansion of Enhanced Vulnerability Discovery abilities to assist in rapidly and automatically characterizing, discovering, and reporting cyber vulnerabilities within complex software configurations. CADAVER is intended to leverage AI/machine learning to allow identification of potential vulnerabilities to mitigate cyberattack access points through automated and semi-automated means. Combined, these programs ensure warfighters have the necessary tools to assess cyber effectiveness/vulnerability using tri-Service-approved data standards and streams. Leveraging technology and lessons learned of these three programs provide consistent, credible data and methodology for both offensive and defensive cyberspace operations.

Newly discovered vulnerabilities can be added to COLE's Common Vulnerability database to document and share Government-off-the-Shelf vulnerabilities amongst DoD organizations and cyber assessment teams.

In FY23, JTCG/ME also teamed with the DoD Test Resource Management Center to create a Cyberspace Effects and Enabling Capabilities Cyberspace Live-Fire Evaluation Framework (CLEF) to provide a realistic test environment for cyber capabilities generating accredited performance data. The CLEF effort will set the standards for generating and analyzing Cyber performance, analogous to kinetic area testing capabilities and standards for fragmentation.

Influence Operations

In FY23, JTCG/ME initiated a pathfinder for an influence operations JMEM aimed at considering how our military action affects an adversary's decision making towards achieving our own strategic aims. Behavioral influences analysis can help inform how the U.S. applies military force and what specific adversary elements to attack. Sandia National Laboratories has been developing a tool to assess how various populations and groups perceive U.S. actions. JTCG/ME's pathfinder works to expand capabilities in the dynamic multi-scale assessment tool for integrated cognitive-behavioral actions. JMEM pathfinder development focuses on the ability to assess influence operations on courses of action. This pathfinder effort will develop an approach to verify and validate an influence operations effectiveness digital tool that relies on integration of AI-engines, subject matter expertise-informed machine learning models, and extensive data sources to forecast how U.S. actions in all phases of operations will influence the decisions of adversary leadership.

EMS Fires

In FY23, JTCG/ME continued the development of weaponeering tools to enable mission planning and execution in contested, congested, and constrained EMS operations. These tools will estimate electronic attack (EA) effects and the ability of the warfighter to effectively prosecute adversary targets in contested, congested, and constrained EMS operations as shown in Figure 12.

JMEM for EMS Fires will allow mission planners and targeteers to assess weapon and combat effectiveness in the presence of adversary EA

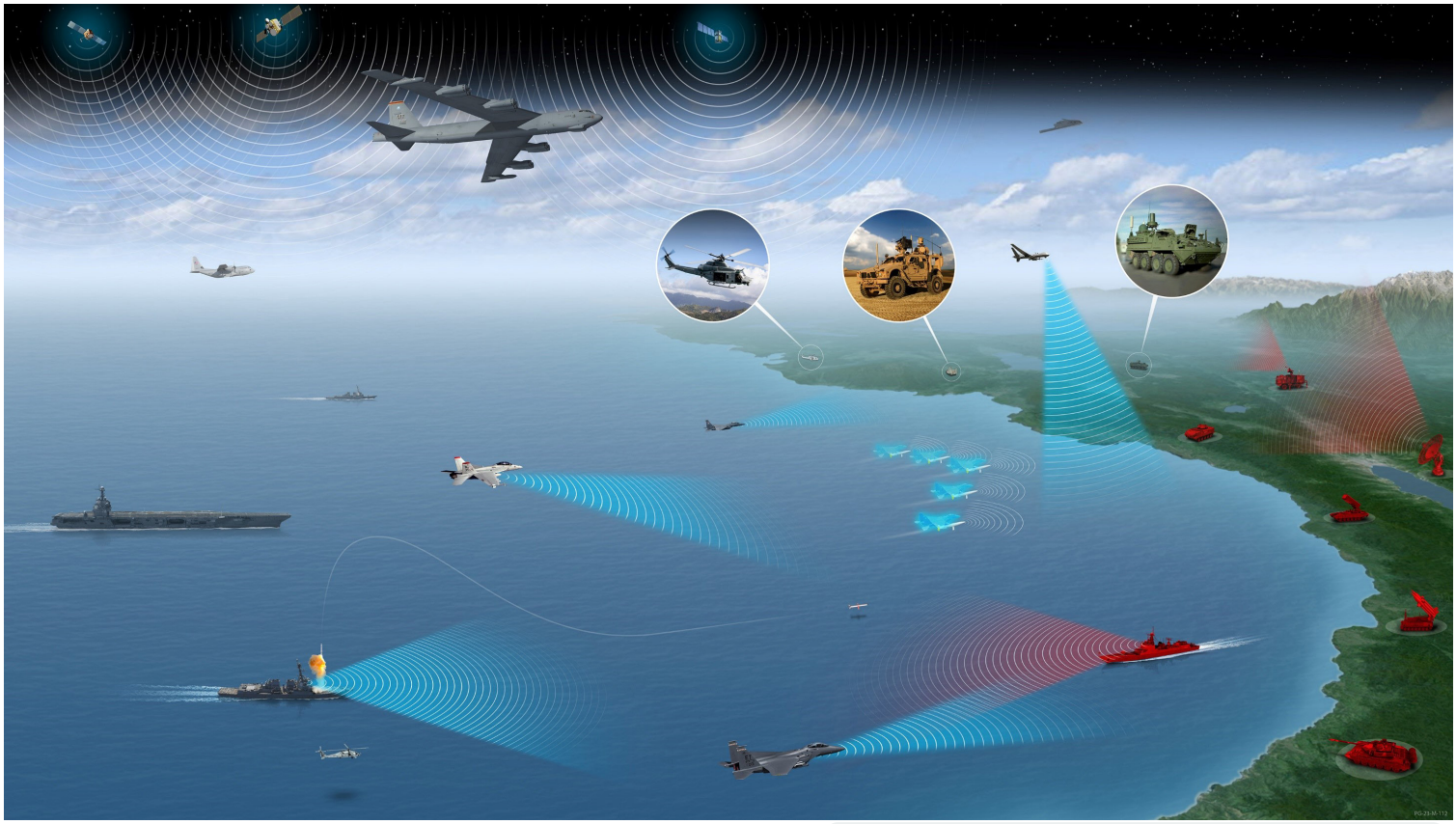


Figure 12. Sample notional EMS environment

(e.g., GPS denial and its effect on kinetic weapon guidance systems). It will also estimate the effects of friendly EA capabilities against adversary targets (e.g., jamming), which create a foundation of joint standard EA effectiveness data and models used across the Joint Targeting Cycle. In FY23, JTCG/ME further refined the program plan, data standards, capabilities requirements, and developed an initial cross service model to demonstrate EA effectiveness. The objective is to work towards developing an initial set of JMEM capabilities via the Joint EA Predictive tool by 1QFY24.

» SUPPLYING WEAPONEERING TOOLS TO SUPPORT INTEROPERABILITY WITH U.S. ALLIES AND PARTNERS

In FY23, JTCG/ME supported the delivery of weaponeering tools, data sets, and training to 25 coalition partners in support of current operations under Foreign Military Sales agreements. This included the release of weapon effectiveness tables, collateral effects radii tables, and advanced target development capabilities that will help minimize collateral damage and reduce civilian casualties. These efforts directly supported the Presidential Conventional Arms Control Policy to build partner capacity and prevent civilian casualties. A second effort supported information exchange forums via information exchange annexes with coalition partners. These exchanges facilitate collaboration with partners on methodologies and efforts of mutual interest in weapons effectiveness and CDE for both kinetic and non-kinetic weapons. In FY23, multiple International Exchange Agreements were continued to provide weapons effectiveness analytical exchanges and to expand the scope of topics to better represent complex strategic and operational environments.