8305 Catamaran Circle
Lakewood Ranch, FL 34202

What can I do with BSI products?
2025 v1

Battlespace Simulations, Inc.
8305 Catamaran Circle
Lakewood Ranch, FL 34202
Phone: 210-857-9672

8305 Catamaran Circle
Lakewood Ranch, FL 34202

CONTENTS

1 INTRODUCTION 3

2 PRODUCT SUMMARY 4

2.1 MACE 4
2.2 ARMOR 6
2.3 DEVICE SIMULATION CONTAINER (DSC) & VIPER DIS RADIOS 8
2.4 DISCORD 10

3 USE CASES 12

3.1 MISSION PLANNING ANALYSIS & REHEARSAL 12
3.2 COMPUTER GENERATED FORCES (CGF) 14
3.3 ACCREDITED JOINT FIRES TRAINING 16
3.4 ISTAR TRAINING 18
3.5 OPERATIONAL ANALYSIS 19
3.6 LIVE VIRTUAL CONSTRUCTIVE TRAINING 21
3.7 ELECTRONIC WARFARE TRAINING 23
3.8 SPECIFIC DEVICE TRAINING 25
3.9 PILOT/ROLE PLAYER STATIONS 27
3.10 EMULATED MILITARY EQUIPMENT 30
3.11 WARGAMING 31

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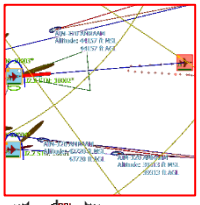
1 INTRODUCTION

Thank you for your interest in BSI products, which can be combined in different ways to meet diverse simulation and training objectives. They are used widely by militaries and companies all over the world for multiple use cases, especially where near-peer adversary replication is essential. The purpose of this document is to describe what kind of defense use cases our products can solve, such as:

Mission Planning Analysis & Rehearsal (MPAR)

- Uses worldwide GIS data and Mil data to create battlespaces
- Import/Export to mission planning systems formats
- Simulate, iterate, visualize & analyze with diverse toolset



Computer Generated Forces

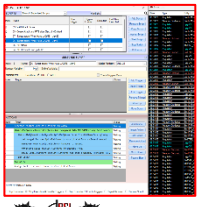
- Multi domain simulation of tactical platforms & pattern of life
- Driving full mission simulators & distributed simulation
- DMON and CAF-DMO certified

Joint Fires Training

- Accredited as part of national JTAC training systems
- Train with accurate weapon, flight, and threat models
- Out of box integration with DACAS systems

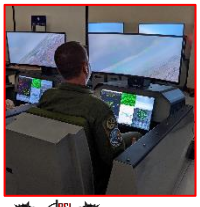
ISTAR Training

- Realistic sensor displays on physics-based aircraft
- Custom dynamic overlays
- Coupled with high detail pattern of life simulation



Operational Analysis

- High detail user definable content and model parameters
- Constructive scripting engine and code scripting interfaces
- Control multiple scenario iterations & logging



Live Virtual Constructive Simulation

- Live connection with military systems
- Drive synthetic tracks in real-world systems
- Drive software defined emitters stimulate real protection systems

EW Training & HITL Testing

- Complex IADS creation, interaction and editing at pulse level
- Physics based countermeasure evaluation
- Multiple visualization and analysis tools

Specific Device Training

- High detail functional equipment emulation
- Integrated into battlespace simulation attached to any entity
- Train device specifics in realistic contested environments

And many more…

2 PRODUCT SUMMARY

This section contains a brief description of the main features of the BSI products. (A 30s video summary of the products is on our YouTube channel https://youtu.be/bdvkdx1vb_U?si=npTciw247fFdwFuU)

2.1 MACE

MACE is a Windows software application and a C# framework capable of performing multi-domain analysis and simulation against near-peer adversaries. MACE is physics-based including pulse-level modeling of the electromagnetic spectrum. The detailed simulation of threat environments and precise modelling of sensors enables users to create highly relevant and accurate battlespaces.

MACE is one of just a very small number of commercial software applications that has been approved for use on the USAF's distributed simulation and training network and is used by more major weapon system trainers in the USAF than any other competing product. MACE is certified alongside several image generators for the delivery of Joint Fires (JTAC) training as part of accredited training programs.

MACE is where uses build and execute scenarios. It has a 2D view, and can consume standard GIS map, elevation and imagery formats (raster and vector).

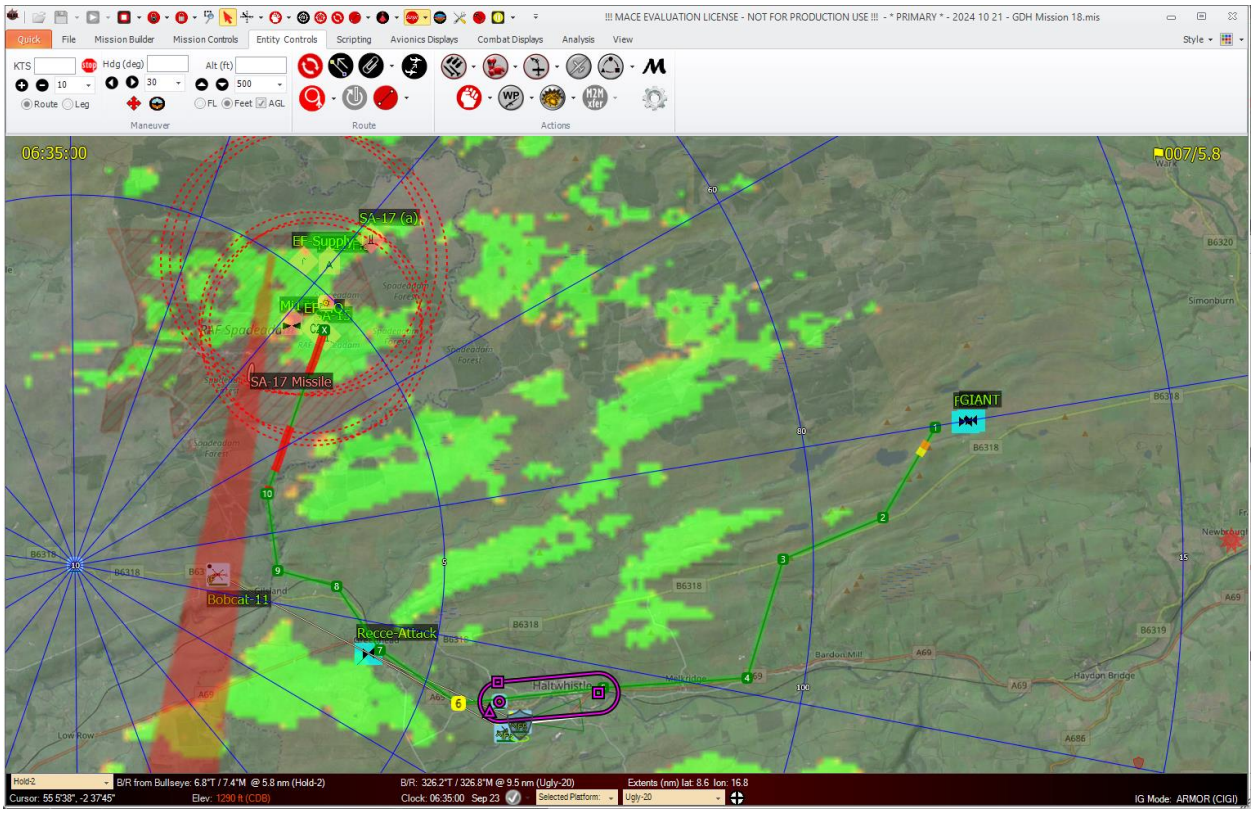


Figure 1: MACE mission area with waypoint route evaluation, radar propagation plot, bullseye, and EW beams; GeoTiff Imagery merged with open street maps tiles

MACE executes physics-based simulation: platform motion (aerodynamic and hydrodynamic models), weapon fly-outs, C3 networks (including radio and datalink networks), ground vehicles. All the models in MACE are user editable.

SIGNAL GENERATOR ENGINE (SGE): MACE simulates the electromagnetic spectrum to include the simulation of advanced, 5th-generation systems (such as electronically scanned radar systems typical of 'double-digit' threat systems) down to the pulse level. Users can define radar systems (including beam, scan and pulse patterns) and then associate these radar systems with platforms within MACE. The component that does this within MACE is called the Signal Generation Engine (SGE). The SGE not only does all RF (radio and radio) generation in MACE, but also does receiver modeling for all entities in the MACE mission and infra-red (IR) signal generation and detection.

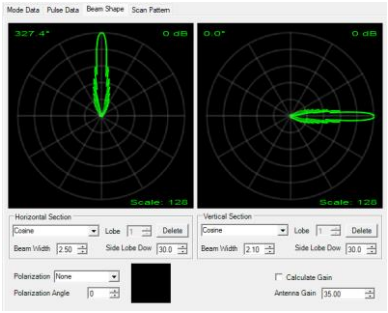


Figure 2: Beam shape editor

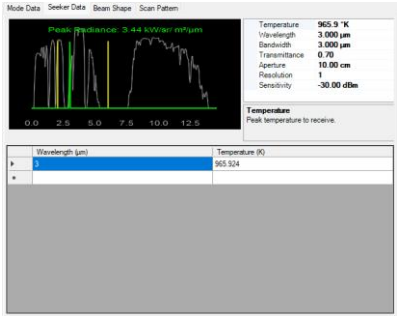


Figure 3: IR seeker editor

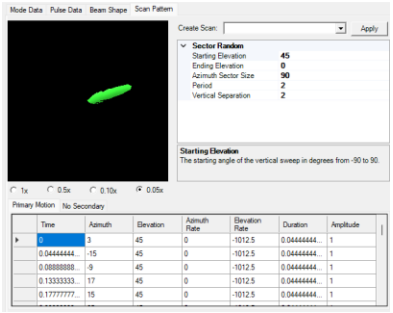


Figure 4: Scan pattern editor

SIMULATION FRAMEWORK: Out of the box, MACE comes with an unclassified database. It also enables non-developer users to extend the MACE order of battle, including not only new platforms and weapons, but also movement and emitter models. End users can edit and adjust the database with accurate data using the same tool as BSI use internally; the Mission Object Configuration Tool (MOCT). For our US DOD customers, there is a classified MACE database available for download.

MACE is a Simulation Framework that includes a plug-in architecture (C#/.NET) allowing any software developer to add or modify features and capabilities. Users can also write their own semi-autonomous functions from within MACE itself either using a simple UI or using snippets of C# code.

2.2 ARMOR

ARMOR is a full-planet, round earth Unity-based 3D visual image generator (IG). It enables interaction with the simulation from any perspective from first-person control to table-top planning. It supports multiple visual systems from screens and multichannel systems and extends to virtual and mixed reality. Users can generate terrain anywhere in the world without any prior GIS expertise.

Figure 5: ARMOR 3rd person view of aircraft and explosions in procedurally generated terrain

ARMOR is a CIGI based image generator and can be used with or without MACE by any application that supports the CIGI 4.0 protocol. ARMOR can run on the same PC as MACE (and every full MACE ships with a copy of ARMOR that can do this at no extra charge) or as a standalone image generator on networked PCs. Running ARMOR with MACE as the CGF opens more capabilities for the user.

With MACE and ARMOR, you can visualize things you normally can't see e.g. radar beam and scan patterns, jamming corridors, 3D radar cross-sections, route vulnerability analysis and line of sight coverage – all of which are critical to planning against a sophisticated adversary. Sensor views provide visual and IR spectrums, including green and white phosphorous Night Vision.

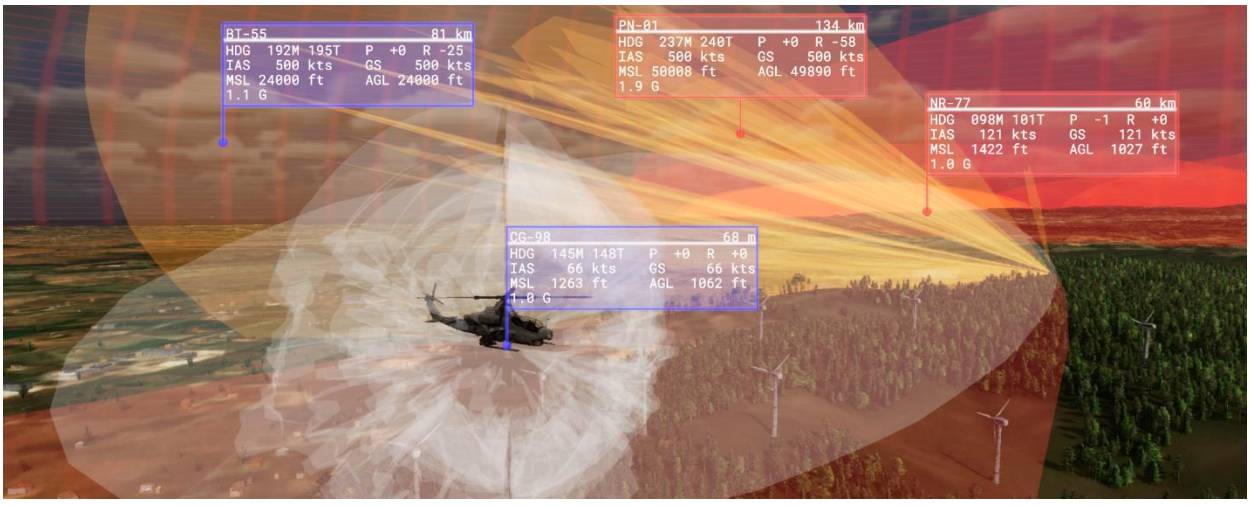


Figure 6: ARMOR showing different radar energy beam types and shapes, radar cross section, and data labels

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RAPID CAPABILITY DEVELOPMENT: With ARMOR it is possible to develop new capabilities at a very rapid pace by leveraging the huge Unity developer community and vast content catalogue. This results in significantly lower engineering costs than when developing with propriety engines.

ARMOR is built with COTS procurement in mind; it runs on normal game specification PCs, and you can plug and play with a multitude commercially available XR equipment.

2.3 DEVICE SIMULATION CONTAINER (DSC) & VIPER DIS RADIOS

The Device Simulation Container (DSC) is an application enabling development of simulated devices which require accurate representation of the human machine interface (HMI). Create new simulated devices, inherit from existing devices, or even host the entire system in another application. We have used internally it to make many BSI products including: ***Viper Radio*** *and Skins, B-EAGR, SA-8 Operator Station and many more.*

Figure 7: SA-8 operator station built in DSC controlling MACE entity SGE devices and receiving visuals from ARMOR

VIPER DIS RADIO SIMULATION: Viper simulates military communications over simulation networks with customizable user interfaces (skins) emulating the look and selected functionality of current Mil-Spec devices. The Viper Radio Simulation is a low-cost, Windows-based, reliable and complete alternative to more expensive server-dependent DIS radios. It is compatible with all other DIS standard radios, and no server is required to run Viper, each radio provides all the features you might expect to find in a large-scale system such as:

- Up to 100 simultaneous transmit/receive frequencies
- Configurable radio frequency, power, bandwidth, sensitivity and dynamic range
- Create edit and load communications plans to setup radios in seconds
- VOX and Push-To-Talk (PTT) on multiple selectable transmit frequencies
- Use joystick and other devices to: PTT, change channels, adjust frequency, swap active channels
- Selectable input/output audio devices (multiple Vipers can run on a single computer)
- Attach to any DIS entity, or specify a geo-location (propagation and terrain masking)
- DIS settings for Modulation, Frequency Hopping, Pseudo Noise, Time Hop, and cryptography

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Figure 8: PRC-117G Viper radio skin

SAME SIGNAL ENGINE AS MACE: Like MACE, all DSC devices such as Viper radios have physics-based signal degradation built into each radio that simulates propagation losses including, frequency spreading loss, Fresnel zone and diffraction over terrain. Signals fade gracefully (depending on frequency) as line-of-sight is lost with increasing static.

2.4 DISCORD

DIScord allows you to record any DIS traffic on your network; insert bookmarks during the recording; play back your recorded DIS PDUs at slow, normal, 4x, or 8x speed and "jump" to key scenario events in your recorded session (bookmarks, fires, detonations, etc).

If you are using BSI software such as MACE, ARMOR, and Viper you can play back the exercise in intimate detail for analysis. You will:

- Hear the radio calls in Viper – able to mute or change volume on any channels
- See the entity movements, emissions, and engagements in MACE
- Experience any perspective from anywhere in the 3D environment in ARMOR
- Use ARMOR overlays and MACE analysis tools to enhance debriefs

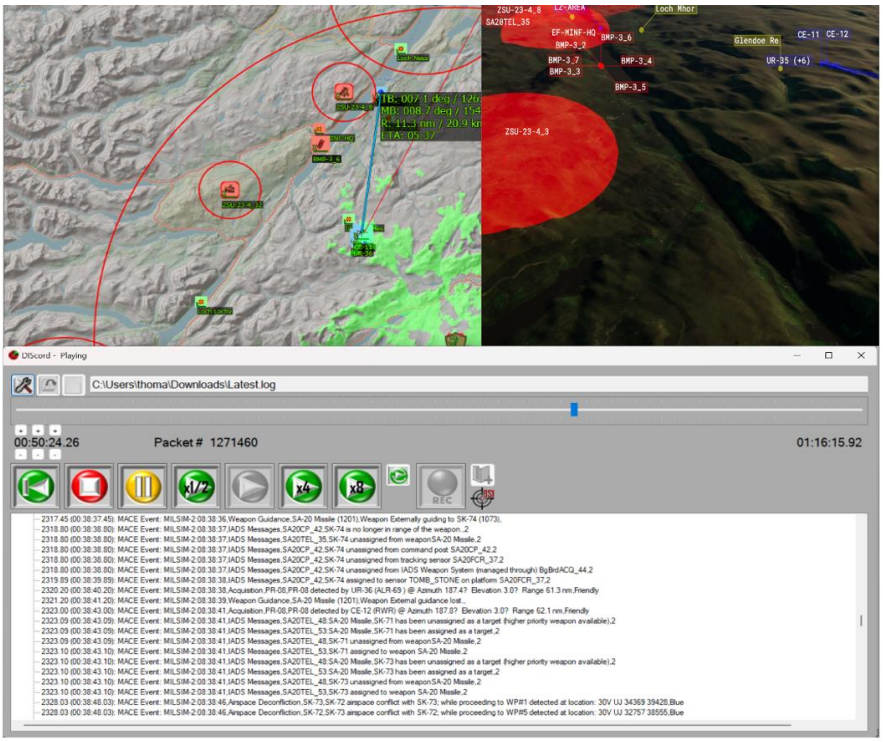

Figure 9: DIScord playback with MACE and ARMOR

MACE Logging enables more data to be logged to the DIScord files than standard DIS. You will be able to jump to key events such as:

- Radar detection, acquisition, guidance, IADS network messages (e.g. target assignations)
- Airspace deconfliction
- Countermeasure deployment and Jamming
- Any data sent from mission forms (9-Lines, 5-Lines, Call for fires)
- TDL messages
- Weapon launches, flight, guidance changes/deception, detonations, entity kills

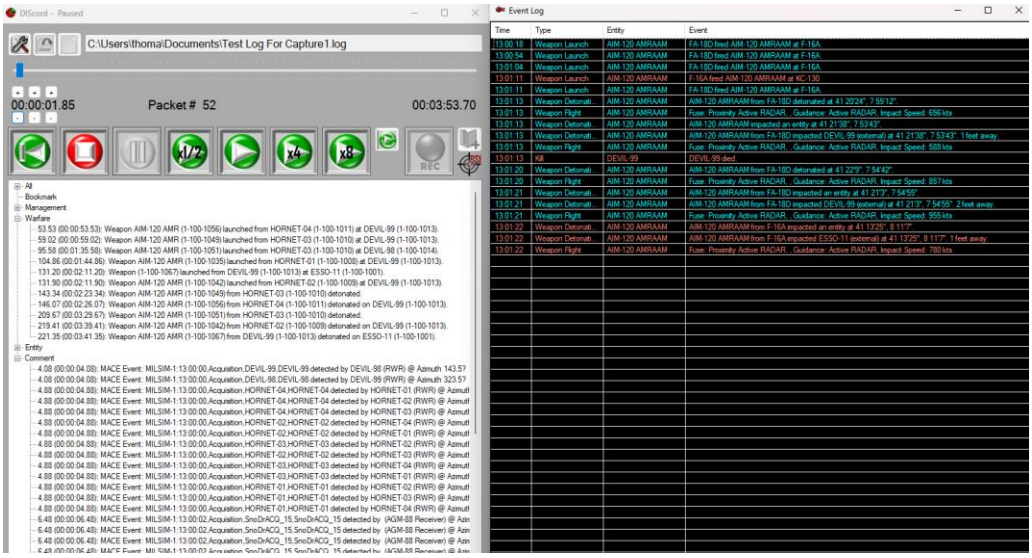

Figure 10: MACE event log populating from DIScord playback

3 USE CASES

3.1 MISSION PLANNING ANALYSIS & REHEARSAL

*Enhance operational preparedness by using MACE and ARMOR **to complement and enhance** your existing mission planning process, using the power of high-fidelity simulation to conduct analysis to refine, test and iterate towards better solutions.*

Users can integrate simulation into the existing planning process sharing data between systems:

BUILD THE BATTLESPACE: use the MACE maps, imagery, elevation and other GIS data to build the 3D battlespace in ARMOR – No GIS expertise required.

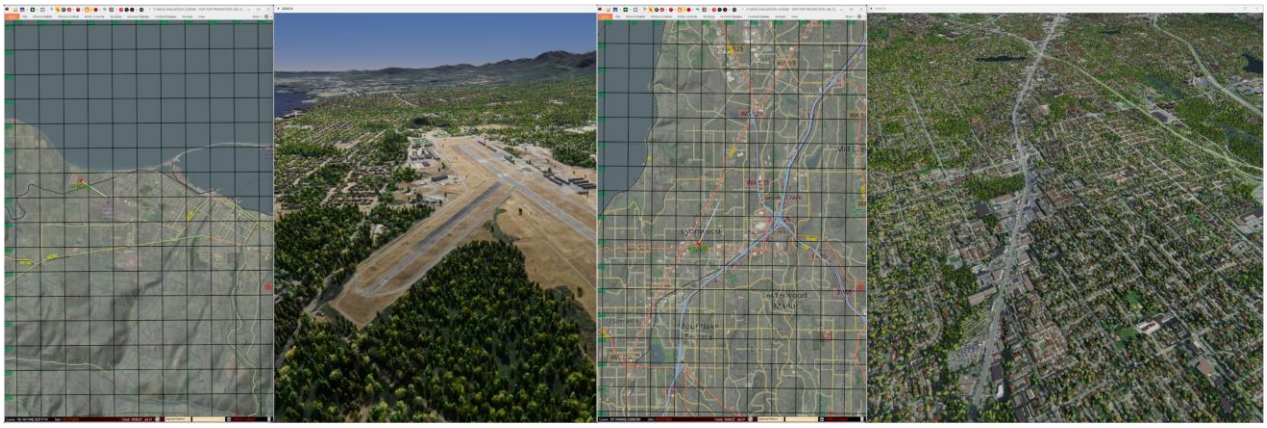

Figure 11: Procedurally generated ARMOR terrain from MACE using standard GIS data formats

IMPORT AND COMBINE MILITARY PRODUCTS: such as NATO standard Air Tasking Orders (.ato), Airspace Control Orders (.aco), Electronic Order of Battle, shape files (.shp .wkt), and aircraft route files (GPX, CRD).

ANALYZE AND PLAN THE MISSION: visualizing the entire battlespace in 2D and 3D from any perspective, with informative and analytical tools that aid decision-making (e.g. MACE mission rehearsal tool).

Figure 12: MACE (2D) and ARMOR (3D) route evaluation and Radar line of sight plots

PERFORM MULTIPLE ANALYSES AND ITERATIONS: including AI-assisted route finding through threats, missile flyouts and vulnerability analysis.

Figure 13: MACE Assisted Route Creation (MARC) in progress vs multiple threats to find optimum route

REHEARSE THE PLAN: in a high-fidelity 3D environment inside the cockpit (manual or autonomous flight), 3rd person and/or observe it from a gods-eye-view visualizing all aspects of the battlespace (e.g. EW energy, waypoint and weapon paths etc.). Assess where radar coverage become familiar with the route and the risks that may be encountered.

Figure 14: ARMOR mission rehearsal in 3rd person and 1st person cockpit views

EXPORT THE DATA: back to aircraft mission planning systems in standard formats (e.g. GPX and CRD).

VIDEO EXAMPLES:

- Demonstration of how to use MACE ARMOR and DISCORD for mission analysis, planning, rehearsal and after-action review. https://youtu.be/-oRYB1qImgo?si=f_Z35TShVAP0M4OT
- Example of how to use the Mission Rehearsal Toolbox to determine the effect of jamming on radio transmissions. https://youtu.be/wVxW4YsFTrA?si=lp4ROjLL6oT7qDjb
- Video demonstrating MACE Assisted Route Creation (MARC) – https://youtu.be/PRzZHgBM6UQ
- Video demonstrating route analysis tool - https://youtu.be/ONWnHmKGI-M

3.2 COMPUTER GENERATED FORCES (CGF)

Multiple major weapons systems with diverse requirements are using our flagship product MACE as their muti-domain Computer Generated Forces (CGF[1]) software of choice. It drives full mission simulators (fixed-wing, rotary-wing, JTAC domes, MQ-9 and more) and provides tactical combat simulation and pattern of life in distributed simulation systems.

Many customers use MACE to generate every aspect of their simulation apart from the host entity. E.g. In a Full Mission Simulator for a nominated combat aircraft: MACE will generate all the enemy forces, threats, civilian pattern of life and additional blue forces in all domains; the full mission simulator covers just the hot combat aircraft simulation (including flight models, sensors and weapons).

TIMESAVING TOOLS: MACE includes many tools and interfaces that reduce user workload when operating as a 'white force' or scenario admin. The intuitive plain-English scripting interface allows users to make and customize their own automated and semi-automated 'buttonizable' functions and behaviors for controlling platforms and other parts of the scenario. Standard military doctrinal layouts for: call for fire, CAS-9 Line, RW and Gunship 5-Lines, and fire plans give military users a familiar interface for calling in effects.

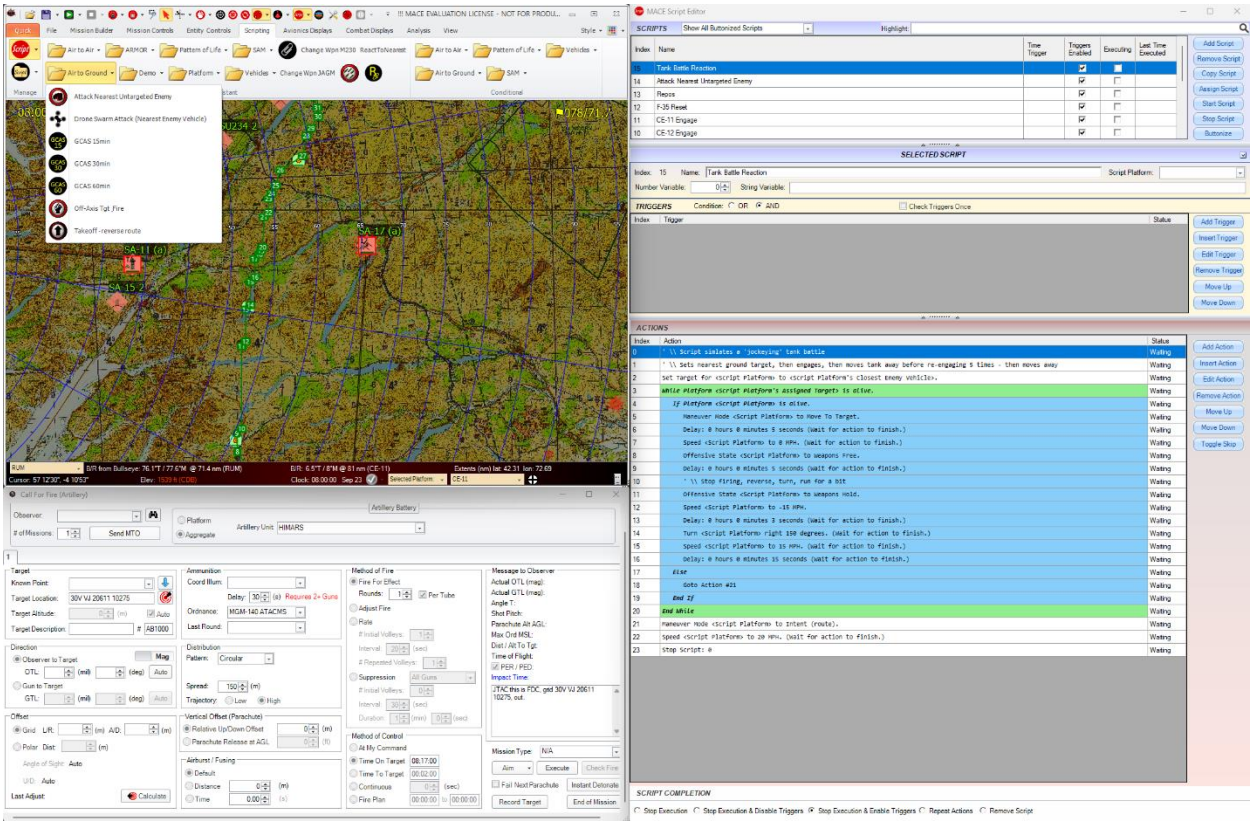

Figure 15: MACE using air mapping, call for fire UI, if-this-then-that style scripting interface, and buttonized scripts

[1] MACE provides computer generated forces (CGFs) also sometimes called Semi-Automated Forces (SAF).

CERTIFIED: MACE is regularly used as a multi-domain CGF in the Distributed Mission Operations Network (DMON), as part of the Combat Air Forces Distributed Mission Operations (CAF-DMO) Program. MACE is also often used as a host for multiple image generator software applications using the Distributed Interactive Simulation (DIS) and Common Image Generator Interface (CIGI) standards laid down by the simulation interoperability organization (SISO).

MACE is one of the most widely adopted CGF/SAF applications in the world, used to provide scenario generation for diverse major weapon system trainers, including:

- **F/A-18** - MACE is used to create and simulate both air-to-air and air-to-ground scenarios, and for entity generation in a customer nation's LVC (live-virtual-constructive) infrastructure.

- **A-10** – MACE is used by the USAF's A-10 program for scenario generation and execution. This exercises MACE's ability to simulate ground targets and threats, including AAA and 'double'digit' tactical surface-to-air-missile (SAM) systems.

- **AC-130/MC-130** – MACE is used by Air Force Special Operations Command (AFSOC) for scenario generation and execution in their AC/MC-130 Weapon System Trainers (WSTs). This exercises MACE's CGF/SAF capabilities to generate not only ground targets and threats, but also to generate scenarios that include MACE-generated gunships and pattern-of-life.

- **UAS** - There are hundreds of MACE-based Unmanned Aerial System (UAS) training systems in use around the world. In the USAF alone, MACE was used as the CGF/SAF for four separate MQ-9 training programs (each with many installations).

- **Rotary Wing** – MH-6, MH-47, MH-60, MH-139, CH-47 (UK MOD) simulators all use MACE for their scenario generation due to MACE's capability to create very realistic tactical environments for low level aircraft, including highly mobile and modern point defense systems.

Figure 16: A 2S6/SA-19 in ARMOR, controlled by MACE

3.3 ACCREDITED JOINT FIRES TRAINING

Over one hundred accredited MACE-based JTAC training systems are being used worldwide, by multiple NATO countries, Japan, UAE, United States Special Operations Command (SOCOM), Air Force Special Operations Command (AFSOC), ANC, ACC, and many more.

MULTIPLE CONFIGURATIONS: With MACE, ARMOR or other IG, and DSC/Viper, you can build a fully accreditable Joint Fires training system and more. Options range from desktop or deployable systems to larger curved displays or, immersive dome projection systems, and mixed reality 'green rooms'. For Joint Fires training, BSI recommends that MACE be paired with one of the following Image Generator applications:

- BSI's ARMOR
- MVR Simulations' Virtual Reality Scene Generator (VRSG)
- Bohemia Interactive Simulations' Blue IG.

Figure 17: Multichannel ARMOR in JTAC simulator with physical and software emulated equipment

CERTIFIED: MACE-based JTAC systems have been fully accredited (to replace the maximum number of live events) by the Joint Fire Support Executive Steering Committee and NATO FAC Standardization Cell.

BEYOND ACCREDITATION: JTAC and Joint Fires live training are costly and challenging to conduct effectively due to real-world constraints. Our software goes well beyond the usual accredited Joint Fires Training. To prepare for a near-peer adversary it is important to accurately model contested environments, including how communications, weapons and sensors are affected by electronic attack and countermeasures. That comes as standard with MACE, as does out-of-the box compatibility with fielded digitally aided joint fires systems.

SOFTWARE EMULATED MILITARY EQUIPMENT: DSC allows for the creation of software emulators of specific joint fires equipment such as radios and GPS (e.g. PRC-117, PRC-148, PRC-152, B-EAGR)

Figure 18: BSI Emulated Advanced GPS Receiver (B-EAGR), PRC-148 and PRC-152 Radios

PHYSICAL EMULATED MILITARY EQUIPMENT: BSI provides a Hardware Integration Board to partners, that is the backbone behind physical Form Fit & Function Joint fires equipment such as: IR pointers and laser target designators, and other optical equipment.

Figure 19: Physical EME: Selex Type 163 Laser

Figure 20: Physical EME: IZLID 1000P

DETAILED DEBRIEFS: If using DISCord to record the missions, users can play back all aspects of the mission and view from any perspective enabling deep analysis in after action review; using the visualization and analysis tools available in MACE and ARMOR and listening to the radio communications in Viper.

VIDEO EXAMPLES:

- Joint Fires Training in ARMOR Video – https://youtu.be/_VPQWK94_fA?si=YQoSZiCsfJ7fv_pg
- JTAC Accreditation Mission 1 Day Type 2 BOT SEAD – https://youtu.be/J3ppIYi0VtI?si=Is1WXu-rhVn9LoVa
- JTAC Accreditation Mission 2 Day Type 2 BOC Ground Laser Designation – https://youtu.be/yU8WWL7RY6w?si=fCa98w3jPClRPyyz
- JTAC Accreditation Mission 3 Night Type 2 BOT VDL – https://youtu.be/q9Cbk7Hsc_U?si=PO-CQjSsxEfxrIOK
- JTAC Accreditation Mission 4 Night Type 2 BOT IR Pointer – https://youtu.be/Q__sYSDGrv0?si=mfbRakxknwJaLm2v

3.4 ISTAR TRAINING

Use MACE and ARMOR to train and practice ISTAR in different terrains, environments and weather conditions within complex and cluttered target areas.

In addition to being able to simulate multi-domain combat operations, MACE is also an ideal platform upon which to build UAS training systems. MACE excels at simulating 'pattern-of-life', including human entities that can path find to their objectives and avoid collisions, a worldwide road network based on the OpenStreetMap dataset, traffic simulation and 'routing' (pathfinding along a road network) for vehicles.

With simple to use tools like 'Easy People' and 'Easy Traffic', users can quickly create entities with representative behaviors in dense urban areas. These tools, combined with MACE's combat simulation capability, mean that MACE is ideally suited for generating challenging training scenarios for your UAS pilot and sensor operator teams.

All you that is required for UAS/Sensor training system is BSI's MACE and ARMOR, or an IG from one of our partner companies.

Figure 21: ARMOR White-hot IR sensor view

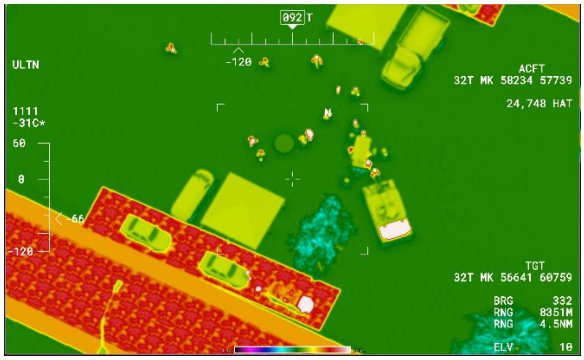

Figure 22: ARMOR multi-spectral IR sensor view

VIDEO EXAMPLES:

- How to create human pattern of life with EZ-People – https://www.youtube.com/watch?v=zIfuAgSdzCk
- How to create vehicle pattern of life with EZ-Traffic – https://www.youtube.com/watch?v=8MXKEusaArI
- Demonstration of ISTAR functions – https://youtu.be/l09F3rfuMU4?si=bBXVJjXAd7dGje_9
- JTAC Accreditation Mission 3 Night VDL – https://youtu.be/q9Cbk7Hsc_U?si=PO-CQjSsxEfxrIOK

3.5 OPERATIONAL ANALYSIS

Iterate across every parameter of platform's movement dynamics and emitters, try new capabilities in an accurately modelled multidomain battlespace, and even go fully automated with your scenarios, let events unfold based on multiple easily authorable criteria.

CONCEPT MODELLING AND DESIGN ANALYSIS: Because MACE is physics-based and high fidelity, it is used by military research organizations and their industry partners worldwide for deep analysis and experimentation, testing new equipment concepts or new tactics techniques and procedures in a comprehensive high fidelity simulation environment. Using our software, they can filter out less promising concepts and take only the best forward for the next stage of implementation.

Model new equipment and configurations with our content tools; then conduct capability design analysis and validate your outputs in a fully representative battlespace. Use automation, logging and iteration tools to converge on ideal parameters and solution sets.

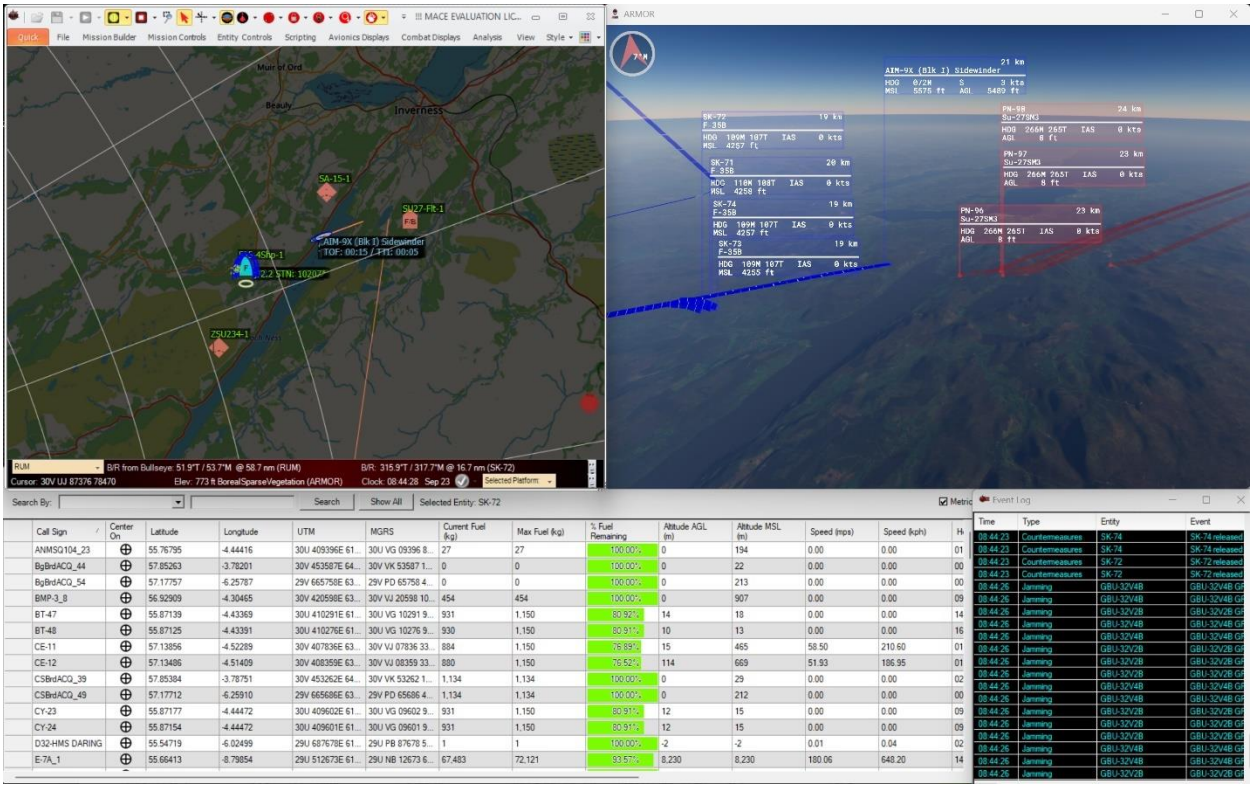

Figure 23:MACE Analysis of Air-to-Air engagement and IADS effectiveness, logging and data views, visualization in ARMOR

COST EFFECTIVE AND SECURE: Running analysis on live trials can be costly, constrained, and insecure. Our software enables iteration and deep analysis in detailed simulated battlespace before committing to live environments.

USE MILITARY STANDARDS: MACE can ingest and output military standard data such as: Link 16 and COT tracks, VMF, ASTERIX air traffic control data and more. You can run live military data formats into and out of the software to augment trials with synthetic and vice versa. You can ingest post trial data such as EAG/ TSPI flight recordings for further analysis and visualization in a synthetic environment.

SIMULATION FRAMEWORK: Written in Microsoft's .NET language and with a robust plug-in API), users have access to all the object models in the MACE mission. This means that your software engineers can add new functionality, change default behaviors and mine data for analysis.

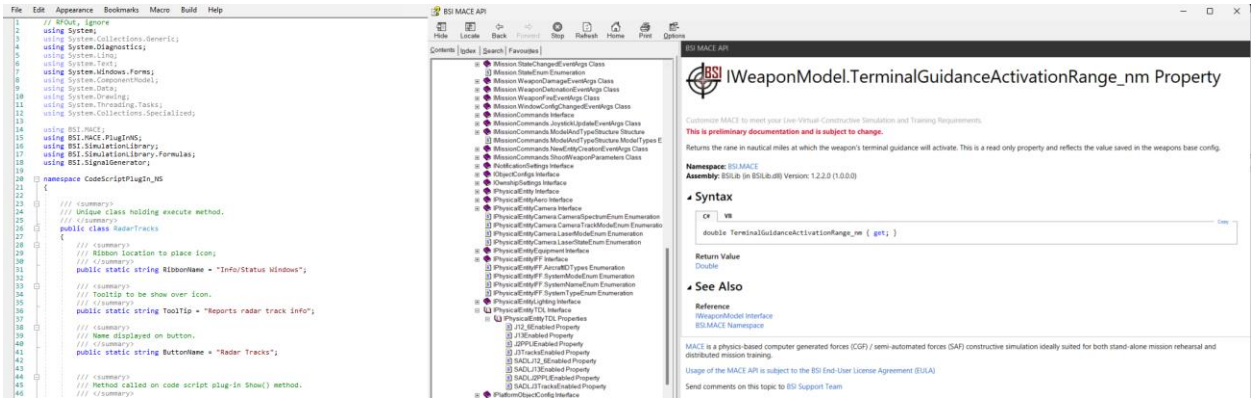

Figure 24: MACE Internal code script editor; API documentation

3.6 LIVE VIRTUAL CONSTRUCTIVE TRAINING

Live training is costly, and often minimal assets are available simultaneously, reducing its efficacy. Using MACE, which can control live emitters, ingest and push out military standard data streams such as Link-16, COT, VMF, ADSB, ASTERIX – you can produce a greater effect in live training as real aircraft systems are stimulated with a plethora of scenario specific inputs.

SYNTHETIC PLATFORMS IN LIVE AIRCRAFT DISPLAYS: Multiple synthetic aircraft can fly in concert with live aircraft correctly appearing as L16 tracks on live aircraft tactical displays. MACE can generate tactical data link messages such as J2 and J3 series messages, in the NATO (STANAG) standard format for J-Series messages. MACE can also 'package' these messages in any of one several protocols, including SISO-J (for interoperability with simulators) and the Joint Range Extension Applications Protocol (JREAP: https://en.wikipedia.org/wiki/JREAP) version C (Link-16 over ethernet).

Figure 25: LVC red-air stations set up at the NATO air tactical leadership program (TLP)

STIMULATE REAL AIRCRAFT SYSTEMS: Ground based software-defined-emitters can be reconfigured and controlled by MACE to replicate threat system engagement sequences, which will stimulate live aircraft threat warning systems.

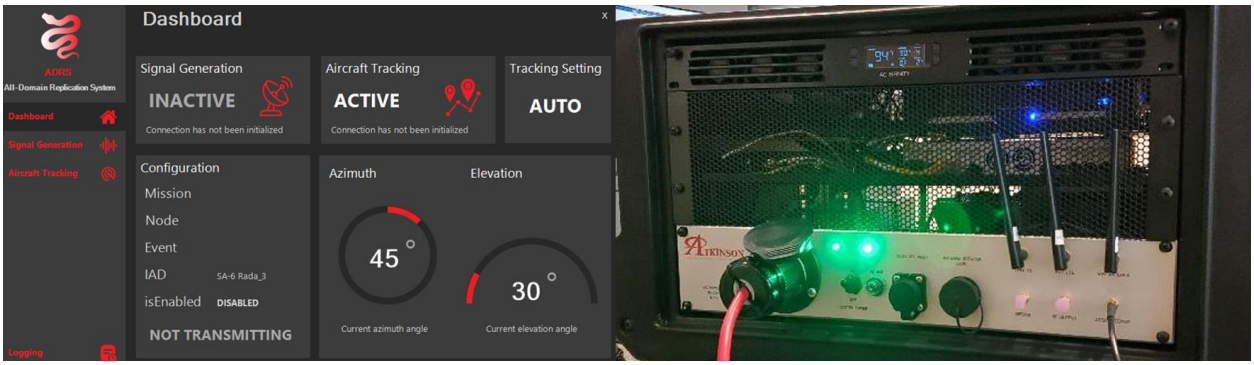

Figure 26: Atkinson Aerospace MACE plugin controlling their software defined emitter at UK EWTR

USE FIELDED DACAS AND OTHER SA SYSTEMS: JTACs and other Joint Fires personnel can use their fielded digitally aided CAS and situational awareness systems (e.g. ATAK) to receive friendly and enemy (COT) tracks from MACE and synthetic ISTAR downlink video feeds from ARMOR (correlated with the real world). Users can task MACE controlled aircraft over the VMF protocol to control air to ground attacks as they would in real life. All while not converting petrol to noise at great cost.

Figure 27: ATAK displaying MACE generated entities passed over COT protocol & ARMOR synthetic streaming ISTAR VDL

3.7 ELECTRONIC WARFARE TRAINING

MACE can simulate radar activity to the pulse level and all emitter parameters are user editable. It is used in the US and multiple allied countries for Electronic Warfare (EW) simulation and training, and even Hardware-in-the-Loop (HITL) testing.

SEE & UNDERSTAND THE UNSEEN: MACE and ARMOR have a plethora of visualization tools that enable users to 'see the unseen' in the EW spectrum. This enables instructors to convey the concepts of EW training in a multitude of visual and easy-to-understand ways.

Figure 28: MACE and ARMOR visualizations showing beam shape, jamming corridors radar propagation; and spectrum analyzer

SIMULATED EW DISPLAYS: MACE-EW includes a large suite of simulated EW displays, suitable for teaching skills such as signal identification, direction finding, threat reaction, countermeasures employment and more.

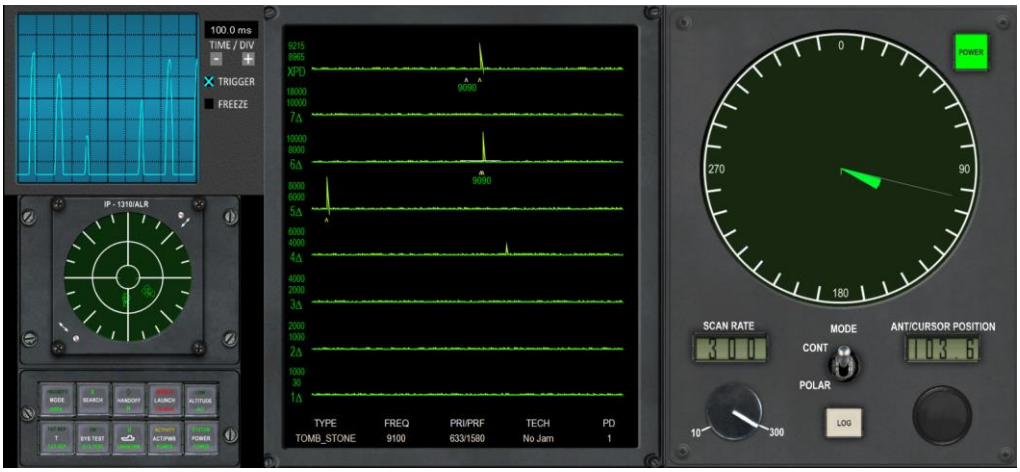

Figure 29: MACE EW DF scope, RWR, ELINT signal analyzer

FULLY USER CONFIGURABLE: The EW Device editor enables users to modify and build signal generation engine (SGE) devices; seeing the effect of the parametric changes they make (e.g. pulse definition, scans, beam shapes, power etc.) within a representative multi-domain battlespace mission.

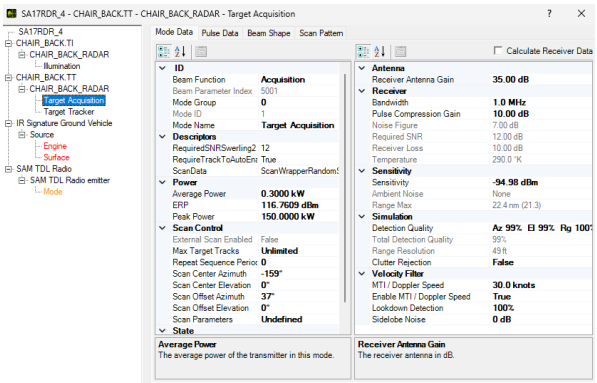

Figure 30: MACE EW Editor mode data

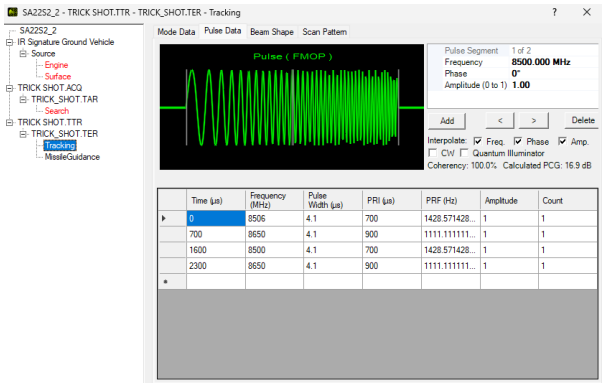

Figure 31: MACE EW Editor pulse data table

3.8 SPECIFIC DEVICE TRAINING

The MACE Plugin API and DSC allow third party developers to rapidly develop and deploy a wide variety of devices (e.g. airframe specific avionics and vehicle displays) that interact with the physical and electromagnetic environments.

MACE PLUGINS: MACE isn't a "black box"; it gives MACE users the ability to rapidly build capabilities or interfaces in MACE without having to wait for a "new release", or funding, or having to work with slow requirement and contracting processes. The MACE plugin API gives the user near-complete control over the MACE runtime environment. Entire simulation environments can be built on the solid bedrock of technologies that MACE consolidates and exposes to the developer, allowing them to focus on the details of their specific implementation while letting MACE take care of the rest.

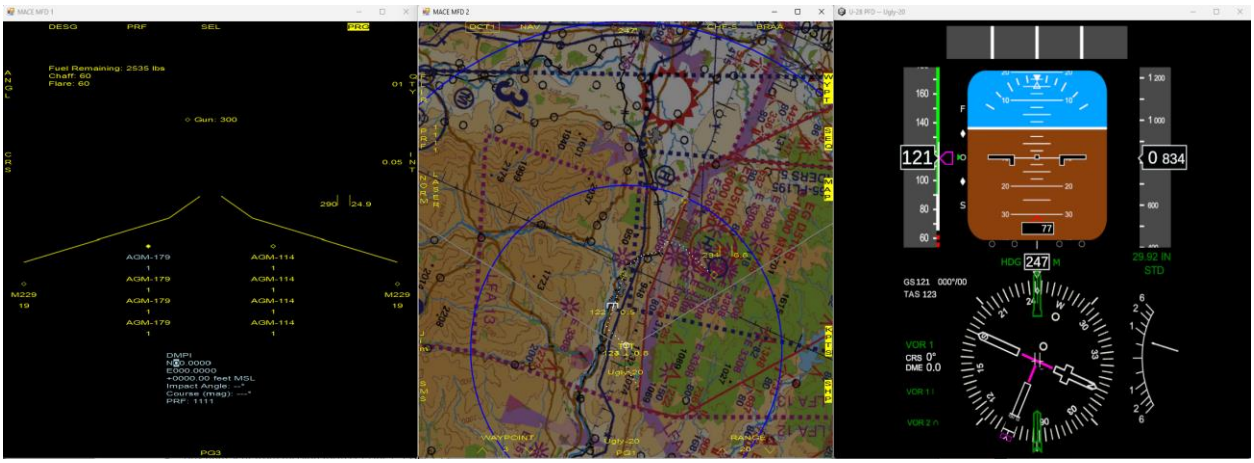

Figure 32: MACE Plugins used to create interactive tactical displays and primary flight instruments

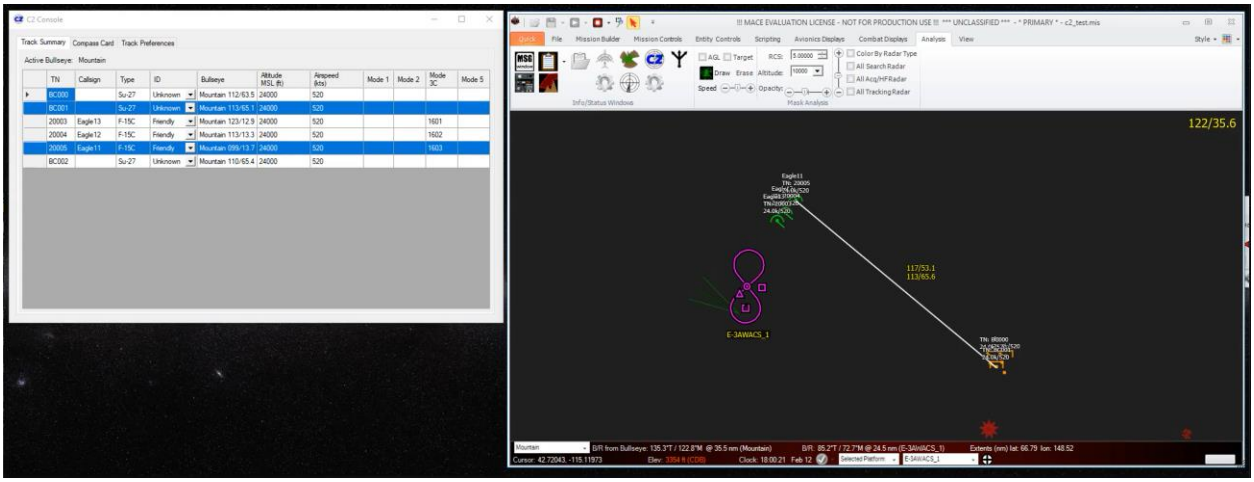

Figure 33: MACE emulating an E-3 AWACS controller's console

DSC FOR MULTI-STATION SIMULATION: Using the Device Simulation Container (DSC) you can create specific replica 'virtual devices' for training that can be hosted on other PCs connected to one MACE host over a network. Multiple weapon and sensor stations can be created that reside on one MACE platform but are controlled by many users on different PCs.

Figure 34: DSC DEWD device

Figure 35: DSC APG-81 radar device

VIDEO EXAMPLES:

- Human manually using DSC SA-8 Operator station controlling MACE SA-8 platform engagement – https://youtu.be/p-abbY6eeJo
- ELINT Device in DSC latched to an RC-135 allows user to select a signal for analysis on the O-Scope – https://youtu.be/2RwvRf3_0VA

3.9 PILOT/ROLE-PLAYER STATIONS

MACE and ARMOR or other IG can be used as a cost-effective way to meet simple to complex training requirements for DMO Operations and single to multi-seat operational or familiarization training

BSI has delivered over 100 combat-capable Pilot/Role-player Stations to customers around the world. These stations are easy to operate yet able to deliver training for a wide range of combat-related skillsets. MACE is designed to satisfy the realism that an experienced aviator would expect, while employing advanced Air-to-Ground and Air-to-Air Weapons, reacting to air and ground threats, deploying expendables or electronic protection, and interacting with other entities in the scenario.

For Role-Play/Pilot, BSI recommends that MACE be paired with one of the following Image Generator applications:

- BSI's ARMOR
- MVR Simulations' Virtual Reality Scene Generator (VRSG)
- Bohemia Interactive Simulations' Blue IG

USER CONFIGURABLE FLIGHT MODELS: MACE currently includes fully user configurable 6-DOF physics-based flyable flight models for fast moving fighter-type and slower moving attack-type aircraft, and rotary-wing aircraft, FPV drones, and 6-DOF hydrodynamic models for all surface and sub-surface platforms. These are realistic for simulating aircraft response to person-in-the-loop flight control inputs. For greater realism MACE also supports the more detailed JSBSim model architecture.

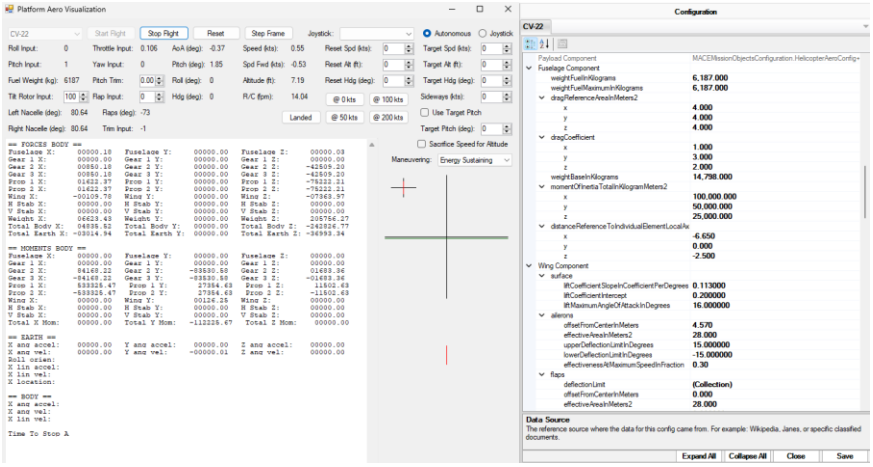

Figure 36: Mission Object Configuration Tool - Aerodynamic model editing and visualization

SEMI/AUTONOMOUS & MANUAL CONTROL OF MULTIPLE AIRCRAFT: In MACE, you can quickly transfer an entity from constructive (computer) control to virtual (person-in-the-loop) control, and back again. For example, a white force operator could take control of and fly an F-16 in support of the blue forces, then with the click of a joystick button release the F-16 and take control of an enemy fighter in support of the red forces. MACE also has an Autopilot feature that can be used during higher workload periods or to easily fly back to the intended route, orbit or target.

AVIONIC DISPLAYS: MACE's Avionics Displays contain the controls you need to select and display various types of avionics equipment to include: attitude indicators, airspeed indicators, altimeters, magnetic compass, BDHI, HSI, NAVAIDS. The MACE API Plugin architecture and DSC enables 3rd parties to develop bespoke interactive avionics and combat displays (see **3.8 Specific Device Training**).

COMBAT DISPLAYS: The combat displays function just like the avionics displays but usually require more user interaction. The combat displays generally include weapons employment, countermeasures, threat warning, threat analysis and electronic attack equipment.

Figure 37: Selection of MACE avionics and combat displays

TACTICAL MULTIFUNCTION DISPLAY: BSI has developed an MFD using MACE's Plug-In Architecture (**3.8 Specific Device Training**). The MFD appears as 2 independent display forms which can be controlled directly with a mouse or using programmed joystick controls. Amongst other functions, it is possible to:

- Stream an ARMOR sensor views into either MFD
- Select a pre-tiled moving map background for the display
- See information about targets such as range bearing, altitude, speed, closure
- Allocate air and ground targets
- Program the MFD 'soft keys' to be initiated by a hardware multifunction display
- Program the individual weapons and equipment on the platform (e.g. weapon parameters) – with the DSC-UFC device and/or with keyboard

Also, it has a powerful feature in that it can be used to give commands (buttonized scripts) to MACE-generated constructive forces (such as a constructive wingman to the Role Player aircraft). These commands can be tactics that the end user creates (with no programming knowledge required).

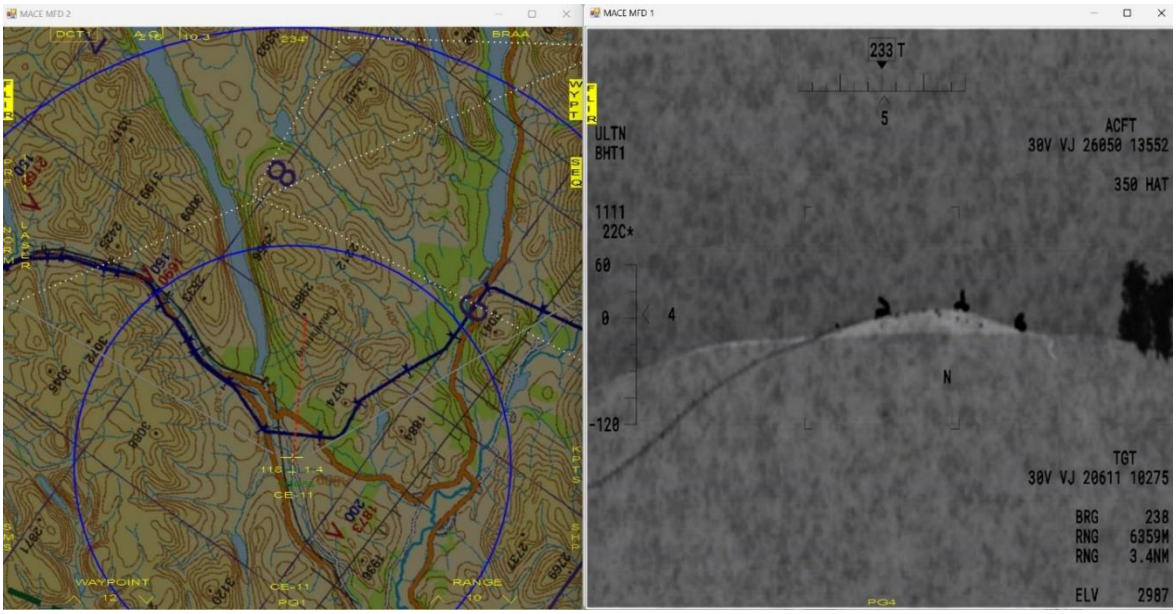

Figure 38: MACE 2xMFDs (left) showing tactical awareness display with moving map (right) showing ARMOR sensor view

HEAD UP DISPLAYS: The HUD makes man-in-the-loop flight and weapons delivery much more realistic and user-friendly. It gives detailed target, timing data and steering cues. The HUD symbology changes in response to the selected weapon displaying CCIP/CCRP, pipper, timing circles as appropriate for the weapon type.

Figure 39: ARMOR aircraft HUD; ARMOR Sensor display

3.10 EMULATED MILITARY EQUIPMENT

Using the BSI Hardware Integration Board design, which already has robust integration with both MACE and ARMOR, 3rd parties can develop realistic emulated military hardware that interacts with the mission.

Developing emulated military equipment (EME) hardware can be time consuming and difficult using traditional simulation development tools. BSI has been a leader in making the EME development process as painless as possible. Our CIGI API in MACE allows for the rapid development of specific equipment displays. BSI also offers a hardware integration board design with integrated 3-DOF orientation tracking and multiple inputs, that can be programmed directly from the MACE C# API – no firmware expertise required.

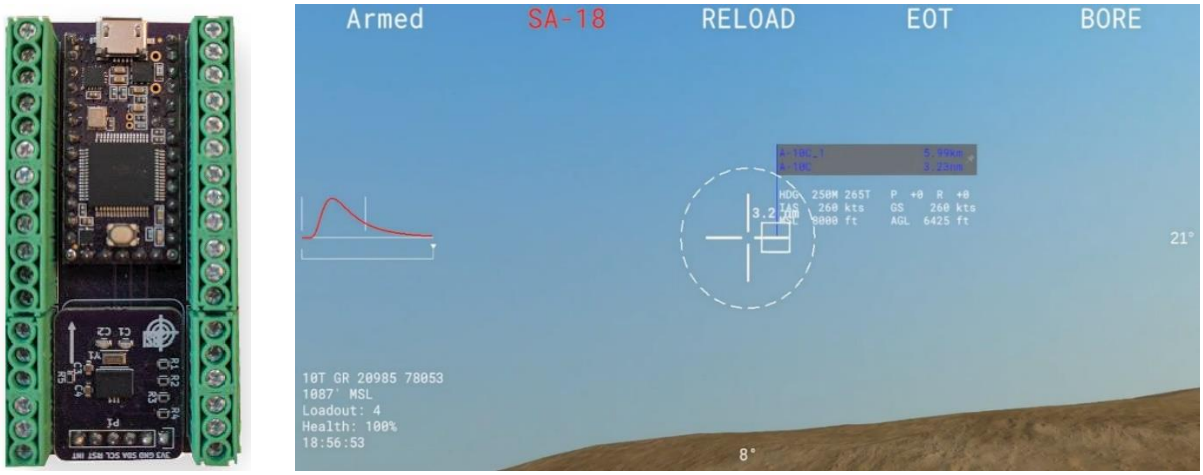

Figure 40: A BSI integration board with a MANPAD trainer built around it

VIDEO EXAMPLES:

- MACE-ARMOR ManPad video – https://youtu.be/ZPL8XdIPZw8

3.11 WARGAMING

MACE offers Wargaming based on high fidelity physics-based engagements not on probabilities. Visualize and analyze contested battlespaces before even running a mission. Play out multiple scenarios varying parameters automatically, and analyze as you go.

NOT MONTE CARLO: MACE is different from many other simulations often used for wargaming because it has very few inherent Monte Carlo elements[2]. MACE does not use probabilities of hit or kill; rather, it takes a physics-based approach to simulating all weapon guidance and missile flyouts, and assesses hit or miss, kill or no kill based on the results of this flyout (miss distance, warhead strength and blast radius and target armor rating are all considered). MACE can accelerate time but is limited to x8 real-time.

COLLABORATIVE VISUALIZATION: MACE can be used to create and run wargaming scenarios by itself or with ARMOR bringing with it all the enhanced visualization features in the 3D Battlespace.

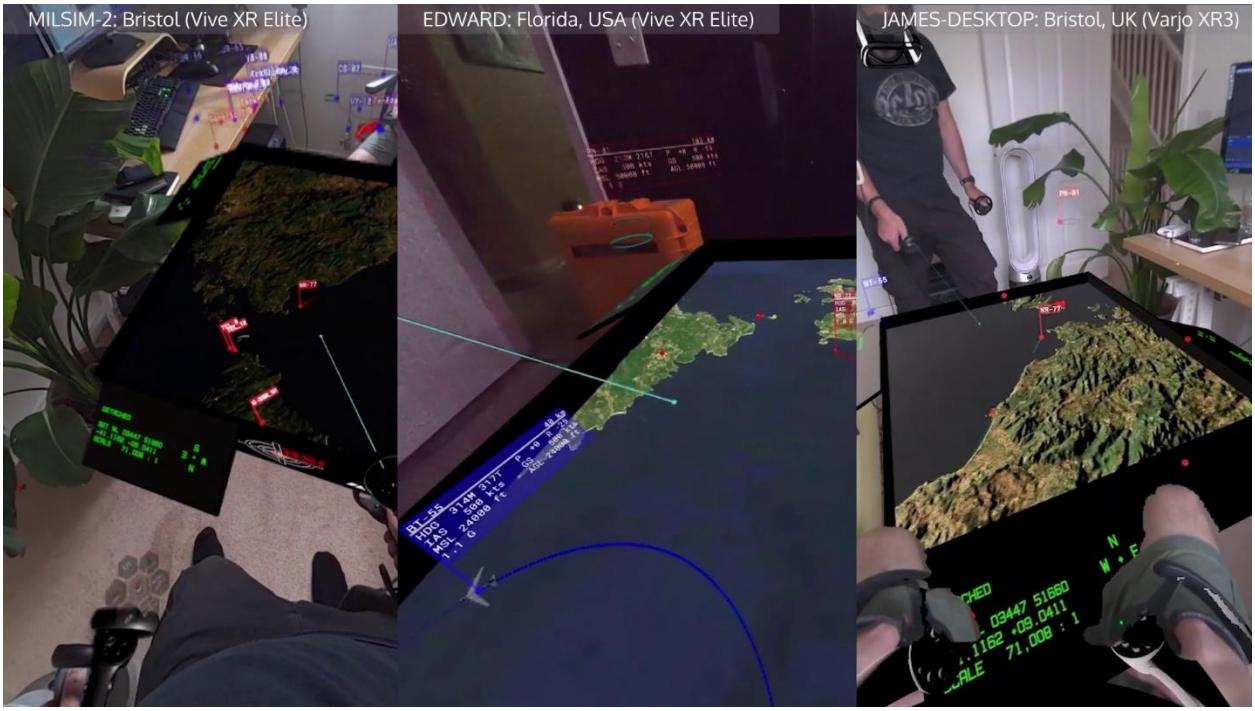

Figure 41: 3 Users (2 Co-located and 1 remote) collaborate in the same scenario using ARMOR Mixed Reality table-top mode

MULTI SCENARIO AUTOMATION: The Scenario Loop Plugin allows users to automatically run a series of different mission sequentially or to run the same mission but run different scripts that can change the scenario conditions, or behaviors and capabilities of platforms

[2] A typical Monte Carlo simulation uses probabilities to determine simulation outcomes (such as probability of hit and probability of kill). For example, when simulating an engagement in a Monte Carlo system, things like the effects of jamming and countermeasures are incorporated into the probability of hit. Monte Carlo simulations are useful for accelerating time much more than you could do with a physics-based simulation like MACE, but of course the tradeoff is loss of fidelity.

BRANCHING: MACE allows users to save a running mission at defined intervals (e.g. every 1 min) so you can go back to a particular point in a mission and make alternate decisions to see what affect it has on mission objectives.

RECORDING & LOGGING: Using DIScord enables scenario playback, when used with MACE Logging it enables more data to be logged to the DIScord files than standard DIS. You will be able to jump to key events such as:

- Radar detection, acquisition, guidance, IADS network messages (e.g. target assignations)
- Airspace deconfliction
- Countermeasure deployment and Jamming
- Any data sent from mission forms (9-Lines, 5-Lines, Call for fires)
- TDL messages
- Weapon launches, flight, guidance changes/deception, detonations, entity kills

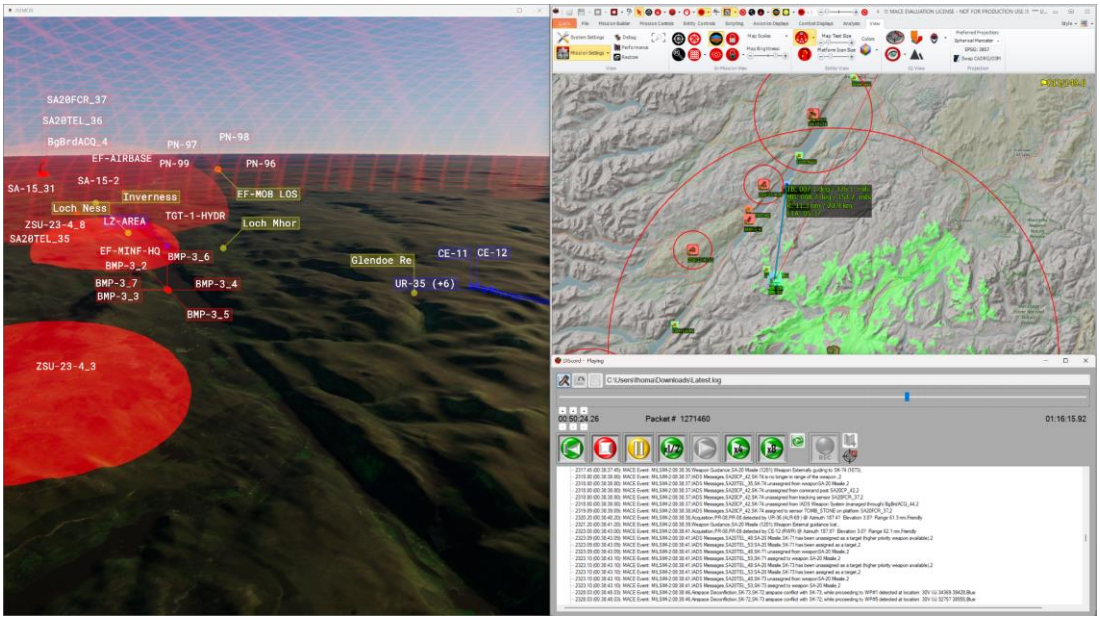

Figure 42: Playback from DISCORD shown in ARMOR with line of sight analysis in MACE

VIDEO EXAMPLES:

- Video of flight through the grand canyon in ARMOR, showing both 1st person VR perspective and observation from 3rd person MR table top perspective - https://youtu.be/eI6ZNn7nzEM
- NEW video soon!