

Implementing a Digital Engineering Environment for Mission Engineering

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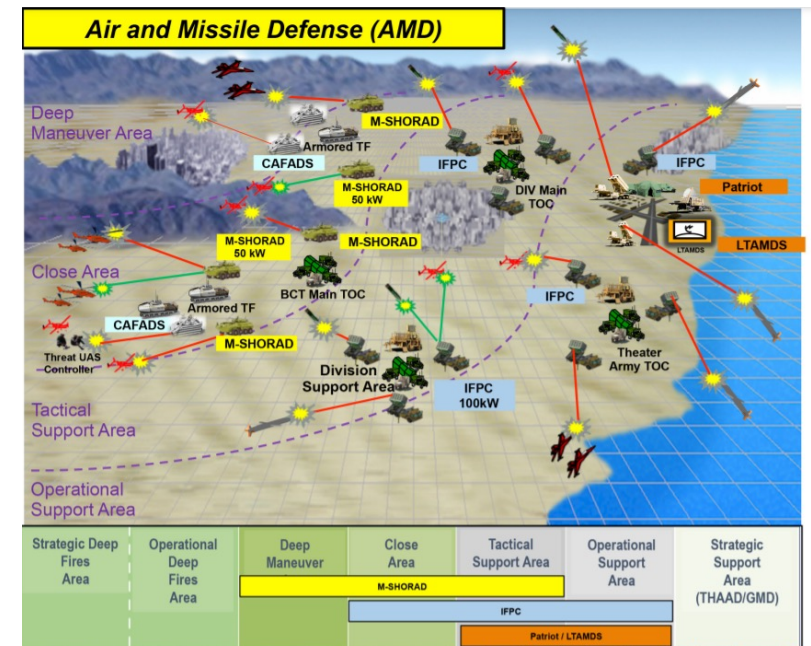
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Introduction

- The presentation describes the broad mission context driving the development and the approach used to creating a **Digital Engineering Environment (DEE)** for the Joint Staff J8's Joint Integrated Air and Missile Defense Organization (JIAMDO).
- This includes the development of top-level mission threads for IAMD which can be specialized to address different mission sets, including **Counter Unmanned Aerial Systems (C-UAS)** as well as **Cruise Missile Defense (CMD)**.
- The presentation includes perspectives from the DEE team, MITRE, as well as the end user, JIAMDO.

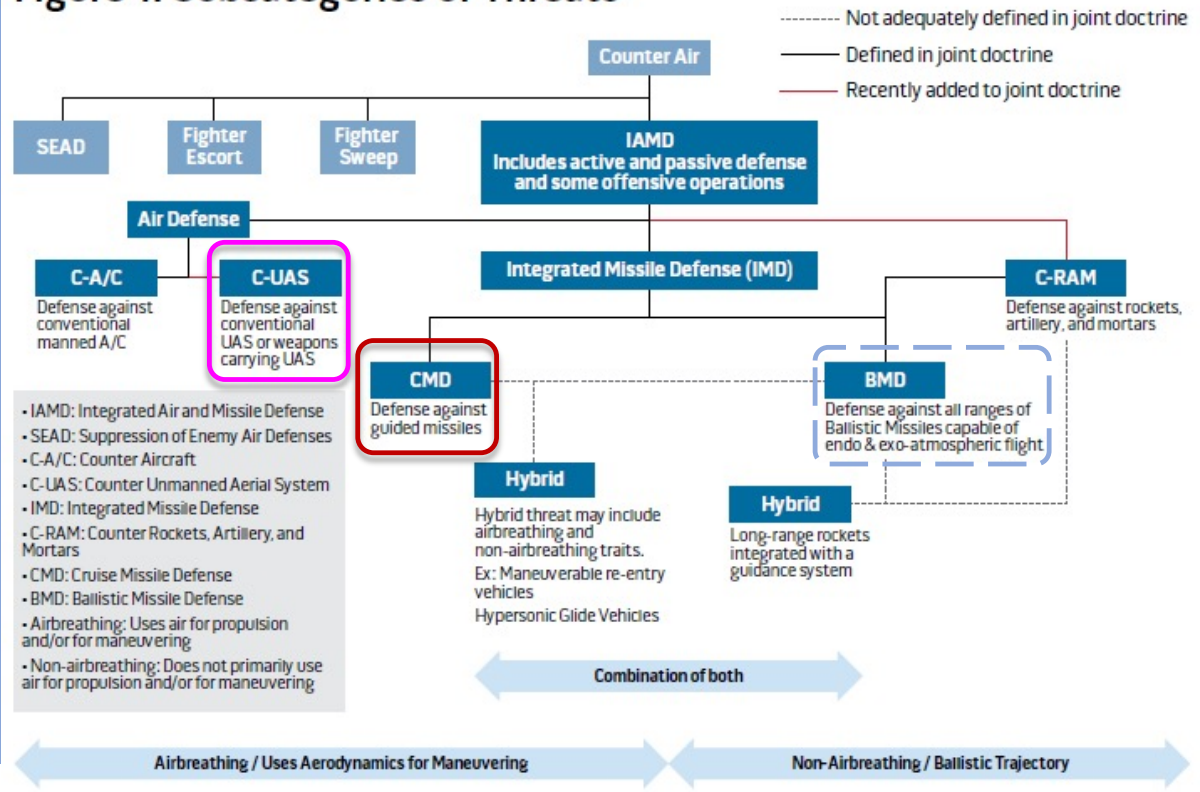


Source: Army Air and Missile Defense Vision 2028, USASMD/ARSTRAT



IAMD Mission Space

Figure 1. Subcategories of Threats

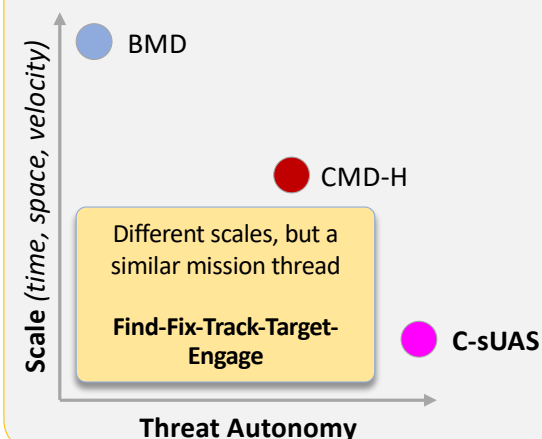


Credit: Gabriel Almodovar, Daniel P. Allmacher, Morgan P. Ames III, and Chad Davies, JFQ 88, 1st Quarter 2018

Key Insight

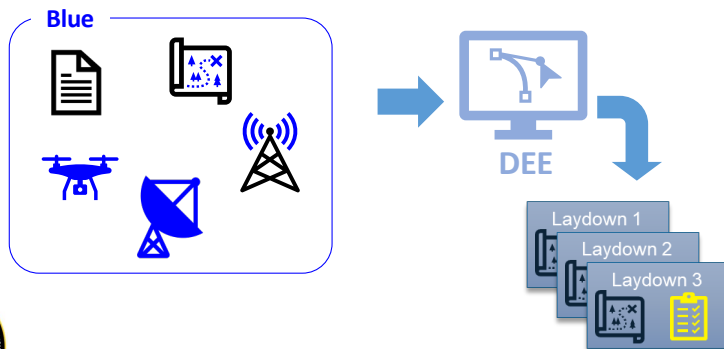
A Digital Engineering Environment developed for any IAMD mission can be easily re-factored to address the others.

Current work is focused on analysis of Countering Small Unmanned Aerial Systems (**C-sUAS**) – has been expanded to Cruise Missile Defense of the Homeland (**CMD-H**) in FY21, and will be expanded to support Ballistic Missile Defense (**BMD**) in FY22



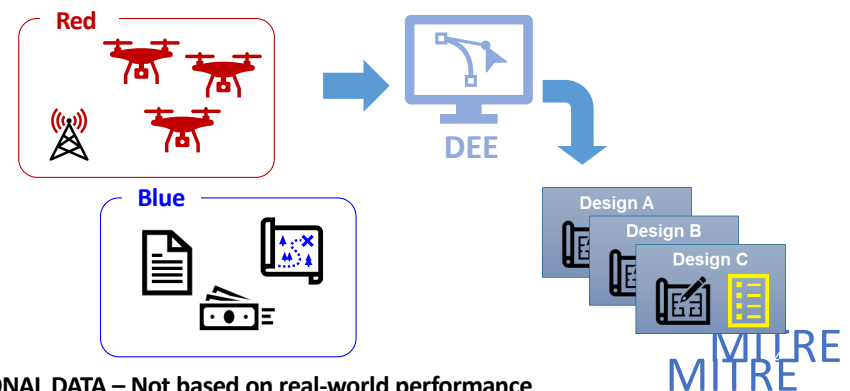
Two Complementary Analytical Approaches

- Start with knowns – *“Make the most of what you have”*
- Given existing C-sUAS system parameters, **determine the optimal set of capabilities** for a given scenario.



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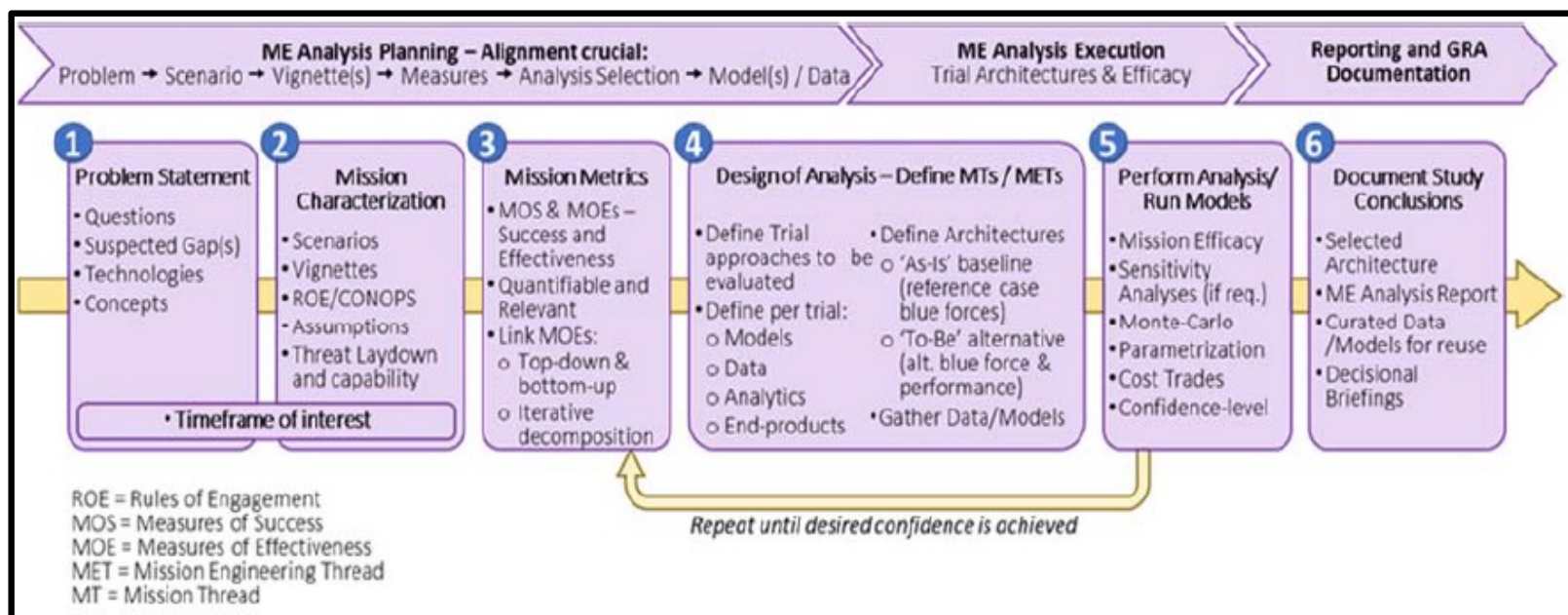
- Start with requirements – *“Buy the best of what you need”*
- Given adversary capabilities and BF CONOPs, **derive the required C-sUAS capabilities and parameters** that optimize performance for a given scenario.



NOTIONAL DATA – Not based on real-world performance



ME Approach and Methodology



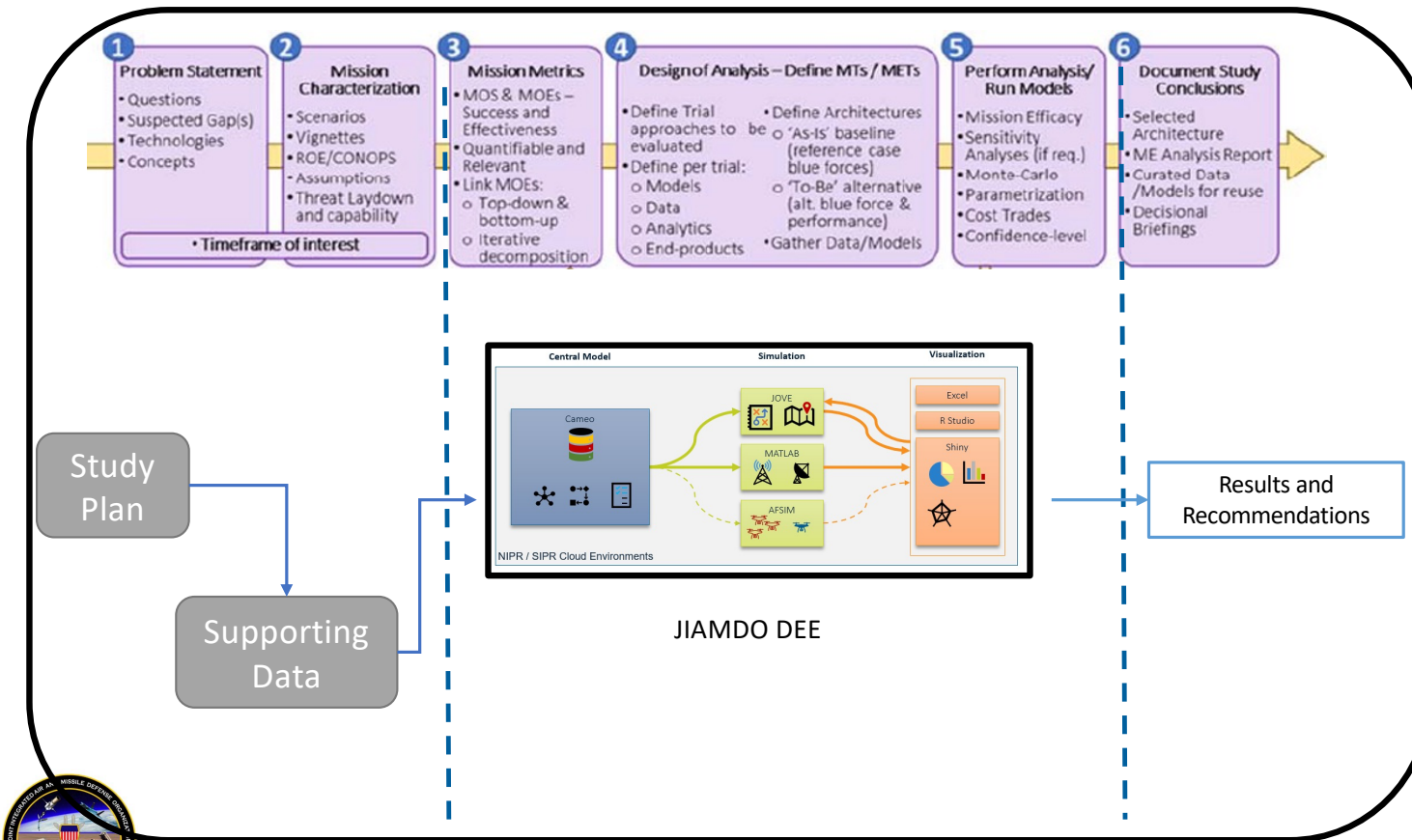
ME process begins with the end in mind, a carefully articulated problem statement, the characterization of the mission and identification of metrics, and working through the collection of data and models needed to analyze the mission and document the output results.



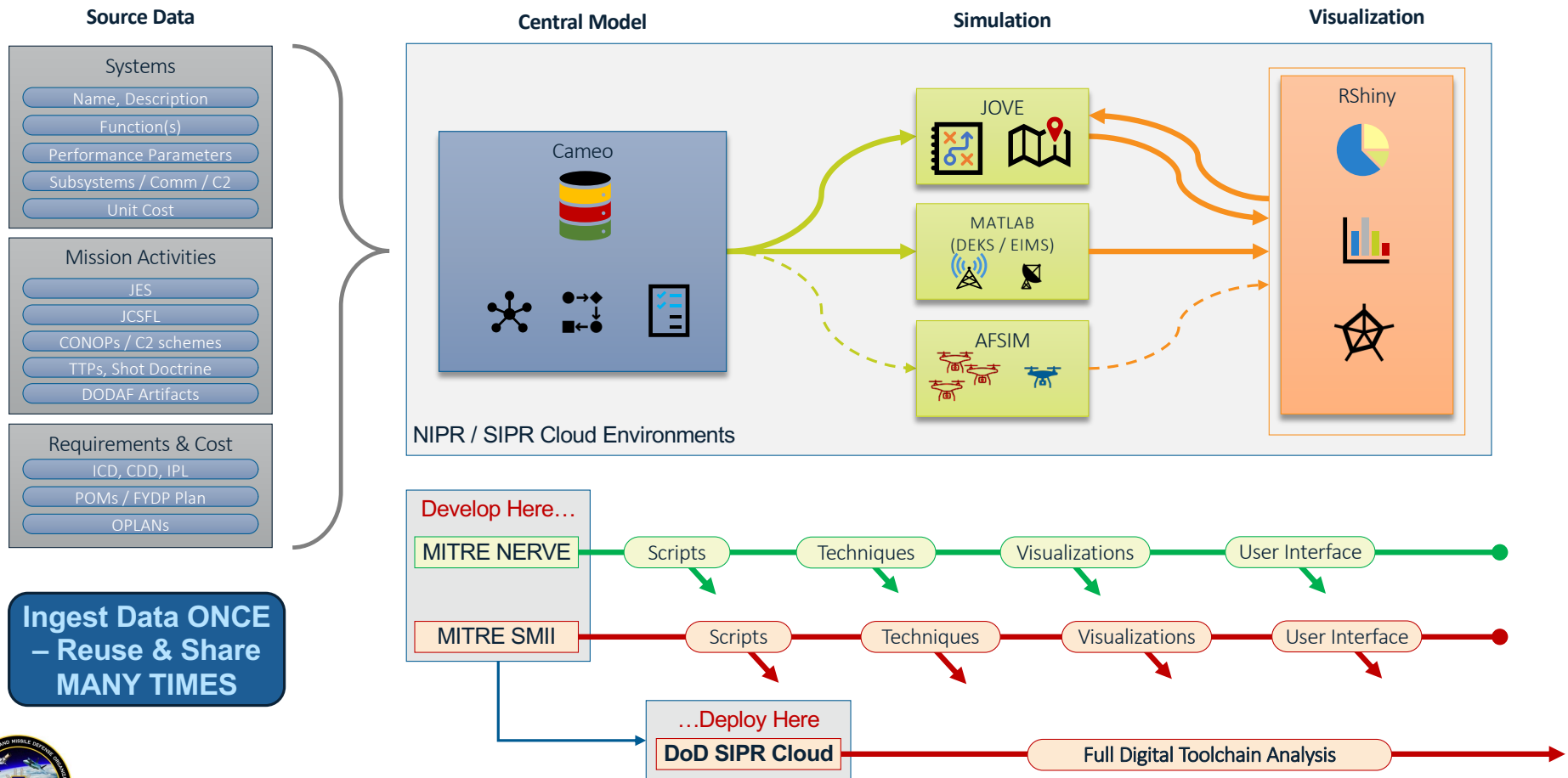
Source: OSD Mission Engineer Guide - https://ac.cto.mil/wp-content/uploads/2020/12/MEG-v40_20201130_shm.pdf

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DE Framework within Mission Engineering (ME)



JIAMDO DE Environment – Process Flow



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CUAS Digital Engineering Environment

	Product Type: Scopes the viewpoint of each product			
	REQUIREMENTS	BEHAVIOR	STRUCTURE	PARAMETERS
Mission Level: What problem is being modeled	Stakeholder Needs  Fixed / Semi-Fixed Mission Overview  C-UAS CDD Requirements	Use Cases  Dynamic Targeting Use Case  C-UAS Dynamic Targeting	System Context  C-UxS Systems	Measures of Effectiveness  Measures of Effectiveness  Cost Items
System of Systems: Describes the SoS to address the problem and verify the solutions.	System Requirements  System Satisfy Matrix  Notional SoS	System Behavior  C-UAS System A  C-UAS System B	System Structure  C-UAS System A  C-UAS System B	Measures of Performance  System Sensing Performance  Kinetic Effectors Performance  Non-Kinetic Effectors Performance
Model: Describes how the M&S application will represent a portion of the problem space to validate the solutions	Simulation Requirements	Simulation Behavior  Baseline Config  To Be Config	Simulation Structure  Baseline Systems  To Be Systems	Test Case  

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	Name	Attributes			Attributes
1	blm-core	<code>GroupType: GroupType = Rapid Prototype</code> <code>Spawner: string = ...</code>	17	Enturkair	<code>GroupType: GroupType = Disconnected</code> <code>Spawner: string = CTTSD</code>
2	APS	<code>GroupType: GroupType = USA</code>	18	FAAD_Q2	<code>GroupType: GroupType = Q2</code> <code>Spawner: string = USA</code>
3	indul	<code>GroupType: GroupType = SOCIM</code>	19	GAZDIN	<code>GroupType: GroupType = Rapid Prototype</code> <code>Spawner: string = ...</code>
4	CH-CHS	<code>GroupType: GroupType = Disconnected</code> <code>Spawner: string = SOCIM</code>	20	HAARDEN	<code>GroupType: GroupType = Mobile / Mount / Afflict</code> <code>Spawner: string = USMC</code>
5	4050	<code>GroupType: GroupType = Fixed / Semi-F</code> <code>Spawner: string = USAF</code>	21	LPWIS	<code>GroupType: GroupType = ...</code> <code>Spawner: string = USA</code>
6	Chadrl	<code>GroupType: GroupType = Disconnected</code> <code>Spawner: string = SOCIM</code>	22	HL-IDS	<code>GroupType: GroupType = Fixed / Semi-F</code> <code>Spawner: string = CTTSD</code>
7	GLANS	<code>GroupType: GroupType = Rapid Prototype</code> <code>Spawner: string = ...</code>	23	HAIDS	<code>GroupType: GroupType = Mobile / Mount / Afflict</code> <code>Spawner: string = USAF</code>
8	CONDR	<code>GroupType: GroupType = Fixed / Semi-F</code> <code>Spawner: string = USA, USN</code>	24	MEUSDA	<code>GroupType: GroupType = Mobile / Mount / Afflict</code> <code>Spawner: string = USMC</code>
9	CONSTR BL-X	<code>GroupType: GroupType = Rapid Prototype</code> <code>Spawner: string = ...</code>	25	MEUSDA_Q2	<code>GroupType: GroupType = Fixed / Semi-F</code> <code>Spawner: string = USAF</code>
10	Chadrlng	<code>GroupType: GroupType = Disconnected</code> <code>Spawner: string = USN</code>	26	MEUSDA Mobile	<code>GroupType: GroupType = Q2</code> <code>Spawner: string = USAF</code>
11	HAWE	<code>GroupType: GroupType = ...</code>	27	MOX-0	<code>GroupType: GroupType = ...</code> <code>Spawner: string = USMC</code>
12	Stone Defender (S+)	<code>GroupType: GroupType = Disconnected</code> <code>Spawner: string = ...</code>	28	Harphouse	<code>GroupType: GroupType = Rapid Prototype</code> <code>Spawner: string = ...</code>
13	Stone Defender (LS+)	<code>GroupType: GroupType = Disconnected</code> <code>Spawner: string = ...</code>	29	NINDA	<code>GroupType: GroupType = Fixed / Semi-F</code> <code>Spawner: string = SOCIM</code>
14	QNE-Q2	<code>GroupType: GroupType = USA</code>			
15	LEDS	<code>GroupType: GroupType = Fixed / Semi-F</code> <code>Spawner: string = USA</code>			
16	LEDS	<code>GroupType: GroupType = ...</code>			

Name	Test
1.1 Detect and Track	(U) The Joint C-UAS capability shall detect and track multiple threat type /agent, multi-agent/swarm UASs simultaneously (Group 1, 2 & 3) with 360 degree coverage in an operational electromagnetic environment prior to their effective range to support C-UAS operations.
1.1.1 Detect and Track Size	(U//SI//NF) Must detect and track UASs to include the Immanned Aerial Vehicle (UAV) weighing less than or equal to 1 lbs. (Group 1-2) which may include a ground control station (GCSS), < X km and the Group of UASs weighing > X lbs. (Group 3). (Ames A).
1.1.2 Detect and Track Altitude	(U//SI//NF) Must detect and track UAS operating at an altitude of $\leq X$ M. Mean Sea Level (MSL) (Groups 1-2) and UAV(Group 3) at $\leq X$ MSL.
1.1.3 Detect and Track Speed	(U//SI//NF) Must detect and track UAS hovering and traveling $\geq X$ knots indicated airspeed (Groups 1-2) and UAV (Group 3) at $\geq X$ knots indicated airspeed.
1.1.4 Detect and Track Range	(U//SI//NF) Must detect at ranges to prevent threat UAS from performing <u>missile</u> and missile attack operations
1.1.4.1 Fixed Active Sensor Threshold	(U) The Joint C-UAS capability shall detect Group 1, 2, & 3 UASs active at ranges up to > X km (Group 1), > X km (Group 2) and > X km (Group 3)
1.1.4.1.1 Fixed Active Sensor Objective	(U) The Joint C-UAS capability shall detect Group 1, 2, & 3 UAS active at ranges up to > X km (Group 1), > X km (Group 2) and > X km (Group 3)
1.1.4.1.2 Fixed Passive Sensor Threshold	(U) The Joint C-UAS capability shall detect Group 1, 2, & 3 UASs passive at ranges up to > X km (Group 1), > X km (Group 2) and > X km (Group 3)
1.1.4.1.2.1 Fixed Passive Sensor Objective	(U) The Joint C-UAS capability shall detect Group 1, 2, & 3 UASs passive at ranges up to > X km (Group 1), > X km (Group 2) and > X km (Group 3)
1.1.4.2 Mobile Detect and Track Range	(U) Mobile C-UAS capability shall detect Group 1 & 2 UAS while on the move or at halt
1.1.4.2.1 Mobile Active Sensor Threshold	(U) Mobile C-UAS capability shall detect Group 1 & 2 UAS active at > X km
1.1.4.2.1.1 Mobile Active Sensor Objective	(U) Mobile C-UAS capability shall detect Group 1 & 2 UAS active at > X km
1.1.4.2.1.2 Mobile Passive Sensor Threshold	(U) Mobile C-UAS capability shall detect Group 1 & 2 UASs passive at > X km
1.1.4.2.1.2.1 Mobile Passive Sensor Objective	(U) Mobile C-UAS capability shall detect Group 1 & 2 UASs passive at > X km
1.1.4.2.2 Mobile Detect and Track Probability	(U) Joint C-UAS Capability shall track with > X probability of error for tracking based on method used for tracking/geo-location

		Product Type: Scopes the viewpoint of each product			
		REQUIREMENTS	BEHAVIOR	STRUCTURE	PARAMETERS
Mission Level: What problem is being modeled	Stakeholder Needs	 Fixed / Semi-Fixed Mission Overview C-UBS COO Requirements	Use Cases Dynamic Targeting Use Case C-UBS Dynamic Targeting	System Context C-UBS Systems	Measures of Effectiveness Measures of Effectiveness Costs
	System of Systems: Describes the SoS to address the problem and verify the solutions.	System Requirements System Safety Matrix National SoS	System Behavior C-UBS System A C-UBS System B	System Structure C-UBS System A C-UBS System B	Measures of Performance System Sensing Performance Kinetic Effectiveness Performance Non-Kinetic Effectiveness Performance
Model: Describes how the M&S application will represent a portion of the problem space to validate the solutions	Simulation Requirements		Simulation Behavior Behavioral Config To Be Config	Simulation Structure Baseline Systems To Be Systems	Test Case

	Name	Source	Target	Range KM	PD	Falser Alarm Rate Per Hour
2.3.2 C-UAS System Building Blocks	AUIS					
	C-UAS System A	C-UAS System A Se...	D3I	5	1	
	C-UAS System B					
	Subsystems					
	Radar B	Radar B	D3I	25	0.75	
	Radar A	Radar A	D3I	15	0.75	10
	Diamond Sensor	Diamond Sensor	D3I	1.82	0.7	
	RED					
	Sensors	EO @ Camera	BVT	1.852		
	2.3.4 Placeholder Systems					

[illegible]

#	Name	Documentation	Specification
1	☐ JSR Mission		
2	☐ Spider Check Mode		
3	☐ % of red threats killed before Threshold requirement Range from JSR	Of the total # of red threats flown, how many are killed before they get to $800m - 4.3m$	# lost
4	☐ % of red threats killed before Threshold detection	The JSR "round-trip" red events will be good for this sense if not killed.	# of red that make at least 1 sense (S) / # of total red (S)
5	☐ % of Red Collects Presented	% of red threats killed in row, how many can detect the blue one (do they get close enough to use the sensor?)	# average detects for architecture in single exploitation / # detects in baseline
6	☐ % of Red threats killed	In comparison to the baseline - how many collect does the blue prevent - good - normalized metric	# killed / # of total red (S)
7	☐ Cost Metrics	Of the total # of red threats flown in, what % are neutralized	
8	☐ % of Non-Kinetic vs Kinetic Kills		# of kills logged by a weapon that starts with JSR / total kills
9	☐ Average Cost of Config		Average total cost of config (use # of expended coyote for Coyote costs)
10	☐ R/I Collected	How long can the red platforms detect blue assets?	For each red use - T_first_detect - T_first_detect
11	☐ R/I Shared	How long can the red platforms share detections of blue assets back to their controllers	For each red use -> T_end_report - T_start_report
12	☐ R/I Collected	How many detects does the red platform have on the JSR	For all red platforms, total # of detects

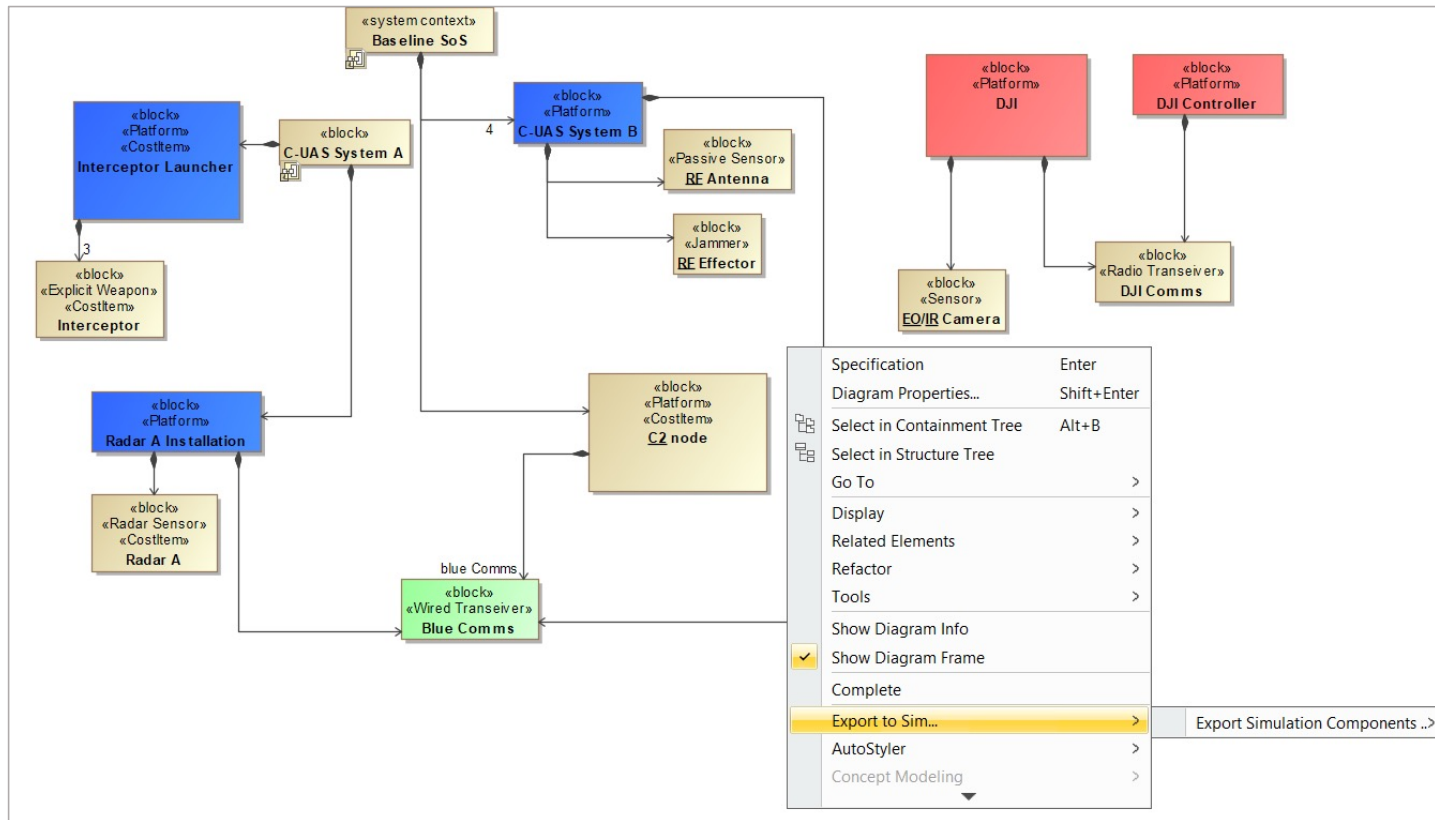
△ Name	○ unitCost	○ expends
CUAS System A	150	<undefined>
C2	50	<undefined>
Dismount Effector	30	<undefined>
Dismount Sensor	10	<undefined>
EW Effector	100	<undefined>
Interceptor	20	☒
Interceptor Launcher	1000	<undefined>
Rader A	3416	<undefined>
Rader B	5000	<undefined>



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Data Exchange with Operational Simulation

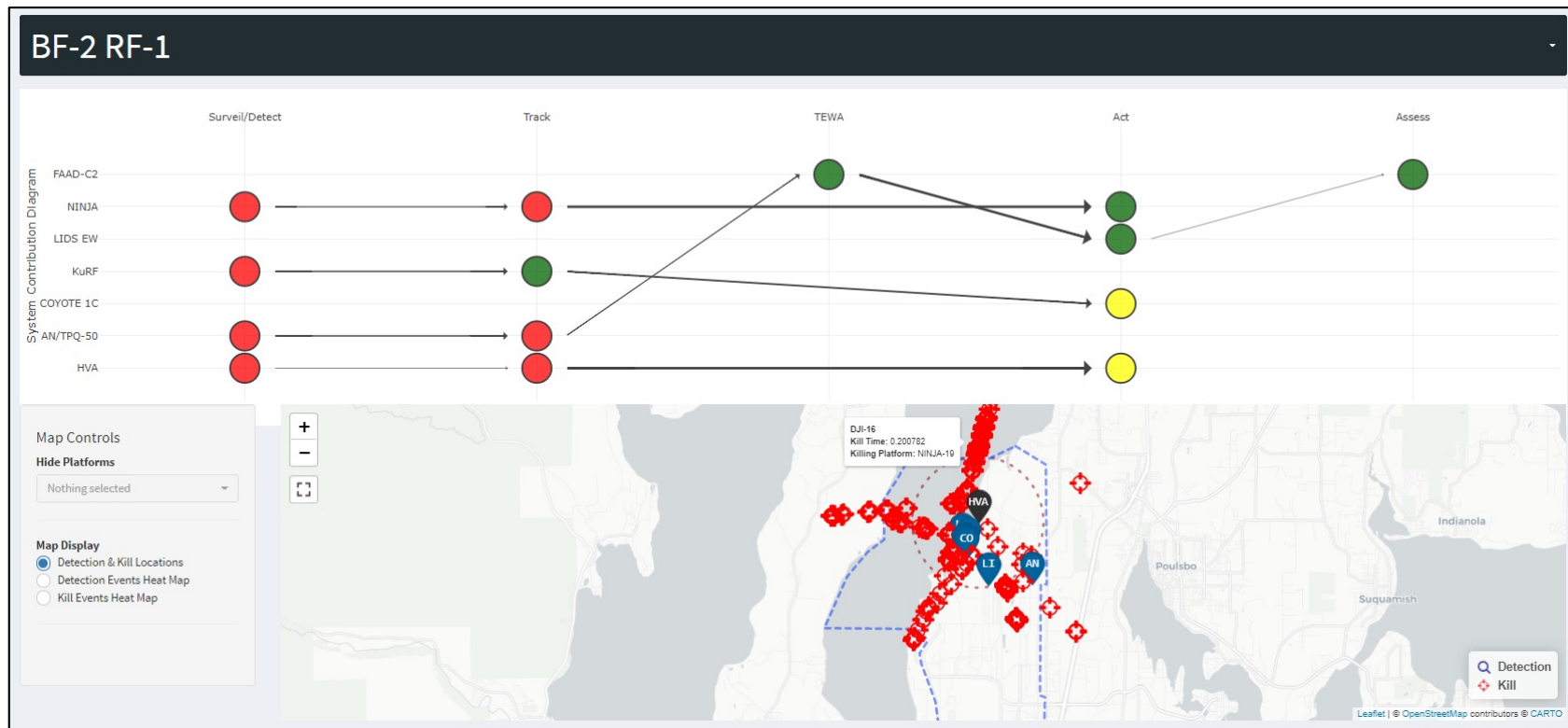


Operational Simulations: A Comparison

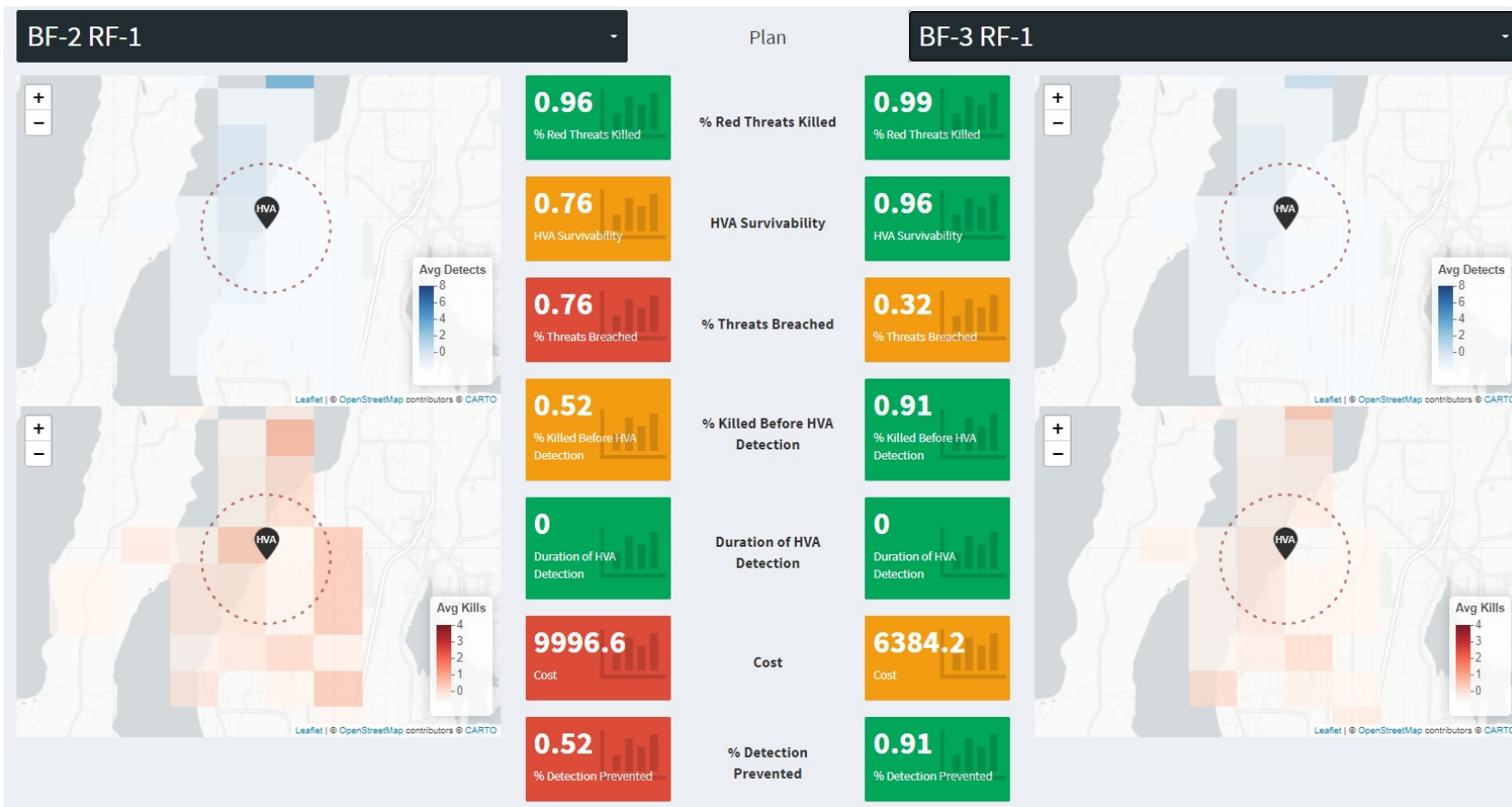
Operational Sim Feature	JOVE	DEKS	EIMS
Capable of Effects Chain Analysis	✓	✓	✓
Graphical User Interface	Yes	In Progress	No (Planned)
Simulation Type	Discrete Event	Discrete Event	Batch Monte-Carlo
Scenario Scale	Scalable	Single Base	Single Base to Theatre Level
Fidelity	Low-Med	Low	Med-High
Simulation Timeliness	Fast	Med	Slow
Real-Time Simulation View	✓	✓	
Applicable Missions	C-UAS, CMD	C-UAS	CMD, BMD
Base Laydown System		✓	
Defended Area Analysis		✓	✓
Physics-Based Behaviors		✓	✓
Blue C2 Modeling	✓		(In Progress)
Red C2 Modeling	✓	✓	
Terrain Specification	✓	✓	✓
Engagement Metrics Calculated (Out of Box)	✓	✓	✓
Surveillance Metrics Calculated (Out of Box)		✓	✓
Threat Tracking Metrics Calculated (Out of Box)			✓



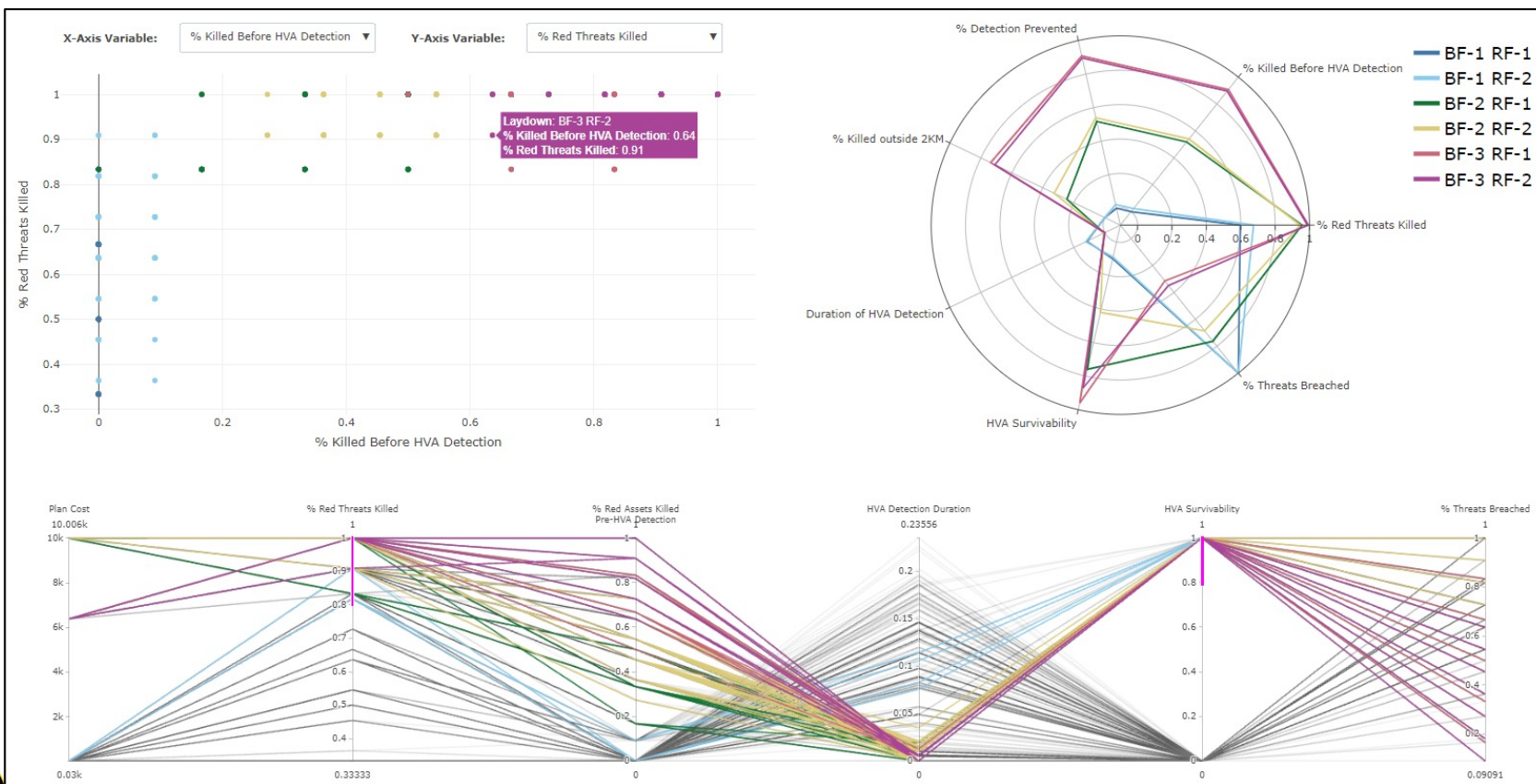
Visualization Dashboard: System Summary



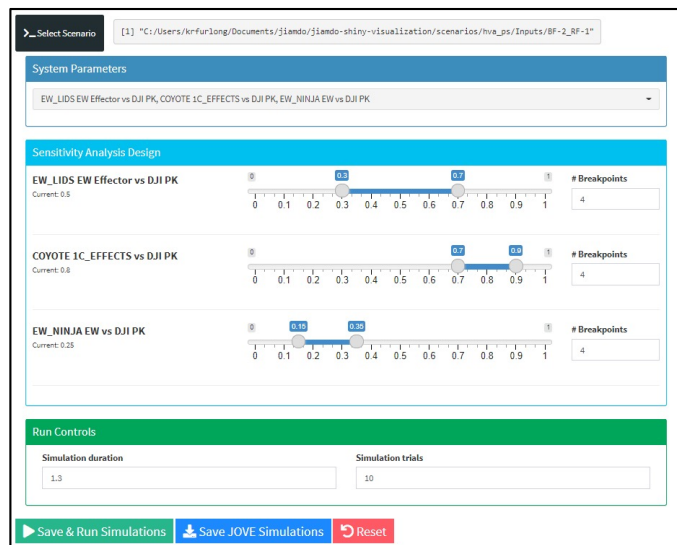
Visualization Dashboard: Laydown Comparison



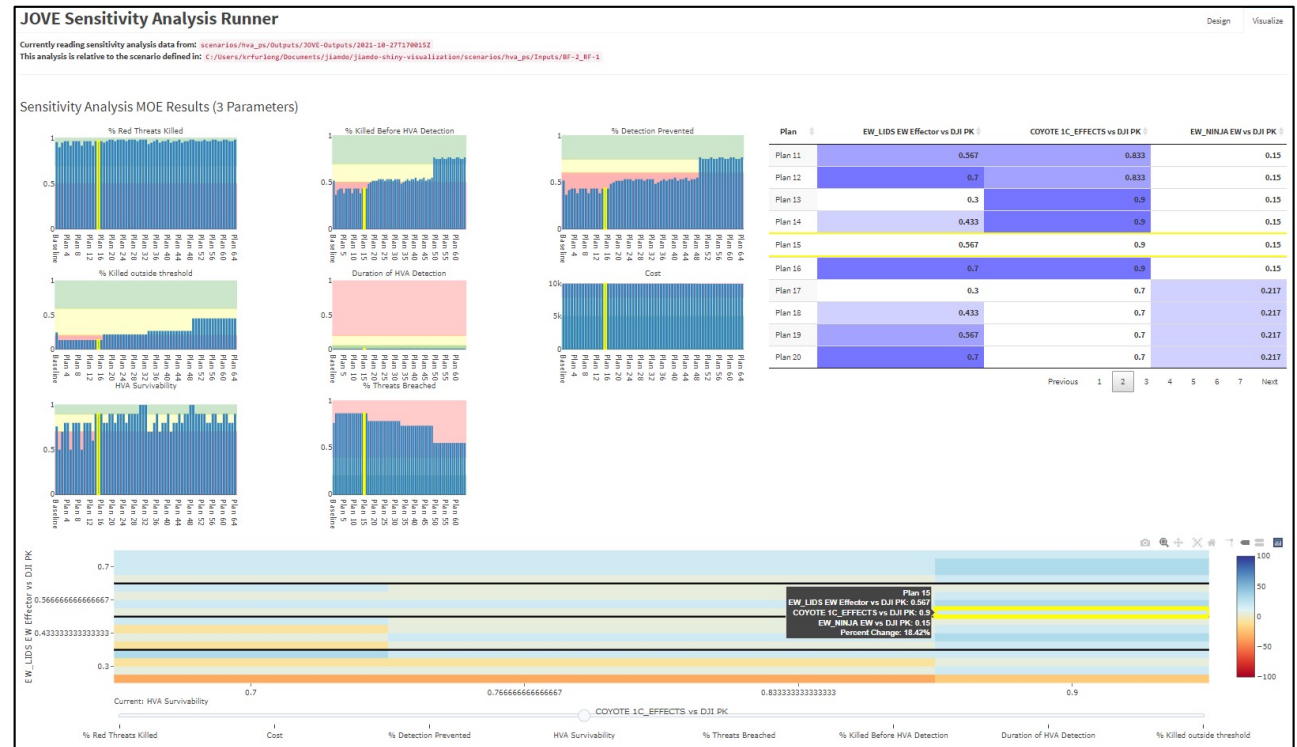
Visualization Dashboard: MOE Analysis



Visualization Dashboard: Sensitivity Analysis



Real-time experimentation and
visualization of results



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Summary And Future Plans

- Digital Engineering Environment live and supporting C-UAS and CMD-H analytical exercises with multiple M&S tools available
 - Available at UNCLASS external to MITRE for JIAMD0
 - Available at SECRET internal to MITRE
- FY22 Next Steps
 - SIPR Deployment
 - AFSIM Integration
 - BMD Analysis Capability

Thank-You!

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