SoSECIE Webinar

Welcome to the
2021 System of Systems Engineering Collaborators Information Exchange (SoSECIE)

We will start at 11AM Eastern Time

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NDIA System of Systems SE Committee

- **Mission**
  - To provide a forum where government, industry, and academia can share lessons learned, promote best practices, address issues, and advocate systems engineering for Systems of Systems (SoS)
  - To identify successful strategies for applying systems engineering principles to systems engineering of SoS
- **Operating Practices**
  - Face to face and virtual SoS Committee meetings are held in conjunction with NDIA SE Division meetings that occur in February, April, June, and August

NDIA SE Division SoS Committee Industry Chairs:
Mr. Rick Poel, Boeing
Ms. Jennie Horne, Raytheon
OSD Liaison:
Dr. Judith Dahmann, MITRE

Simple Rules of Engagement

- I have muted all participant lines for this introduction and the briefing.
- If you need to contact me during the briefing, send me an e-mail at sosecie@mitre.org.
- Download the presentation so you can follow along on your own
- We will hold all questions until the end:
  - I will start with questions submitted online via the CHAT window in Teams.
  - I will then take questions via telephone; State your name, organization, and question clearly.
- If a question requires more discussion, the speaker(s) contact info is in the brief.

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2021-2022 System of Systems Engineering Collaborators Information Exchange Webinars

Sponsored by MITRE and NDIA SE Division

June 29, 2021
Digital Engineering: From Toolchain to Platform
Dr. Aleksandra Markina-Khusid

July 13, 2021
Developing Meta Systems Architectures for Leading Innovation with Complex Societal and Technical Challenges
Dr. Cihan Dagli

July 27, 2021
Advancements Towards a Digital Approach for Mission Engineering
Todd Shayler and Daniel Browne

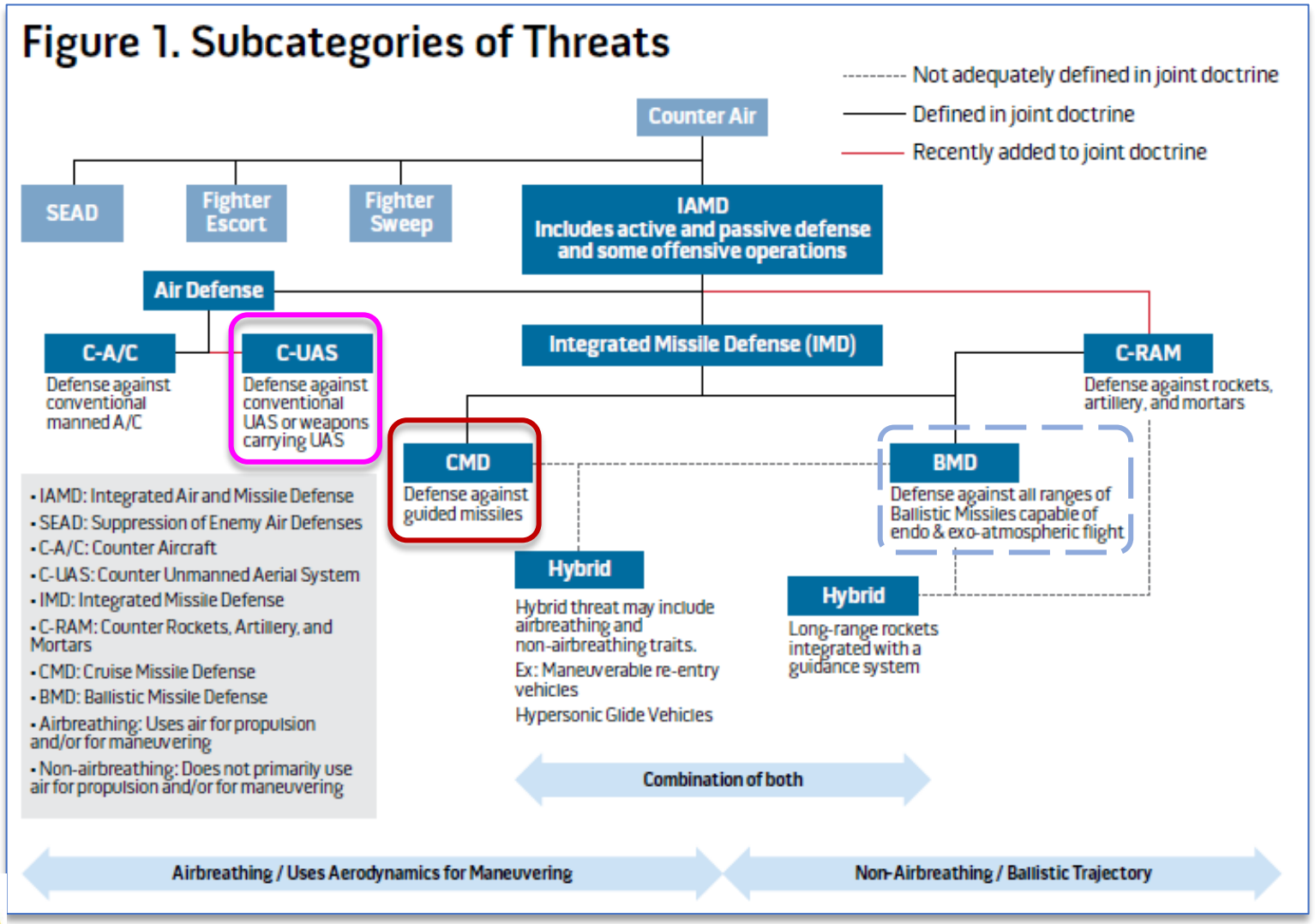
https://www.mitre.org/capabilities/systems-engineering/collaborations/system-of-systems-engineering-collaborators

Implementing a Digital Engineering Environment for Mission Engineering

Dr. Jeffrey C. Boulware
Joint Staff J8 JIAMDO

Jon Kim
Nathan Norwood
Matt Cotter
Eric Beene
Jason Anderson
MITRE

IAMD Mission Space

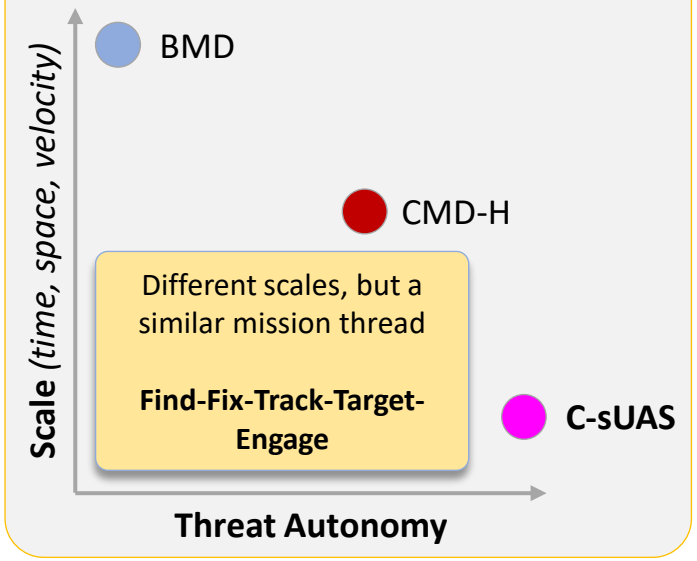


Credit: Gabriel Almodovar, Daniel P. Allmacher, Morgan P. Ames III, and Chad Davies, JFQ 88, 1st Quarter 2018

Key Insight

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

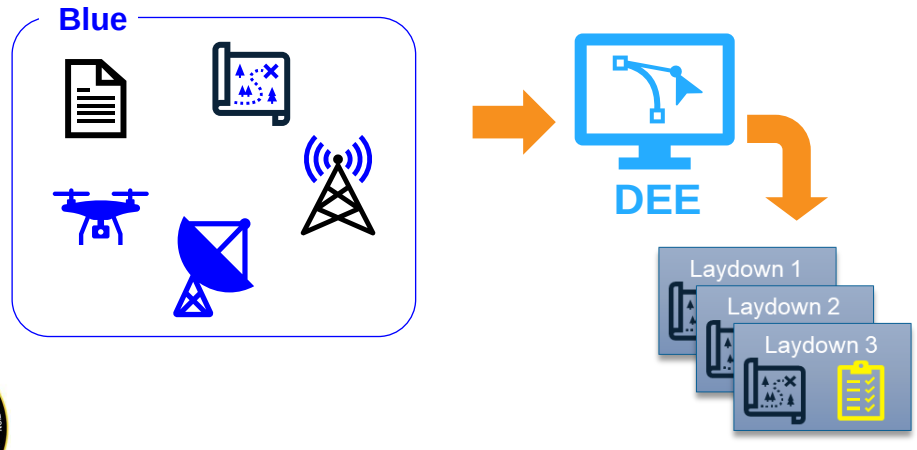
Current work is focused on analysis of Countering Small Unmanned Aerial Systems (**C-sUAS**) – which has been expanded to Cruise Missile Defense of the Homeland (**CMD-H**) in FY21.



Two Complementary Analytical Approaches

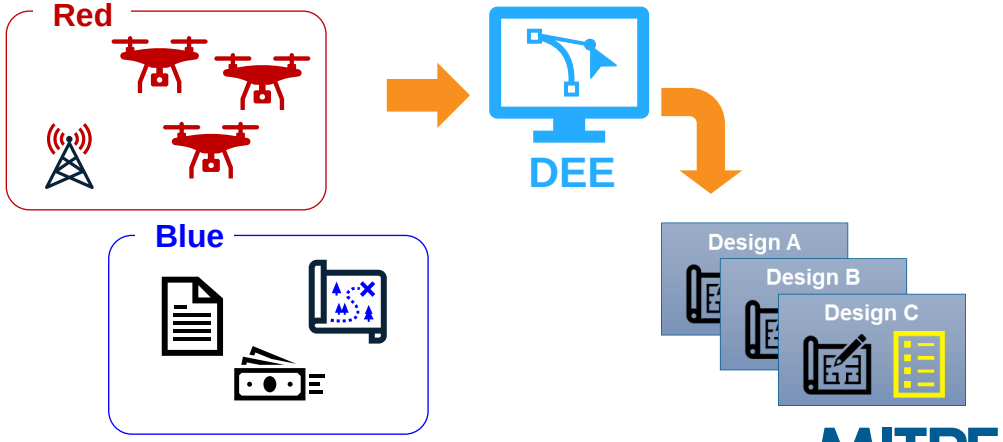
Start with knowns – *"Make the most of what you have"*

Given existing C-sUAS system parameters, **determine the optimal set of capabilities** for a given scenario.



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.



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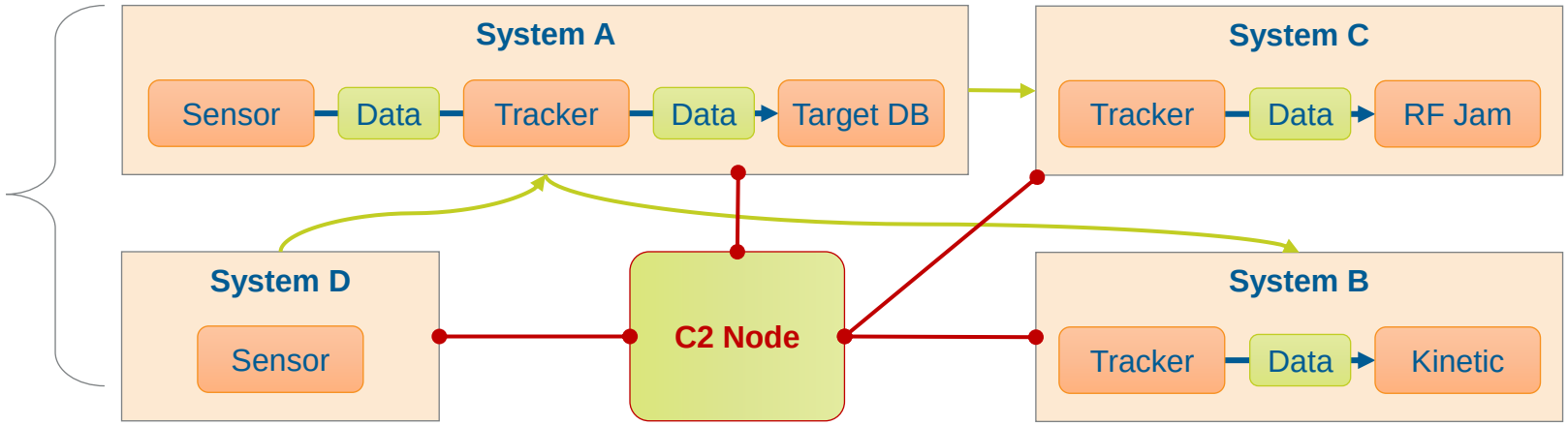
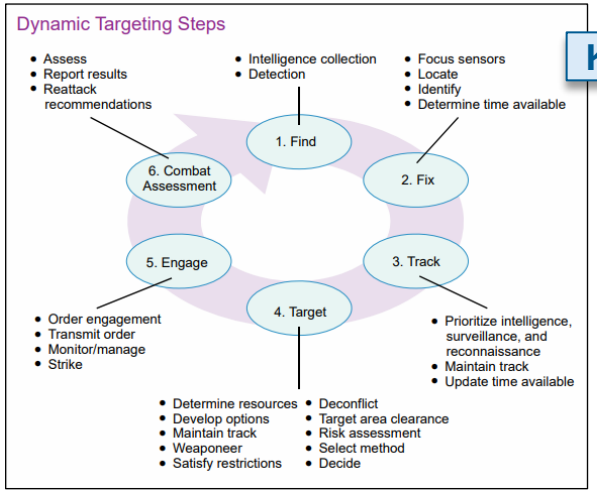
Operational Use Case – C-UAS Concepts

C-sUAS Components & Capabilities

- C-sUAS System may have one or more than one of the components required to complete the kill web
- Complete kill web **may require multiple C-sUAS Systems** for a given scenario **and appropriate C2 linkages**





Source: Joint Publication 3-60, 2018

Kill Web → (Find) Fix → Track → Target → Engage

A useful model must capture both what is done and what is used to do it

- **Activity**: Information on the steps (and sub-steps) in the kill web, and which equipment is used to conduct them
- **Inventory**: Information on each C-sUAS system (and subsystem)

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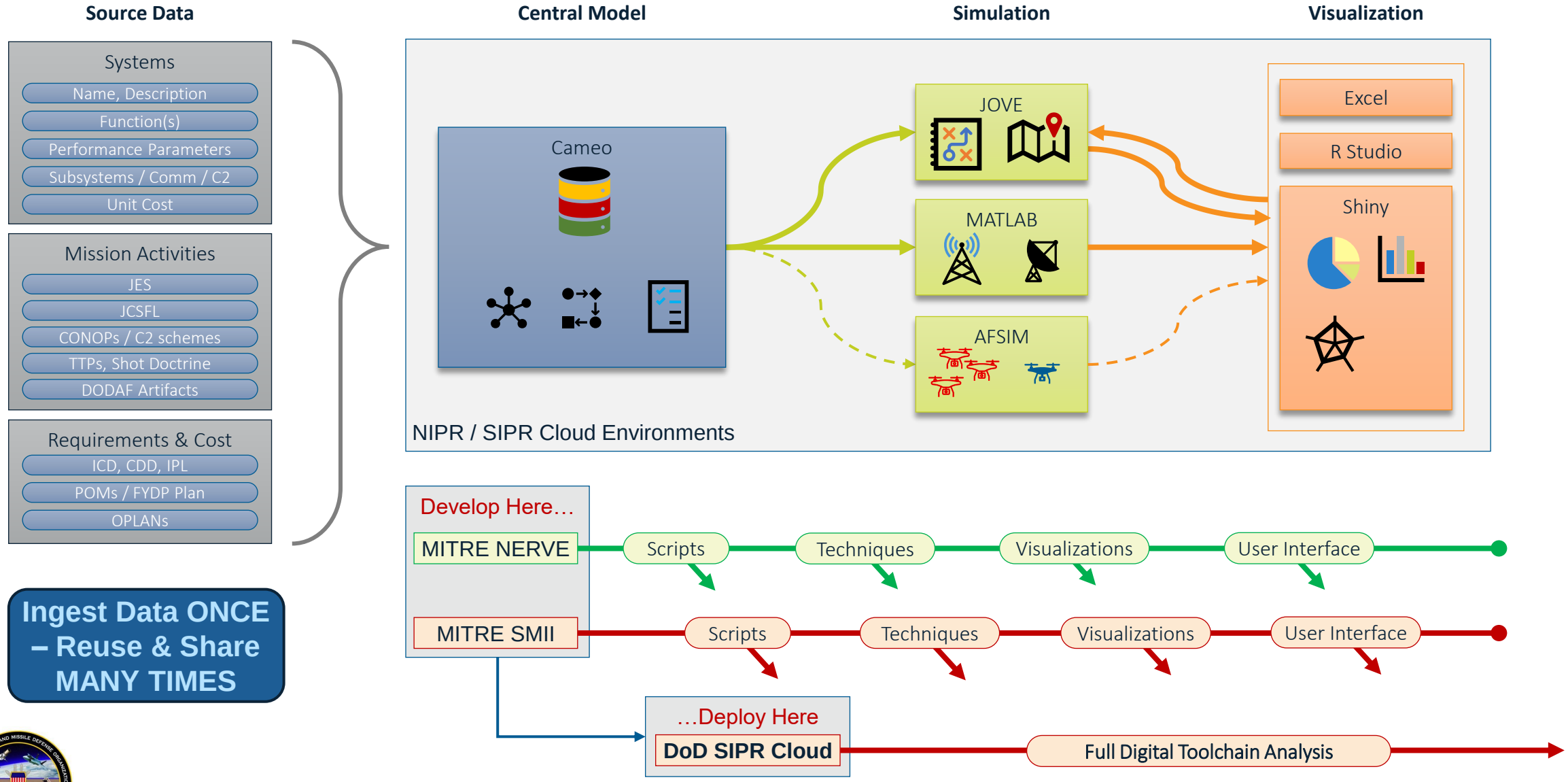
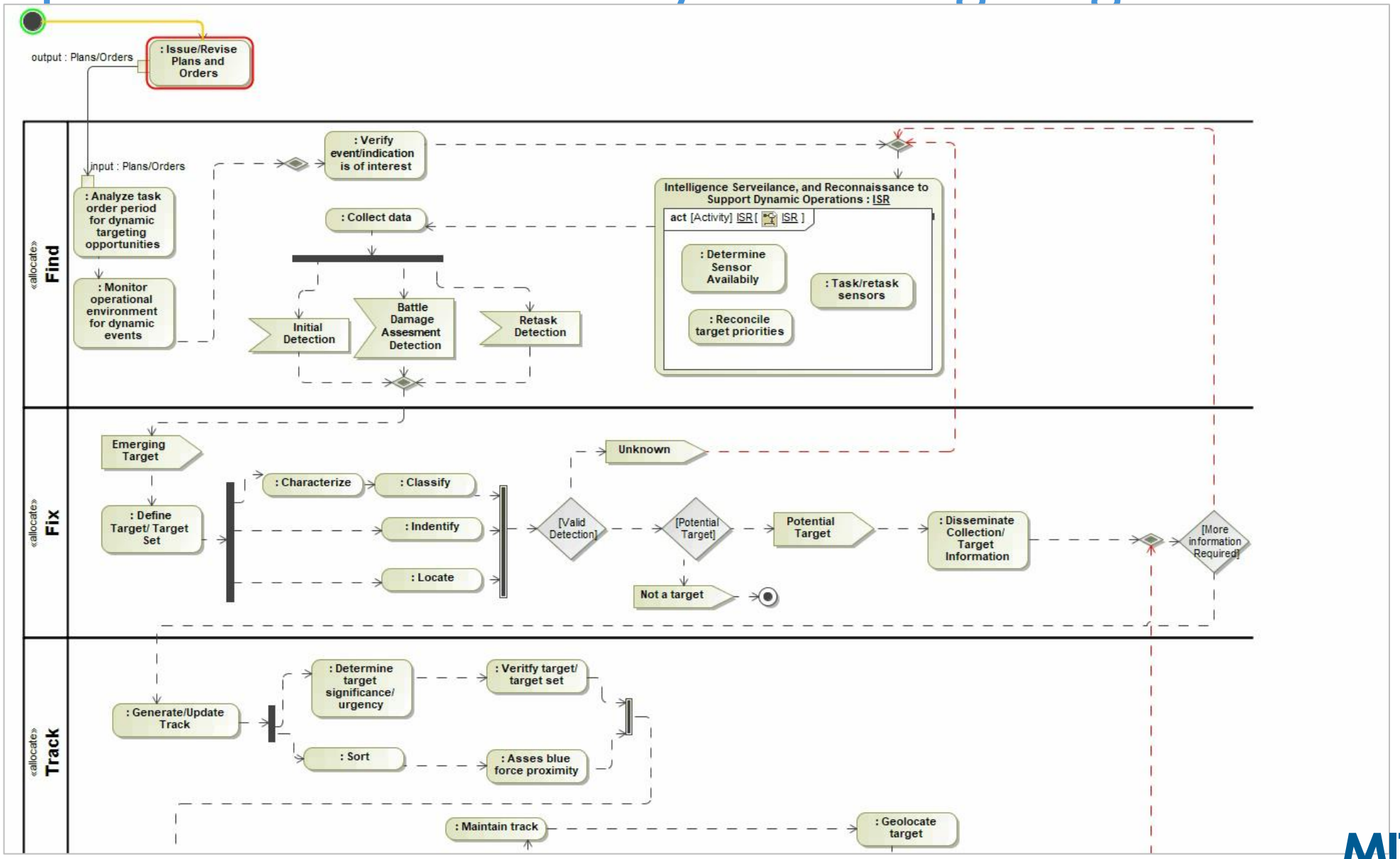
JIAMDO DE Environment – Process Flow



Digital Engineering Environment – CUAS Mission Model

	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 CostItems
System of Systems: Describes the SoS to address the problem and verify the solutions.	System Requirements System Satisfy Matrix Notional SoS	System Behavior SV-4 C-UAS System A SV-4 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 applicaton will represent a portion of the problem space to validate the solutions	Simulation Requirements	Simulation Behavior SV-4 Baseline Config SV-4 To Be Config	Simulation Structure Baseline Systems To Be Systems	Test Case

Operational Behavior – Dynamic Targeting Process



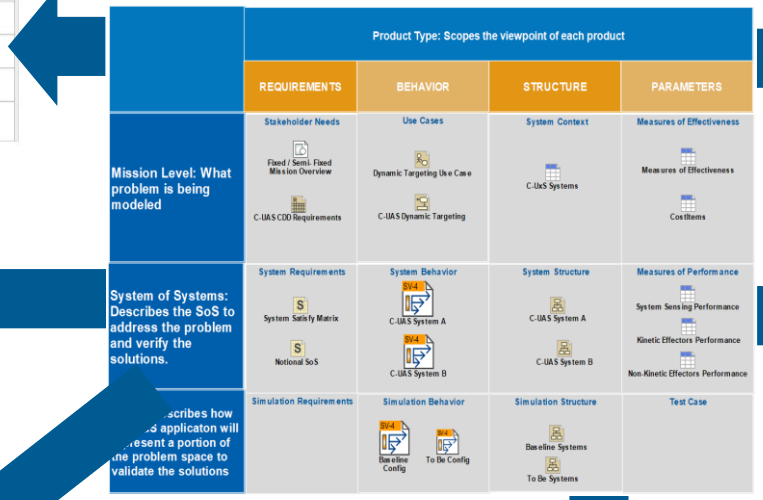
Analytic Elements

System Context – C-UAS System List

#	Name	Attributes
1	30mm Cannon	groupType : GroupType = Rapid Prototype Sponsor : string = -
2	ALPS	groupType : GroupType Sponsor : string = USA
3	Anduril	groupType : GroupType Sponsor : string = SOCOM
4	Bal Chatri	groupType : GroupType = Dismounted Sponsor : string = SOCOM
5	C-AUDS	groupType : GroupType = Fixed / Semi-F Sponsor : string = USAF
6	Citadel	groupType : GroupType = Dismounted Sponsor : string = SOCOM
7	CLAWS	groupType : GroupType = Rapid Prototype Sponsor : string = -
8	CORIAN	groupType : GroupType = Fixed / Semi-F Sponsor : string = USA, USN
9	COYOTE Blk 1C+	groupType : GroupType = Rapid Prototype Sponsor : string = -
10	DarkBridge	groupType : GroupType = Dismounted Sponsor : string = DDS
11	DRAKE	groupType : GroupType Sponsor : string = USN
12	Drone Buster v3+	groupType : GroupType = Dismounted Sponsor : string = -
13	Drone Defender v1.5+	groupType : GroupType = Dismounted Sponsor : string = -
14	DUKE v5	groupType : GroupType Sponsor : string = USA
15	E-LIDS	groupType : GroupType = Fixed / Semi-F Sponsor : string = USA
16	EGON	groupType : GroupType
17	EnforceAir	groupType : GroupType = Dismounted Sponsor : string = CTTSO
18	FAAD C2	groupType : GroupType = C2 Sponsor : string = USA
19	Guardian	groupType : GroupType = Rapid Prototype Sponsor : string = -
20	L-MADIS	groupType : GroupType = Mobile / Mount / Afloat Sponsor : string = USMC
21	LPWS	groupType : GroupType Sponsor : string = USA
22	M-LIDS	groupType : GroupType = Fixed / Semi-F Sponsor : string = CTTSO
23	MADIS	groupType : GroupType = Mobile / Mount / Afloat Sponsor : string = USAF
24	MEDUSA	groupType : GroupType = Mobile / Mount / Afloat Sponsor : string = USMC
25	MEDUSA C2	groupType : GroupType = Fixed / Semi-F Sponsor : string = USAF
26	MEDUSA Mobile	groupType : GroupType = C2 Sponsor : string = USAF
27	MOI II	groupType : GroupType Sponsor : string = USMC
28	Morpheus	groupType : GroupType = Rapid Prototype Sponsor : string = -
29	NBOA	groupType : GroupType = Fixed / Semi-F Sponsor : string = SOCOM

Operational Requirements from JCO CDD

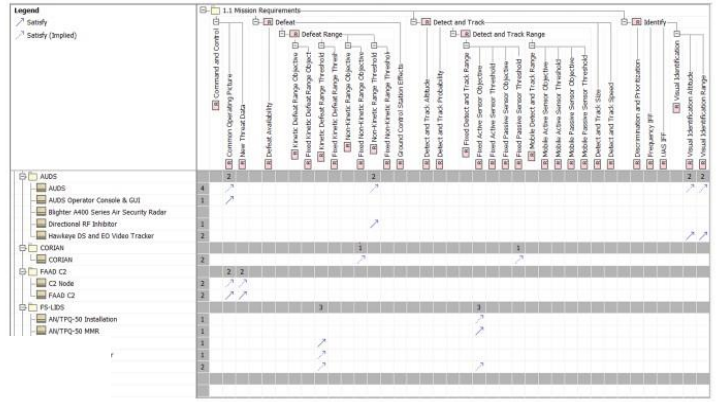
Name	Text
1 Detect and Track	(U) The Joint C-UAS capability shall detect and track multiple threat type /agent /multi-agent/swarm UASs simultaneously (Group 1, 2 & 3) with 360 degree coverage in an operational electromagnetic environment prior to their effective range to support C-UAS operations.
1.1 Detect and Track Size	(U//FOUO) Must detect and track UAS to include the Unmanned Aerial Vehicle (UAV) weighing less than or equal to X lbs. (group 1-2) which may include a ground control station (GCS), X km on the ground and UAVs weighing > X lbs. (Group 3). (Annex A)
1.2 Detect and Track Altitude	(U//FOUO) Must detect and track UAS operating at an altitude of ≤ X ft. Mean Sea Level (MSL) (Groups 1-2) and UAV(Group 3) at ≤ X MSL.
1.3 Detect and Track Speed	(U//FOUO) Must detect and track UAS hovering and traveling ≤ X knots indicated airspeed (Groups 1-2) and UAV (Group 3) at ≤ X knots indicated airspeed.
1.4 Detect and Track Range	(U//FOUO) Must detect at ranges to prevent threat UAS from performing ISR missions and attack operations
1.4.1 Fixed Detect and Track Range	(U) The Joint C-UAS capability shall detect group 1, 2, & 3 UASs actively and passively
1.4.1.1 Fixed Active Sensor Threshold	(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)
1.4.1.2 Fixed Active Sensor Objective	(U) The Joint C-UAS capability shall detect group 1, 2, & 3 UAS active at ranges up of > X km (Group 1), >X km (Group 2) and > X km (Group 3)
1.4.1.3 Fixed Passive Sensor Threshold	(U) The Joint C-UAS capability shall detect group 1, 2, & 3 UAS passive at ranges up to > X km
1.4.1.4 Fixed Passive Sensor Objective	(U) The Joint C-UAS capability shall detect group 1, 2, & 3 UAS passive at ranges up to > X km
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
1.4.2.1 Mobile Active Sensor Threshold	(U) Mobile C-UAS capability shall detect group 1 & 2 UAS active at > X km
1.4.2.2 Mobile Active Sensor Objective	(U) Mobile C-UAS capability shall detect group 1 & 2 UAS active at > X km
1.4.2.3 Mobile Passive Sensor Threshold	(U) Mobile C-UAS capability shall detect group 1 & 2 UAS passive at > X km
1.4.2.4 Mobile Passive Sensor Objective	(U) Mobile C-UAS capability shall detect group 1 & 2 UAS passive at > 8km
1.5 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



Measures of Performance Sensing Performance

Name	Source	Target	Range KM	PD	False Alarm Rate Per Hour
2.3.2 C-UxS System Building Blocks					
BLUE					
C-UAS System A					
	C-UAS System A Se...	DJI	5	1	
C-UAS System B					
Subsystems					
Radar B					
	Radar B	DJI	25	0.75	
Radar A					
	Radar A	DJI	15	0.75	10
Dismount Sensor					
	Dismount Sensor	DJI	1.82	0.7	
RED					
Sensors					
	EO/IR Camera	HVT	1.852	1	
2.3.4 Placeholder Systems					

System Requirements – C-UAS System to CDD Requirements Matrix



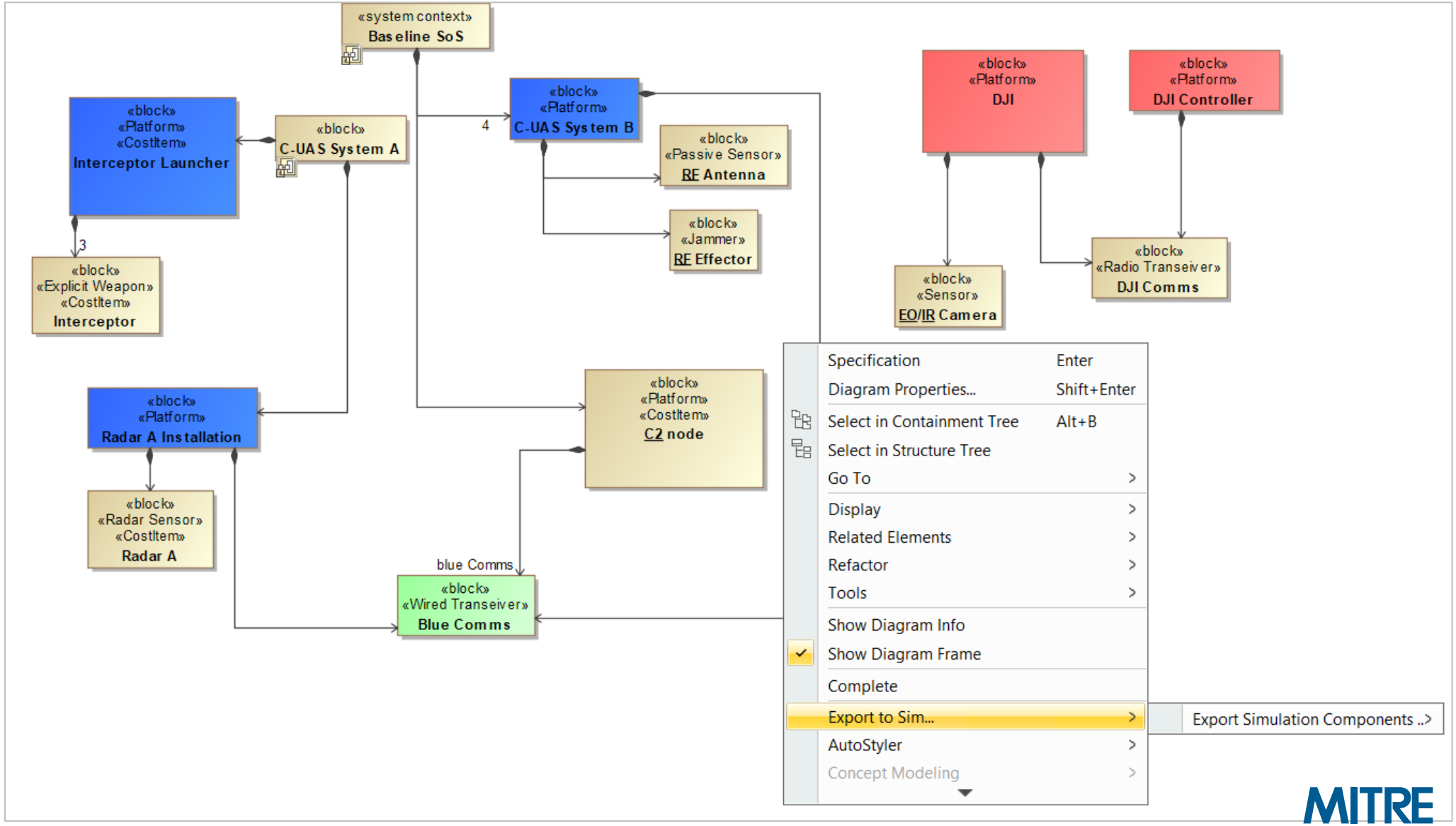
System Costs

Name	unitCost	expends
C-UAS System A	150	<undefined>
C2	50	<undefined>
Dismount Effector	30	<undefined>
Dismount Sensor	10	<undefined>
EW Effector	100	<undefined>
Interceptor	20	true
Interceptor Launcher	1000	<undefined>
Radar A	3416	<undefined>
Radar B	5000	<undefined>

Measures of Effectiveness

#	Name	Documentation	Specification
1	ISR Mission		
2	Spider Chart MOEs		
3	% of Red threats killed before Threshold requirement Range from HVT	Of the total # of red threats flown, how many are killed before they get to 8Km ~ 4.3 nm The HVT "Ground Truth" lost events will be good for this If threat is not killed, use 0	# lost
4	% of Red threats killed before HVT detection	Of the total # of red threats flow in, how many can detect the HVT at all, (do they get close enough to use their sensor?)	# of red that make at least 1 sense of HVT/ # of total red (5)
5	% of Red Collects Prevented	In comparison to the baseline - how many collects does the blue defense prevent - good normalized metric	# average detects for architecture in single replication / # detects in baseline
6	% of Red threats killed	Of the total # of read threats flown in, what % are neutralized	# killed / # of total red (5)
7	Cost Metrics		
8	% of Non-Kinetic vs Kinetic Kills		# of Kills logged by a weapon that starts with EW / total kills
9	Average Cost of Config		Average total cost of config (use # of expended coyote for Coyote costs)
10	R(t) Collected	How long can the red platforms detect blue assets?	for each red uas->T_last_detect - T_first_detect
11	R(t) Shared	How long can the red platforms share detections of blue assets back to their controller?	for each red uas ->T_last_report - T_first_report
12	R # Collected	How many detects does the red platform have on the HVT	for any red platform, total # of detects

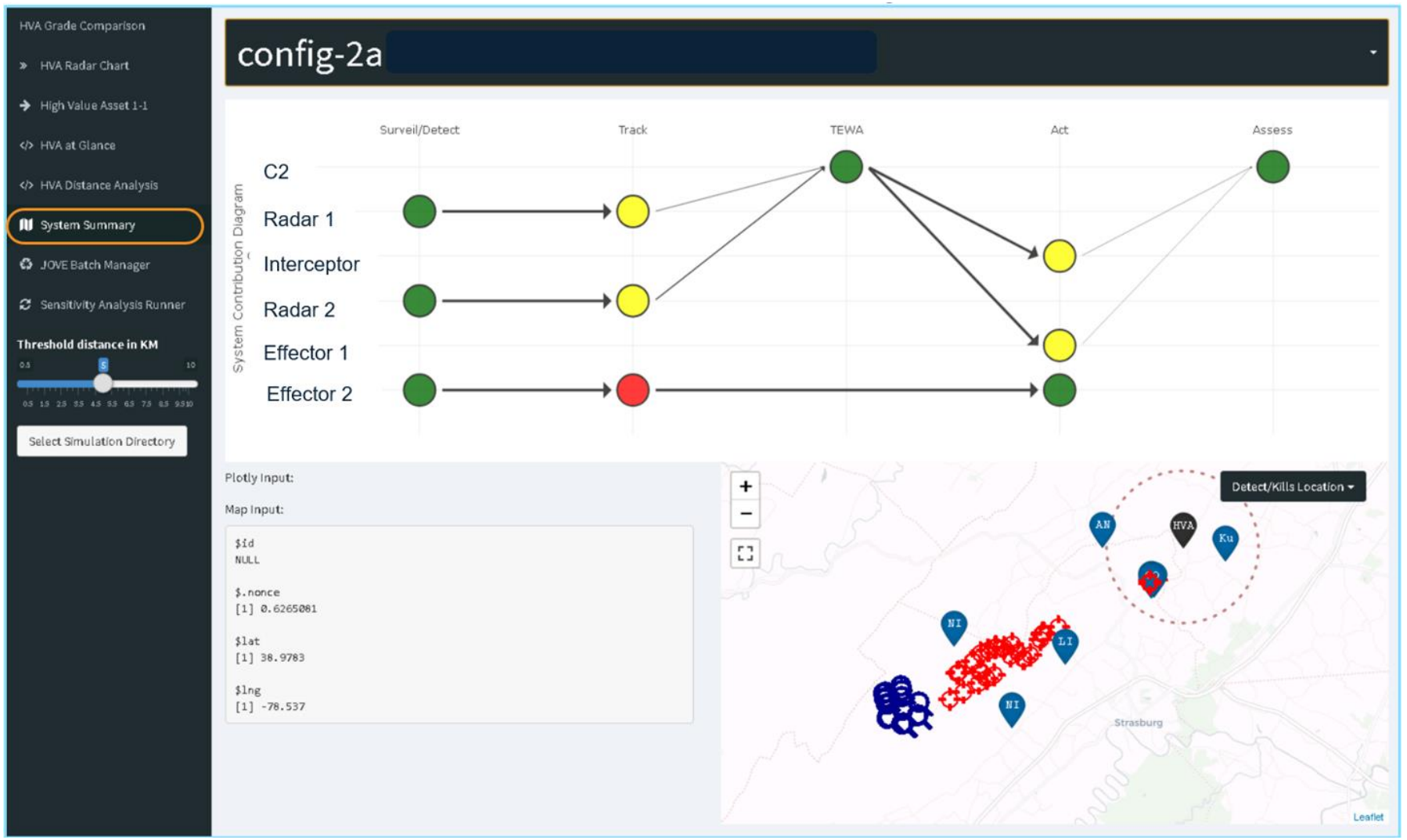
Data Exchange with Operational Simulation



Data Visualization & MOE Analysis

Deep Dive a Single Architecture

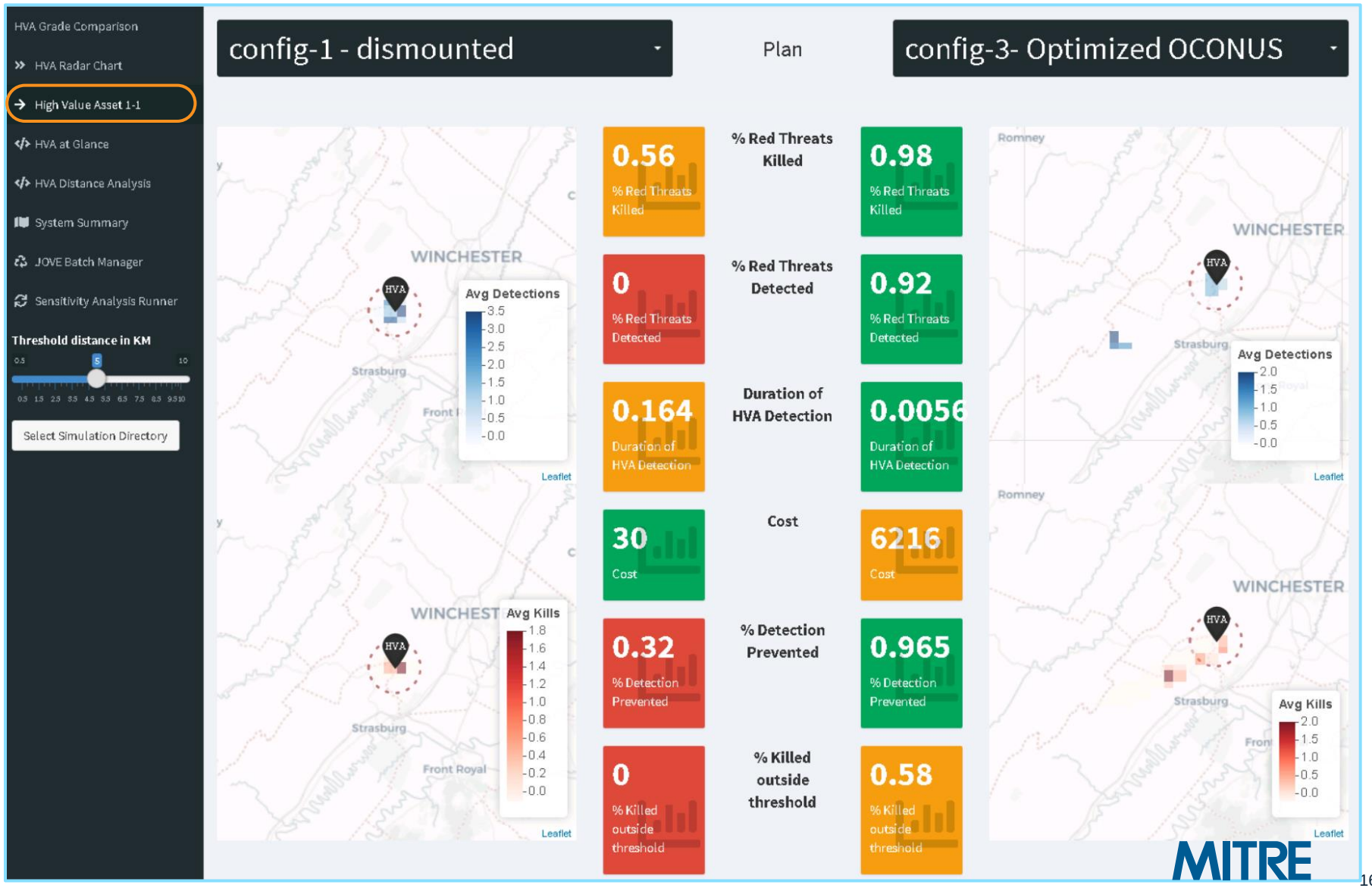
- System contribution to effectiveness across the kill chain
- Actual detect / kill locations
- Heat maps of detections and kills



Data Visualization & MOE Analysis

Directly Compare Two Architectures

- Dynamic updates
- Various MOEs defined by the analyst
- Heat maps of detections and kills



Lessons Learned

- Access to collaborative tools directly correlates to efficiency – *NERVE provided ability to move quickly even in the COVID-19 work environment*
- Security-driven logistical hurdles can cause work to slow – *Classified analysis required multiple air-gapped networks to complete; a SIPR cloud network is essential*
- Sponsor-provided data is both a limiting factor and a driver of success – *JIAMDO struggled to obtain data from CCMDs and Services; once provided, data (and sponsor SME access) enabled feasible and authoritative analysis*
- The right people are critical – *Task succeeded due to team's skillsets and availability*

Biggest obstacle – access to secure, cloud environment to support distributed teamwork

Keys to Success

Digital Access – *Take smart risks to develop tools and capabilities on unclassified systems where possible – but must have classified environment*

Data Access – *Sponsor must provide authoritative information as soon as possible*

Sponsor Access – *Frequent collaboration drives continued improvement and sponsor satisfaction*

People Access – *Modern digital tools require equally modern skillsets – find the right people up front*

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