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Applying Mission Engineering to the U.S. Department of Defense Rapid Defense Experimentation Reserve

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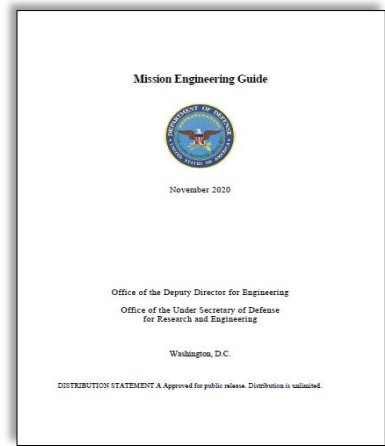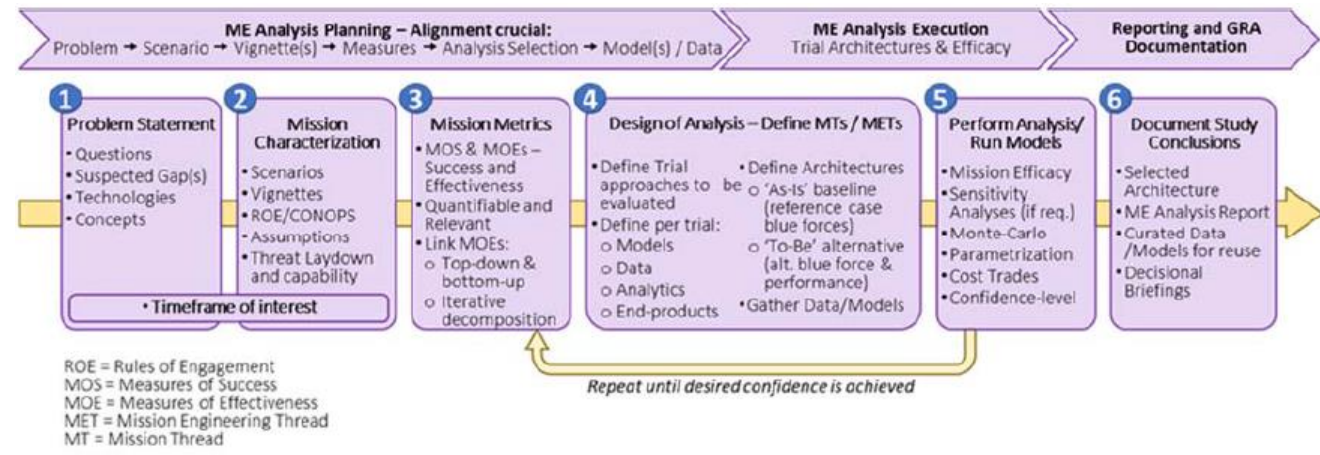Technical Fellow
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Mission Engineering

ME Guide

Mission Engineering (ME) Methodology

The 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.
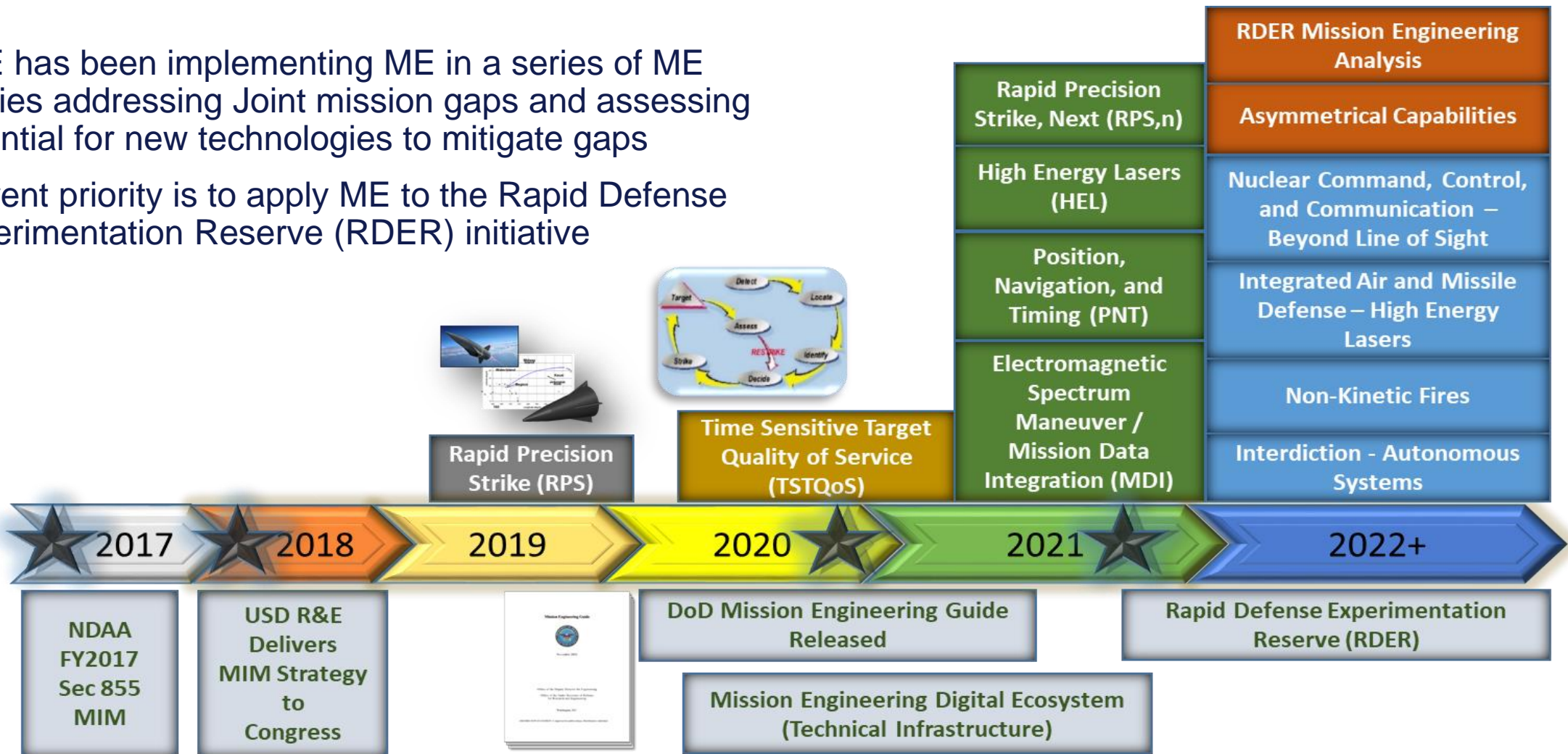
DoD ME Guide, 2020, p5

ME provides consistent methodology to deliver analytically and data-driven, mission-focused, threat-informed outputs to help guide future mission superiority

R&E Mission Engineering Implementation Based on Experience With FY20-22 Studies
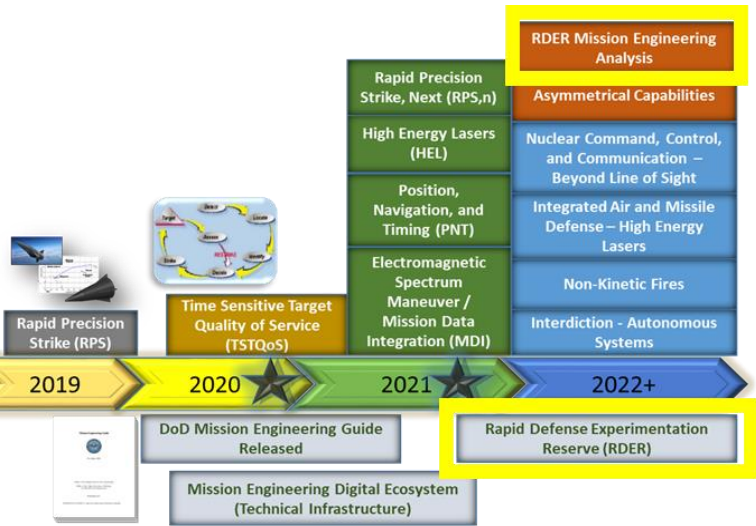
- R&E has been implementing ME in a series of ME studies addressing Joint mission gaps and assessing potential for new technologies to mitigate gaps

- Current priority is to apply ME to the Rapid Defense Experimentation Reserve (RDER) initiative

2017	2018	2019	2020	2021	2022+

Rapid Precision Strike (RPS)

Time Sensitive Target Quality of Service (TSTQoS)

Rapid Precision Strike, Next (RPS,n)
High Energy Lasers (HEL)
Position, Navigation, and Timing (PNT)
Electromagnetic Spectrum Maneuver / Mission Data Integration (MDI)

RDER Mission Engineering Analysis
Asymmetrical Capabilities
Nuclear Command, Control, and Communication – Beyond Line of Sight
Integrated Air and Missile Defense – High Energy Lasers
Non-Kinetic Fires
Interdiction - Autonomous Systems

NDAA FY2017 Sec 855 MIM

USD R&E Delivers MIM Strategy to Congress

DoD Mission Engineering Guide Released

Mission Engineering Digital Ecosystem (Technical Infrastructure)

Rapid Defense Experimentation Reserve (RDER)

Rapid Defense Experimentation Reserve (RDER)

The Secretary of Defense established RDER to:

- Focus multi-Component experimentation in a structured, multi-year campaign of learning.

- Proposed experiments based on alignment to Joint missions and potential to yield demonstrable warfighting utility in the near-term.

- Demonstrations and experiments will be conducted at key exercise venues (INDOPACOM Focused).

- Successful demonstrations and experiments can be quickly transitioned to the Components for fielding as new systems or approaches.

"*RDER will drive efforts to compete with peer and near-peer adversaries through the development of capabilities that support the Joint Warfighting Concept (JWC) including, but not limited to, fires, command and control, logistics, and capabilities that will drive information advantage.*" – Deputy Secretary of Defense Dr. Kathleen Hicks
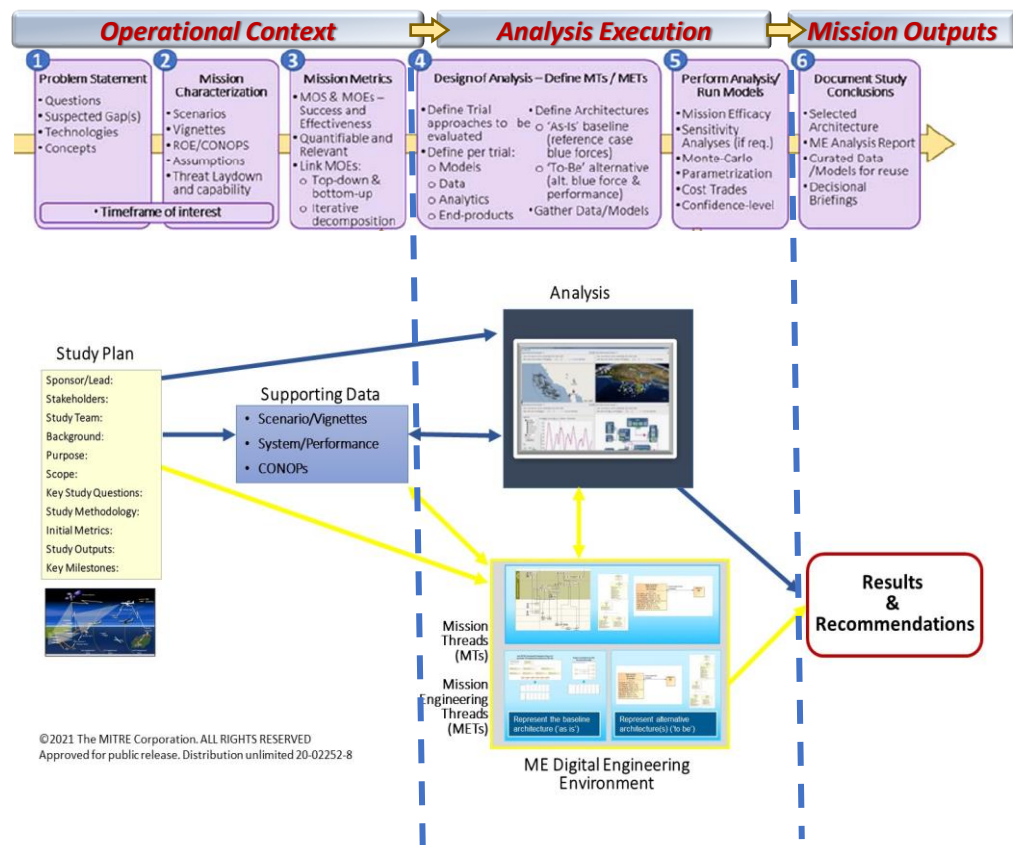
RDER will bring five benefits to DoD:

1. Accelerate Joint Warfighting Capability
2. Expand International Partnerships and Multi-lateral engagement
3. Focus Service experimentation to enable the JWC
4. Quickly demonstrate and assess innovative ideas
5. Provide feedback to future Warfighting concept development

Apply *Mission Engineering* across RDER → utilize mission context products and artifacts to make mission-focused decisions

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ME Implementation Applied Across R&E ME Studies

Study Plan (Terms of Reference)

- The scope: stakeholders, background, problem statement, key questions, hypothesis, methodology/approach, mission context, products/deliverables

Supporting Data

- Mission Characterization: Detailed data on the mission scenario and vignette (context for the analysis), threat, systems and their role in execution the mission, etc., assumptions

ME Digital Engineering Environment

- Digital representation of the mission architecture (Mission Threads (MT), Mission Engineering Threads (MET)) for baseline and the alternatives
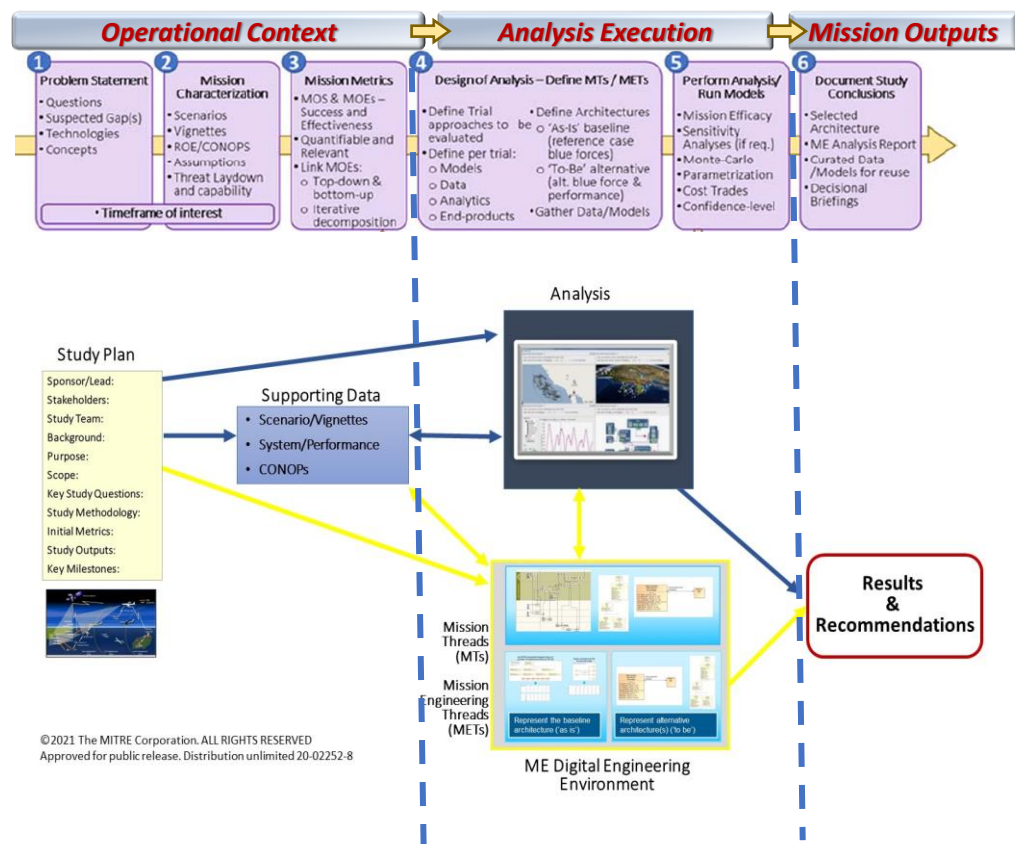
Mission Analysis

- Implementation of the scenario, systems and activities in operational analysis tool(s)
- Simulation runs for baseline and alternatives; outputs quantitative metrics

Results

- Outputs, trends, observations, and recommendations based on mission analysis

RDER Applies and Extends the ME Approach

Operational Context → **Analysis Execution** → **Mission Outputs**

①Problem Statement • Questions • Suspected Gap(s) • Technologies • Concepts

②Mission Characterization • Scenarios • Vignettes • ROE/CONOPS • Assumptions • Threat Laydown and capability • Timeframe of interest

③Mission Metrics • MOS & MOEs – Success and Effectiveness • Quantifiable and Relevant • Link MOEs: ○ Top-down & bottom-up ○ Iterative decomposition

④Design of Analysis – Define MTs / METs • Define Trial approaches to be evaluated • Define per trial: ○ Models ○ Data ○ Analytics ○ End-products • Define Architectures ○ 'As-Is' baseline (reference case blue forces) ○ 'To-Be' alternative (alt. blue force & performance) • Gather Data/Models

⑤Perform Analysis/ Run Models • Mission Efficacy • Sensitivity Analyses (if req.) • Monte-Carlo • Parametrization • Cost Trades • Confidence-level

⑥Document Study Conclusions • Selected Architecture • ME Analysis Report • Curated Data /Models for reuse • Decisional Briefings

Study Plan: Sponsor/Lead: Stakeholders: Study Team: Background: Purpose: Scope: Key Study Questions: Study Methodology: Initial Metrics: Study Outputs: Key Milestones:

Supporting Data • Scenario/Vignettes • System/Performance • CONOPs

Analysis

Mission Threads (MTs)
Mission Engineering Threads (METs)
Represent the baseline architecture ('as is')
Represent alternative architecture(s) ('to be')
ME Digital Engineering Environment

Results & Recommendations

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RDER ME Implementation Builds on the ME Experience

RDER Sprint Focus / Plans (Terms of Reference)
- Mission Scenario/Vignette
- RDER Proposal Concepts

Supporting Data
- Scenario documentation (i.e, JFOS)
- Kill Chain data (i.e., Long Range Fires)
- Data on RDER Concepts

ME Digital Engineering Environment (DEE)
- Extend Reusable DEE for ME for digital representation of the mission architecture (MTs, METs) for baseline and the concepts

Mission Analysis
- Implementation of scenario, systems and activities in operational analysis tool(s) in AFSIM
- Simulation runs for baseline and concepts; outputs quantitative metrics
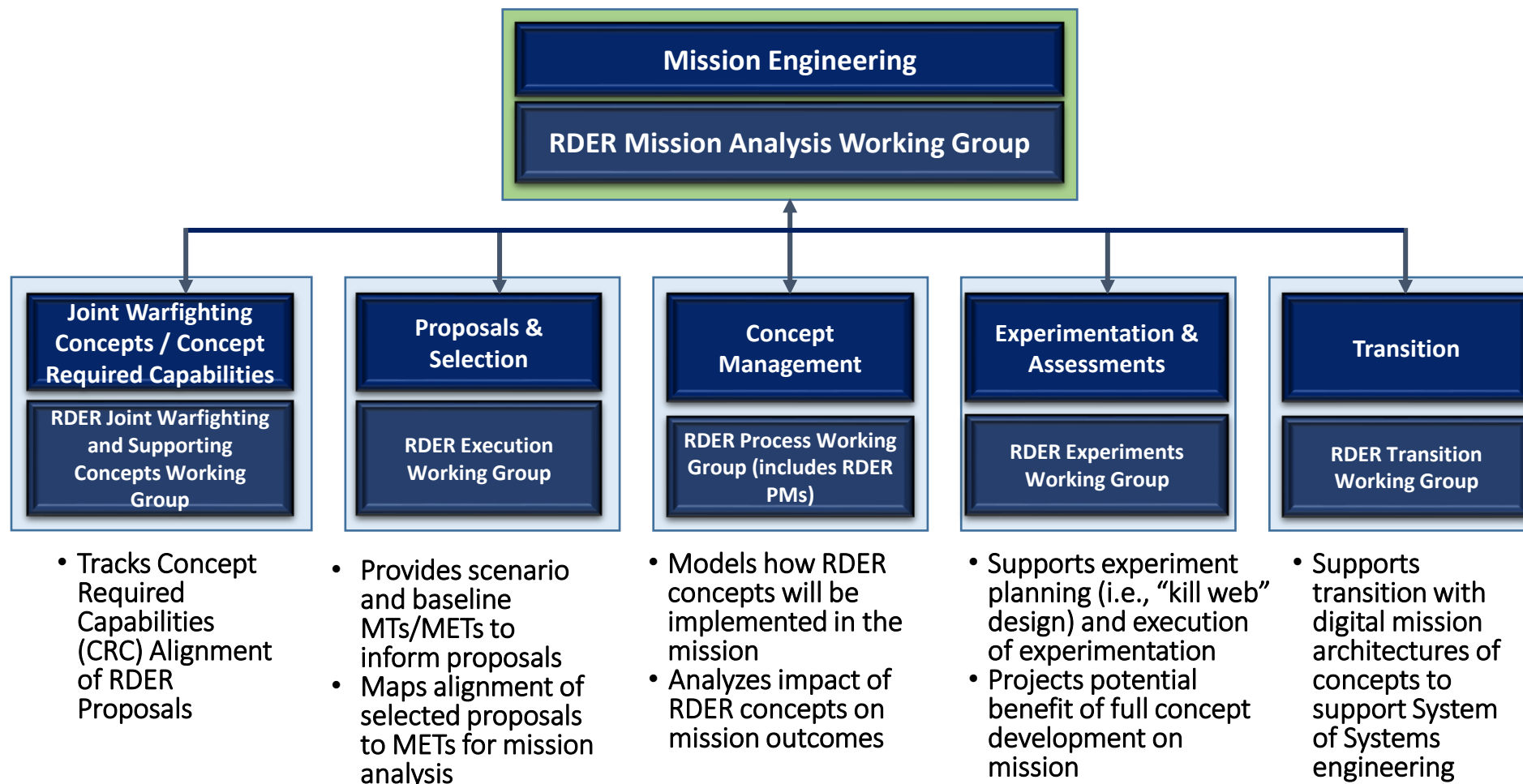
Results
- Results, trends, observations, and recommendations based on mission analysis provided to Concept leads, RDER Proposal managers, Experimentation Leads

Mission Engineering Across RDER

Mission Engineering

RDER Mission Analysis Working Group

Joint Warfighting Concepts / Concept Required Capabilities	Proposals & Selection	Concept Management	Experimentation & Assessments	Transition
RDER Joint Warfighting and Supporting Concepts Working Group	RDER Execution Working Group	RDER Process Working Group (includes RDER PMs)	RDER Experiments Working Group	RDER Transition Working Group

- Tracks Concept Required Capabilities (CRC) Alignment of RDER Proposals

- Provides scenario and baseline MTs/METs to inform proposals
- Maps alignment of selected proposals to METs for mission analysis

- Models how RDER concepts will be implemented in the mission
- Analyzes impact of RDER concepts on mission outcomes

- Supports experiment planning (i.e., "kill web" design) and execution of experimentation
- Projects potential benefit of full concept development on mission

- Supports transition with digital mission architectures of concepts to support System of Systems engineering

RDER R&E Mission Engineering Activities and Products

Lines of Effort

Mission Models — Tool: CAMEO/SysML

Represent the baseline architecture ('as is')

Represent alternative architecture(s) ('to be')

Operational Simulation — Tool: AFSIM

Baseline

- Digital representation of the baseline Mission Threads (MTs) scenario independent activities and Mission Engineering Threads (METs) adding scenario specific organizations and activities

Alternatives

- Updated MTs and METs to include RDER Concepts with associated changes

- Representation of the baseline MTs/METs within scenario including threat, systems' attributes and behaviors – conduct baseline analysis of mission metrics

- Update the systems' attributes and behaviors as specified in RDER concepts and assess impact on mission metrics

MISSION THREAD ALIGNMENT [TRACEABILITY]

QUANTIATIVE ANALYSIS [MISSION METRICS – OUTPUTS]

Obtain Kill Chain Source Information

informs

Baseline MTs/METS

Provides basis for

RDER Concepts - Represented as changes in the MT/METs
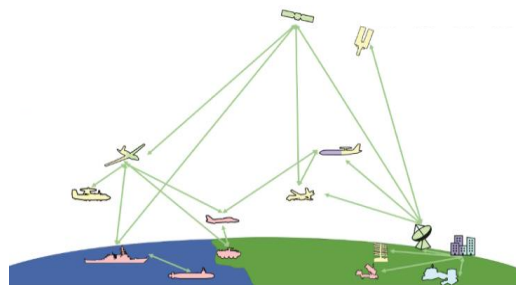
Alignment with Scenario Documentation (i.e., JFOS)

Represented in AFSIM

Represented in AFSIM

informs
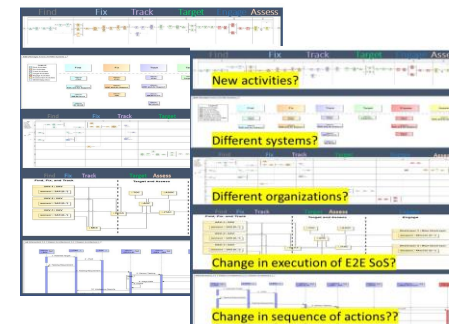
Analysis of Baseline Compared to Concept on Mission Outcome Metrics In Selected RDER Scenario

<u>Mission Thread (MT)</u>: An end-to-end sequence of tasks, activities and events to execute a mission.
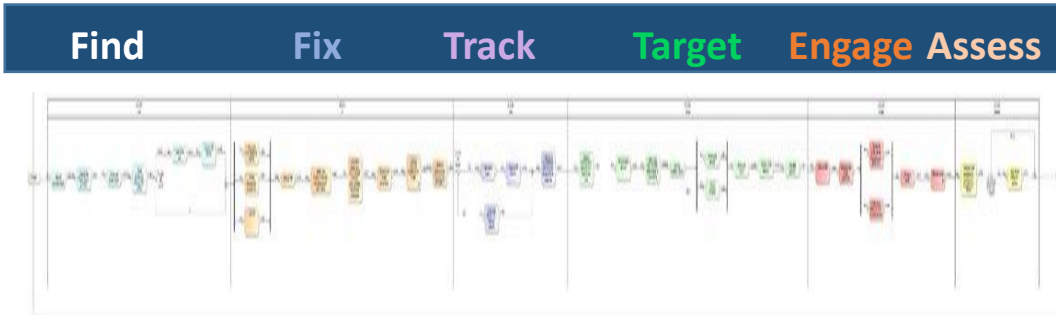
<u>Mission Engineering Thread (MET)</u>: Mission threads that include technical details of the capabilities and systems required and utilized to execute the tasks and activities for a mission.
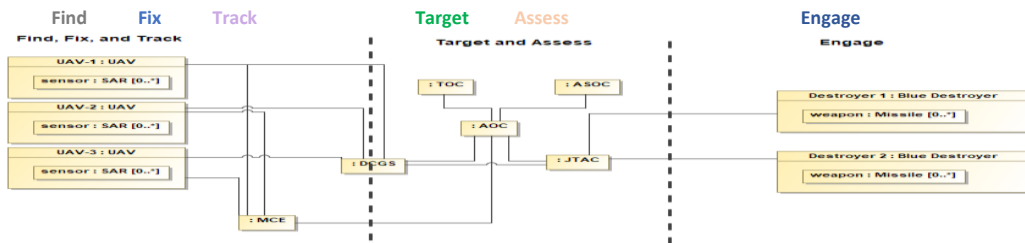
In executing ME

- MTs define the essential sequence of activities in the execution of the mission

  key elements of the operational mission architecture

- METs are used to define the systems / SoS in the execution of the mission activities

  key elements of the systems of systems architecture

MTs and METs provide an organizing construct across RDER proposal selection, concept maturation, experimentation, and transition

ME Digital Mission Models

- **How would BLUE fight in this scenario (independent of RDER)?**

  - Identify BLUE kill chains – develop BLUE mission engineering threads (Baseline METs)

- **How will these change when we introduce the concepts in the RDER 23-1 proposals?**

 - Update the baseline METs to add concepts (RDER METs)

Baseline MT and MET Models
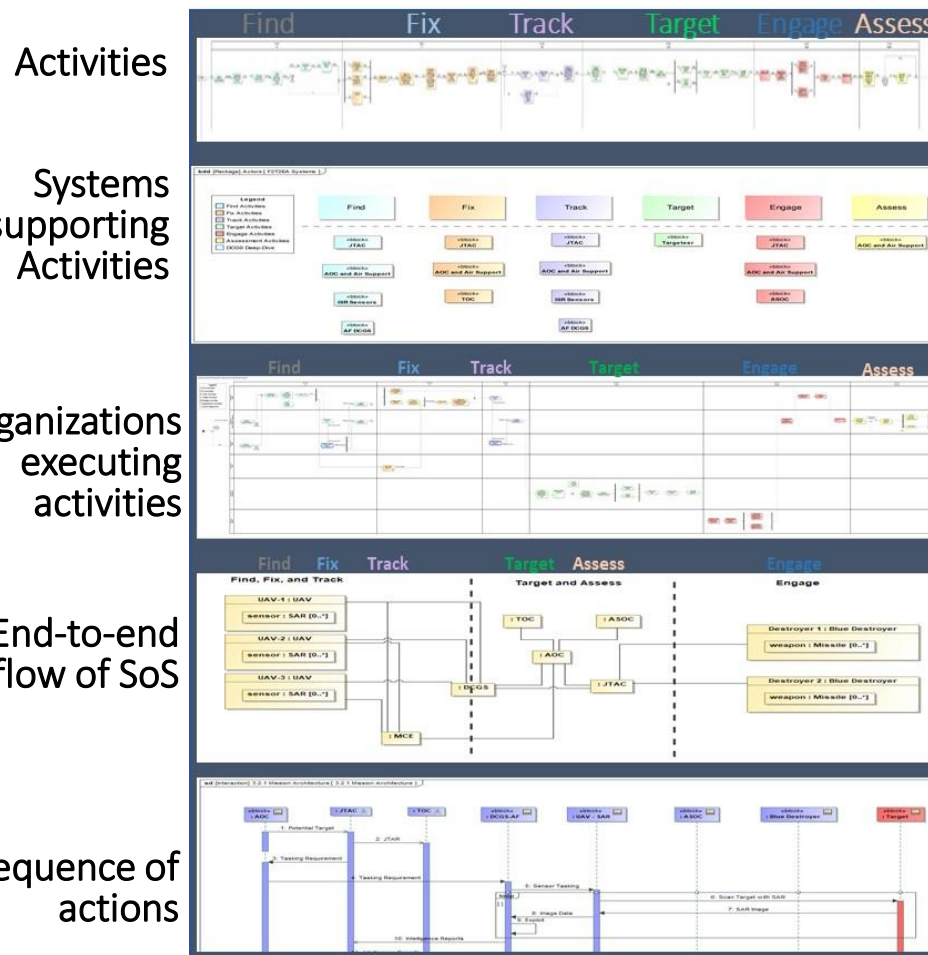
RDER Concepts

What ==new activities== are now needed to execute the mission?

What ==new systems== does the concept require?

What ==different organizations== are now part of mission execution? Which activities do they execute?

How does this change the execution of the ==End-to-end== (E2E) ==SoS==?

How does this change the ==sequence== of actions?

Baseline Mission Thread – Joint Targeting

Mission Thread – lays out the set of actions needed to accomplish the mission

Find   **Fix**   **Track**   **Target**   **Engage**   **Assess**
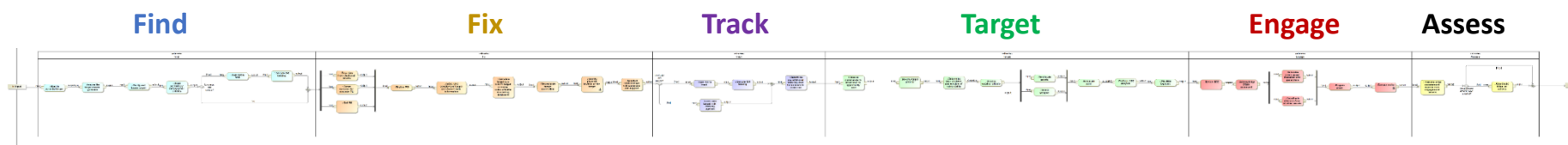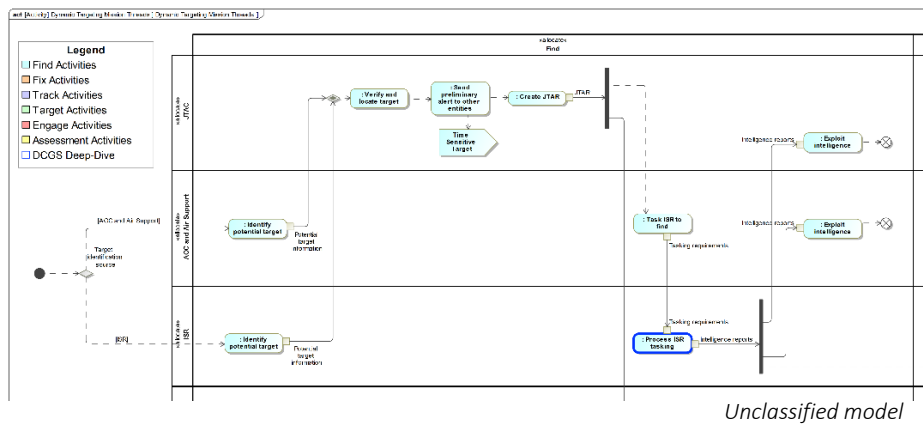

Unclassified model

- This core RDER mission thread provides context for representing the activities and systems

  - Found in the baseline RDER scenario

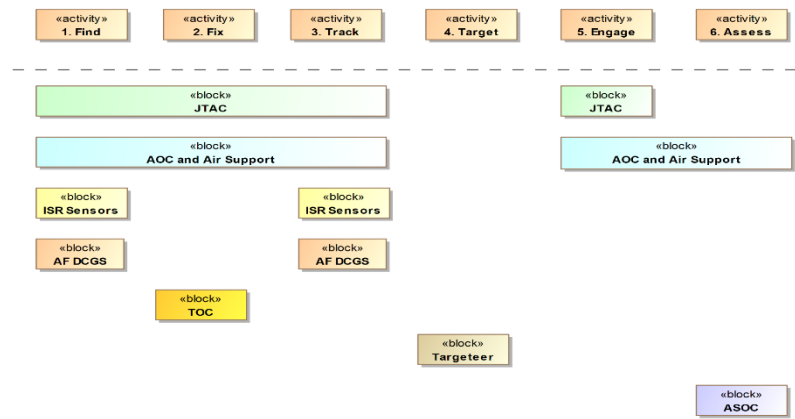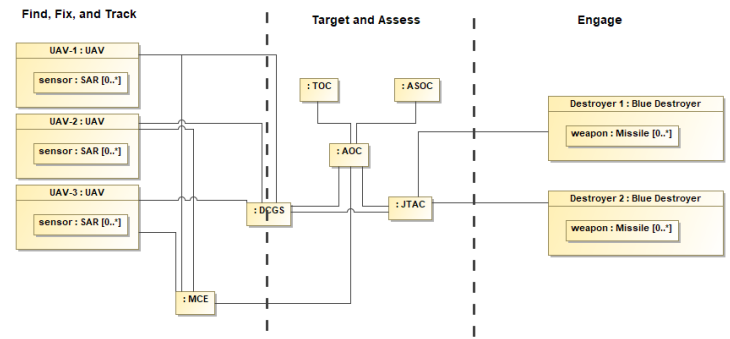 - Changes in the baseline activities and systems when the concept is introduced into the scenario

Views of Digital Mission Models
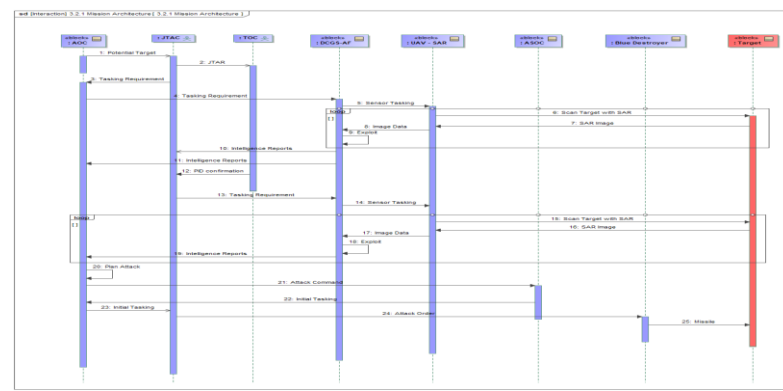## Baseline Scenario & Concepts As Implemented in Scenario

Unclassified model

Apply systems and organizations to base mission thread

Systems employed to execute MT activities

**End-to-end flow of systems interaction**

Sequence of system to system interactions

Overview of RDER AFSIM

- Represent baseline in the operational context for analysis and generate the baseline mission metrics
- Represent the changes made in the baseline to represent each concept to:
  - Compute the impact on mission metrics of the concept
  - Compute metrics on the performance of the particular concept as represented in the scenario and analysis
    - Calibrate the inputs the concepts have on the outcomes
    - Drive the metrics prototyping & experimentation
    - Support transition
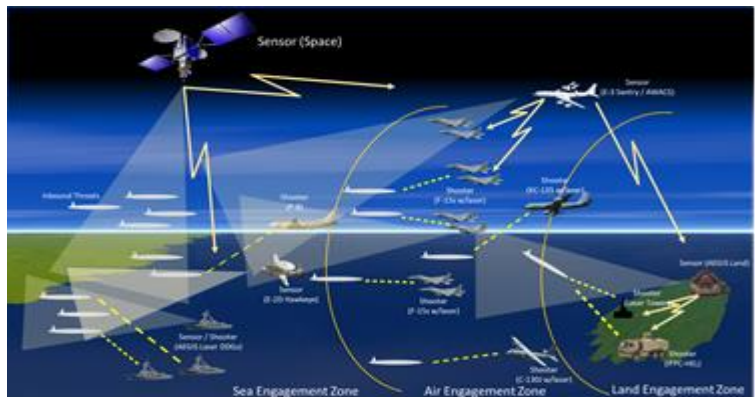
RDER R&E ME Analytical Approach

(U) Mission Engineering Analysis will be:

- An agile and iterative approach;
- Conducted on:
  - Each individual RDER Concept; and
  - Combinations of RDER Concepts

(U) ME Analysis Approach:

- How is the RDER Concept to be implemented in the scenario (across METs)?
- What is the objective of the concept (e.g., increased ISR coverage, increased weapons platform survivability)? How is this measured?
- Under what conditions do we expect the concept to impact mission outcomes (e.g., day without space)?
- What are the concept dependencies on baseline (organic) systems?
- What is the performance of each element in the concept?

Drive the run matrix

### Example Run Matrix (Tailored For each RDER Concept)

Case	
Baseline A - Uncontested *(run once)*	Do nothing to respond to adversary *(Green only)*
Baseline B - Baseline Scenario *(run once)*	Implement the baselines METS
Baseline C - Tailored Scenario (each concept)	Conditions addressed by concept (e.g., no space)
Alternative 1 - Baseline Scenario (B) with RDER Concept Excursions to explore tradespace	RDER Concept implemented in updated METs *(specific for each RDER Concept)*
Alternative 2 - Tailored Scenario (C) with RDER Concept Excursions to explore tradespace	

Similar agile and iterative approach will be applied to individual or combined RDER Concepts

- Digital mission models support experimentation planning (design of "kill web")

- Results of AFSIM operational simulation support:
  - Selection of RDER Concepts
  - Drive metrics for experiment data collection
  - Inform transition activities

- Experiment results may lead to added ME analysis

RDER Concepts · AFSIM Sandbox · Integrated Model of "Kill Web" · Experiment Design and Planning · Transition
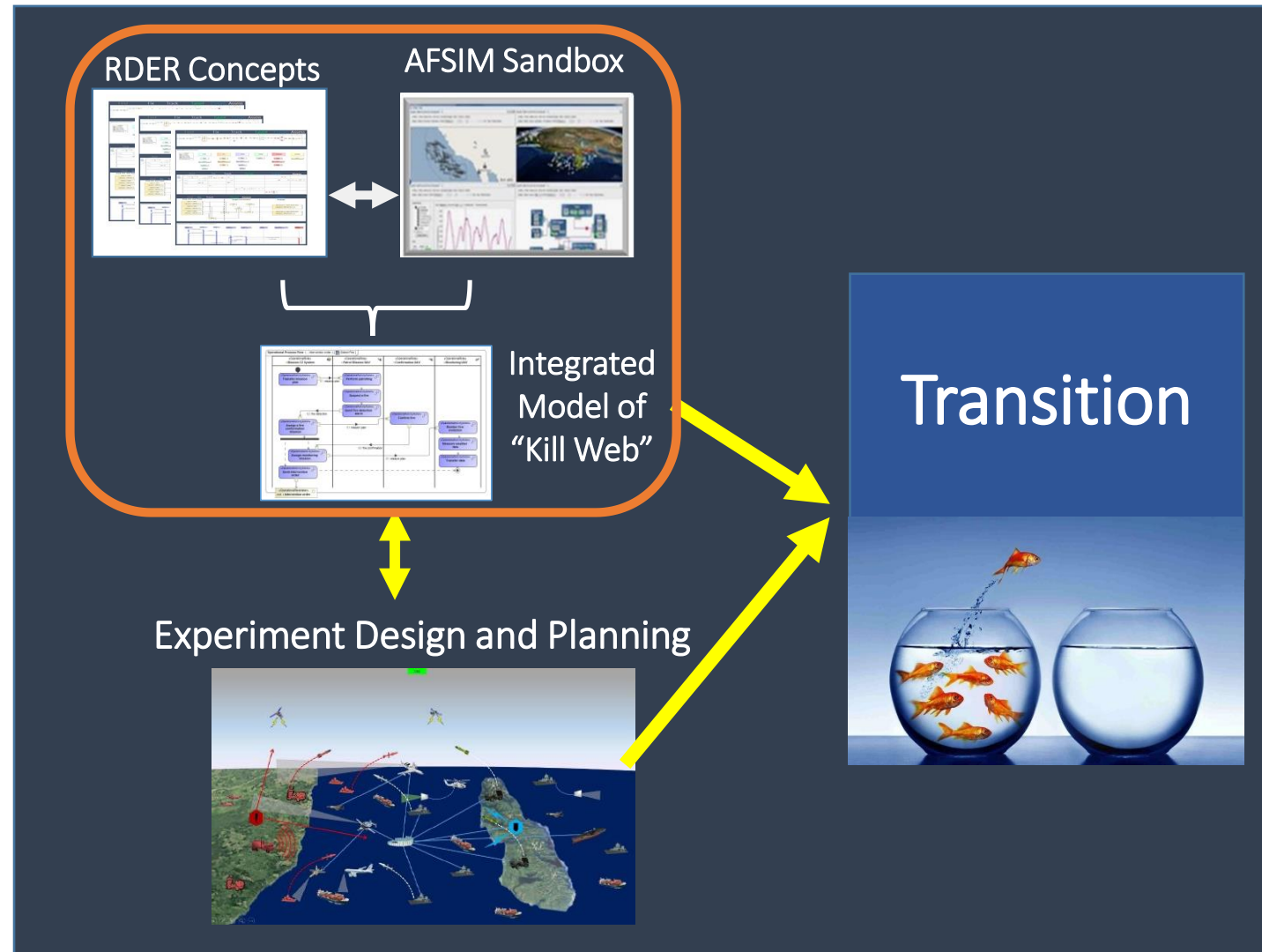
Summary

- Digital <u>Mission Threads</u> and <u>Mission Engineering Threads</u> are developed for each scenario/vignette and submitted as part of the Call for Proposals

- MTs/METs align the RDER concepts and put the concepts into a <u>mission context</u>

- <u>Mission Engineering analysis</u> will model the concepts into an operational environment (AFSIM) to assess and evaluate the mission effectiveness of concepts (excursions from the as-is mission architecture)

- ME analysis outputs quantitative results in terms of <u>mission metrics</u>

- Results will support <u>selection</u>, <u>prioritization</u> and <u>development</u> of RDER Concepts; and shape <u>future RDER call for proposals</u>

- Leverage data and lessons learned from experiments to discover and mature <u>future Warfighting Concepts</u>

This is an <u>Iterative</u> and <u>repeatable</u> process to support continuous evaluation and assessment of JWC CRCs through RDER experimentation in a mission context

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