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Analytical Assessment Methods to Directly Measure Impact and Resilience of USAF Mission Assurance

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Analytical Assessment Methods to Directly Measure Impact and Resilience of USAF Mission Assurance

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Team members include: John Beck (INL), Michael Shurtliff (INL), Liam Boire (INL), Corey Beebe (INL), Chris Dieckmann (INL), Michael Darby (INL), Kyle Oswald (INL), and John Collins (retired INL)

Presentation is Unclassified

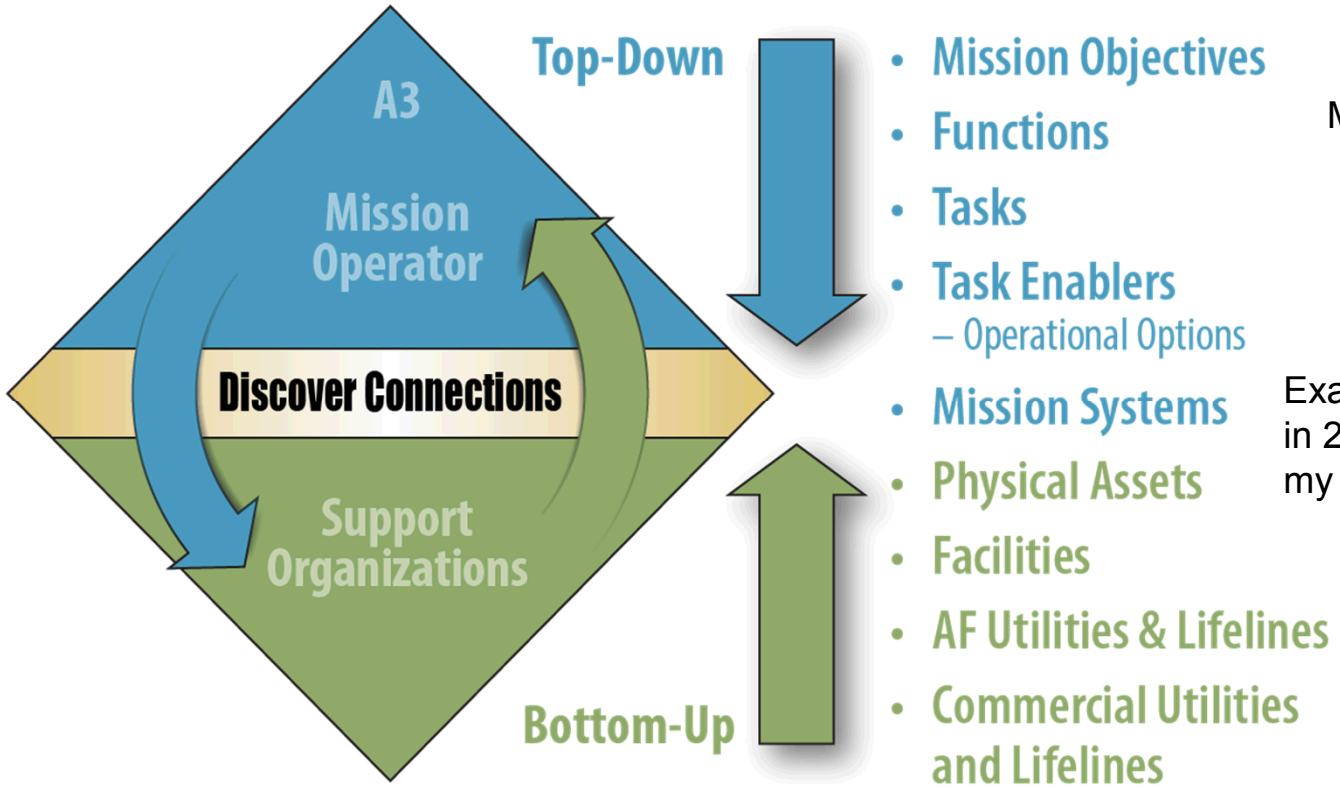
Agenda

- AF Problem Statement given to INL
- DEEPR (Decomposition for Energy Assurance and Electrical Power Resilience) Analytical Framework
- Mission Availability algorithm
- Static and dynamic analyses
- Path Forward to improving dynamic and interdependency analyses
- Conclusions

AF Problem Statement & Challenge to INL

- Air Force is increasingly networked systems and that makes them potentially more vulnerable to power interruptions
- Interdependency of installations and systems expose the enterprise to greater risks
- Current assessment approaches focus solutions on installation's assets and do not account for other methods to resolve mission impacts
- Analysis of Alternatives (AoA) are too focused on power infrastructure as the way to improve resilience
- Need for a method/metric that values resilience to the mission
  - Understand As-Is resilience value
  - Enables a return on investment (ROI) value for COA/alternatives

Mission Thread Analysis Uses Analytical Framework to Measure Impact



Mission operators consistently reported backup approaches
- "We would use a different method to avoid telling the commander we can't do a mission"
- Took 1-4 organizations to detail the "blue" portion

Example Response: "This mission thread workshop was the first time in 20 years that I understood what the entire mission was and how my part fit into making it happen"

Installation support and communications built in backup options for power and networking
- "If power goes down on my watch, I hear about it quickly and they expect miracles"
- Took 2-4 organizations to defined the "green" portion

Analytical Framework and Algorithms, Part 1

- Mission Objectives
- Functions
- Tasks
- Task Enablers
  – Operational Options
- Mission Systems
- Physical Assets
- Facilities
- AF Utilities & Lifelines
- Commercial Utilities and Lifelines

Mission Systems logical enabler needs

Mission system logical relationships

Logic Allowed	Description of Logic
AND	Assets required for mission system to be available
OR	Assets where 1 of 2 or more elements required to be available
OR-Capacity	Assets that supply a quantity of capacity required

Algorithm Steps

Assets and Mission Systems calculate availability:

Availability = Minimum of three terms;
Minimum of Term 1[“AND gate logic”],
Maximum of term 2 [“OR gate group logic”], and
Minimum of term 3 [1,Summation(“OR-Capacity group logic”]

Validation: Civil engineers, communication squadrons, facility managers review the findings:

- If “asset” is lost, then impact is confirmed
- Method found much more effective than looking at the model

Analytical Framework and Algorithms, Part 2

- Mission Objectives
- Functions
- Tasks
- Task Enablers
  – Operational Options
- Mission Systems
- Physical Assets
- Facilities
- AF Utilities & Lifelines
- Commercial Utilities and Lifelines

Operational Options may degrade the ability to perform the task to the same level as the preferred option

Operational options degradation levels

Degradation Level	Degradation Value	Description
No Impact	0	Option has same performance level as primary path.
Very Small	5%	Barely noticeable degradation to capability.
Small	10%	Noticeable impact to a capability.
Moderate	20%	Reportable impact to capability.
Significant	40%	Sufficient capability degradation that there may be outcomes that require additional mitigation.
Catastrophic	100%	Cannot perform capability, mission may be in serious jeopardy, “showstopper.”

Algorithm Steps

1. Each Operational Option calculates its Mission Availability by multiplying: MS’ availability * (1-OO’s Degradation)
2. Task Enablers seeks the maximum OO score

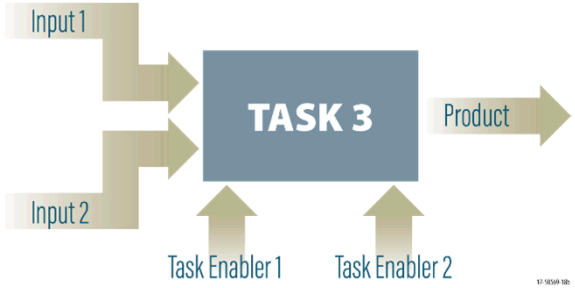
Validation: Mission operators performing the tasks review the findings:

- If x “mission system” is lost, then y operational option is used with this defined degradation level

Analytical Framework and Algorithms, Part 3

- Mission Objectives
- Functions
- Tasks
- Task Enablers
  – Operational Options
- Mission Systems
- Physical Assets
- Facilities
- AF Utilities & Lifelines
- Commercial Utilities and Lifelines

Constrained & Weighted Rollup Approach



Weighting definitions

Weighting Level	Weight Value	Description and Value of Weight
Essential	100	Must be available for the Task to be completed. Limits the mission availability value of the task.
Important	50	Half as important to the Task as an Essential enabler.
Non-Essential	10	One tenth as important to the Task as an Essential enabler.

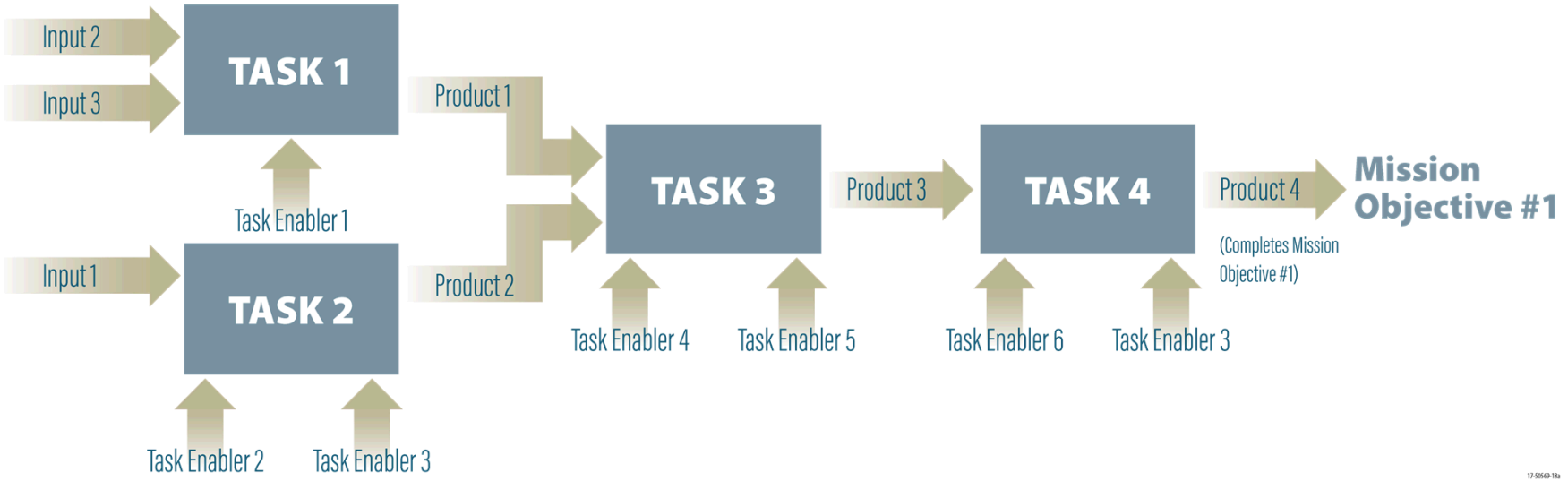
Algorithm Steps

1. Calculate constrained score of essential inputs and enablers
2. Weight average constrained score with other less important inputs and enablers

Validation: Mission objective owner and/or task operators

- Essential and other weighted inputs/task enablers confirmed

Analytical Framework and Algorithms, Part 4

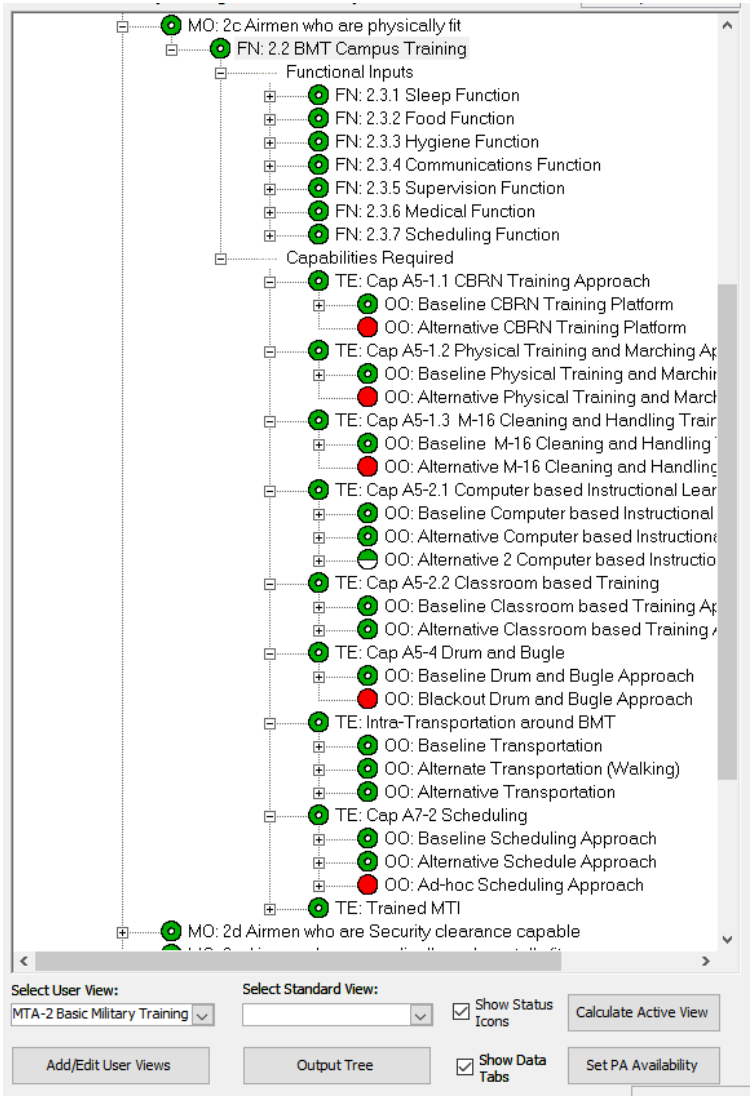


Algorithm Final Steps

- Each Mission Objective is connected to the tasks via a Functional Flow Block Diagram
- Task 4 is based on task 3's product and its task enablers
  - Task 3 uses task 1 and 2 products plus its own task enablers etc.
  - Degradation of the system is perpetuated along this FFBD to the last task
  - The Mission Objective inherits the final task's product score
    - If more than one product completes the Mission Objective, the completing products are averaged
- Mission Objectives roll up to the mission using importance weights of the objectives to the Mission

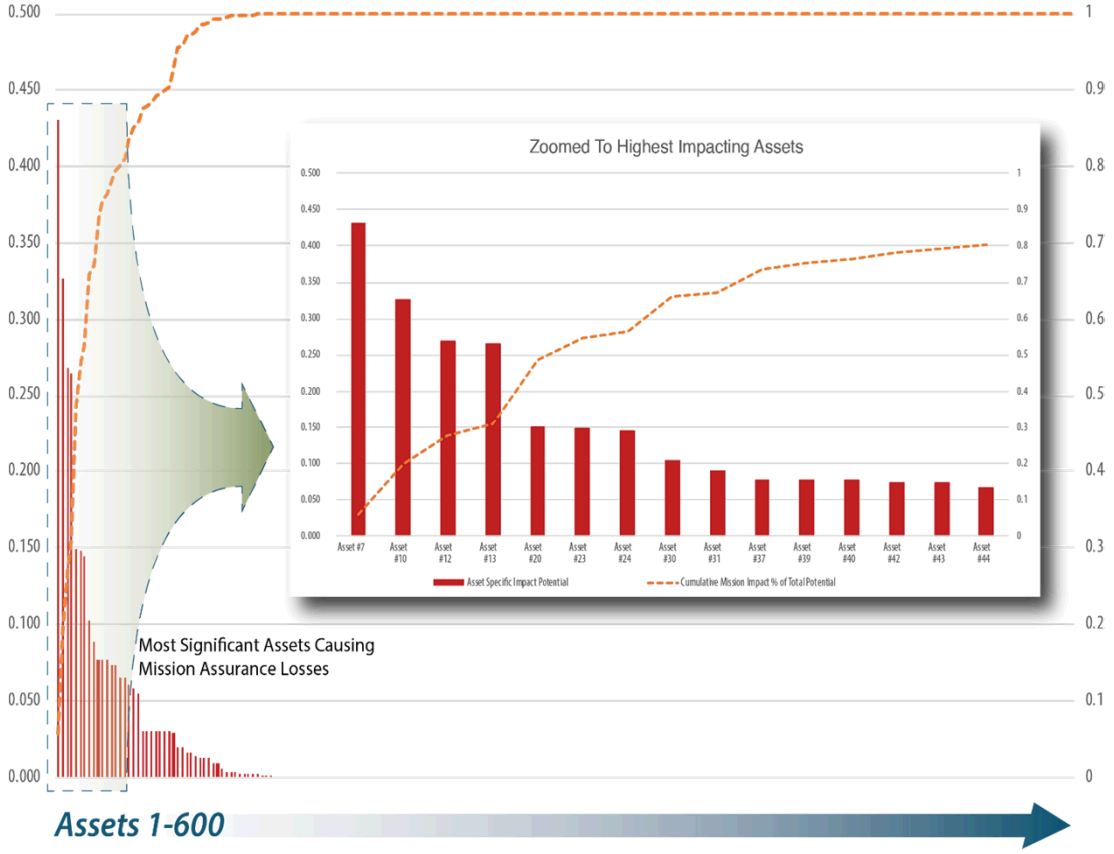
Analytical Framework Model Evaluates Static Points of Failure

Normal Operating Conditions



What If an asset was unavailable?

Point of Failure Analyses Identifies Sensitive Assets



N-1, N-2, and N-3 Analyses Performed

Notional Data

Threat-Informed Scenarios Provide Opportunity for Dynamic Analyses

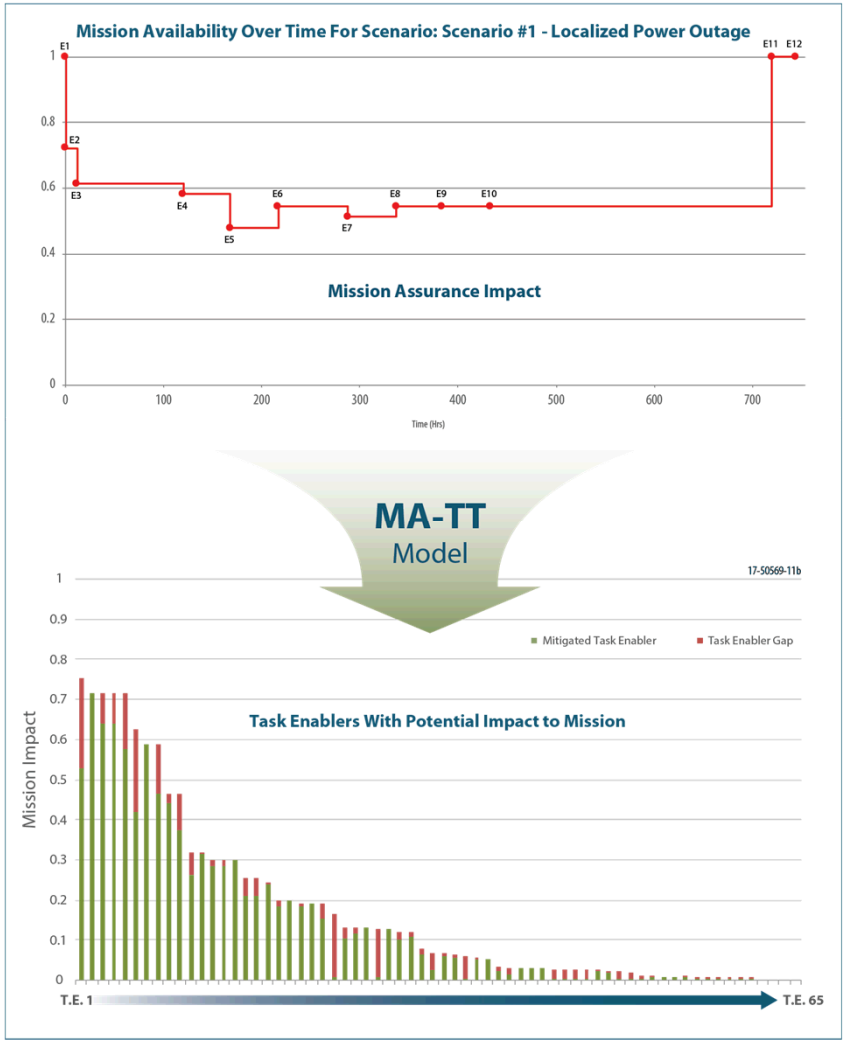
Four Standard Scenarios Plus Unique Scenarios provide mission impacts testing environment

Represents events/conditions AF desires resilience to:

Scenario Conditions	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Power Outage Type	Base power off.	Base power off.	Base power off. Power outage for 45mi radius.	Base power off. Regional Interconnect power outage (see Appendix F).
1. Duration	30 days	30 days	30 days	30 days
2. Resupply Availability	Resupply available.	No resupply for first 14 days.	No resupply for first 21 days.	No resupply for 30 days, personnel relocation unavailable.
3. Equipment repair	Equipment repaired normally.	Equipment repair delayed 14 days.	Equipment repair delayed for 21 days.	Equipment repair delayed for 30 days.
4. Commercial Communications			• ISPs off line after 8 hours. • Cell phones fail after 48 hours. • Landlines fail after 7 days.	• ISPs off line after 8 hours. • Cell phones fail after 48 hours. • Landlines fail after 7 days.

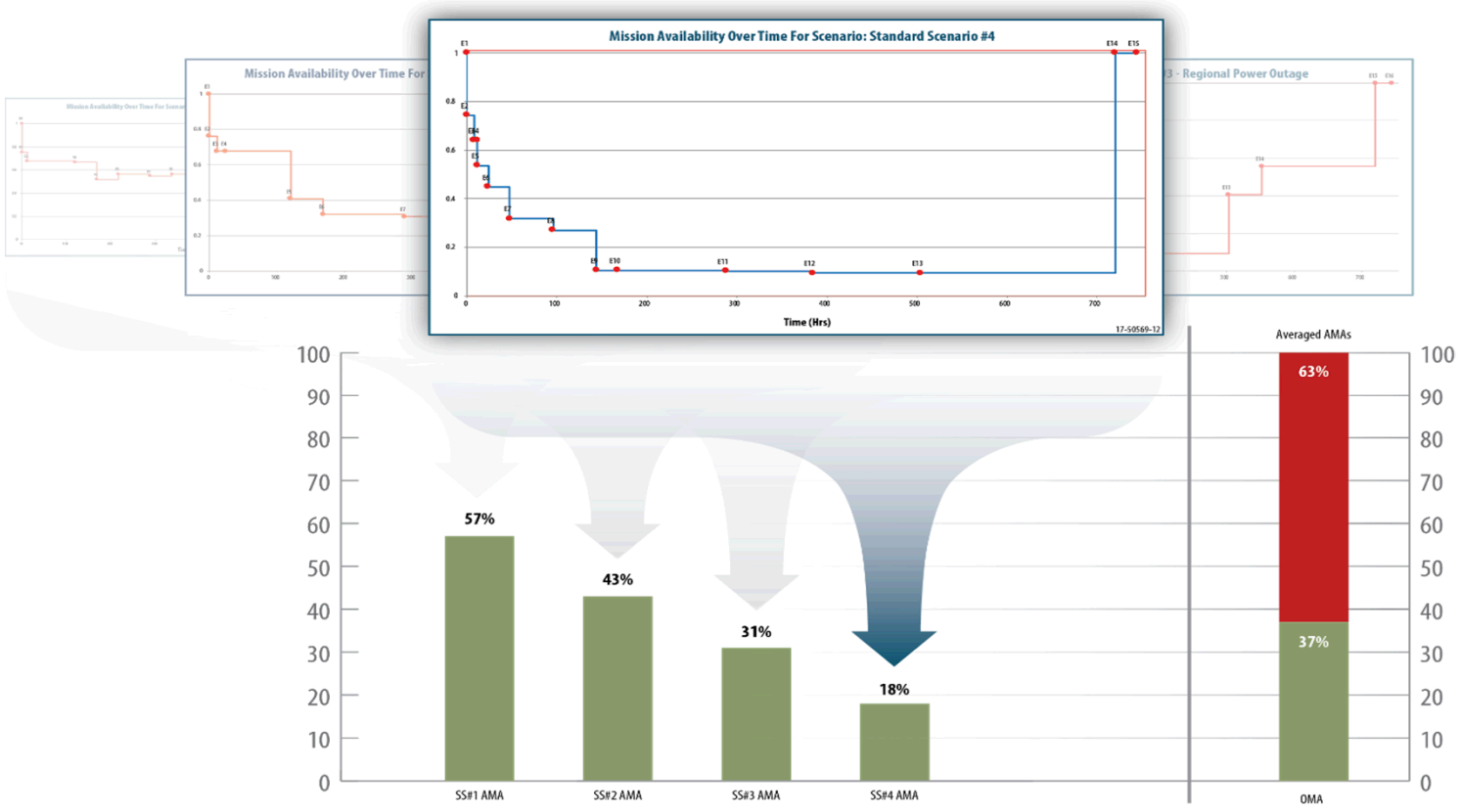
Notional Data

Dynamic analysis defines mission impact from task enablers and size of enabler's gap



Mission Availability, Average Mission Availability (AMA) and Overall Mission Availability (OMA) Measures

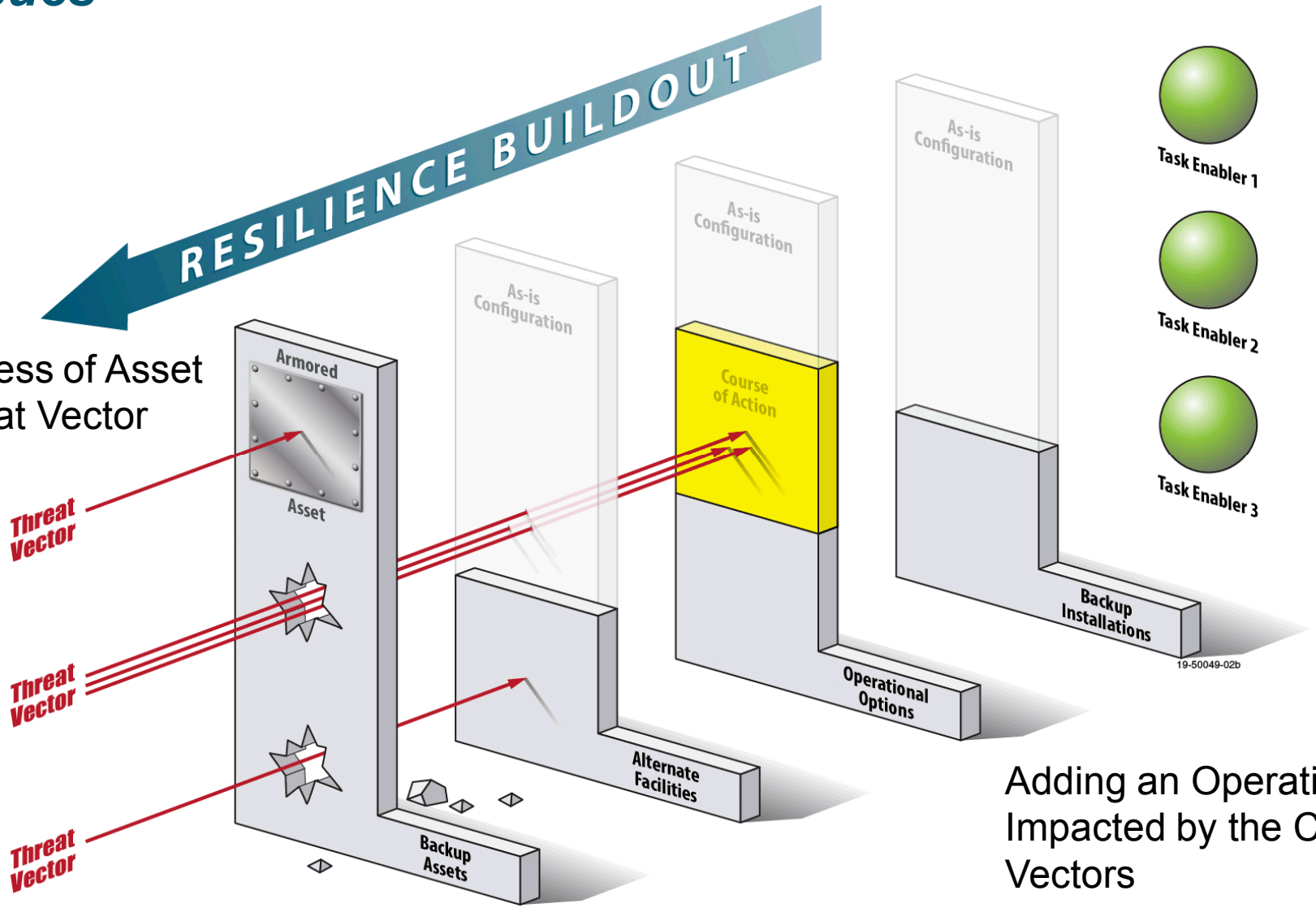
- AMA provides measure of mission impact across a scenario
- Averaging the AMAs provide an OMA for the mission's As-Is configuration
- Increasing AMAs and OMA results in resilience improvements
- Improvements in resilience provides the value function for ROI comparisons



Notional Data

DEEPR's Analytical Framework Provides Multiple Approaches to Resolving Resilience Issues

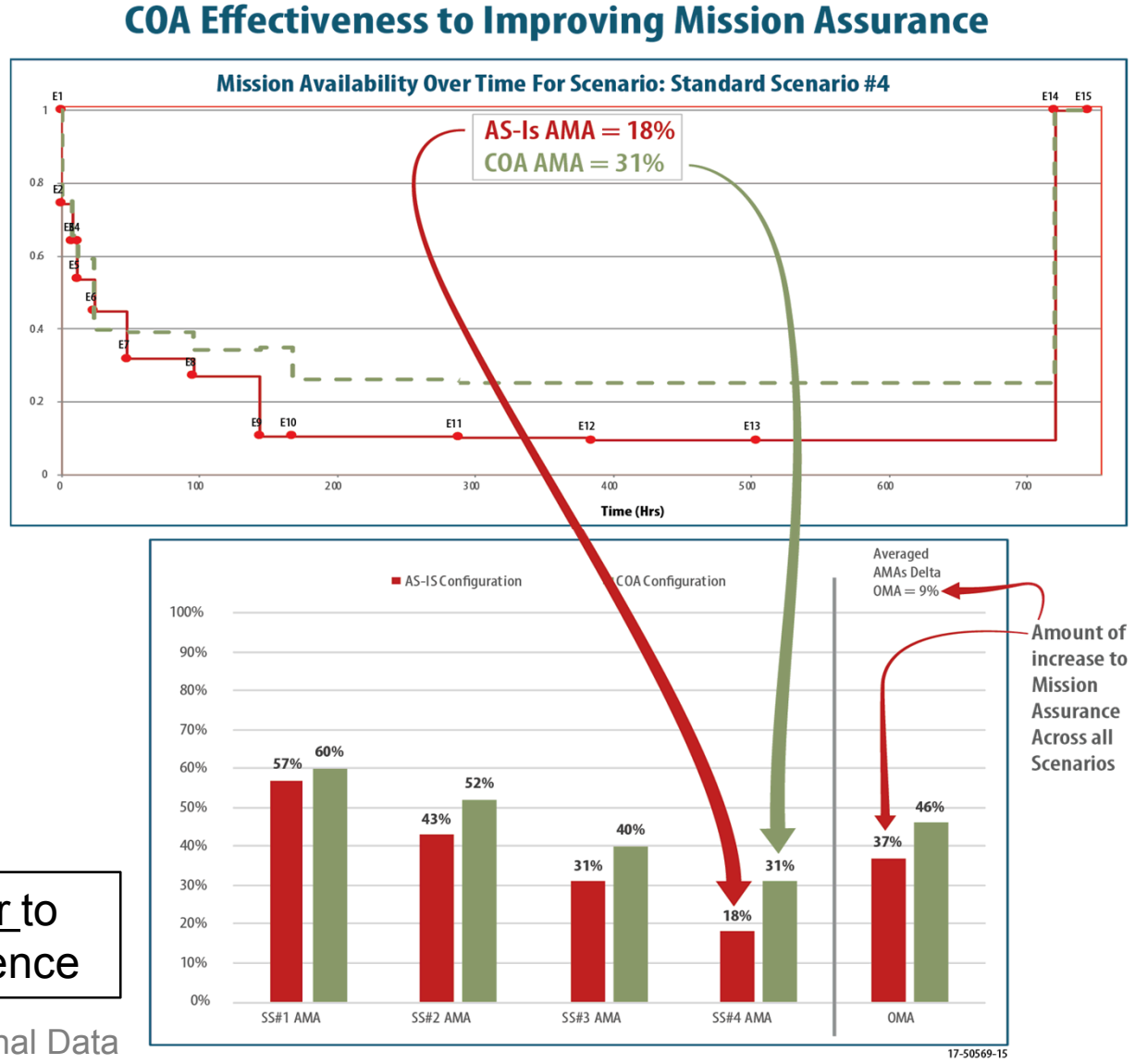
Increasing Robustness of Asset Against Upper Threat Vector



Adding an Operation Option Not Impacted by the Central Threat Vectors

Measuring Resilience Value for Alternatives and Courses of Action

- "Bigger picture" problem definition
  - Increases solution creativity
  - Multiple scenarios avoids point solutions
- Evaluates Alternatives/COAs using same scenarios
  - Scenario prioritization allowed
  - Delta OMA provides resilience value (e.g. input to ROI analysis)
- Evaluates system of solutions
  - Complimentary solutions show compounded benefits
  - Competitive solutions would not yield compounded benefits



All mission supporting organizations can work together to identify what each should do to improve mission resilience

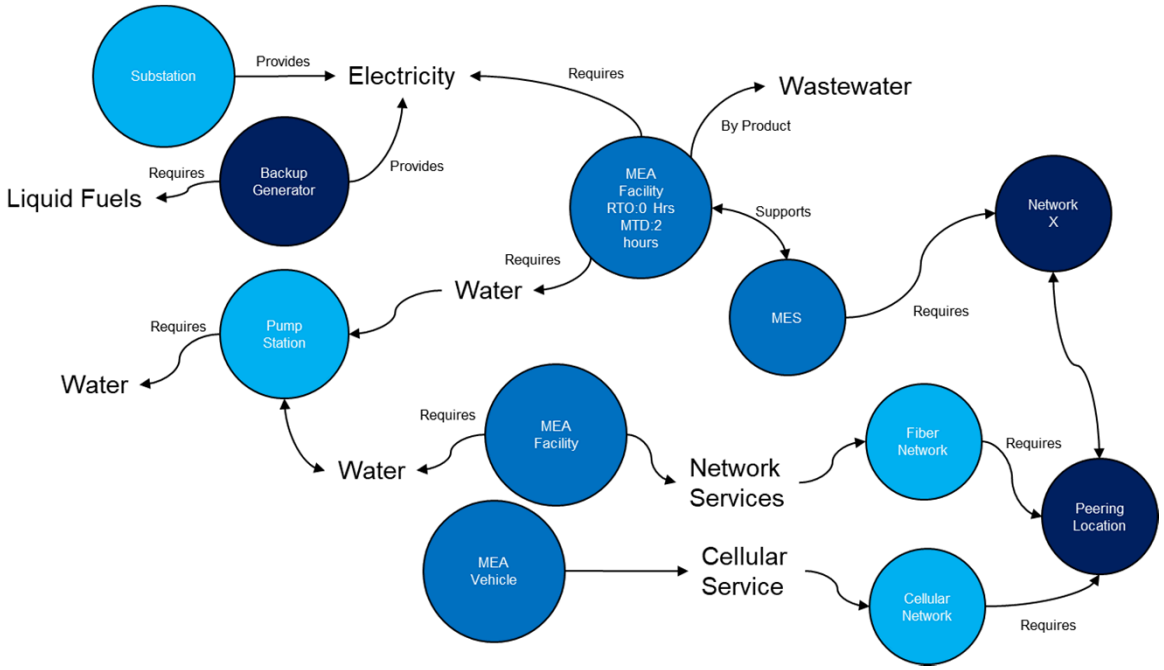
Notional Data

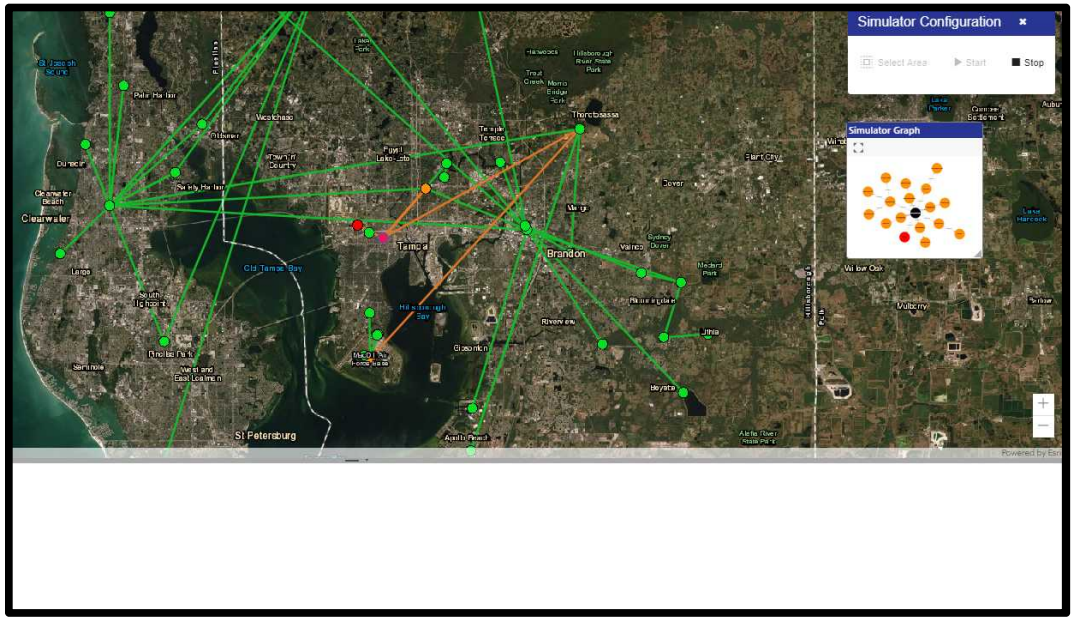
Path Ahead

- Opportunity exists to define a leading indicator metric for resilience
  - Mission availability measures when mission impact begins
  - Need a measure that shows when reductions are occurring prior to mission impact
    - Evaluating loss of Operational Options to the essential Task Enablers
- Integrating INL's DEEPR and AHA (All Hazards Analysis) Interdependency methods and tools
  - Commercial systems impact each other
  - Regional events impact installation's missions directly and indirectly
    - Obscured by secondary or tertiary effects
    - Time delays obscure causal factors
    - Increases difficulty defining adequate mitigation approaches
  - Improve the efficiency of analysis
    - Automate data importing
    - Increase reuse of data

Continued Areas of Development

- Integrating DEEPR Modeling approach with the All-Hazards Analysis (AHA) interdependency analysis techniques to better understand wide-spread infrastructure impact on missions
  - Identify interconnectivity and enabling needs of commercial systems with each other and understanding the impact on AF mission supply chain, utilities, communications, etc.
  - Simulate the threat-informed scenarios on both the commercial and AF communities to measure mission impact from additional coupling effects





Notional Data

Project Outcomes

Observations:

- Resilience metrics at the static level were not helpful and could actually be problematic in investment strategies
- Defining what to be resilient to is important to understanding the current state and where to improve
- Relationships and logic define what assets matter and enable drill down to further understand impact

Issues to Resolve:

- Precursor resilience metrics may help understand when Mission Availability impact is approaching
- Interdependencies are largely difficult to evaluate due to indirect effects without modelling the relationships

Conclusion:

- Mission resilience is a dynamic result from eliminating mission impact due to adverse events
  - Not a static metric in itself.
  - Defining applicable threat informed scenarios provide both an evaluation breadth and desire to be resilient
  - Measuring Mission Availability across the scenarios establishes baseline or As-Is effectiveness
  - Improving mission resilience is a result of increasing mission availability across scenarios and supports ROI analyses

Resiliency-valued investment decisions are made possible

Thank You,

Contact Information

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Questions?

Backups

- Definitions to include, stories to build into notes in appropriate locations.

DEEPR Architectural Elements & Descriptions

Mission	Mission is decomposed into critical outcomes called Mission Objectives
Mission Objectives	Mission Objectives decompose into a logical set of Tasks (e.g. FFBD)
Functions	Functions are used to hierarchically organize Tasks
Tasks	Tasks convert inputs into products using Task Enablers
Task Enablers	Task Enablers provide the ability to perform a Task
Operational Options	Operational Options are alternative approaches to provide the Task Enabler with or without degradation
Mission Systems	Mission Systems are required to be available to provide the associated Operational Option
Physical Asset & Sub-Systems	Physical Assets & Sub-Systems required to provide Mission Systems availability
Facilities	Facilities contain the Physical Assets and Sub-Systems and connect to AF Utilities and Lifelines
AF Utilities & Lifelines	AF Utilities and Lifelines provide Physical Assets and Sub-Systems required enablers
Commercial Utilities & Lifelines	Commercial Utilities & Lifelines provide the AF Utilities and Lifelines