RDECOM

System of Systems Survivability, Lethality, Vulnerability Assessment (SoS SLVA):

Ballistic Vulnerability Modeling Demonstration

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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To present a concept of a System of Systems SLVA and a demonstration to support methodology development.

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- Concept of System of Systems SLVA
  – Our concept of a SoS
  – System-of-System Survivability Simulation (S4)
- Methodology
  – New metrics
  – Decision making process (DMP) in S4
- Demonstration overview
- Benefits to Test & Evaluation community
- Summary

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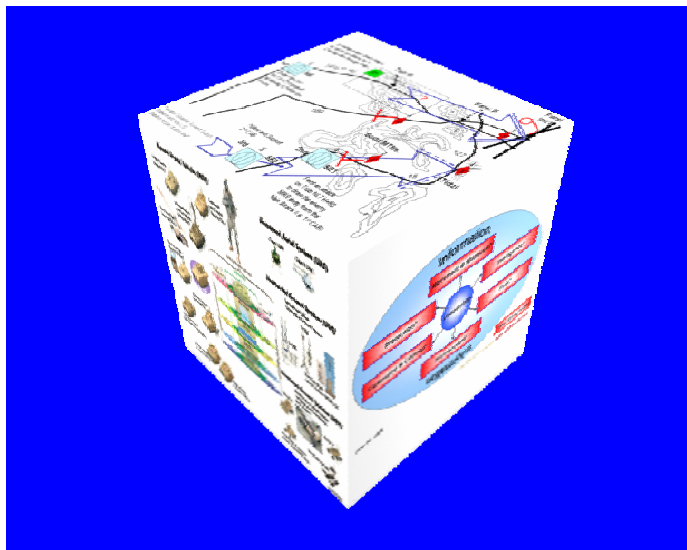
A design connecting multiple levels of decision makers and assets through which decision makers at every level can adapt the application of their assets to achieve their purpose.

he Physical Systems:

e.g., Future Brigade Combat Team (14+1+1).

The Leaders

Capabilities conceptualized as combat power, a term that encompasses all means available to a given unit at a given time.

Leaders at the center, enabled by information, execute the six traditional warfighting functions.

The Context

While we can discuss each of the above abstractly, a domain context grounds the assessment.

Within this context, assessment is a

- "Doing the correct thing well".
  - Assesses an ability to reach the chosen position of attack, or to maintain formation and arrangement of forces, etc.
  - Is more about the physical situation, and focuses more on the internals of a unit.

- "Doing the correct thing"
  - Traces the flow of information (e.g., an enemy spot report) through the network to its consumer (a leader); thence, to an observable domain impact upon a war fighting function.
  - Is more about the information system, and looking outward from a unit.

- SoS effectiveness is a joint result these measurements.

SoS Effectiveness
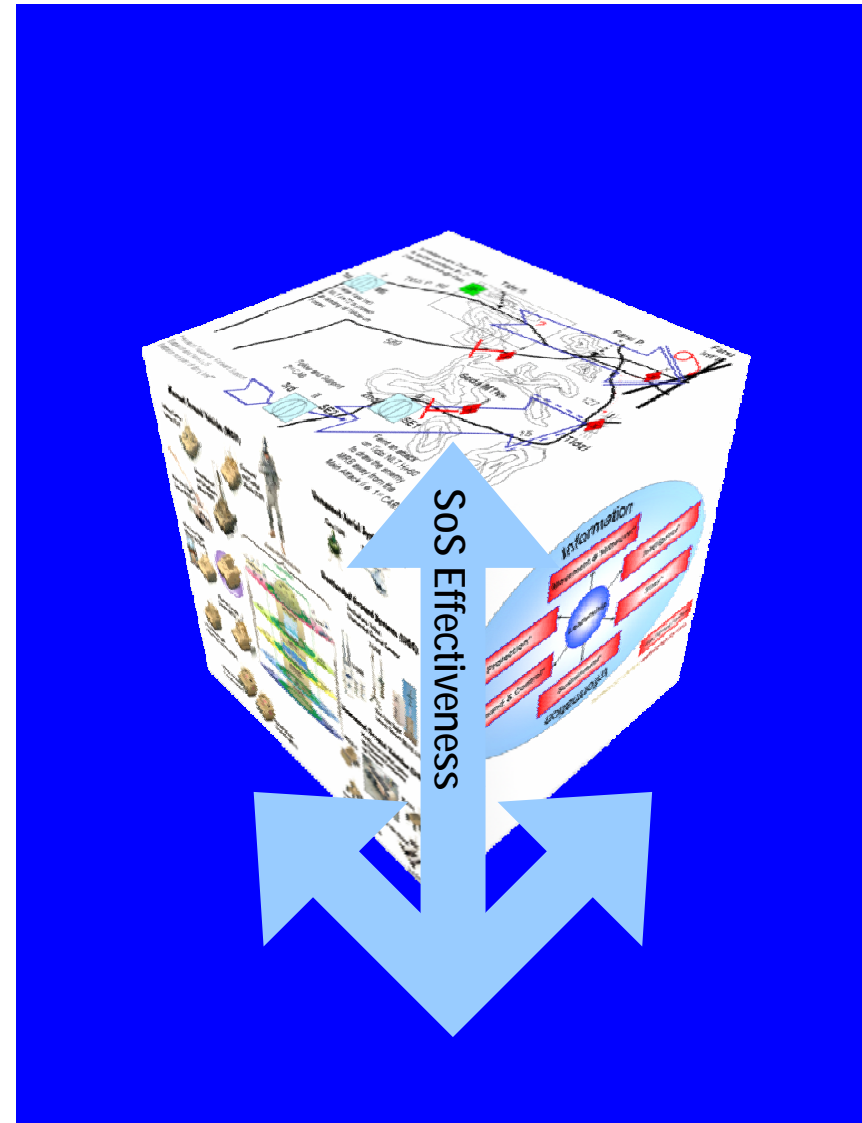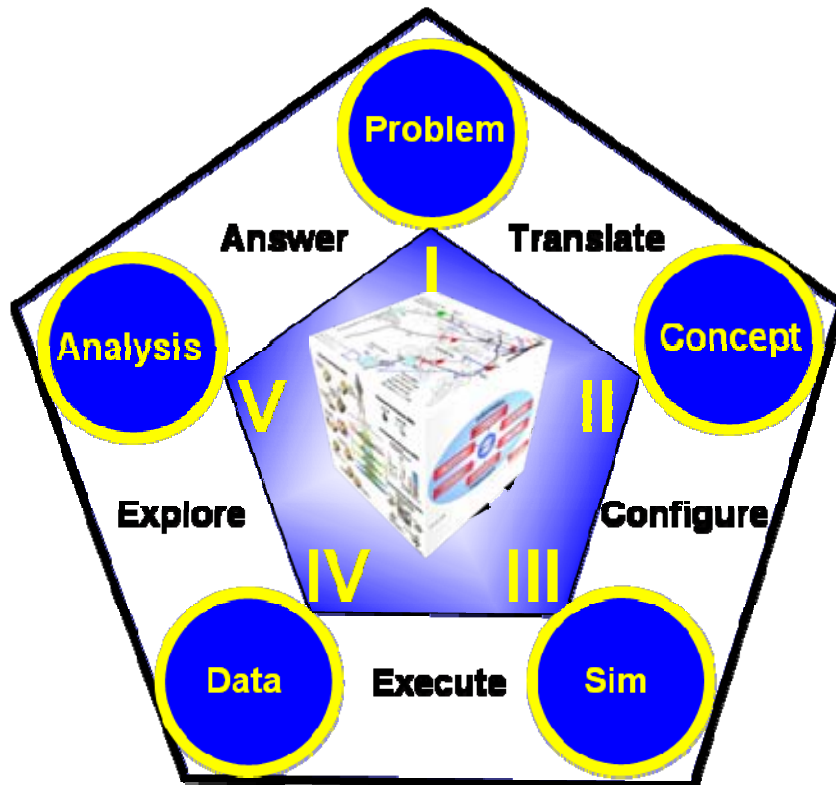
I.   Identify customer questions.

II. Define the concept that addresses customer questions.

III. Determine simulation requirements and develop model configuration.

IV. Generate metrics from simulation results .

V.   Apply analysis methods to address customer question.

- S4 is a small-unit force-on-force Agent based simulation designed to assess SoS effectiveness.

- As an Agent based model, the approach to decision making is very different than current Army force-on-force models.

  – Emphasis is placed upon the military decision making processes (DMPs) and the communications network that link these DMPs within a SoS.

  – Each DMP represents human decision makers on the battlefield that is dynamically driven by the information available during simulation execution
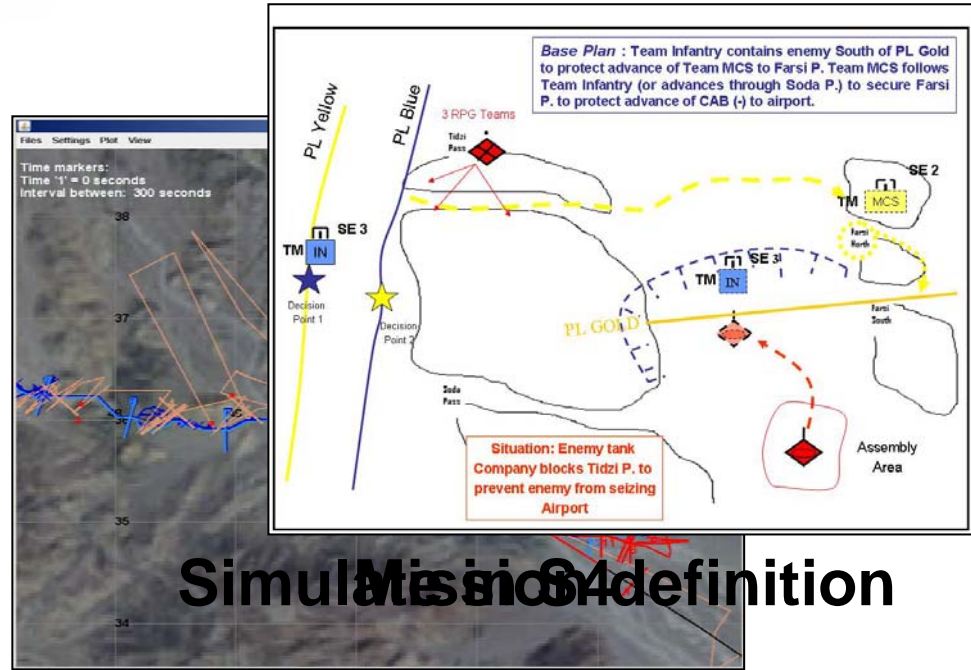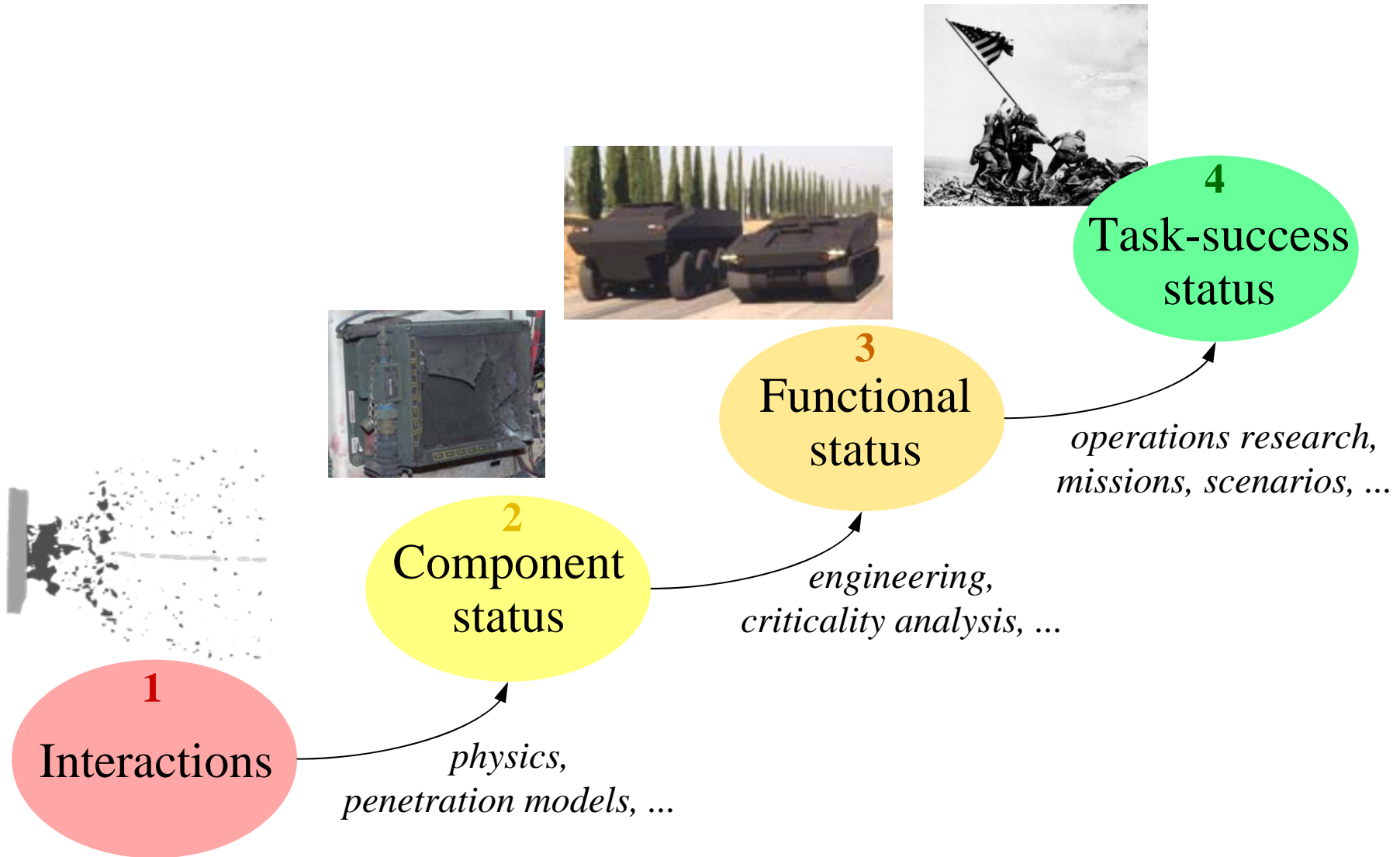

Simulate S4 **Mission definition**
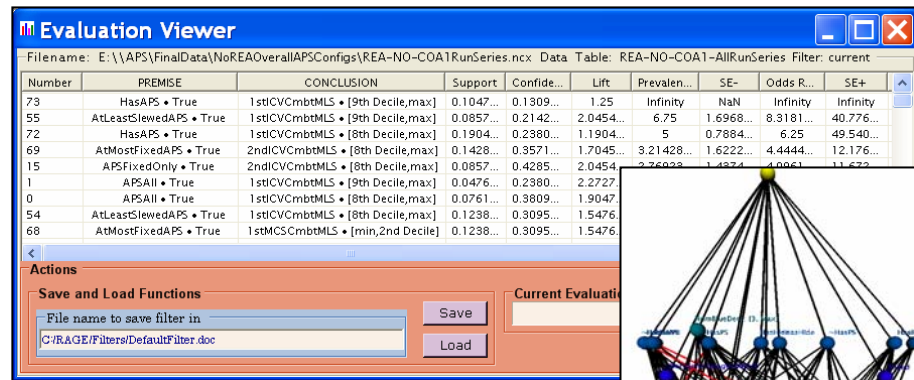
Analyze results
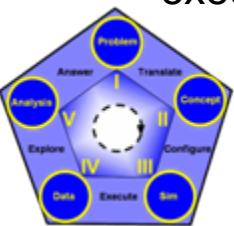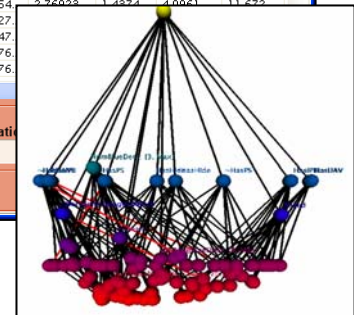
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1 Interactions

physics, penetration models, ...

2 Component status

engineering, criticality analysis, ...

3 Functional status

operations research, missions, scenarios, ...

4 Task-success status

(12) Level 2, (40) Level 3 Elements of Functional Degradation (EFD) , and (2) Level 4 Loss-of-Functional (LoF) Utility

Level 2

Crew

c_1 Commander Incapacitated
c_2 Squad Leader Incapacitated
c_3 Driver Incapacitated

Passengers

p_1 Passenger 1 Incapacitated
p_2 Passenger 2 Incapacitated
p_3 Passenger 3 Incapacitated
p_4 Passenger 4 Incapacitated
p_5 Passenger 5 Incapacitated
p_6 Passenger 6 Incapacitated
p_7 Passenger 7 Incapacitated
p_8 Passenger 8 Incapacitated

Catastrophic Loss

$k1$ Fuel/Ammo

Level 4

Loss of Function

MLOF Mobility Loss of Function
FLOF Firepower Loss of Function

Level 3

Mobility

$m_{1.1}$ Reduced Maximum Speed 20%
$m_{1.2}$ Reduced Maximum Speed 40%
$m_{1.3}$ Reduced Maximum Speed 60%
$m_{1.4}$ Reduced Maximum Speed 80%
$m_{1.5}$ Reduced Maximum Speed 100%
$m_{2.1.1}$ Reduced Acceleration 20%
$m_{2.1.2}$ Reduced Acceleration 40%
$m_{2.1.3}$ Reduced Acceleration 60%
$m_{2.1.4}$ Reduced Acceleration 80%
$m_{2.1.5}$ Reduced Acceleration 100%
$m_{2.2.1}$ Reduced Steering 20%
$m_{2.2.2}$ Reduced Steering 40%
$m_{2.2.3}$ Reduced Steering 60%
$m_{2.2.4}$ Reduced Steering 80%
$m_{2.2.5}$ Reduced Steering 100%
$m_{2.3.1}$ Reduced Braking 20%
$m_{2.3.2}$ Reduced Braking 40%
$m_{2.3.3}$ Reduced Braking 60%
$m_{2.3.4}$ Reduced Braking 80%
$m_{2.3.5}$ Reduced Braking 100%
$m_{2.4}$ Reduced Visibility (driver's sensor)
$m_{3.1}$ Stop After 60 Minutes
$m_{3.2}$ Stop After 30 Minutes
$m_{3.3}$ Stop After 10 Minutes
$m_{3.4}$ Stop After 1 Minute
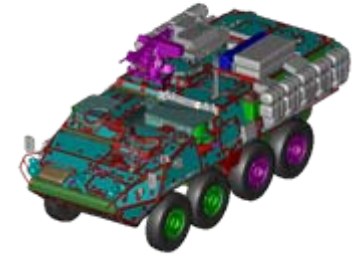
Firepower

f_1 Lost Ability To Fire Buttoned Up Main (RWS)
f_3 Degraded Initial Rate of Fire of Main (RWS)
f_4 Degraded Subsequent Rate of Fire of Main (RWS)
f_7 Total Loss of Firepower Main
f_{12} Total Loss of Firepower Secondary

Communication

$x_{1.1}$ Reduced Range (antenna loss)
$x_{1.2}$ Reduced Range (power amp loss)
x_2 Lost Line-of-Sight (LOS) Data
x_3 Lost LOS Voice
x_4 Lost Non-LOS Data
x_7 Lost External Communications
  $x_{7.1}$ Lost Encryption Capability
  $x_{7.2}$ Lost Channel/Frequency Selection Capability
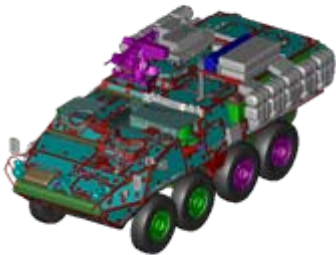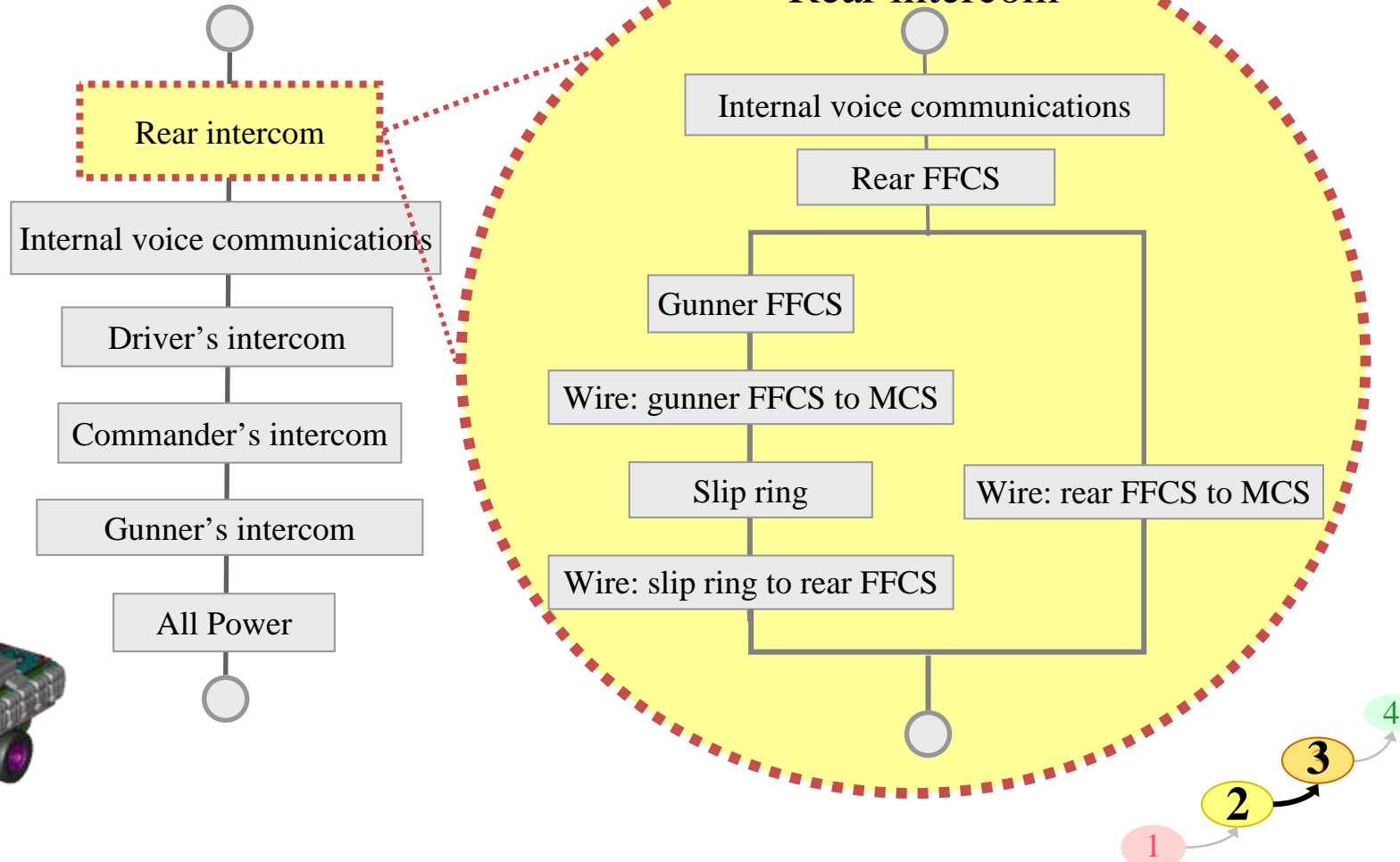
Target Acquisition ('sensing')

a_1 Lost Daylight Acquisition
a_2 Lost Night Acquisition
a_3 Lost Range Finder Capability

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The x_6 fault tree… cutting it degrades the system with **lost internal communications**

Rear intercom

Rear intercom

Internal voice communications

Driver's intercom

Commander's intercom

Gunner's intercom

All Power

Internal voice communications

Rear FFCS

Gunner FFCS

Wire: gunner FFCS to MCS

Slip ring

Wire: rear FFCS to MCS

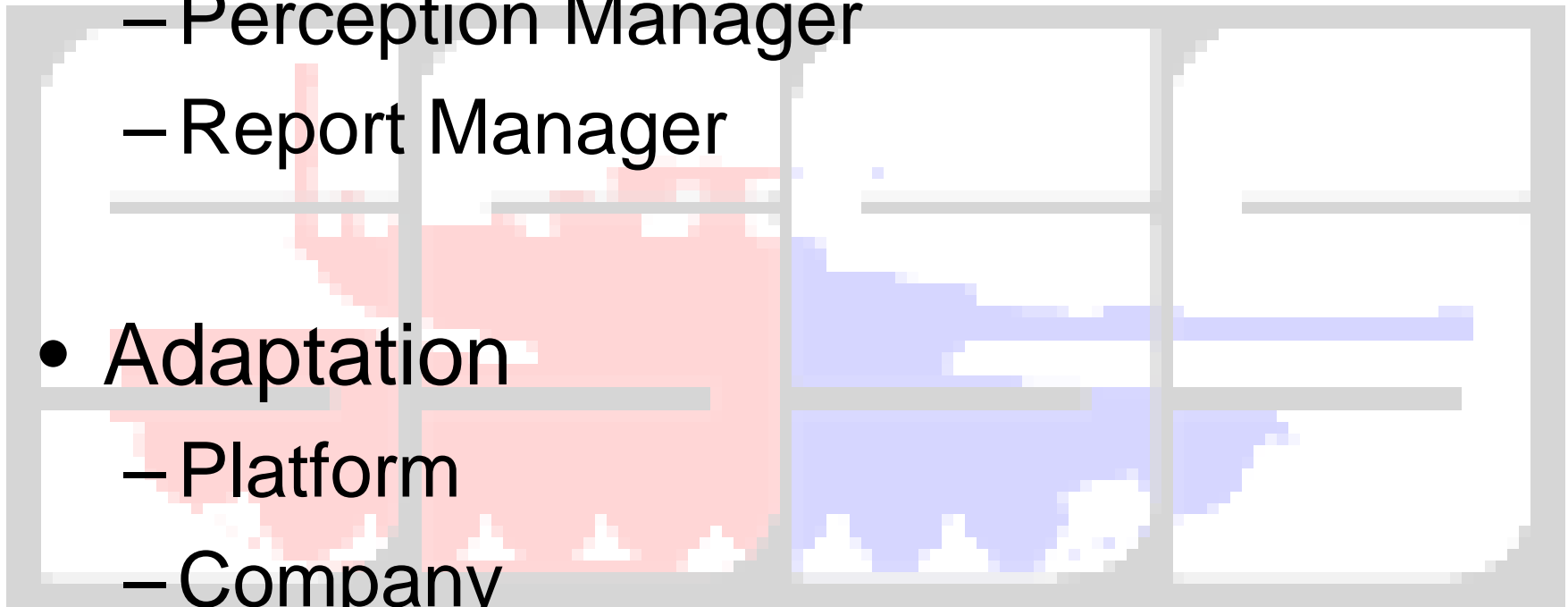Wire: slip ring to rear FFCS

1 2 3 4

- # Awareness of EFDs
 - ## Perception Manager
  - ## Report Manager
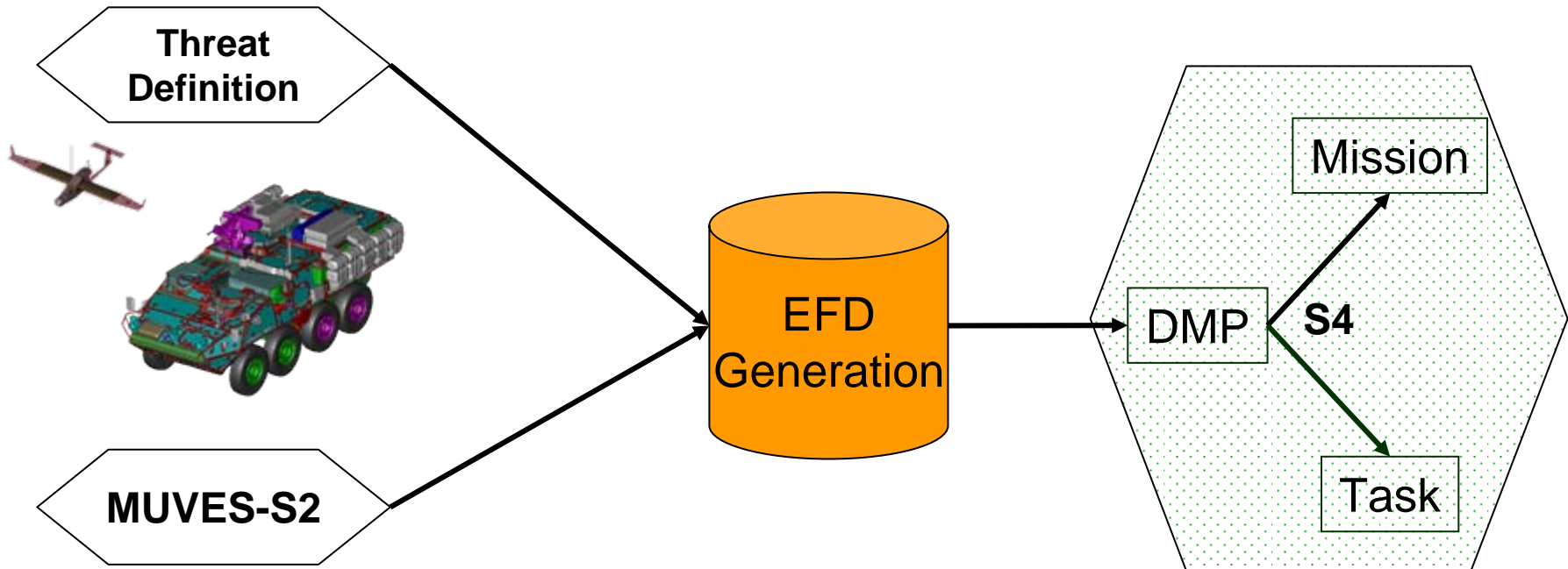
- # Adaptation
  - ## Platform
  - ## Company
  - ## Platoon

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- How can Mission-based analysis support cost effective test planning, i.e., Live-Fire shot selection and Developmental/Operational Testing?
    - What EFD are critical to operational testing ($O_{3,4}$)?
    - What performance parameters are important to capture in developmental testing?
    - What are the platform vulnerability issues to assess with MUVES-S2?
- How can the impact of a test event be shown in a mission context?
    - What EFDs impact mission success?
    - By contrast, for which EFDs can the unit compensate?
- Can unknown SLV issues be revealed (discovered) via simulation involving adaptive agents?

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Threat Definition

MUVES-S2

EFD Generation

DMP   S4
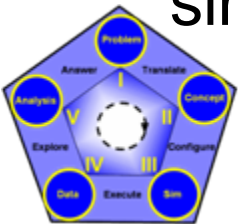
Mission

Task

- $O_{3,4}$ in a controlled environment:
  - Assess task execution to "attack by fire"
- $O_{3,7}$
  - Assess EFD impact on mission

Demonstration objective was to put ballistic damage into mission context.

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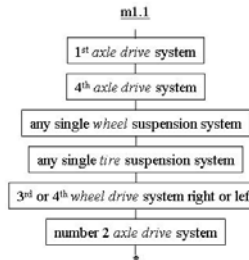- Benefits to Test & Evaluation community
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Mission-based T&E
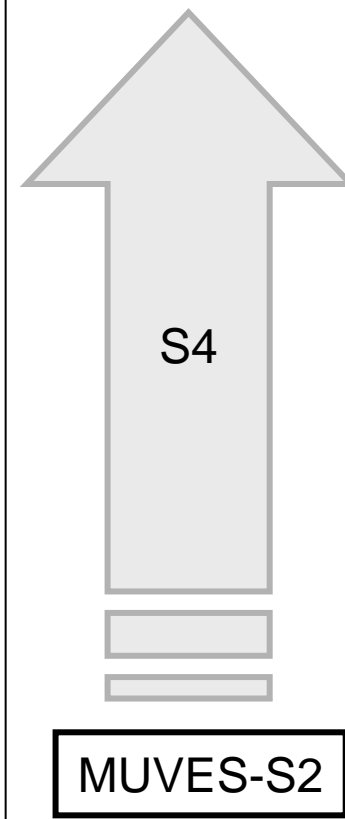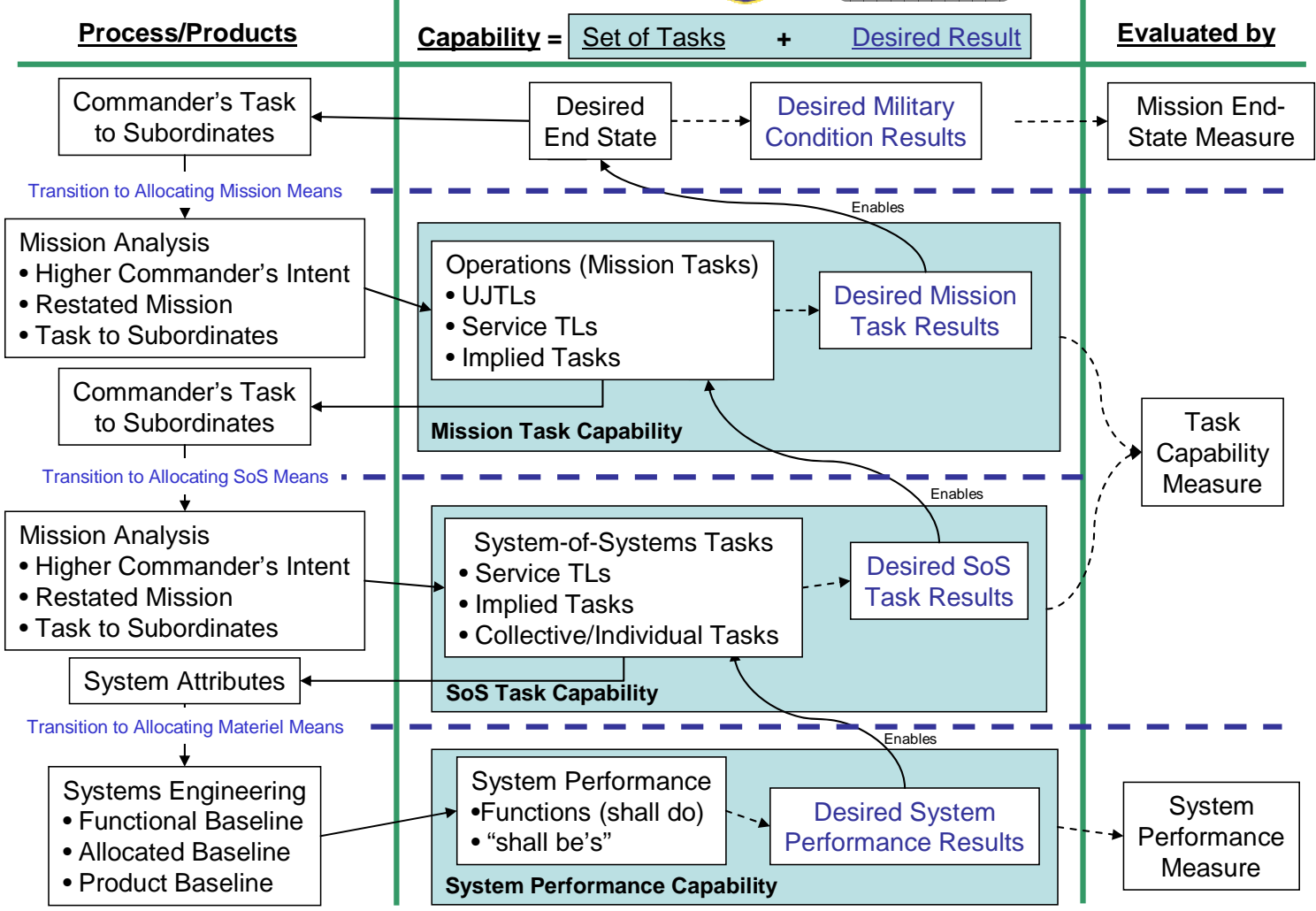
System representation (for each variant)

- Criticality analysis:
  - List of elements of functional degradation (EF...
  - System (critical categories and EFD) represen...
- Identified tasks.
- Task to requirement capability mapping.

Model results analysis

- Cell-by-cell
  - Probability of each EFD per threat.
  - Probability of task failure.
- Bar charts
  - Probability of each EFD per threat.
  - Probability of task failure.
- View average tables
  - Probability of each EFD per threat.
  - Probability of task failure.
- Identified critical categories/components and EFD driving vulnerability.
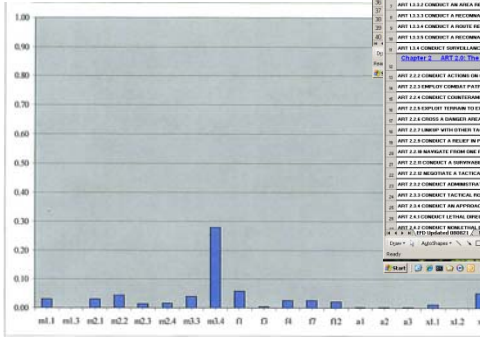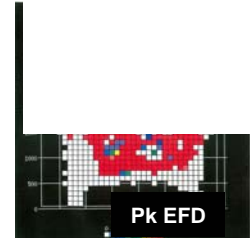
Damage assessment and post-shot analysis report

- Identified critical categories/components and EFD driving vulnerability.
- Correlate ballistic damage to mission essential task failure.

Pk EFD

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For each platform

- Cumulative time that the platform spent with each EFD.

For each platform type

- A count of the total number of hits on platforms of each type by all munition types.

- Correlation of critical category to EFD.

- The absolute mean time a platform of a given type spends in each EFD.

Mean cumulative time in each ECD for instance: ICV-A15
Cumulative time spent in ECD 0 (m1.1) = 0.0 or 0.0 %
Cumulative time spent in ECD 1 (m1.2) = 0.0 or 0.0 %
Cumulative time spent in ECD 2 (m1.3) = 0.0 or 0.0 %
Cumulative time spent in ECD 3 (m1.4) = 364.75 or 29.53 %
Cumulative time spent in ECD 4 (ml.5) = 0.0 or 0.0 %
Cumulative time spent in ECD 5 (m2.1.1) = 0.0 or 0.0 %
Cumulative time spent in E
Cumulative time spent in E
Cumulative time spent in E

hits on platform type ICV by munition type ExampleLargeKE is 3
P(m3.3 | hit by threat ExampleLargeKE) = 0.6666666666666666
P(m3.2 | hit by threat ExampleLargeKE) = 0.6666666666666666
P(m1.1 | hit by threat ExampleLargeKE) = 0.6666666666666666
P(m3.1 | hit by threat ExampleLargeKE) = 0.6666666666666666
P(m3.4 | hit by threat ExampleLargeKE) = 0.6666666
P(m2.1.2 | hit by threat ExampleLargeKE) = 0.666666
P(m2.1.3 | hit by threat ExampleLargeKE) = 0.666666
P(m2.1.4 | hit by threat ExampleLargeKE) = 0.666666
P(m2.1.5 | hit by threat ExampleLargeKE) = 0.666666
P(m2.2.2 | hit by threat ExampleLargeKE) = 0.666666
P(m1.3 | hit by threat ExampleLargeKE) = 0.6666666

Results for cc antenna (1) vs EFD m1.2 (1):
Sample size = 5
Prob (Y | X) = 0.75
   Raw data
   1   0
   1   3
mean and std dev for X = 0.8 0.39999999999999997
mean and std dev for Y = 0.6 0.4898979485566356
Covariance of X and Y = 0.12
Correlation of X and Y = 0.6123724356957946

Mean cumulative time in each EFD for all targets of type: ICV
Cumulative time spent in EFD 0 (m1.1) = 388.0 or 38.8 %
Cumulative time spent in EFD 1 (m1.2) = 388.0 or 38.8 %
Cumulative time spent in EFD 2 (m1.3) = 388.0 or 38.8 %
Cumulative time spent in EFD 3 (m1.4) = 388.0 or 38.8 %
Cumulative time spent in EFD 4 (ml.5) = 388.0 or 38.8 %
……………..
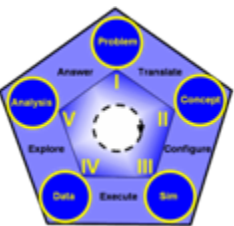
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- Integration of higher fidelity V/L data within the SoSA process has been demonstrated.

- DMPs have been enhanced to utilize additional information provided by higher fidelity V/L data.

- In light of the Mission-based T&E strategy, the community can benefit from higher fidelity V/L data and SoSA capability development in SLAD.

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