



Using the Missions and Means Framework to Generate Cost-Effective Live-Fire Test and Evaluation Strategies

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Introduction



Live-fire testing (Joint Live Fire and Title 10 LFT&E) is now in its third decade.

Contributions of LFT&E

- Identification and verification of system and munition design strengths and weaknesses
- Quantification of crew hazards from the spectrum of insults
- Motivation of verification & validation (V&V) of system-level analytical models

Key to success: Identification of critical evaluation issues — significant design and deployment concerns — on which to focus testing and analysis



Issues Addressed



- Are current Live-Fire Test & Evaluation (LFT&E) processes relevant and useful in light of current changes in:
 - war-fighting?
 - system designs?
 - integrated information-centric battlefield?
 - extended mission timelines?

- What changes are needed in LFT&E strategies to address the role of the tested platform in the context of a collection of assets available to the unit commander to prosecute a wide range of complex missions?



Issues Addressed

- Considering risk, cost, availability of hardware, and production schedule, how can LFT&E programs be constructed to ensure decision-makers are provided with data in a format that allows them to ascertain the likelihood of completing system of system (SoS) collective tasks?
- How does the Missions and Means Framework (MMF) provide a foundation for the development of cost-effective LFT&E strategies and programs?
- What issues must be addressed in the implementation of the proposed MMF-based SoS task-focused approach to LFT&E?



Objective of Test and Evaluation



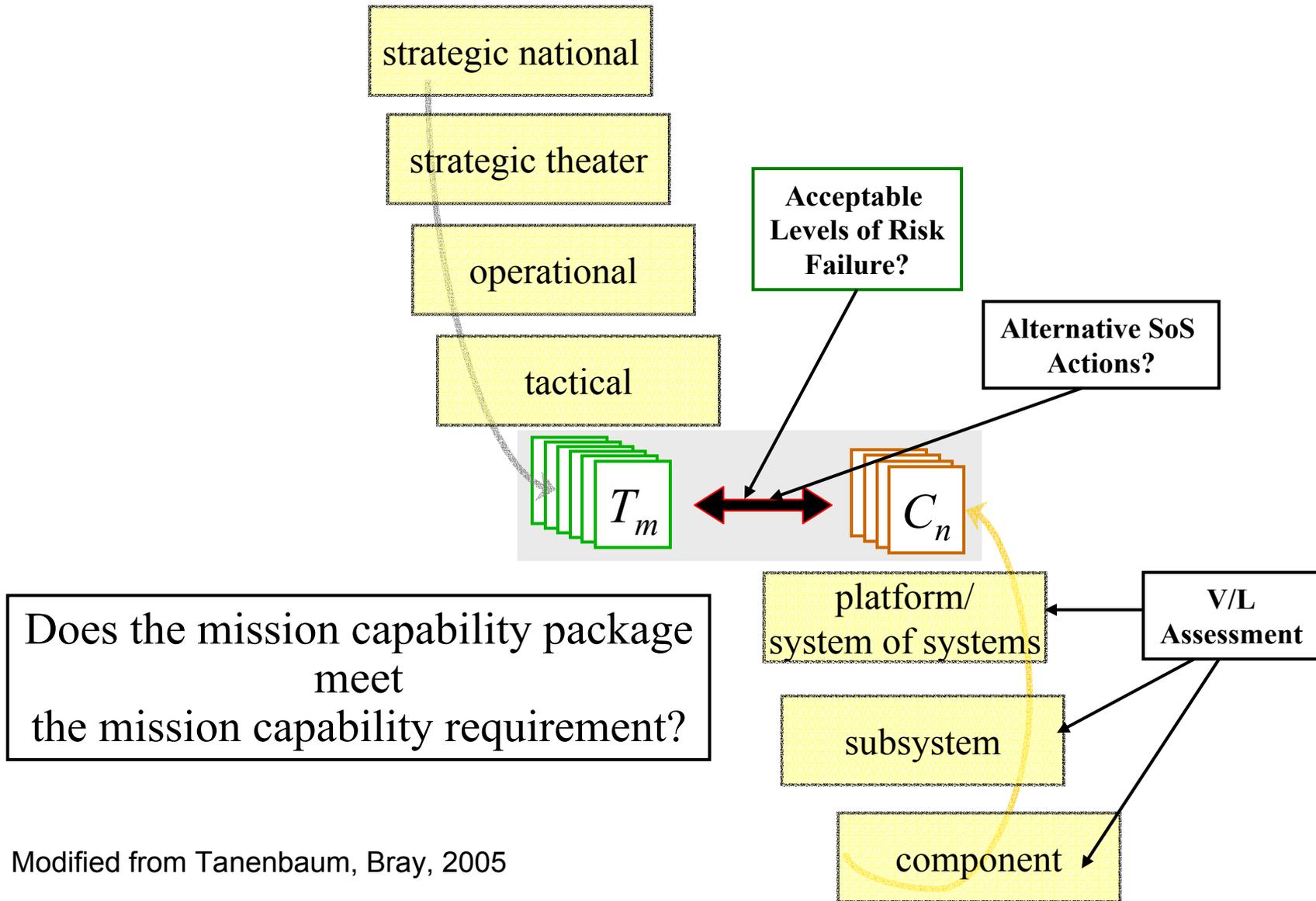
Assess capabilities of SoS platforms, individually and collectively, to complete identified tasks in tactically realistic scenarios

Understanding of
Hardware Hierarchy
that Induces
Capabilities

Understanding of
Mission Hierarchy
that Induces
Tasks
Standards
Conditions



Assessing Capabilities Against Mission/Task Requirements





Objectives of an Effective LFT&E Program

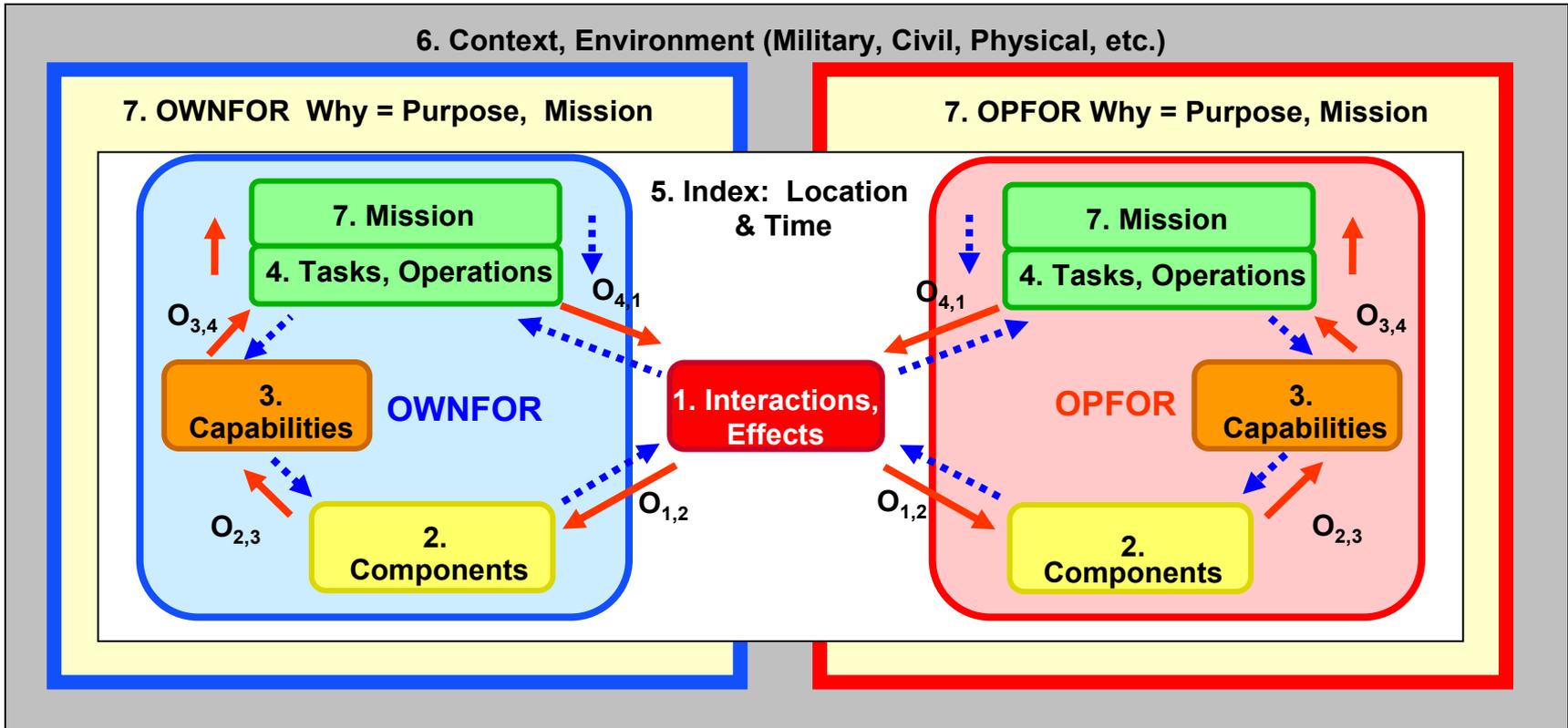


An effective vulnerability LFT&E program in an SoS environment provides data that allow evaluators to assess:

- The extent to which the platform retains those capabilities determined to be needed for completion of SoS tasks, when the system interacts with the full spectrum of ballistic threats likely to be encountered in combat.
- The extent to which the SoS is able to complete the identified mission tasks in the joint environment, given the residual and available (as determined in LFT&E) capabilities of the tested platform.



Missions and Means Framework: Foundation for Cost-Effective LFT&E



The MMF provides the foundation for developing cost-effective LFT&E strategies by establishing the links among mission tasks, platform capabilities, platform components, and interactions of ballistic threats and tested platform.



Critical Issues – Keys to LFT&E Success

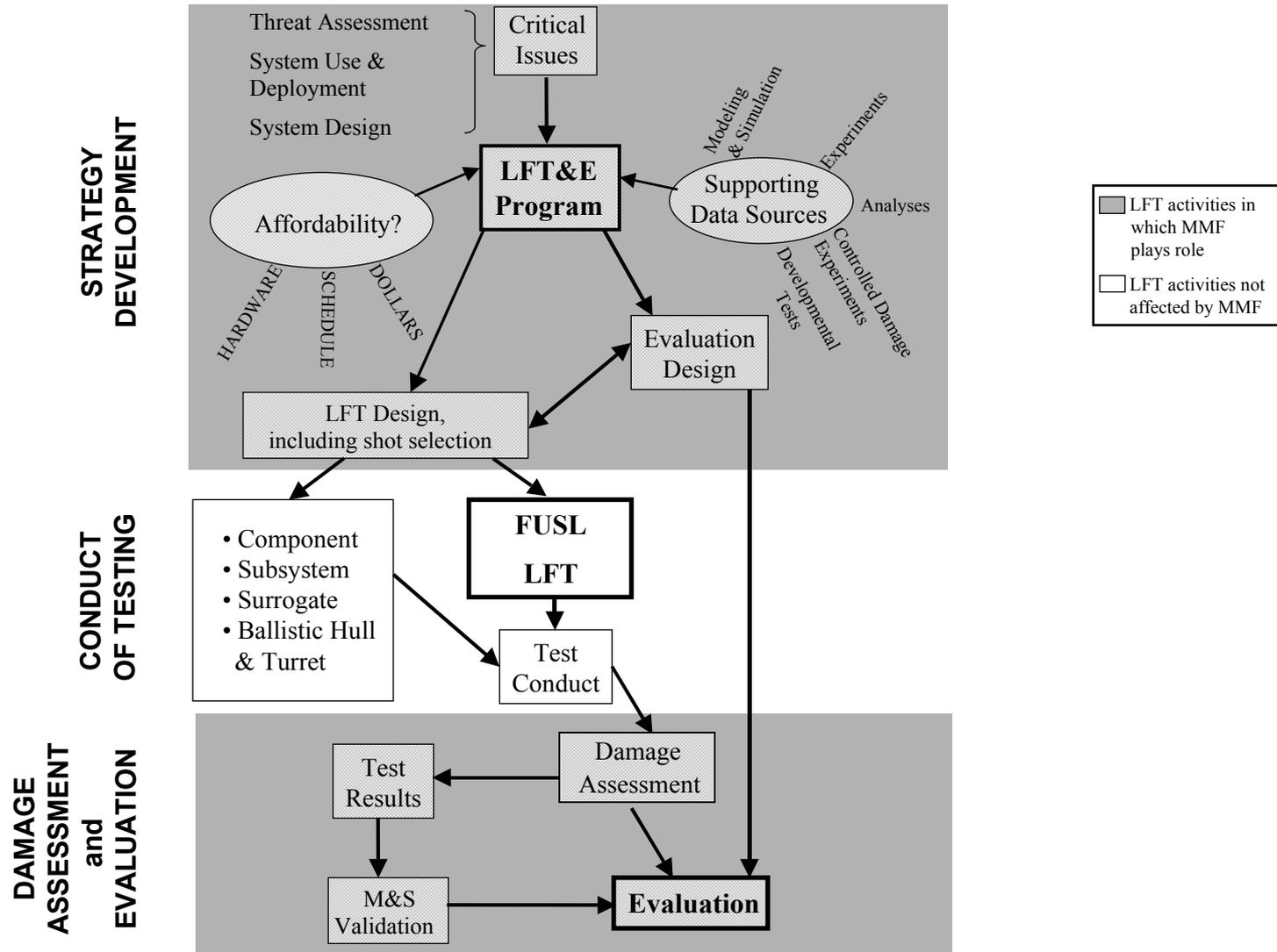


- To evaluate armor platform vulnerability solely through FUSL testing, tens of thousands of FUSL tests would be required.
 - Example for armor platform:
 - 10+ threat classes (small arms, mines, etc; several variants in each)
 - 8+ attack directions per threat
 - 500+ impact points per attack direction ...
 - ➔ easily over 40,000 firings
 - Fortunately we don't rely only on testing; many combinations can easily be eliminated.
 - Inspection and engineering judgment
 - Analysis
 - Etc.
 - Even if 90% can be easily eliminated, several thousand possible firings remain.
- A typical FUSL LFT can afford 10 – 20 firings.
 - Critical issues in LFT&E strategy specify rationale for which 10 or 20 shots of the possible thousands will be most productive.
 - Define critical evaluation issues, i.e., questions to be answered through FUSL LFT.
 - Determine how supplementary data can be combined with FUSL results.

MMF provides basis for rational cost-effective strategy.



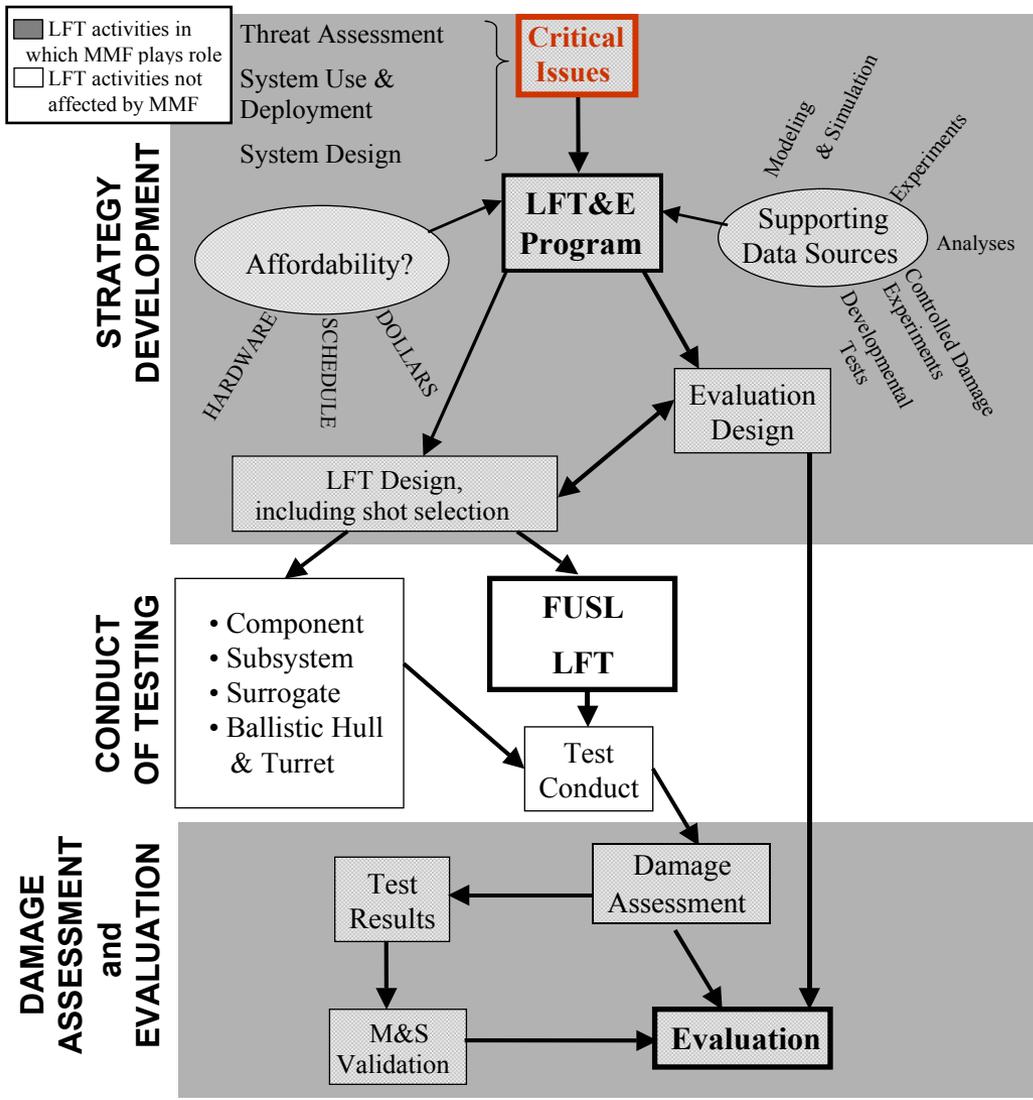
Influence of MMF on LFT&E Process





Differences Between Platform-Centric and MMF Task-Focused Strategies

- Critical Issues -



Critical Issues

Platform-centric strategy

1. **Vulnerability of the platform?**
2. Remaining **platform mission utility?**
3. Role of BDAR in restoring **platform functional capability?**

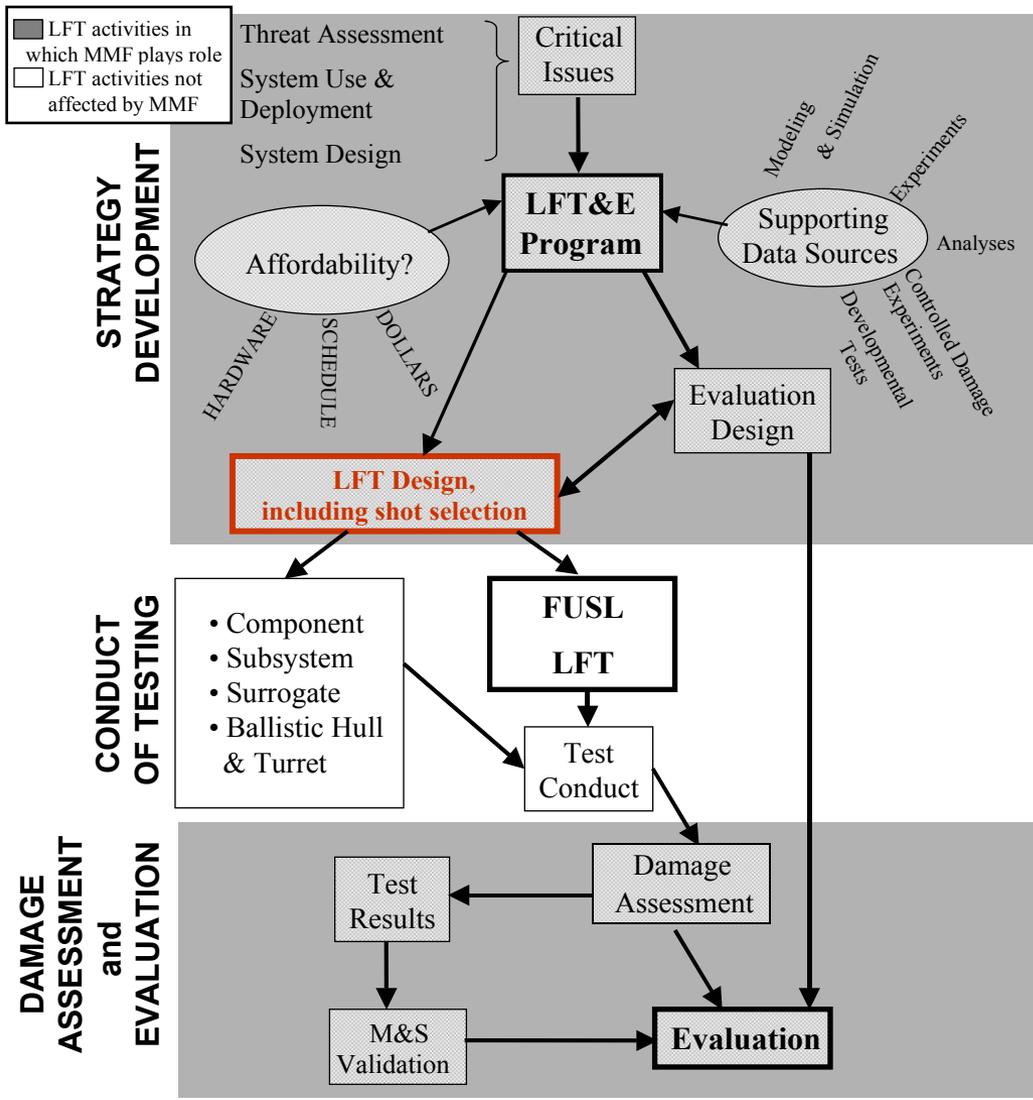
MMF-based SoS task-focused strategy

1. **Reduction in the ability of the SoS to prosecute typical missions?**
2. Remaining **platform capabilities?**
3. Role of BDAR **and other maintenance actions in restoring SoS capabilities critical to mission prosecution?**

[With both strategies, causes and effects of crew injury are usually critical sub-issues.]



Differences Between Platform-Centric and MMF Task-Focused Strategies - Shotline Selection -



Shotline Selection

Platform-centric strategy

Shotlines are selected on basis of technical risk associated with inability to determine **platform capability**.

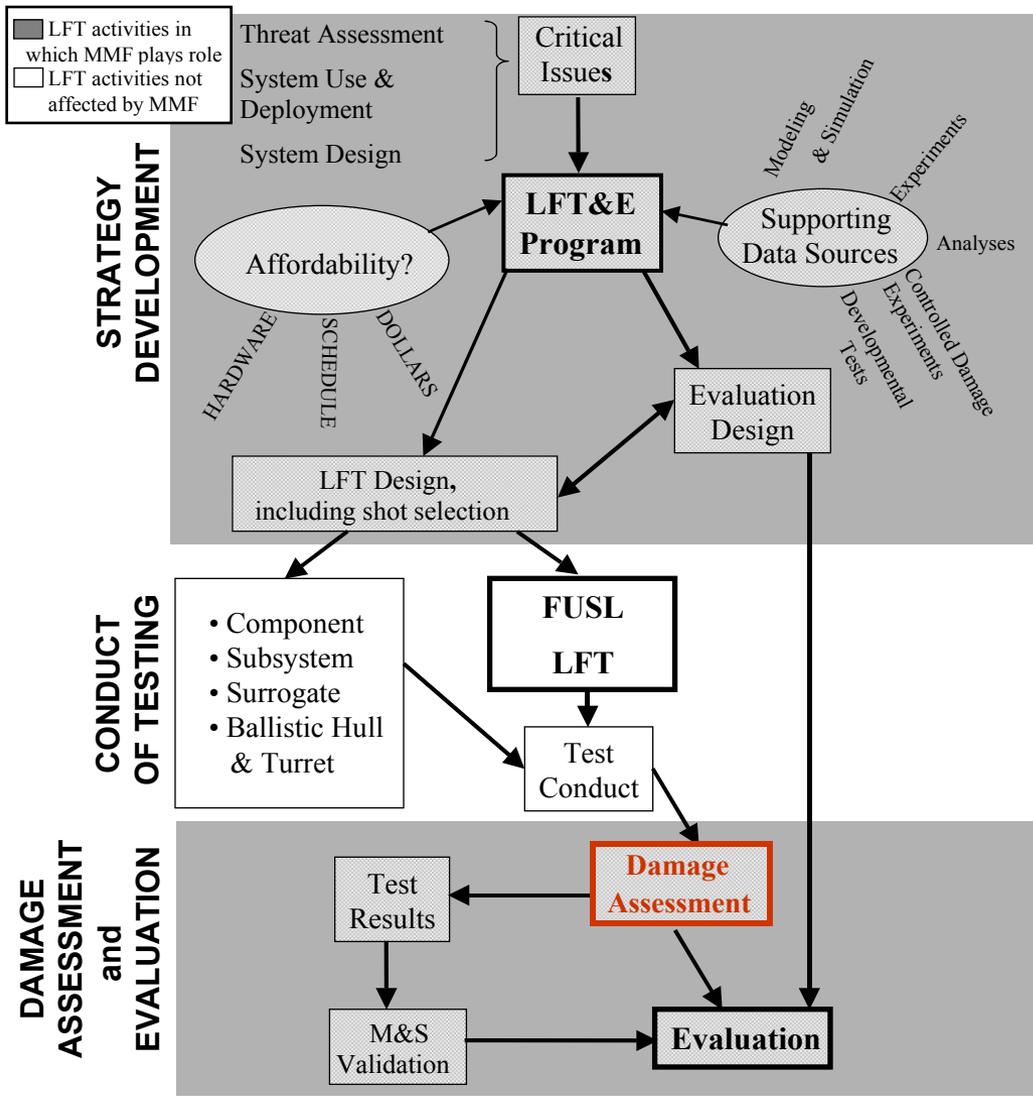
MMF-based SoS task-focused strategy

Shots are selected on basis of technical risk associated with inability to determine **effect on mission prosecution caused by loss of platform capabilities**.

(With both strategies, shots against crew are selected on basis of technical risk associated with ability to predict injury to crew and passengers.)



Differences Between Platform-Centric and MMF Task-Focused LFT&E Strategies - Damage Assessment -



Damage Assessment

Platform-centric strategy

Platform: Map subsystem loss of function to **combat utility via O_{3,4} mapping construct**

Battle Damage Assessment and Repair: Expedient repairs to restore platform to **some level of combat utility**

MMF-based SoS task-focused strategy

Platform: Map subsystem loss of function to **SoS capabilities by analysis and operational-type tests**

Mission Damage Assessment and Repair:

- BDAR: Expedient repairs to restore **some platform capabilities immediately following an engagement**
- **Other maintenance procedures to anticipate future mission engagements**

(With both strategies, crew and passenger casualties are assessed.)



Building a Cost-Effective LFT&E Program



Consideration of Budgetary Constraints

Cost-Effective LFT&E Program

Identification of critical issues to be addressed in elements of LFT&E program

Prioritization of data voids and the design of LFT (including shot selection) to address the prioritized data voids

Design & execution of the evaluation process, in which results of LFT & other program-supporting activities are considered

Foundation: Missions and Means Framework



Cost-Effective LFT&E: Assessing Vulnerability Risk



Likelihood that a significant vulnerability (personnel casualties, catastrophic loss of system, failure to complete mission tasks) will remain undetected in a fielded platform

Inherent
Risk

Operating environment: susceptibility of system to significant system & personnel vulnerabilities

Control
Risk

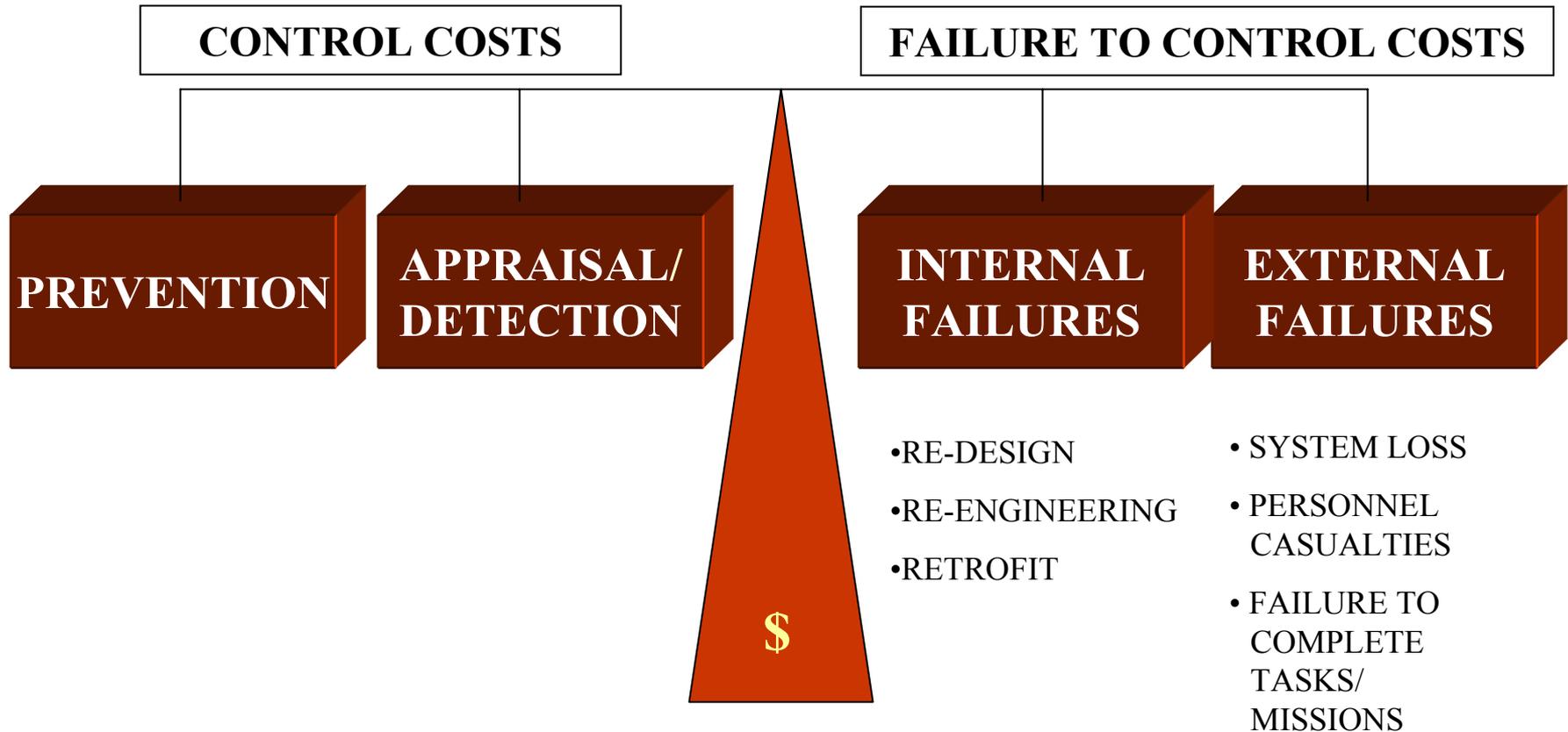
Survivability/
vulnerability
program activities of project manager office (PMO)/contractor: risk that significant vulnerability will not be prevented during the design & production phases of system

Detection
Risk

Activities performed by sources independent of PMO/contractor: risk that significant vulnerability will not be discovered prior to fielding



Cost-Effective LFT&E: Weighing Costs of Vulnerability Assessment

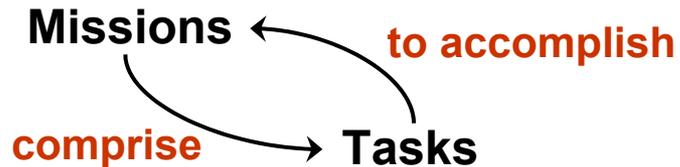




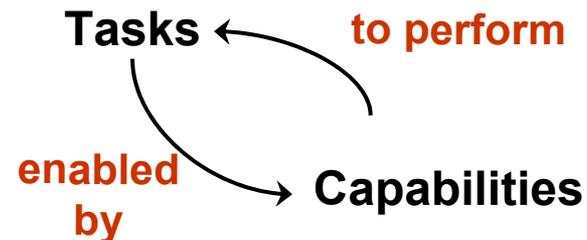
Cost-Effective LFT&E Programs: Assumptions



- Decomposition of relevant missions into lower-level tasks will have been completed.



- A relationship between lower-level tasks and the minimum levels of system capabilities needed to complete those tasks will have been established.

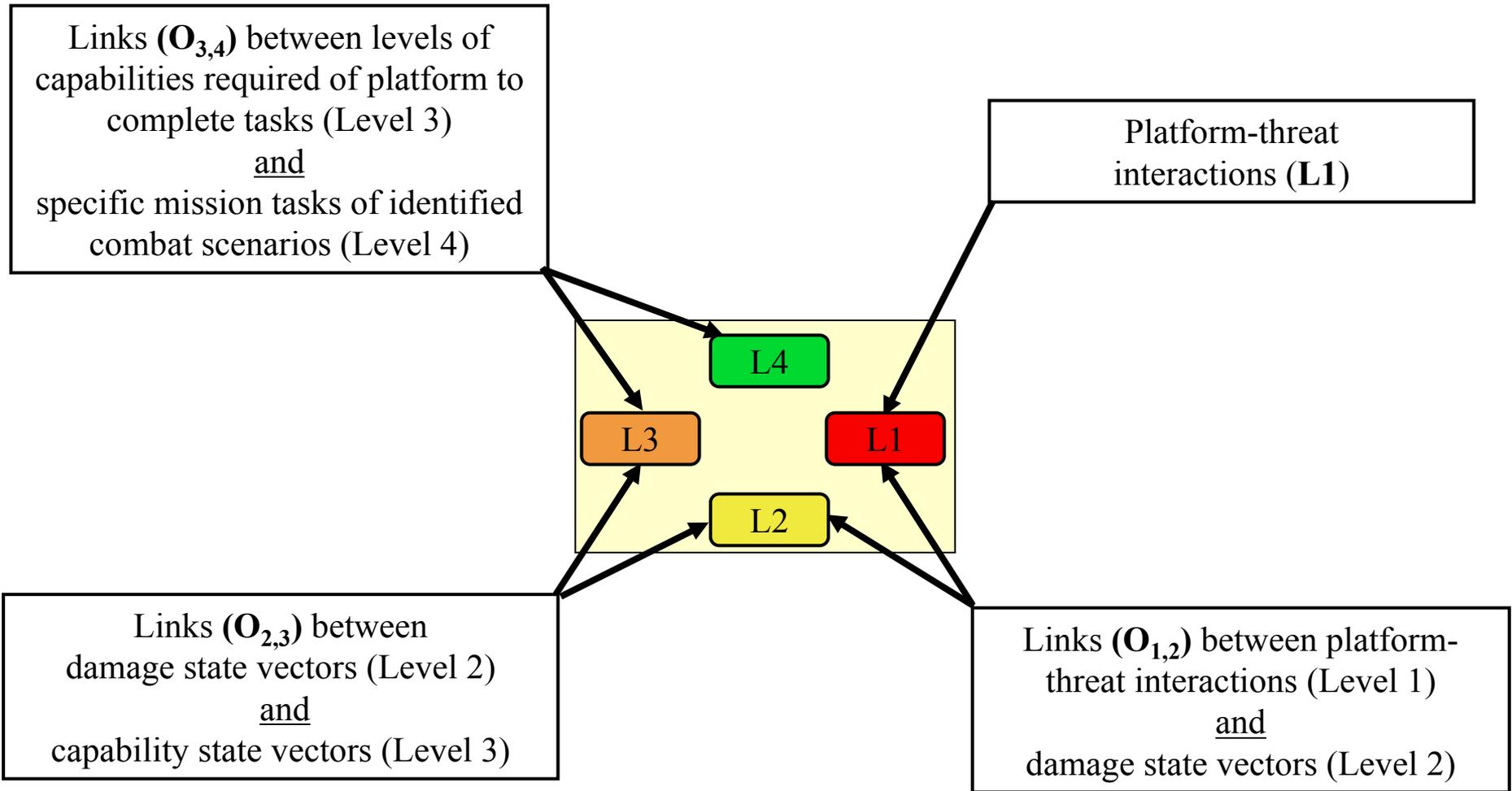


- The platforms and SoSs that provide the capabilities to complete the tasks will have been identified; redundancies and interdependencies between platforms are known.

**Operational Requirements capture
required capabilities.**



Cost-Effective LFT&E: Identify Data Required to Assess Vulnerability in Ballistic Interactions





Cost-Effective LFT&E: Sources for Required Data



- Results of material, component, subsystem, & system-level tests of:
 - earlier models or current model of system
 - earlier or contemporary models of systems with similar technologies
- Design analyses with consideration to new materials/technologies
- Combat data relevant to damage mechanisms, system damage, and residual capabilities of system as associated with the identified threats
- Advanced technology and concept technology demonstrations
- Force development tests/experiments
- Warfighting experiments
- Engineering analyses and controlled damage experiments
- Modeling and simulation runs that incorporate system description, threat characteristics, and damage-mechanisms expected in threat-system interactions
- Failure Modes, Effects, and Criticality Analyses
- Results of developmental, operational, and production qualification tests



Cost-Effective LFT&E: Building Program



Identify available and reliable data.
Identify data voids.

Prioritize data voids (use experts with domain-specific experience, Analytic Hierarchy Process, Quality Function Deployment, etc.).

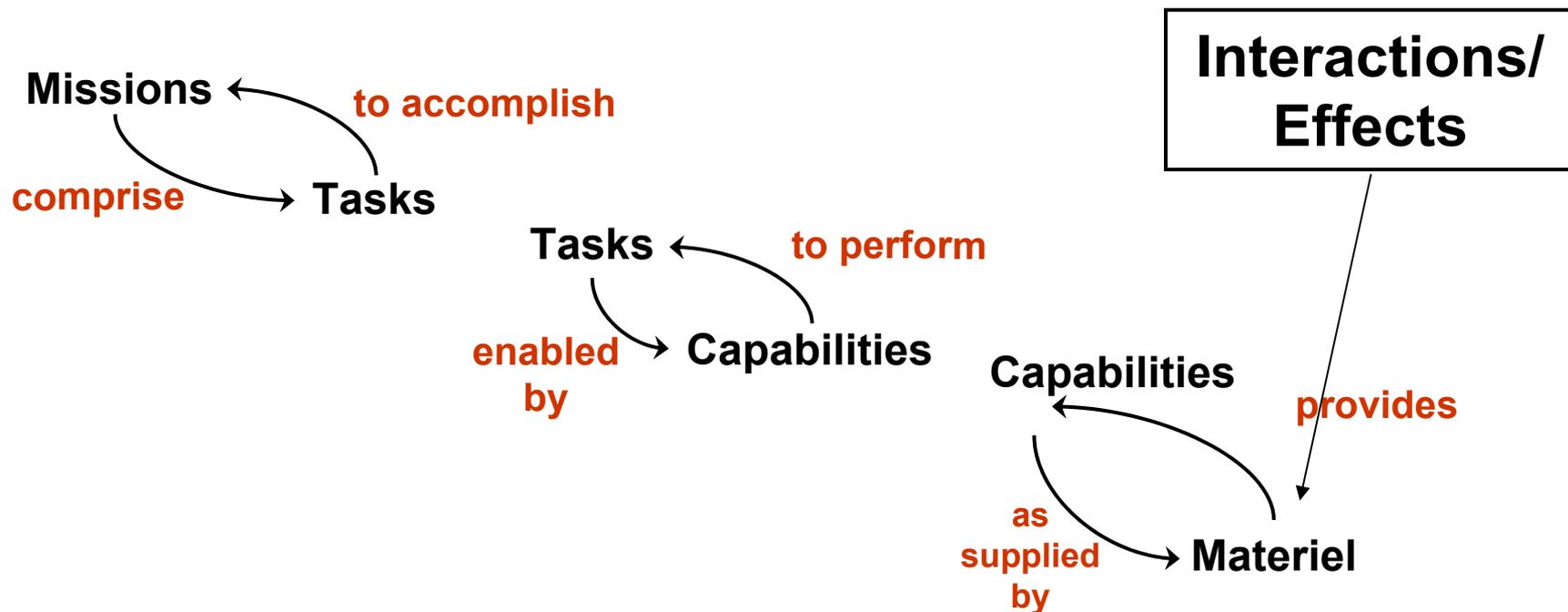
Identify alternative elements in a LFT program to fill data voids and select from among those elements.
Consider data priorities, element performance, costs, & risks.



Contribution of MMF to Planning for LFT and Evaluation of Results



The ability and inability to obtain reliable data pertaining to specific data voids have consequences for specific mission tasks, as shown through the links of:





Cost-Effective LFT&E: Building Program



**LFT&E Program
Element**

CDE

Component-Level Tests

Interaction Effect

Blast

Fire

**Critical
Data Void
X**

**Critical
Data Void
Y**

Critical Data Voids

**Cost
Of
elements?**

Capacity
To
address
data void?

Time
constraints
of
program
schedule?

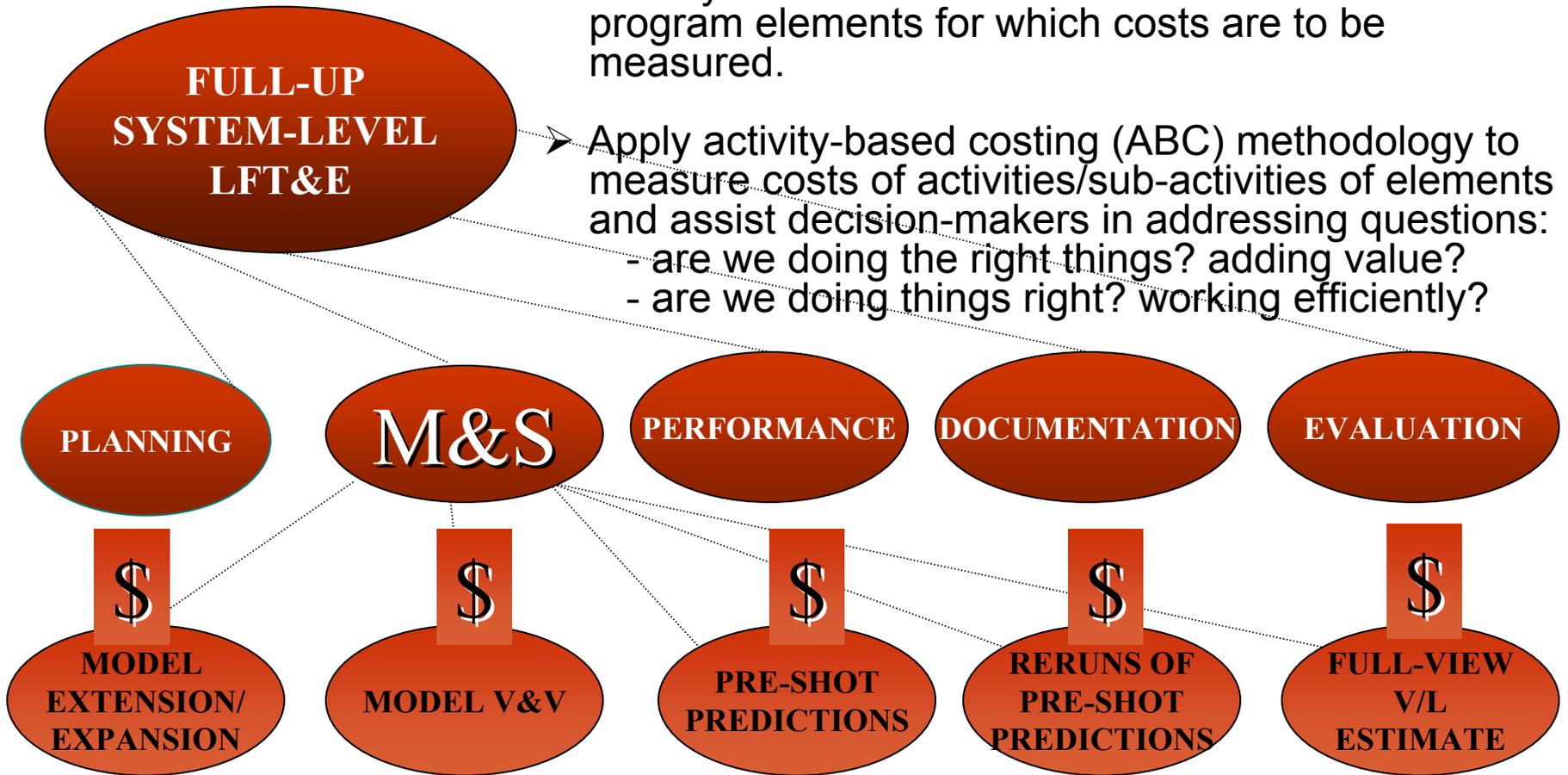
Production
schedule
& system
hardware
availability?



Cost-Effective LFT&E: Measuring Costs of FUSL LFT&E Element



- Identify the activities and sub-activities of the LFT program elements for which costs are to be measured.
- Apply activity-based costing (ABC) methodology to measure costs of activities/sub-activities of elements and assist decision-makers in addressing questions:
 - are we doing the right things? adding value?
 - are we doing things right? working efficiently?





Cost-Effective LFT&E: Measuring Costs of FUSL LFT&E Element



Applying ABC: Identify the direct material costs and the costs of resources used in cross-functional activities of the LFT program element.

DIRECT MATERIALS

Test Articles

Spare Parts

Munitions

Targets

COST OF ACTIVITIES

Planning

M&S

Test

Performance

Documentation

Evaluation



Cost-Effective LFT&E: Cost Complexities



- Costs of elements of vulnerability assessment are:
 - incurred by a multiple number of players.
 - reimbursed from a multiple number of sources.

- Methodologies for measuring and reporting costs across systems/divisions/Services are not uniform.

- Cost database with uniform accounting principles is not currently available for purposes of cost management/control and/or projection of future costs:
 - to afford consistency across time periods.
 - to afford comparability across systems/Services.



Cost-Effective LFT&E: Cost Database Requirements



- Identify specific data to be collected and reported.
- Identify methods for the measurement of costs, including the allocation of costs.
- Identify procedures for disclosure of cost measurement/allocation methods if alternative methods are available.
- Identify format for reporting costs (e.g., level of cost aggregation).
- Identify procedure for handling missing and incomplete data.



Cost-Effective LFT&E: Implementation Issues



To implement a cost-effective MMF-based SoS task-focused approach to LFT&E, need:

- Integration under the MMF of the efforts of acquisition, requirements, M&S, T&E, and training communities, achieved only through the support of top levels of defense administration
- Allocation of resources to appropriate Service divisions to ensure availability of test assets, including hardware, testing facilities/ranges, and people with the levels of expertise needed for the planning and evaluation processes



Cost-Effective LFT&E: Implementation Issues



To implement a cost-effective MMF-based SoS task-focused approach to LFT&E need:

- Construction of platform operational requirements based on the capabilities needed for the completion of multiple tasks of multiple missions
- Identification and measurement of costs of LFT&E elements according to a consistent methodology to allow a weighing of costs against the value added in conducting individual program elements