VERIDIAN

DELIVERING INFORMATION ON DEMAND

VERIDIAN ENGINEERING DIVISION

Aeronautics Sector

Use of Modeling and Simulation to Test and Evaluate the Interoperability Attribute Within the Context of a System of Systems

NDIA Conference

National Summit on U.S. Defense Policy: Acquisition, Research, Test and Evaluation conference

Discussion Topics

- **The requirement for Interoperable systems**
  - **Re-introduce the concept of a "System of Systems"**
- **Some effects of Acquisition Reform**
  - **Unforeseen consequences**
- **How those effects may be used to improve testing for Interoperability**

System Features and Characteristics

Systems may be defined in terms of the Attributes that must be associated with them.

- **Attributes of a notional aircraft system:**

Parameters

Accuracy
RCS
Range
Logistics Footprint
Payload
IR Signature
Speed
Maneuverability
EO Signature
Redundancy
Hardening
Acoustic Signature
EMCON

Functions

Acquire Target
Generate Sorties
Situational Awareness
Countermeasures
ID the Target
Wep/Sensor Integ
Accurate Navigation
Mission Level Intell
Pass/Rec Timely Info
Assess Bomb Damage
Route Planning
EMCON

Operational Flexibility/ Constraints

Carrier Suitability
Basing Flexibility
All Weather/Night Capability
Multi-Role Capability
Weap. Carriage Versatility
Mission Flexibility
Inter-Operability

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Inter-Operability

Interoperability

Ref: DoDD 5000.1

- **Interoperability is:**

  "the ability of systems, units, or forces to provide data, information, materiel, and services to and accept the same from other systems, units, or forces, and to use the data, information, materiel, and services so exchanged to enable them to operate effectively together."

System of Systems

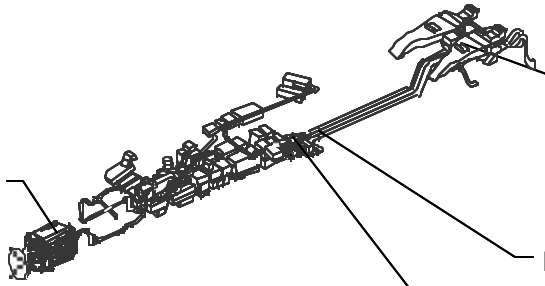
Ref: Admiral Owens (Proceedings, May 1995)

- **A System of Systems is:**

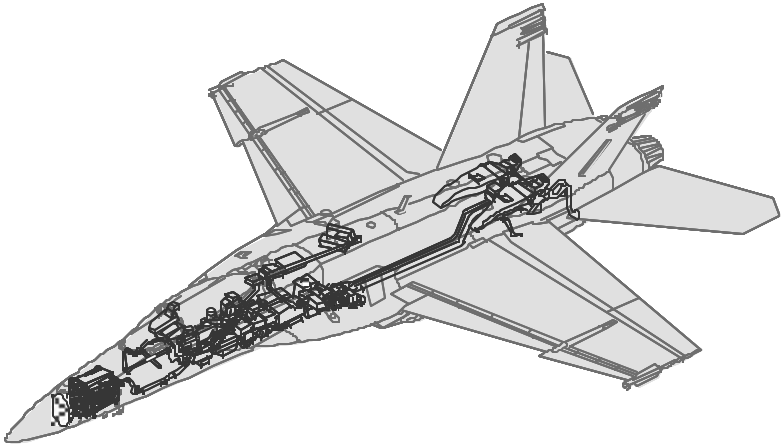
  "a regularly interacting or interdependent group of systems forming a unified whole."

Meta-Physical Systems Engineering Babble

F/A-18 AESA Radar Integration



F/A-18 AESA Radar Integration



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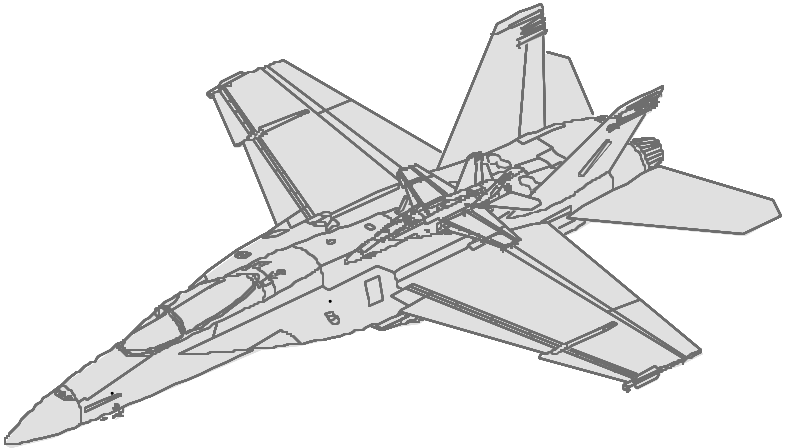
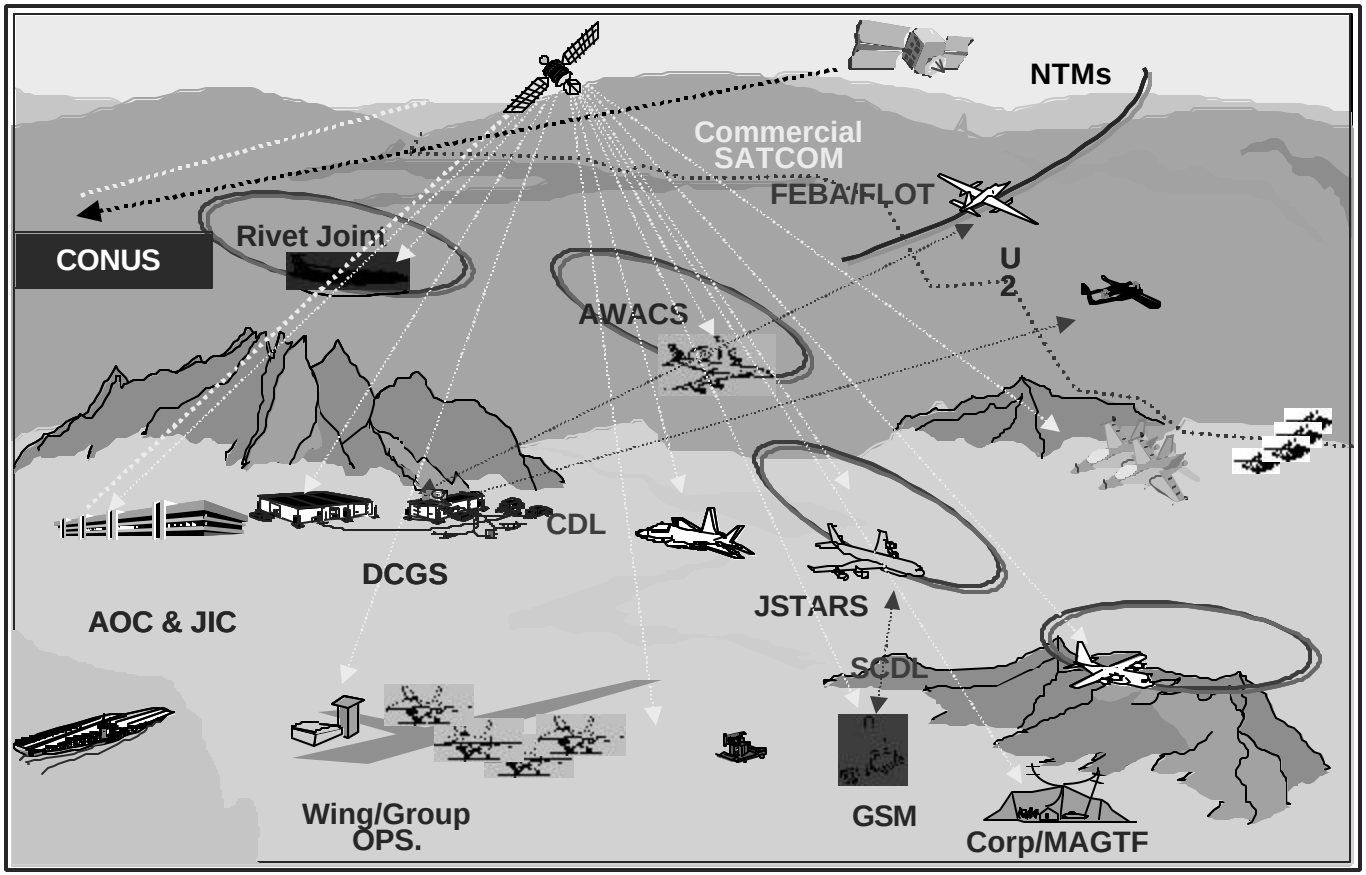
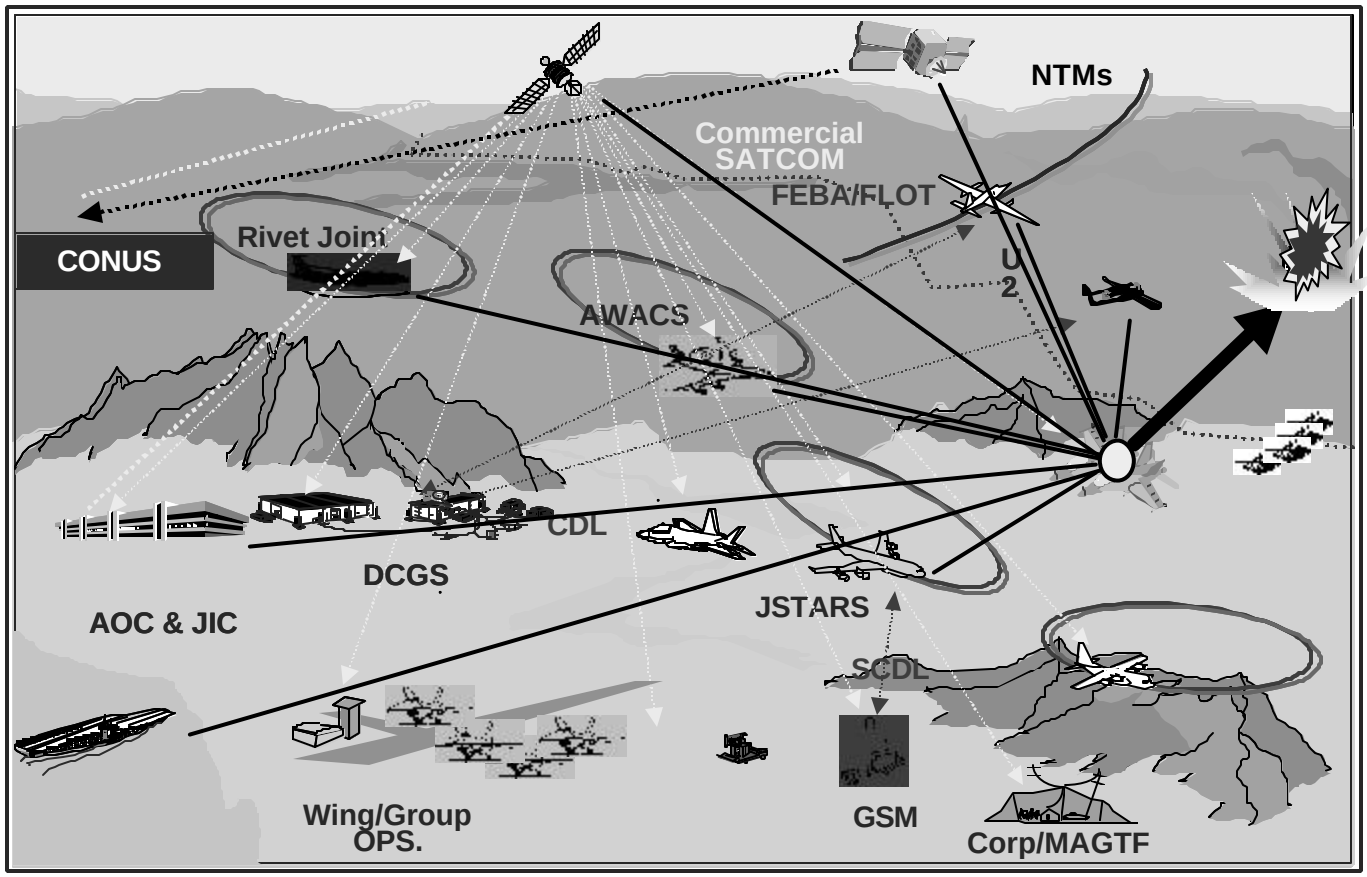


A System of Systems Perspective

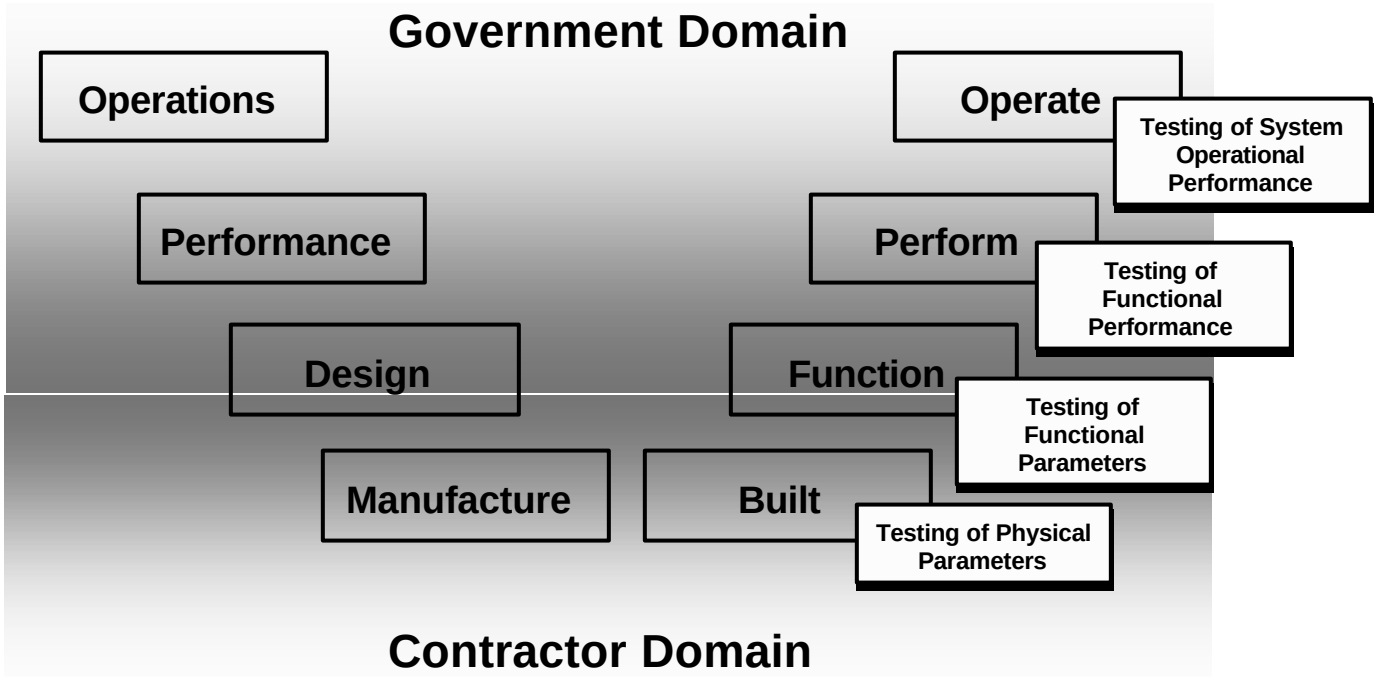


The George Lucas Weapon System Concept

The “Interoperable” and “Unified” Effect

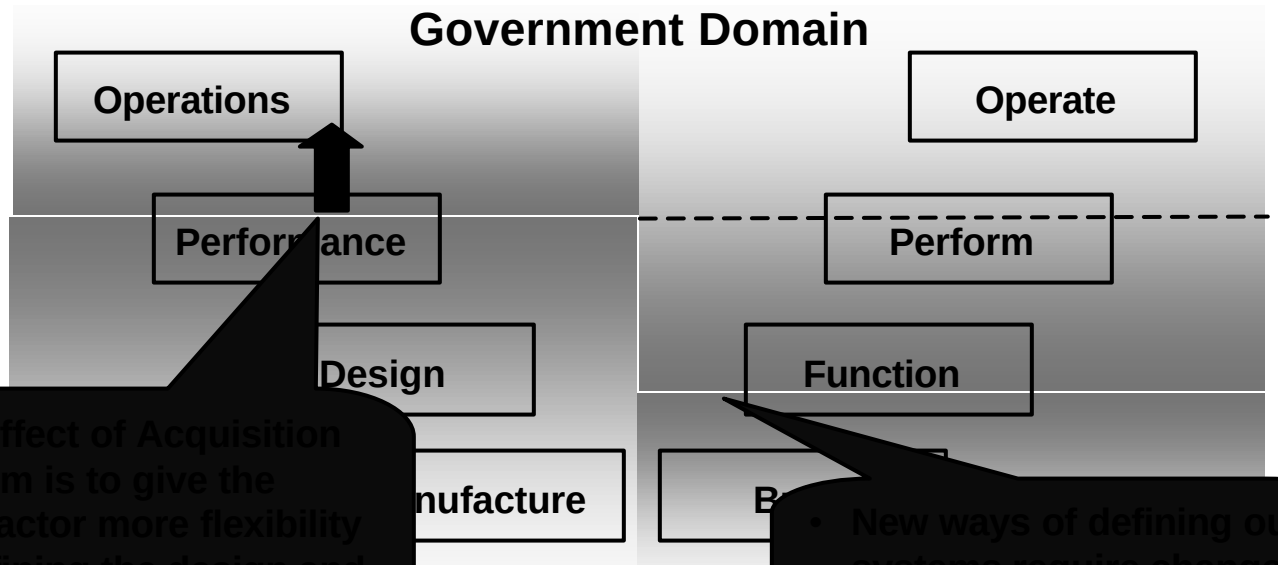


System Definition and Test "Bathtub"



SYSTEM DEFINITION **SYSTEM TEST**

The Effect of Acquisition Reform



- The effect of Acquisition Reform is to give the contractor more flexibility in defining the design and performance of his system.

- New ways of defining our systems require changes in testing concepts and responsibilities.

SYSTEM DEFINITION **SYSTEM TEST**

The Effect of Acquisition Reform

- Government test will increasingly be a series of functional and performance based examinations done within an operational context.

ment Domain

Operate

Performance

Perform

Design

Function

Manufacture

Buil

- Traditional DT will increasingly be the responsibility of industry.

Contractor Do

SYSTEM DEFINITION

SYSTEM TEST

Acquisition Reform
An EMCON Example

Systems may be defined in terms of the Attributes that must be associated with them.

- **Attributes of a notional aircraft system:**

Parameters	Functions	Operational Flexibility/ Constraints
Accuracy	Acquire Target	Carrier Suitability
RCS	Generate Sorties	Basing Flexibility
Range	Situational Awareness	All Weather/Night Capability
Logistics Footprint	Countermeasures	Multi-Role Capability
Payload	ID the Target	Weap. Carriage Versatility
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Hardening	Route Planning	
Acoustic Signature	EMCON	
EMCON		

Acquisition Reform
Performance Based Spedification

- **EMCON as a Parameter**

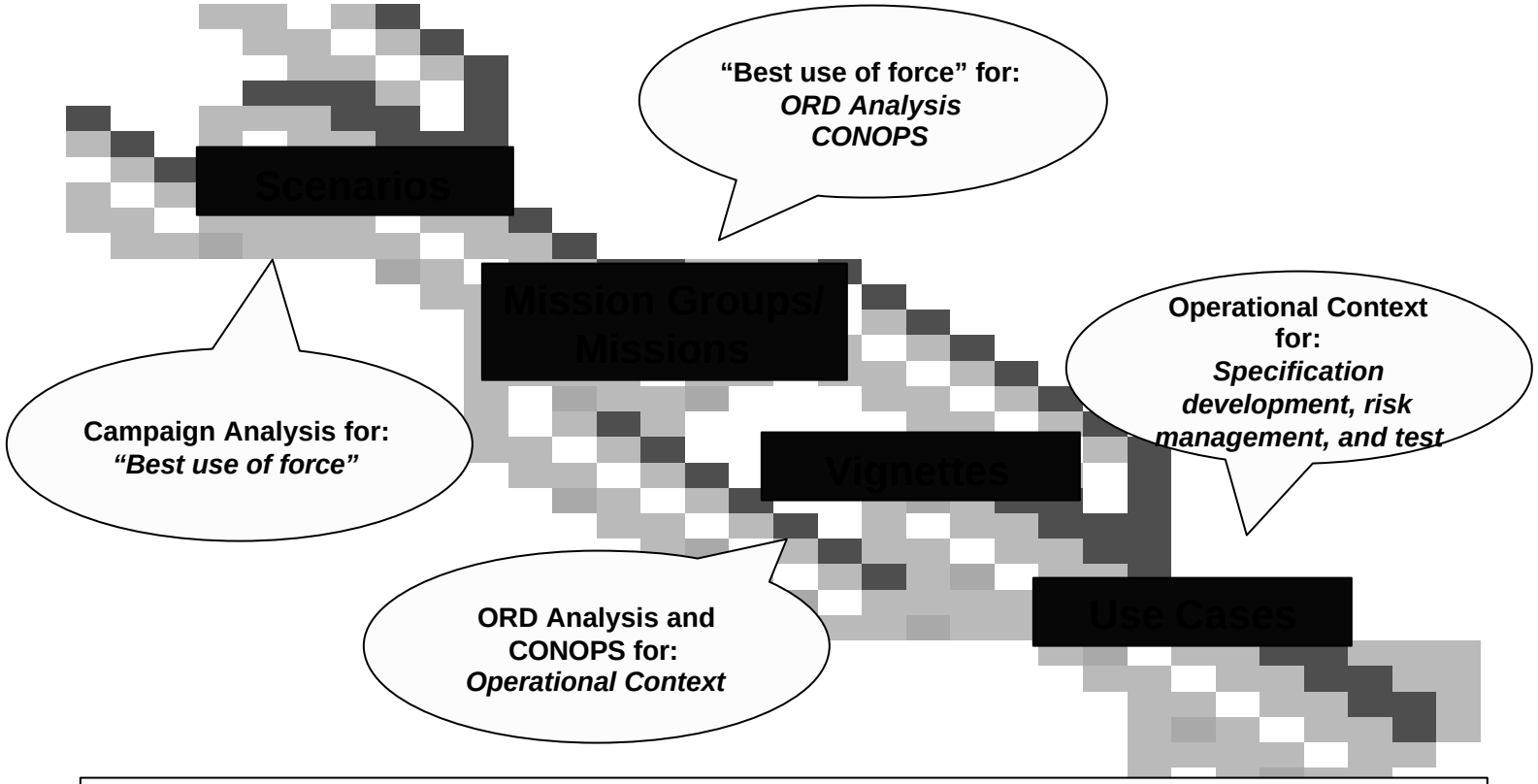
  "… when transmitted into a dummy load, the signal shall not be measurable above X db at a distance from the aircraft in all aspects."

- **EMCON as a Function**

  "… <system> shall provide the capability to selectively reconfigure sensors to eliminate, reduce, mask, or control electronic emissions to accomplish the core missions and minimize susceptibility to threat systems listed in the STAR."

Testing a Parameter is easy. Testing Functions requires clear understanding of the mission, threat, CONOPS <u>and</u> the ability to create the appropriate operational environment.

Acquisition Reform Requirements Generation



Proper Requirements Generation results in a known operational environment that is traceable and re-usable throughout every phase of the program – including System Test.

System Test
Communicating the Functional Requirement

Mission:	Interdiction	Vignette:	Unplanned Air Threat Encounter	Use Case:	Air-to-Ground functions in presence of air threat

Specification Paragraph References:

Core Processing	Radar	Interoperability	
Intra-flight DL	EMCON		

Tactical Situation

- Flight of 2 USAF aircraft attacking last known position of mobile target
- IFR conditions
- Target has moved
- Ground threat consists of RF point defense and IR MANPADS
- Reported red air activity 80 miles east of target
- Navy E-2C airborne and tracking red air - reports contacts inbound to target area

Required Action

- Calculate search area
- Communicate and coordinate search sector responsibility with wingman
- Conduct search
- Minimize opportunity for enemy aircraft to intercept RF emissions
- USAF aircraft rely on E-2C track information to determine best course of action:
  - Continue search
  - Run
  - Engage

Suggested Metrics

- Probability of signal intercept
- Probability of red air engagement
- Probability of target acquisition
- Blue Losses

System Test
Use of Modeling and Simulation

Mission:	Interdiction	Vignette:	Unplanned Air Threat	Use Case:	Air-to-Ground

- **This process doesn't specifically dictate how the test is to be accomplished – the contractor is free to propose the exact methodology and the exact metrics to match his design but,**
- **The TACSIT is difficult to impossible to reproduce in physical flight test**

◆ Flight of 2 USAF aircraft	◆ Calculate search area	◆ Probability of signal intercept

- **Increased reliance on functional requirements, performance based specification, and a complex, highly evolved operational environment means:**

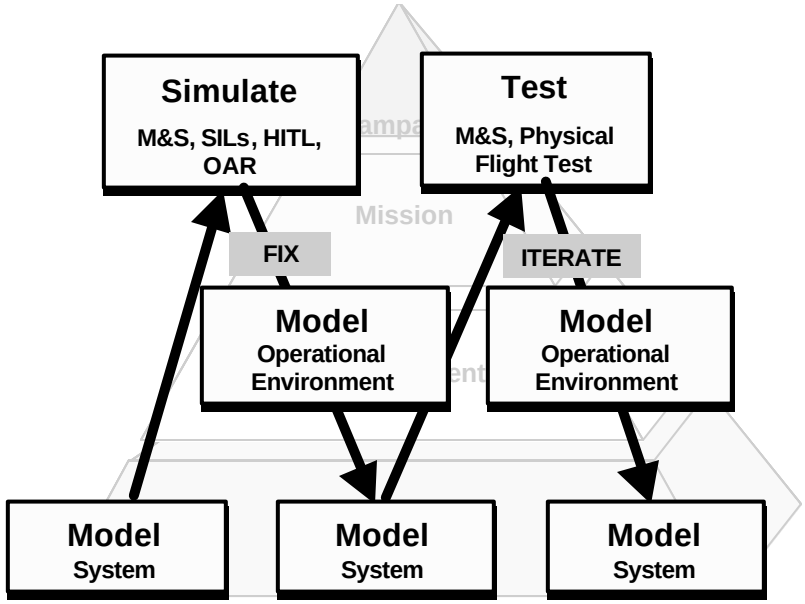
INCREASED RELIANCE ON M&S

DIGITAL REPRESENTATION OF THE OPERATIONAL ENVIRONMENT

TO SUPPORT SYSTEM TEST

The "STEP" Process

- **The Fix-Test-Fix loop has been very successful for DT and, based on Simulation Based Acquisition has been modified for the modeling environment to Model-Simulate-Fix-Test-Iterate (ref: The Simulation Test and Evaluation Process Guide) but,**
  - **Government's increased focus on operational and performance based testing requires a realization that the "Model" includes not only the engineering level representation of the system but the simulated environment as well**



Summary

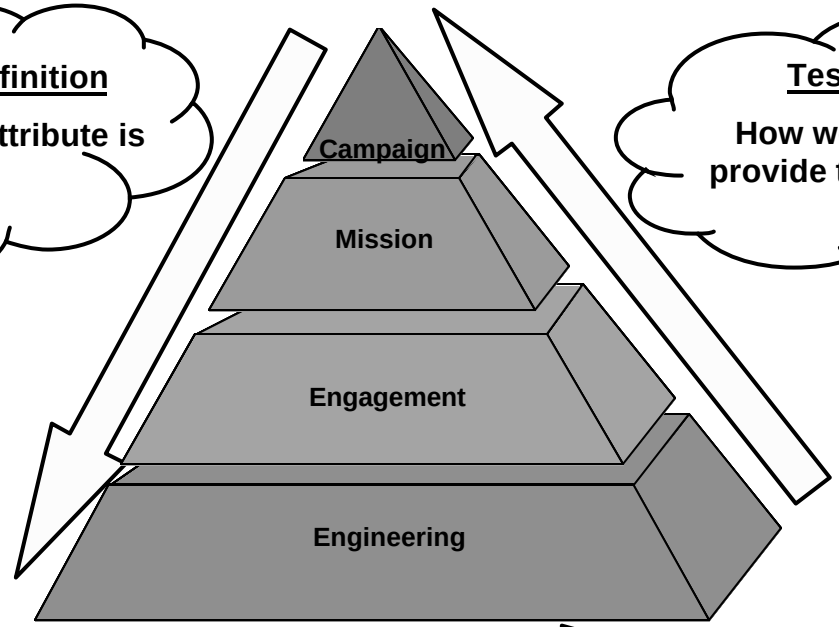
- **The requirement for Interoperable systems**
  - Re-introduce the concept of a “System of Systems”
  - Demonstrated how the concept provides a clue in how we might effectively test for Interoperability
- **Some effects of Acquisition Reform**
  - Unforeseen consequences
  - Performance Based Specifications tend to state functional requirements
  - Blurring of Developmental and Operational Test
  - Increased reliance on Modeling and Simulation to create the complex operational environment
- **How those effects may be used to improve testing for Interoperability**
  - Interoperability is a desired quality of systems that can be associated with operational context like any other design feature
  - Testing for the effect of Interoperability requires the identification of that operational context and the desired system response within it
  - Emphasis must be placed on the digital models, analyst skills, and operational knowledge

BACKUPS

The “M&S Pyramid”

Requirements Definition

How much of this Attribute is needed?



Test and Evaluation

How well does this system provide the needed Attribute?

Design and Development

What does a system that provides the needed Attribute “look like?”

System Test Performance Based Specification

- **Mission Reference Section**
  - **Reference mission, vignette, use case**
- **Specification Reference Section**
  - **Reference specification paragraphs**
- **Tactical Situation Section**
  - **Details regarding the test scenario**
- **Required Action Section**
  - **Detailed description of expected system performance**
- **Metrics Section**
  - **Metrics for test execution**