Integrated Survivability Assessment (ISA): Bridging DT&E, LFT&E, and OT&E

David H. Hall
SURVICE Engineering Company
(760) 382-1618
Dave.Hall@SURVICE.com
www.survice.com

Ronald L. Ketcham
Naval Air Systems Command, Weapons Division
(760) 939-2363
Ronald.Ketcham@navy.mil

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Integrated Survivability Assessment

- **Motivation: comprehensive system survivability evaluations in OT&E**
  - **Integrated LFT&E and survivability OT&E**
    - **Rather than separate assessments**
    - **Linking in DT&E results**
  - **Developed for the Joint Aircraft Survivability Program (JASP) at the request of DOT&E**
    - **Initially for air weapons systems**
    - **Extensible to ground and sea systems**

- **ISA is a process for evaluating all aspects of system survivability in a coordinated fashion**
  - **Using both M&S and T&E resources where appropriate**

The Key to bridging DT&E, LFT&E, OT&E:
Common, Testable Metrics throughout the acquisition process

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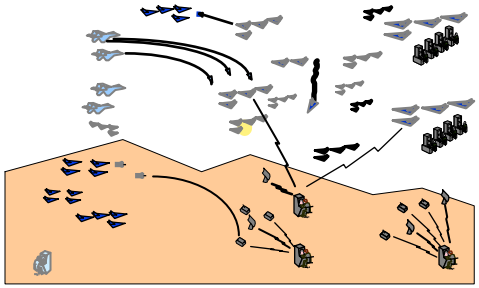
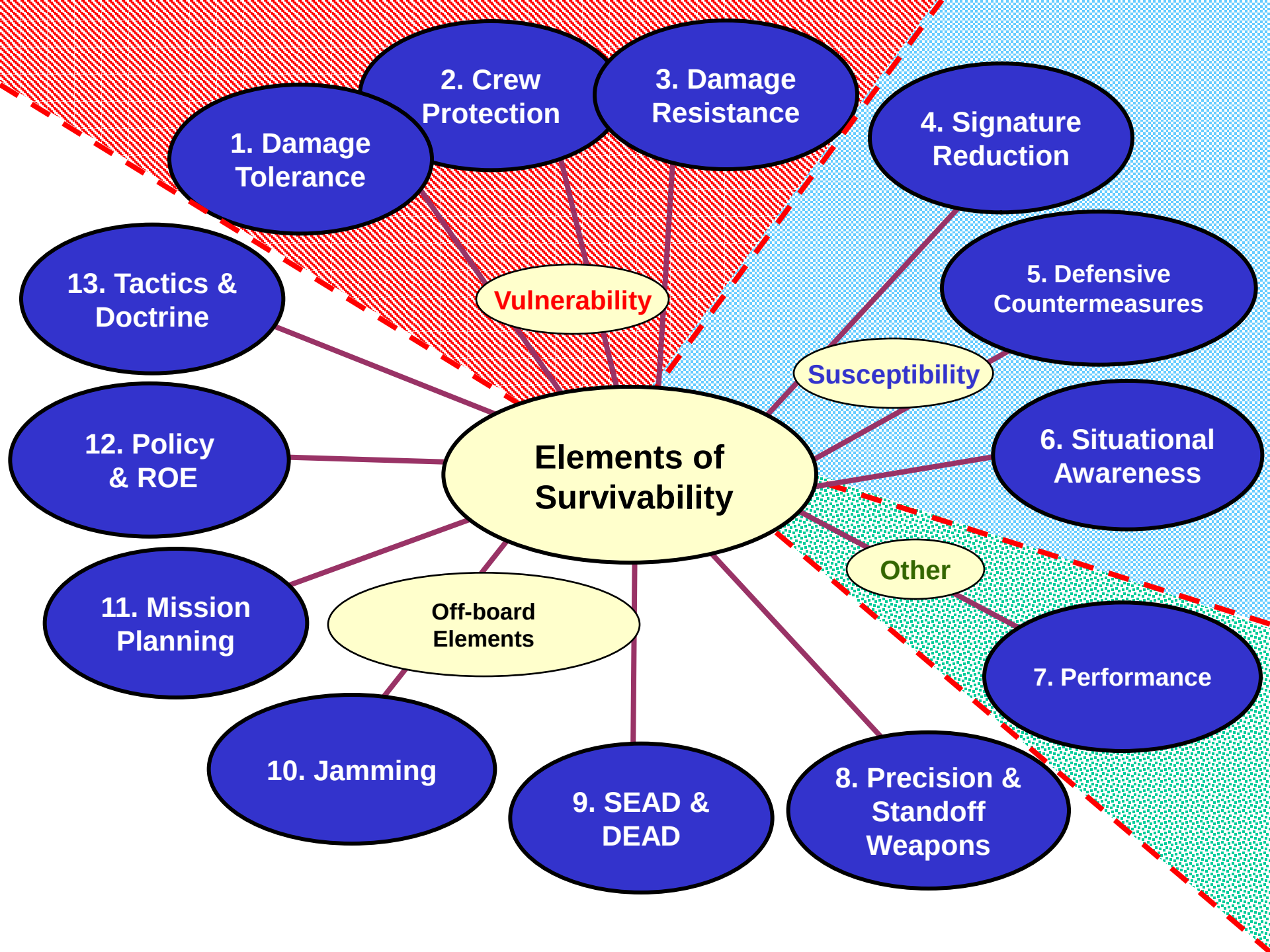
What does the Integrated Survivability Assessment Process Do?

- **Measures system survivability in the context of missions and scenarios**
  - **"Cover the Waterfront" to avoid a point design**
- **Consistent treatment of survivability throughout the system acquisition lifecycle**
  - **Requirements development, AOA, spec compliance, DT&E, LFT&E, OT&E, retrofits, SLEP, system mods, training applications…**
- **Trading Survivability, Effectiveness, and Mission Metrics**
  - **Within a Consistent and Documented Process**




1. Damage Tolerance
2. Crew Protection
3. Damage Resistance
4. Signature Reduction
5. Defensive Countermeasures
6. Situational Awareness
7. Performance
8. Precision & Standoff Weapons
9. SEAD & DEAD
10. Jamming
11. Mission Planning
12. Policy & ROE
13. Tactics & Doctrine
Vulnerability
Susceptibility
Other
Off-board Elements
Elements of Survivability

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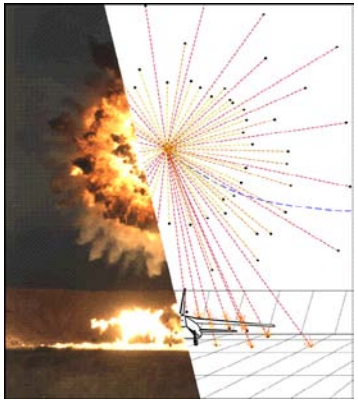
Developing an Integrated Survivability Assessment Process

- **Checklist**
  - Of important survivability factors
- **Metrics**
  - Applied to DT&E, LFT&E, OT&E
- **Assessment**
  - A modeling path to quantify metrics
  - Test range assets and processes to quantify metrics
- **M&S Validation**
  - A path to validating M&S with available test range data
  - Model - test – model approach



The Threat Kill Chain: A Checklist of Survivability Factors

On Platform Factors

Susceptibility:
On-board EA, signatures, countermeasures, speed and altitude, maneuverability, agility (last ditch maneuver), target acquisition (standoff),…

Off Platform Factors

Tactics, standoff weapons, anti-radiation missiles, self defense weapons, off-board EA, night/all weather capability, threat warning, situational awareness, C4ISR

Vulnerability:
Fire/explosion protection, self-repairing flight controls, redundant and separated hydraulics, multiple engines, no fuel adjacent to air inlets, hydrodynamic ram protection, nonflammable hydraulic fluid, rugged structure, armor, …

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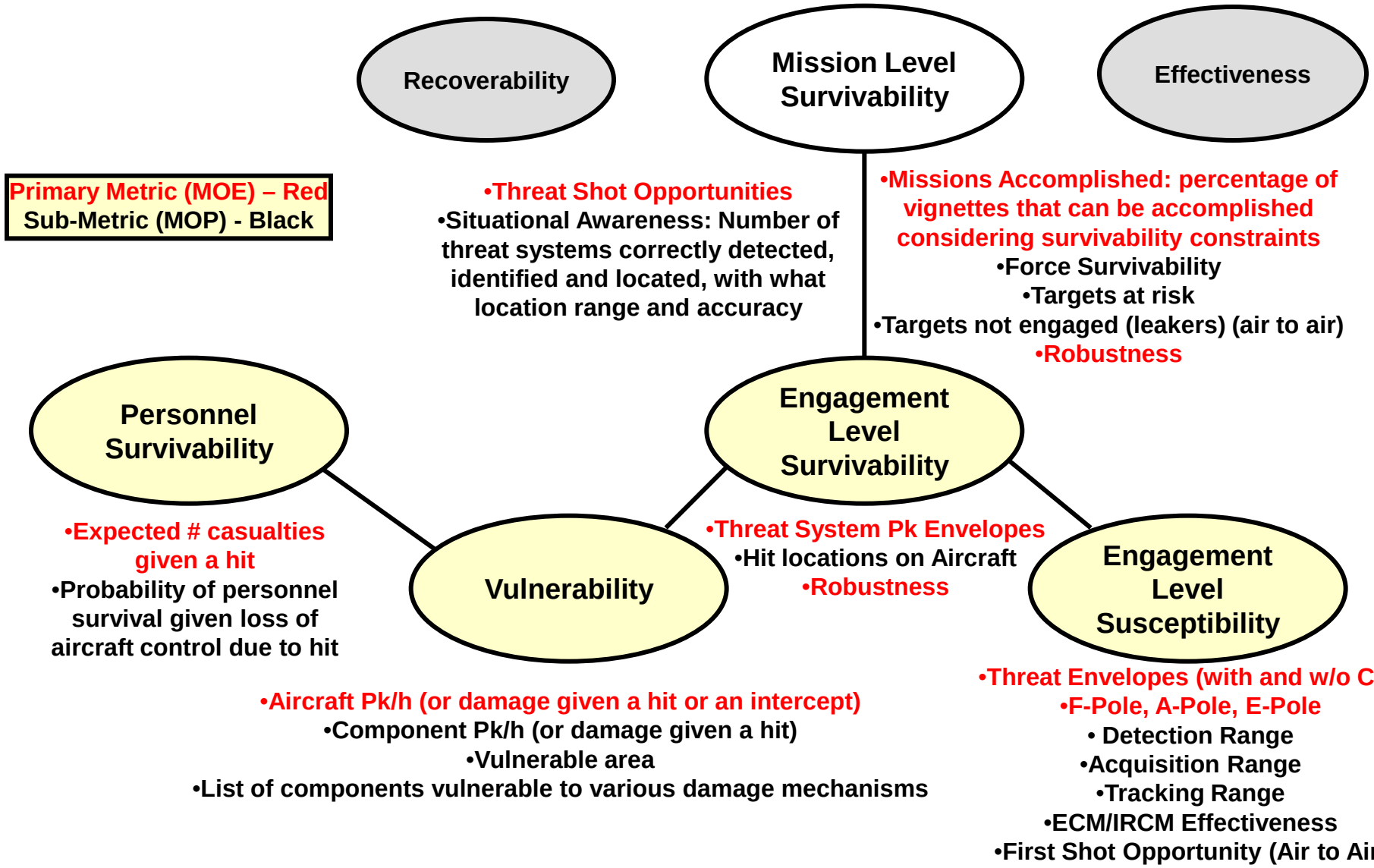
Survivability Metrics



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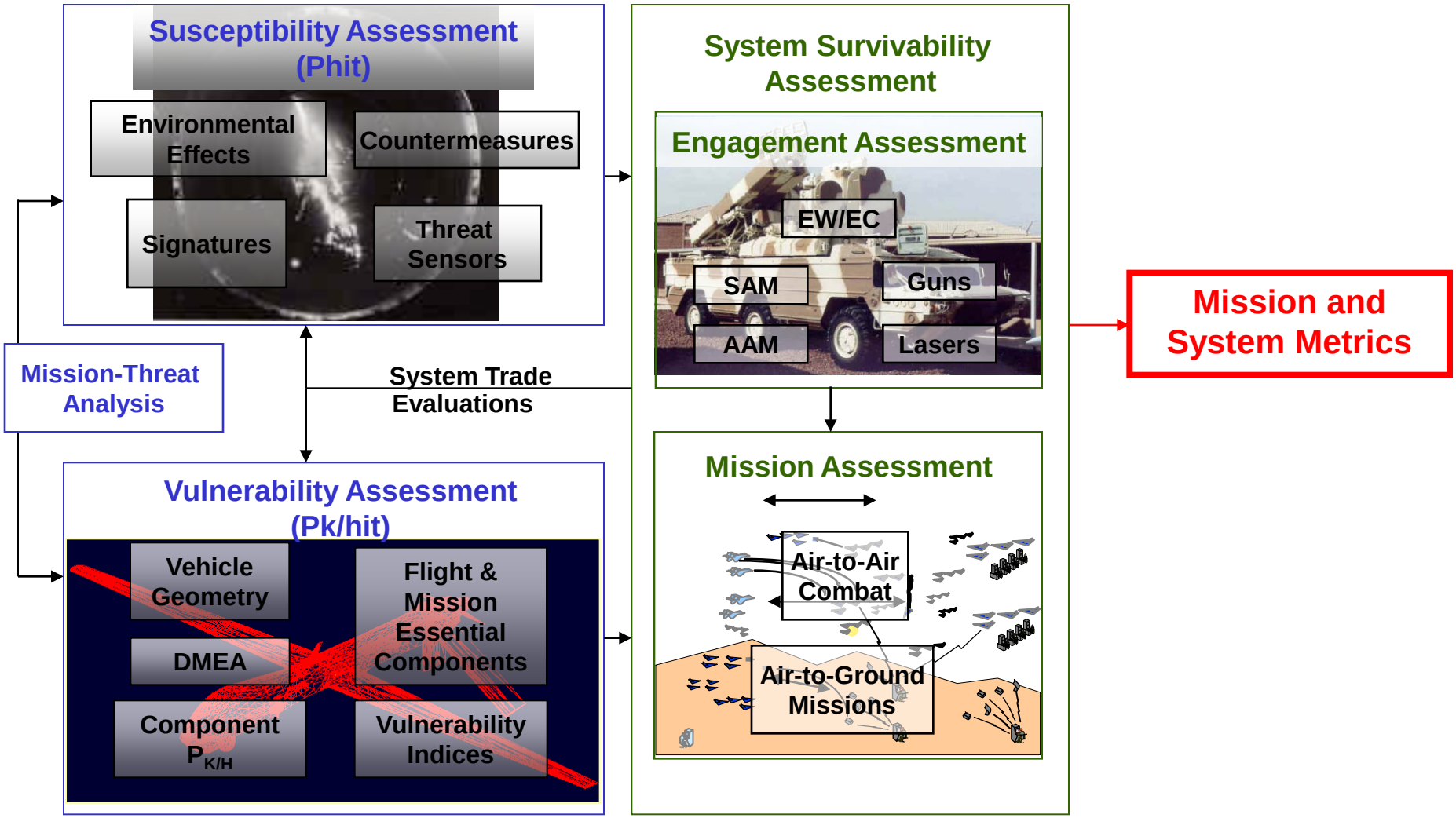
The Survivability Assessment Process



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M&S in DT&E, OT&E, LFT&E

- M&S cannot replace testing, only provide support
- M&S objectives in DT&E, OT&E, LFT&E
  - Support Test Planning
    - "What tests should we conduct?"
    - "What data should we collect, with what fidelity and frequency?"
    - "What do we think will happen?"
  - Support Test Analysis
    - "Why'd that happen instead?"
    - "What should we do about it?"
  - Support COI resolution
    - "So the test result is that – so what?"
- Use of M&S in combined survivability DT&E, OT&E and LFT&E should be from these perspectives
- Integration of M&S and testing enhances credibility of both

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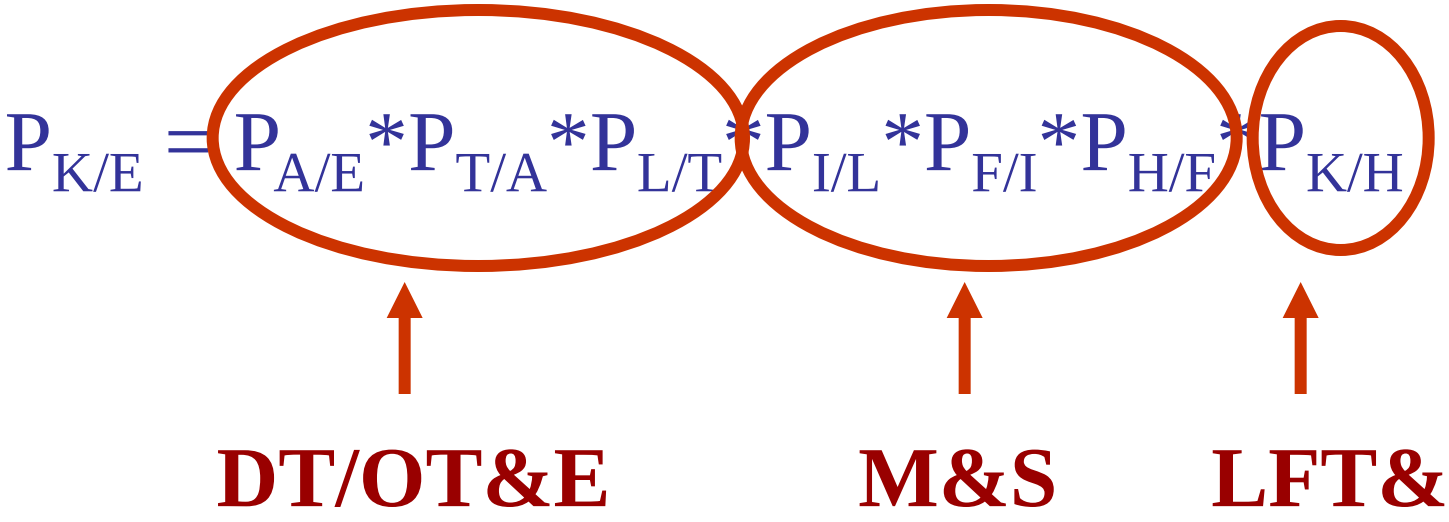
Data Sources for a Typical Survivability Assessment



E = Engagement
A = Acquisition
T = Track
L = Launch

I = Intercept
F = Fuzing
H = Hit

K = Kill

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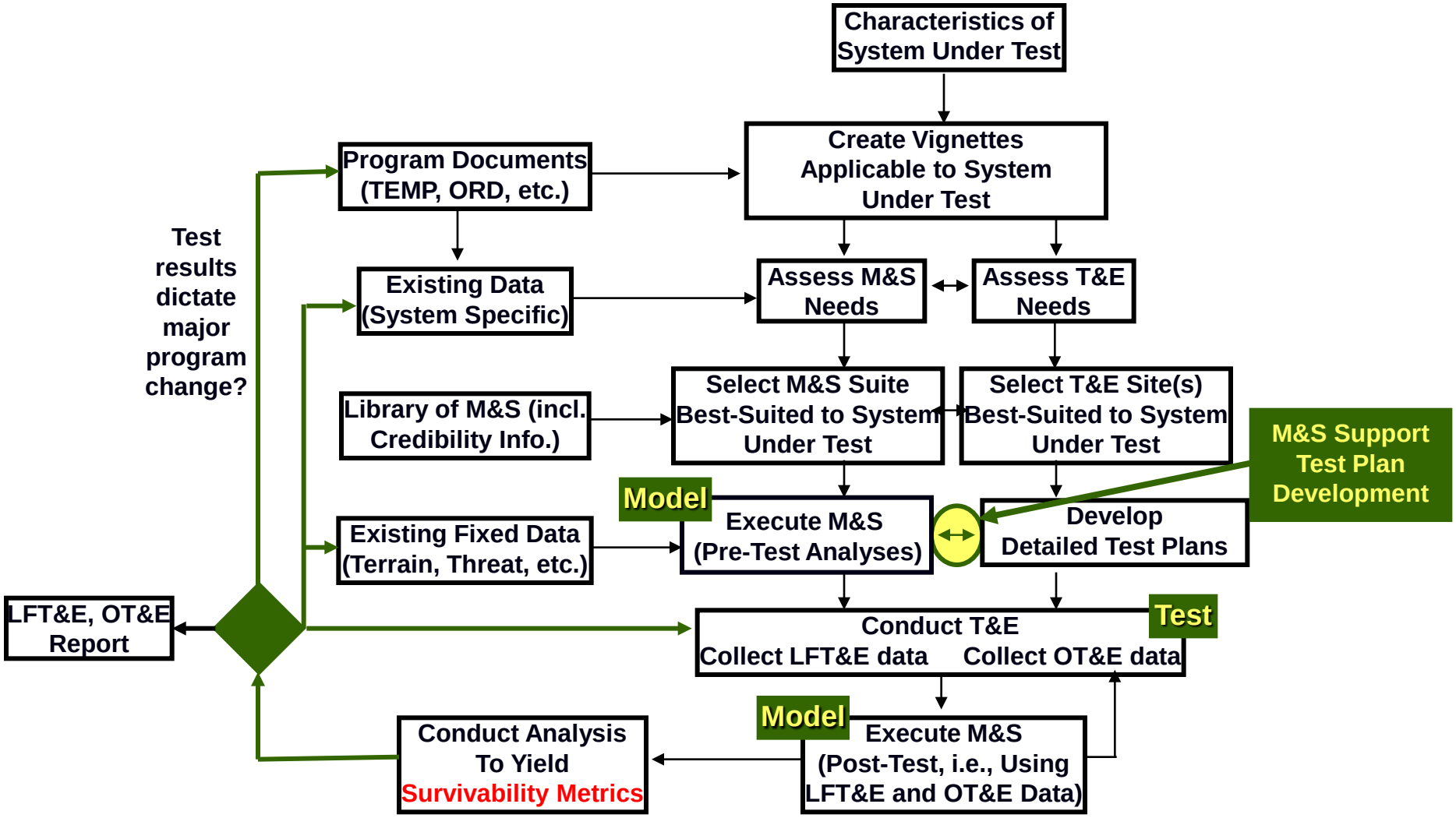
Integrated Survivability Assessment: Model-Test-Model Concept



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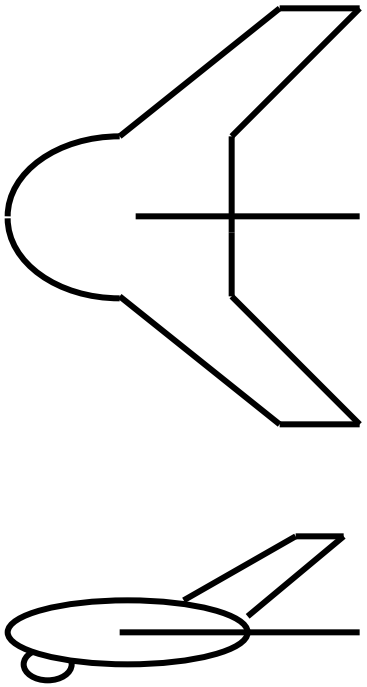
"Case Study" Example

- **Unmanned Combat Aircraft System (UCAS) :**

  Role: CAS, battlefield interdiction, SEAD/DEAD, etc.
  Dimensions:
  Weight:
  Speed:
  Range:

- **To be determined:**

  RCS:
  IR signature:
  DECM/IRCM:
  Vulnerability:
  etc.



EXAMPLE: UCAS VIGNETTES

	3rd World Urban	Advanced Threat, Forested	Conventional Threat, Desert	3rd World Mountains
ISR	Ж	X	X	X
Force Protection	X	Ж	X	X
SEAD DEAD	X	Ж	X	X
C2		Ж	X	X
All Weather, Night Strike	Ж	X	X	X
CSAR	X	X	X	Ж
Driving Factors Ж = Most stressing Scenario	Target Acquisition Difficult Conventional Threat	IADS, Wx, Target Acquisition Advanced Threat	Flat Terrain, Clear Wx High Threat	High Altitude, Rough Terrain Conventional Threat

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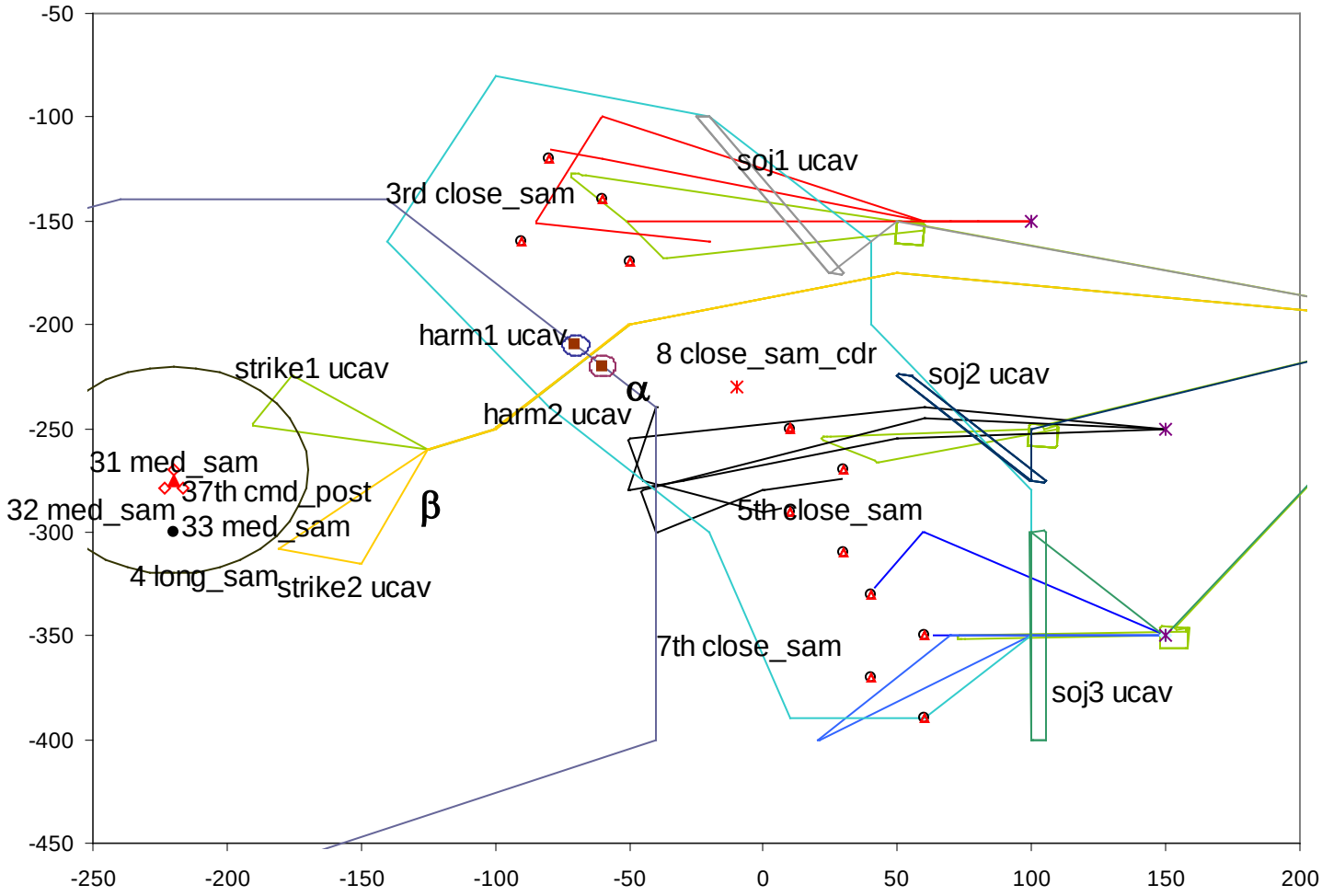
Example: SEAD/DEAD Mission Vignette



Timeline

TOT -12	Checkpoint α
TOT -5	Decoys on @ β
TOT -4	2 x HARMs
TOT -3	2 x HARMs
TOT -2	2 x HARMs
TOT -1	Weapons away
TOT -0	Weapons impact
TOT +1	2 x HARMs

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Threat Engagement Assessment

SIGNATURE PREDICTION, MEASUREMENT

BLUEMAX

ALARM

Flight Paths

Open Air Test Range Tracking, Acquisition Data

RF Detection, Acquisition Range Contours

ECM/IRCM Effects (Test Data - Open air, HWIL, Captive Flight)

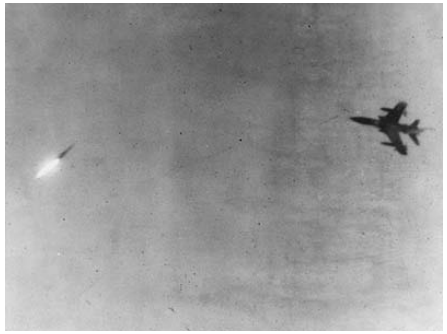
MOSAIC (IR SAMS)

ESAMS (RF SAMS)

DREAM (HPM)

LELAWS (LEL)

ADAM (ADA)



Output Metrics:
Detection, Acquisition Range
Tracking Range Contours
Threat Envelopes
ECM/IRCM Effectiveness

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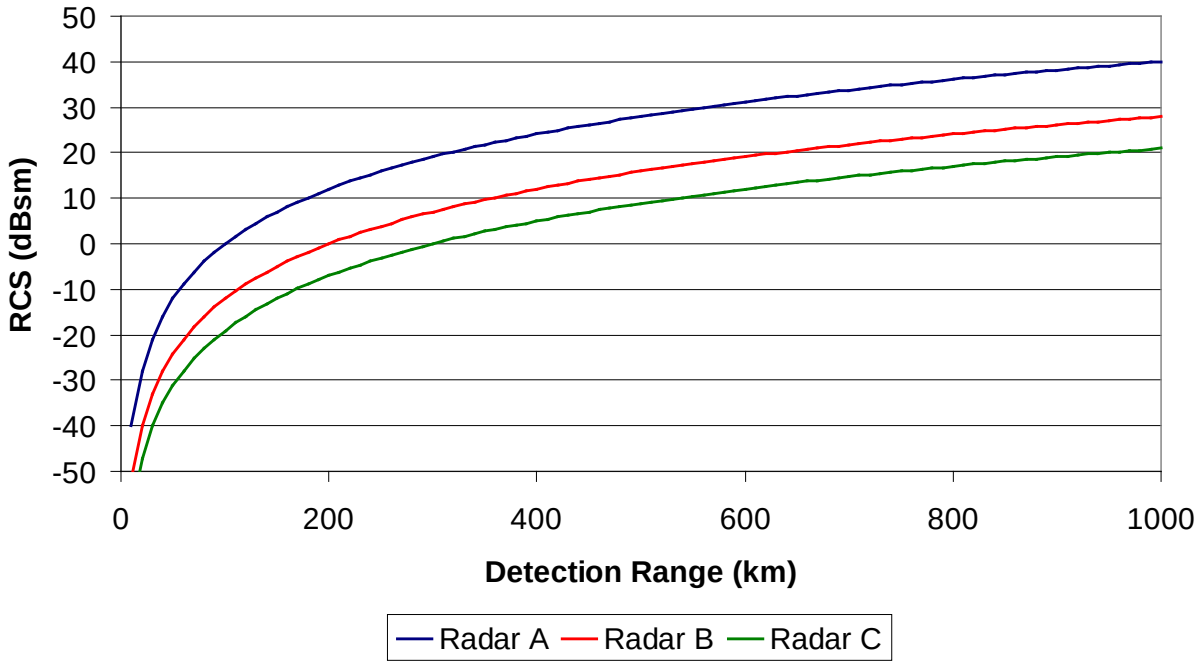
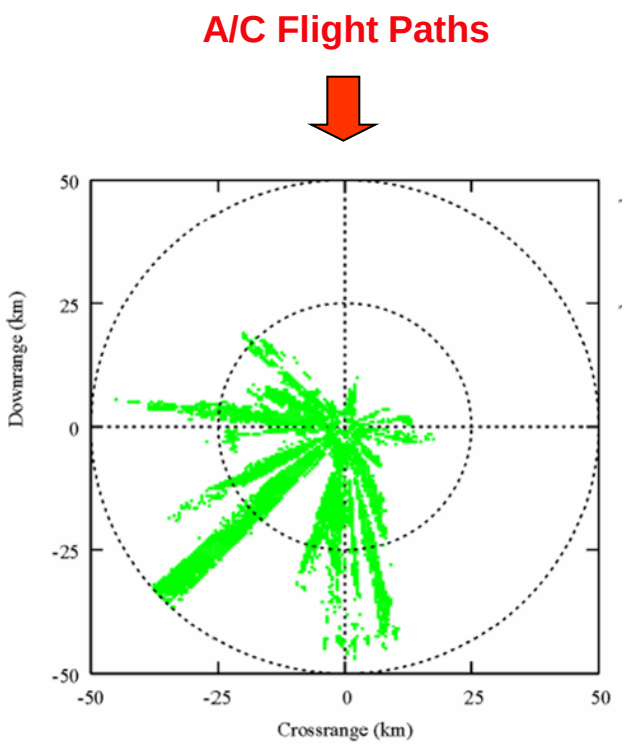
Example Susceptibility Results: Impact of RCS and Terrain on Detection

Detection range vs. RCS



Effects of Terrain Masking on Detection Contour



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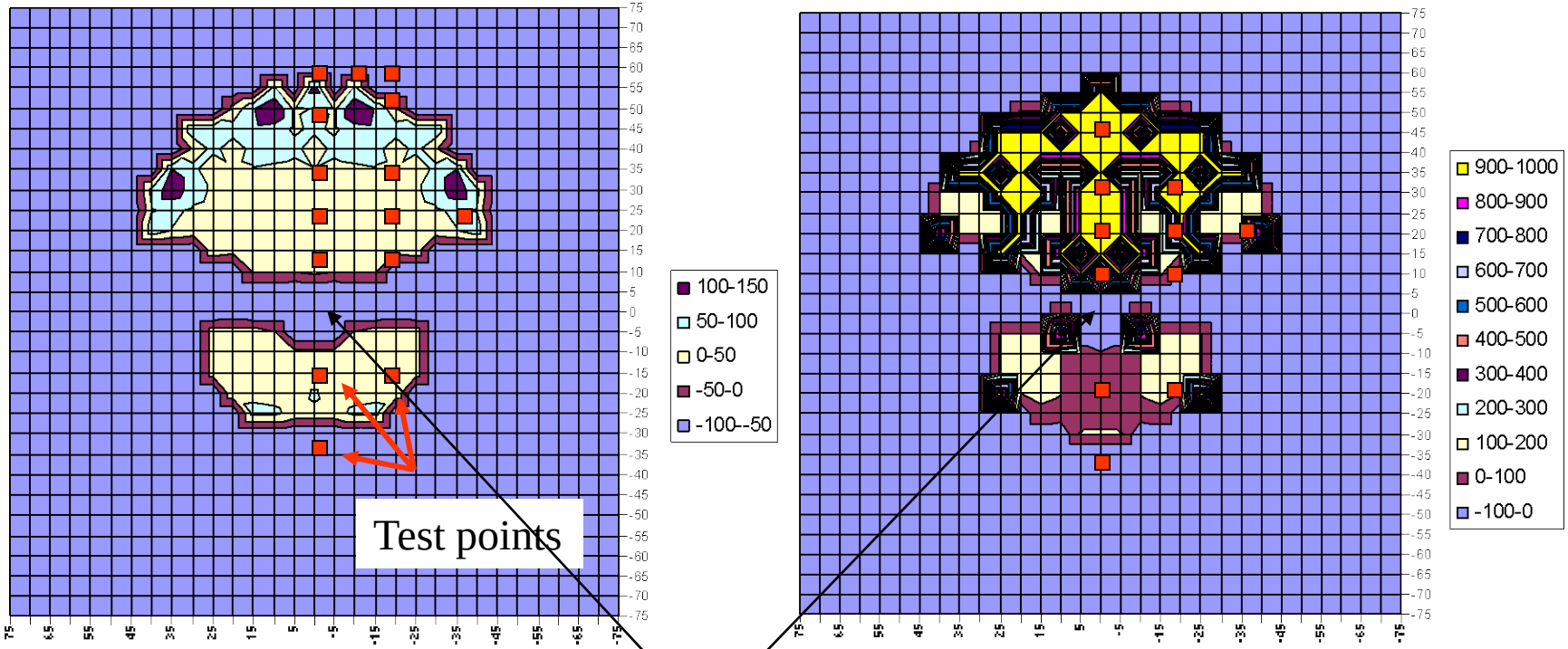
Planning Susceptibility Tests: Impact of ECM on Miss Distance

A/C Flight Paths

A/C Flight Paths



No ECM

With ECM

Threat System

Miss Distances in Meters
Locations in KM

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Susceptibility Test Plans

Assessing M&S results for all vignettes, the following susceptibility-related test data are required:

- Surface-to-air threat acquisition & tracking data applicable to system under test (for IR and RF threats)
- Surface-to-air threat engagement envelopes applicable to system under test (for IR and RF threats)
- IR and RF threat functional element characteristics
- etc.

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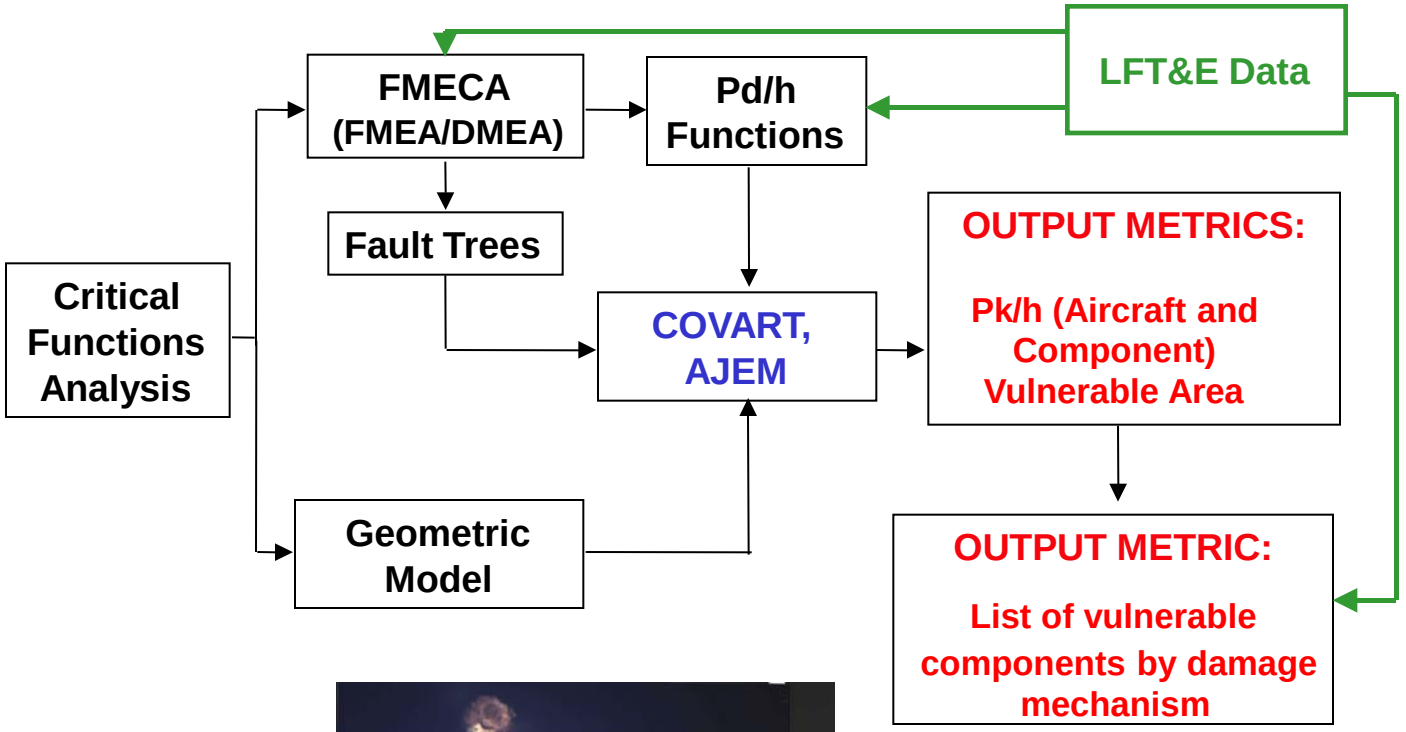
Vulnerability Assessment



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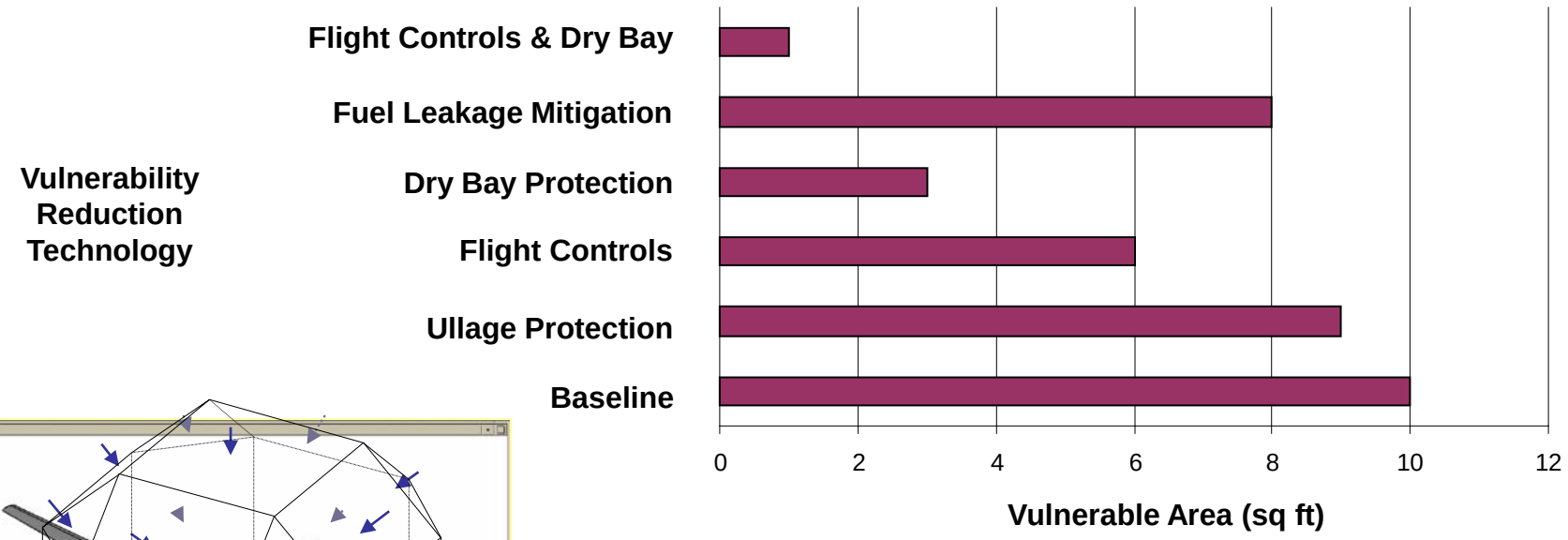
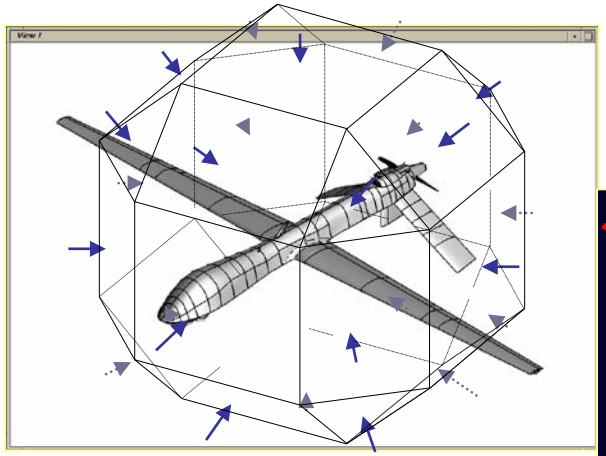
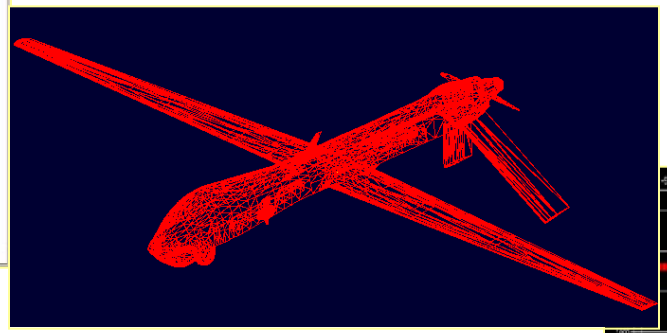
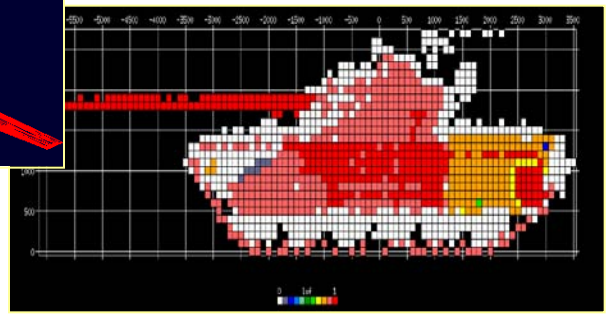
Vulnerability Metric: Vulnerable Area









NOTE: EXAMPLE ONLY

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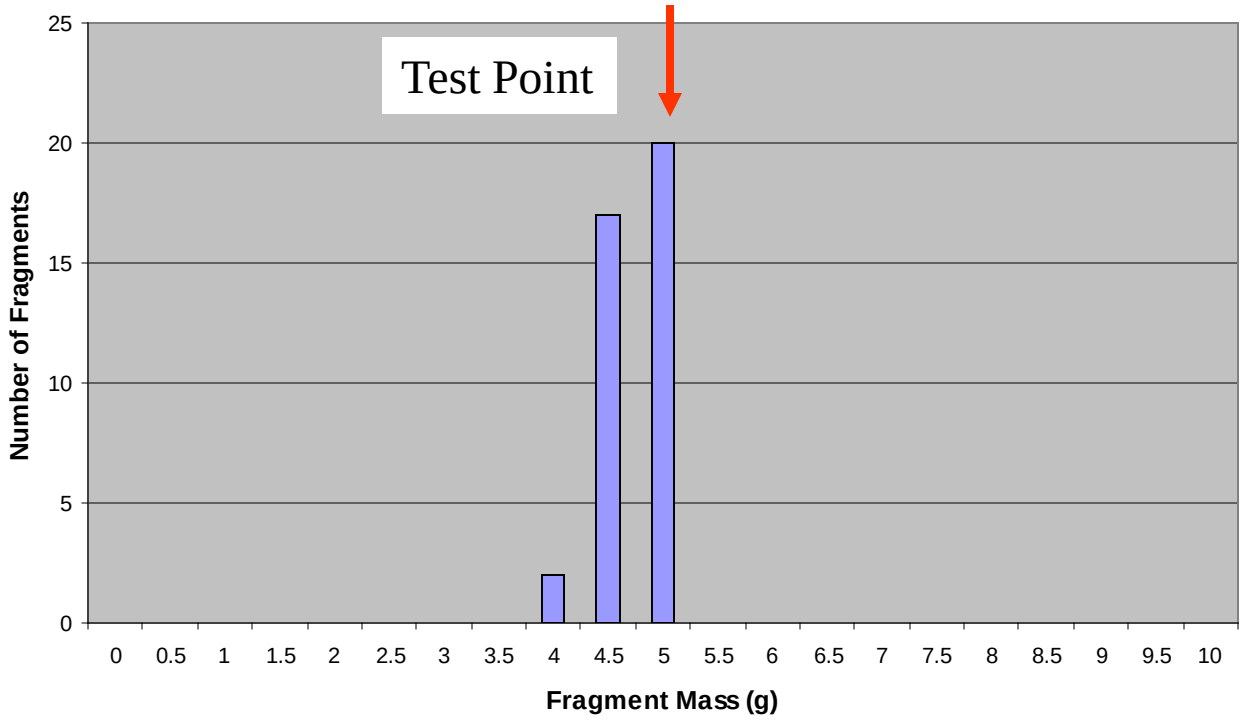
Planning Vulnerability Tests: Warhead Fragment Mass Distribution



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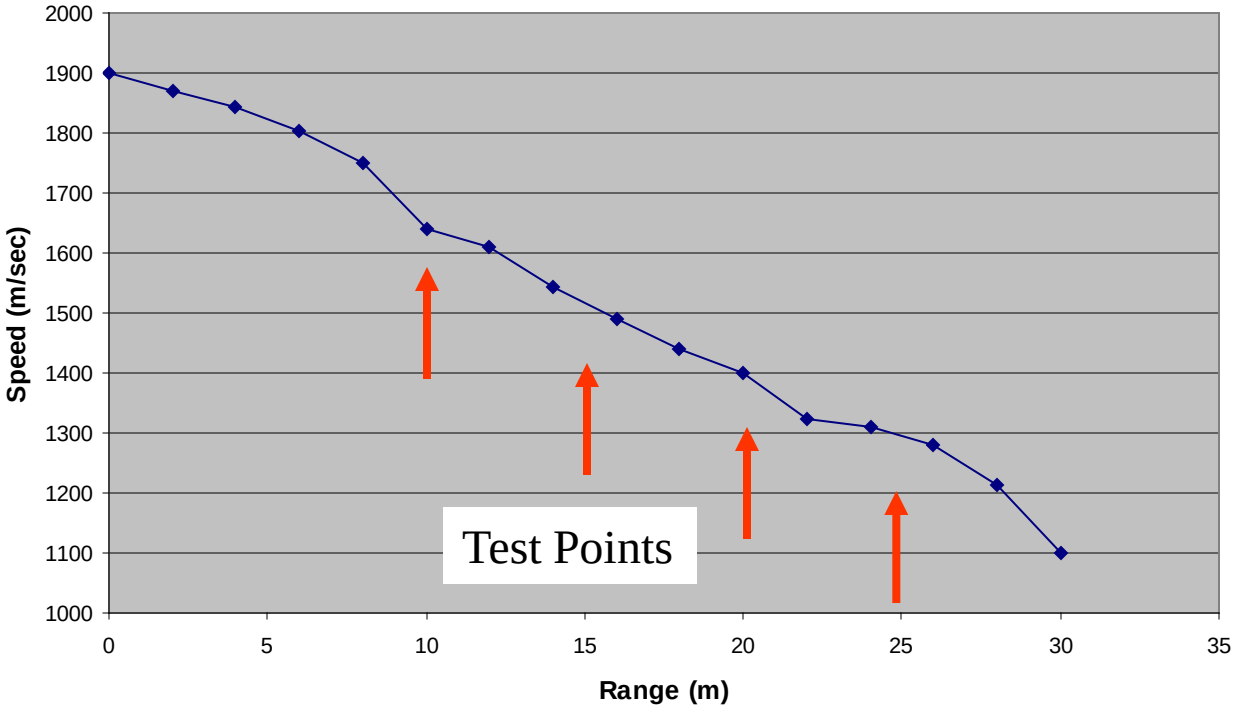
Planning Vulnerability Tests:
Warhead Fragment Velocity



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Vulnerability Test Plans (LFT&E)

Based on an analysis of results from all UAV vignettes (and a survey of existing data), the following live-fire shots are required:

Threat Weapon	Focus of Frags off Warhead Nose		
	Miss Distance, ft	Azimuth, deg	Elevation, deg
A	0	-30	-45
	10	-30	-45
	0	-10	-45
	10	-10	-45
B	0	0	0
	0	90	0
etc.			

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Threat Missile Endgame (Pk) Assessment

Test Range Measurement Data

INTERCEPT PARAMETERS/ DISTRIBUTIONS (from threat performance assessment M&S)

LFT&E Data

PROX FUZE MODEL GTD (RF)

WARHEAD MODEL

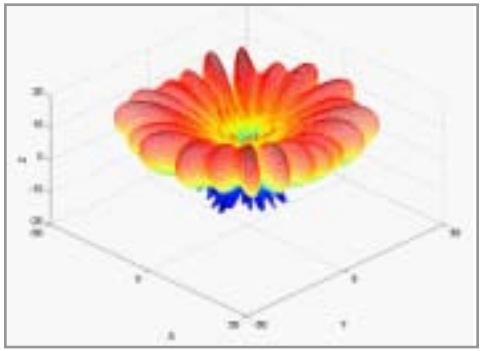
TARGET NEAR-FIELD SIGNATURE MODEL

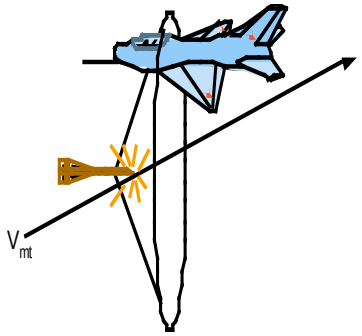
TARGET VULNERABILITY MODEL (COVART)

SHAZAM, AJEM

Blast, Direct Hit, Fragmentation

P_K





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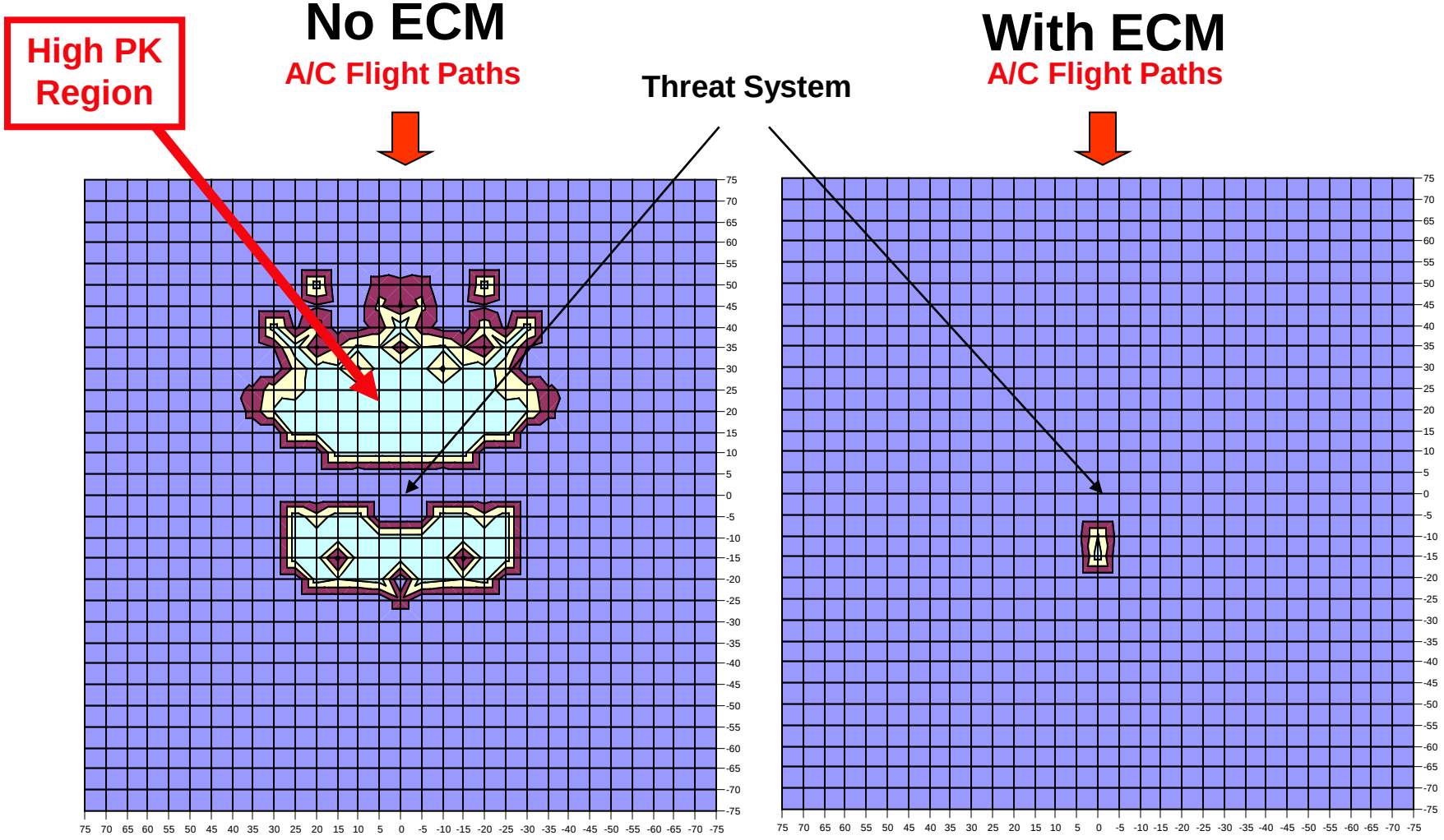
Engagement Survivability Results: Effect of ECM on PK



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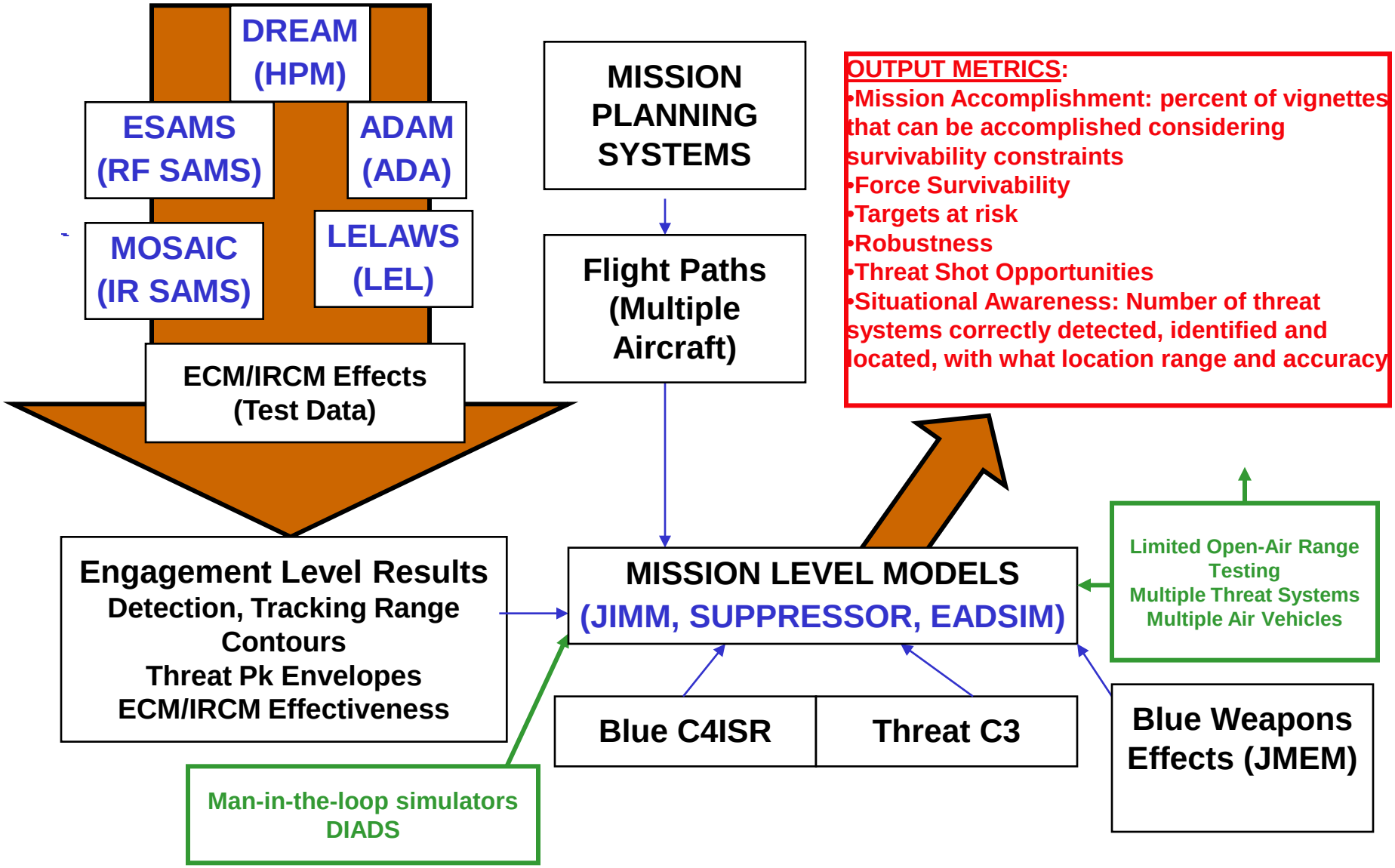
Mission Survivability Assessment



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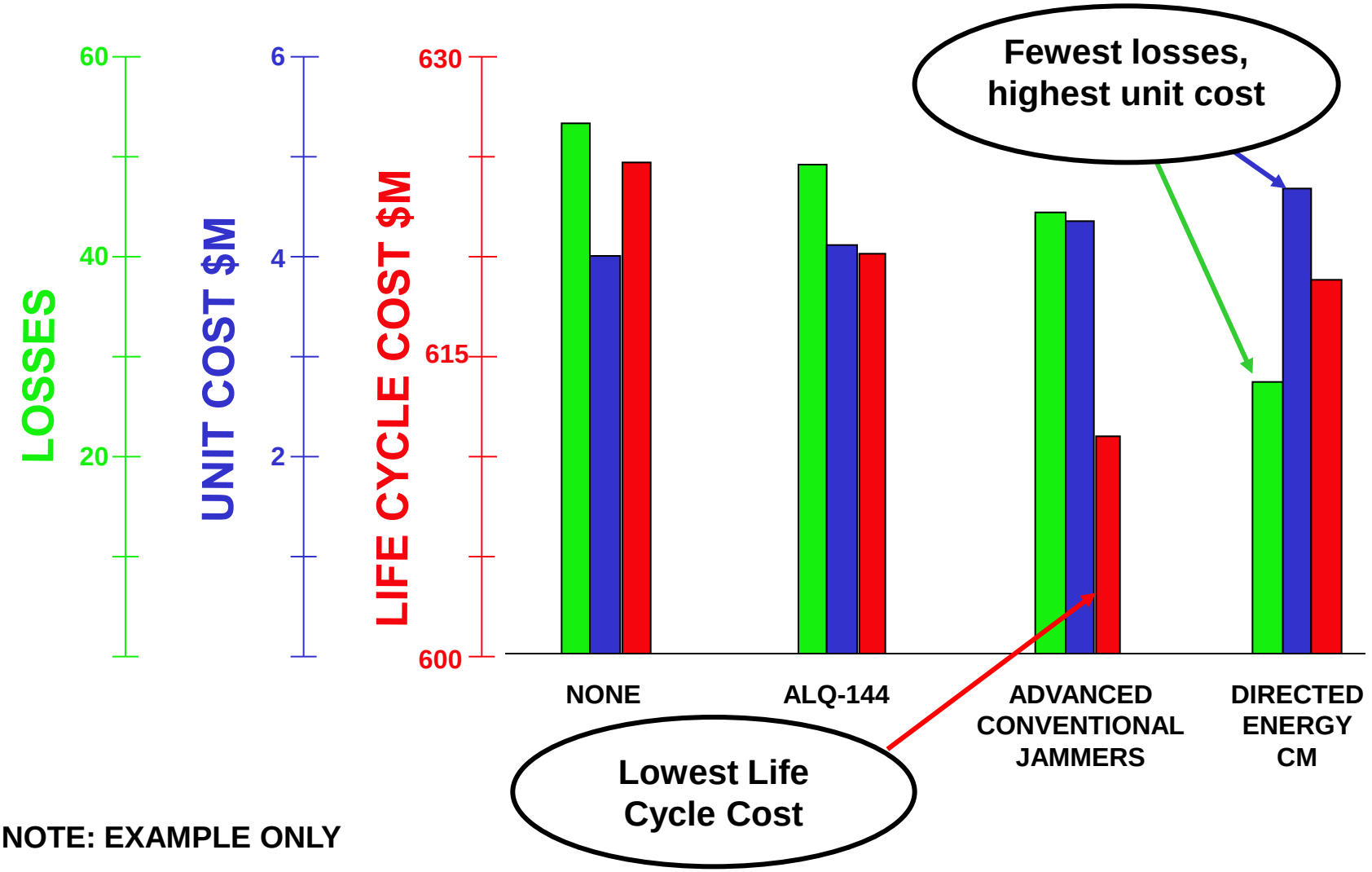
Integrated Survivability Results : Impact of IRCM Improvements



NOTE: EXAMPLE ONLY

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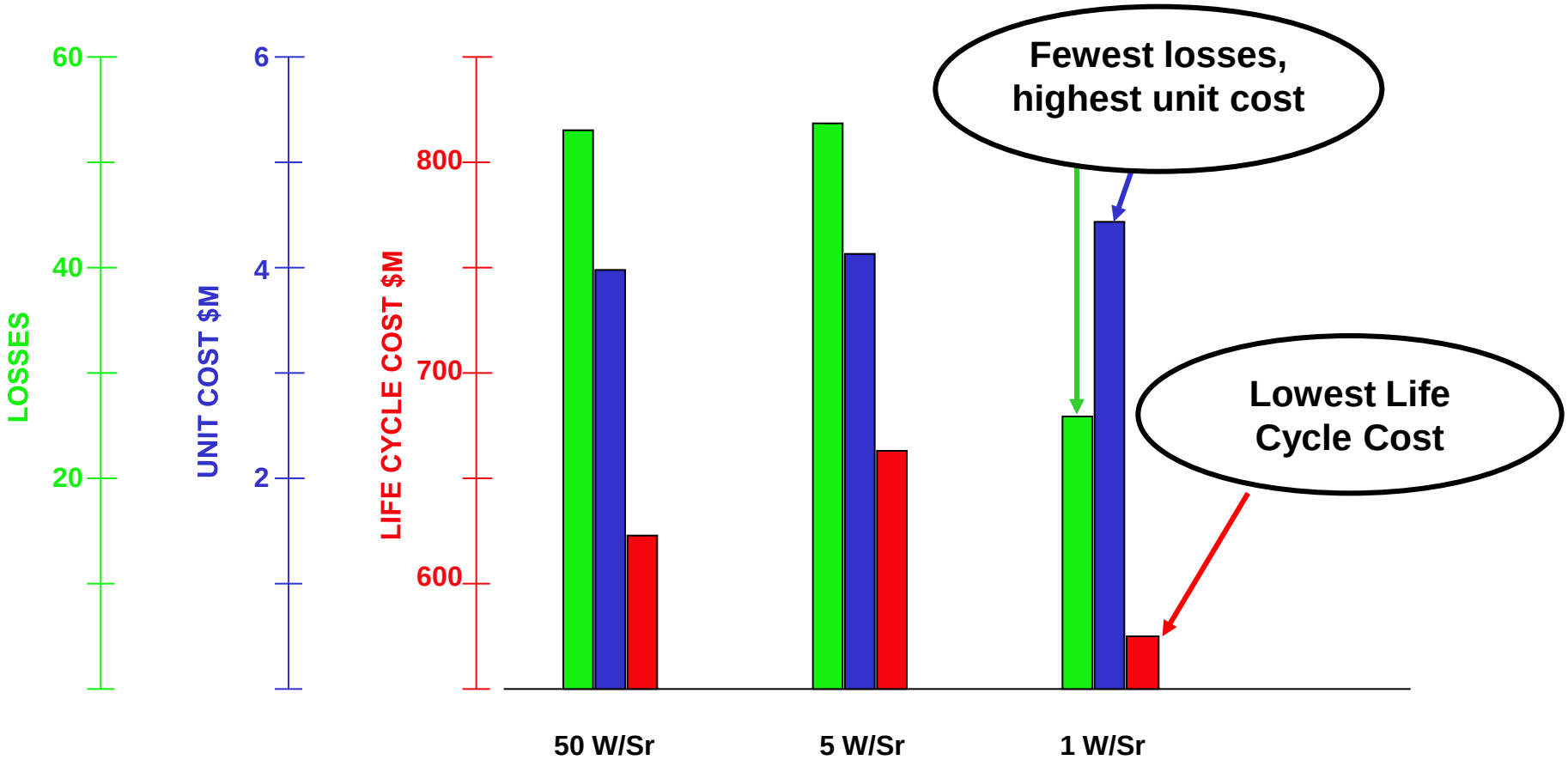
Integrated Survivability Results: Impact of IR Signature Reduction



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Overall Vignette Results

	Urban	Forest	Desert	Mountains
CAS	Ж	X	X	X
Battlefield Interdiction		Ж	X	
SEAD/DEAD	X	Ж	X	X
Strategic		Ж	X	X
Tactical	Ж	X	X	X
Targeting	X	X	X	Ж
& Landing	X	X	X	X
Driving Factors	Target Acquisition Difficult Convention al Threat	IADS, Wx, Target Acquisition Advanced Threat	Flat Terrain, Clear Wx High Threat	High Altitude, Rough Terrain Conventional Threat

Ж = Most stressing Scenario

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Vignette Results for OT&E

- **Red vignette means system cannot be effectively used for that scenario/mission**
  - **Underlying M&S, DT&E, LFT&E and OT&E results show why the SUT fails that vignette**
- **OTA and DOT&E will need to decide the implication of that failure:**
  - **SUT will require additional resources to accomplish the mission in that type of situation**
  - **SUT will require modification to perform the mission**
  - **SUT tactics manual will restrict where the system can be used**
  - **If the vignette is very important, loss of SUT may be deemed acceptable if mission can be accomplished (may be unique to UAV systems)**

  OR,
  - **SUT fails OT&E**

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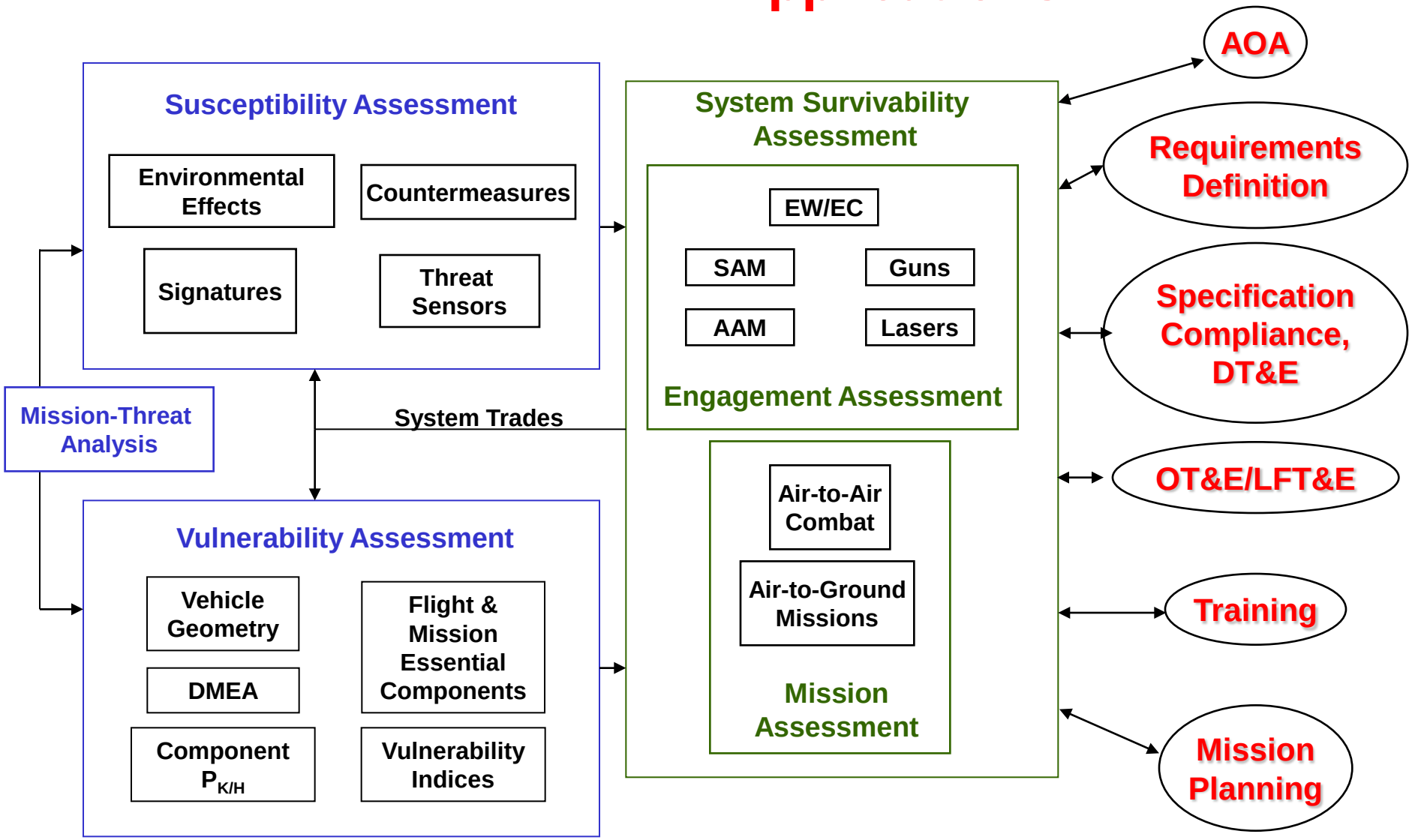
Integrated Survivability Assessment Applications



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Some Known Deficiencies in ISA Process

- **General Issues**
  - Model linkages; data availability, including validation data; links to TEMP; analyst experience
- **Modeling and Simulation Issues**
  - Aggregation of M&S results from lower level models to higher level
  - Engagement level: DECM, threat fuzing, human operator, signatures, body-on-body effects, external blast, DEW, fire & explosion
  - Mission Level: networked systems, operator tactics, data/sensor fusion, C4ISR
- **Test Range Issues**
  - Number of platforms, threats in test, test range size – can't fully test integrated system
    - Signal Density – may not be representative on ranges
  - Limitations in current T&E capabilities
    - Missile Miss Distance Measurement
    - Threat System Variability – system to system variations
  - Insufficient pre-planning:
    - Completeness & fidelity of OT&E data
    - System calibration issues

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Summary

- **ISA process integrates LFT&E data (vulnerability) with DT&E and OT&E survivability data (susceptibility)**
  - **In a "model-test-model" approach, with consistent metrics across system acquisition and test**
  - **M&S results are used to support test plan development and to put test results into context of mission/scenario vignettes**
  - **Test results are used to support improvements to M&S**
- **Vignette approach:**
  - **Provides consistency in evaluation criteria across program development stages (requirements, specification, LFT&E, DT&E, OT&E)**
  - **Highlights any problem areas and potential solutions**
  - **Ensures the SUT is not a point design from the standpoint of survivability**
- **Current deficiencies in M&S and T&E resources need to be addressed**
  - **Gradually being improved via JASP, CTEIP, etc.**

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Contact Info

David H. Hall

Chief Analyst

SURVICE Engineering Company

900E North Heritage Drive, Suite 1

Ridgecrest, CA 93555

(760) 446-4624; FAX: (760) 446-2424

Cell: (760) 382-1618

dave.hall@survice.com

Ronald L. Ketcham

Chairman, Survivability Assessment Subgroup,

Joint Aircraft Survivability Program

Commander (Code 496400D), Naval Air Warfare Center, Weapons Division, China Lake, CA 93555-6001

(760) 939-2363 FAX (760) 939-2062

Ronald.Ketcham@navy.mil