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Integrated Survivability Assessment (ISA) in the Systems Engineering Process

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What is Integrated Survivability Assessment?

- 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
- Developed by SURVICE Engineering Company
  - For the Joint Aircraft Survivability Program (JASP) with funding from DOT&E
- SURVICE's Experience in many related areas led to its selection for this work
  - Survivability, Effectiveness and Mission Modeling and Analysis
  - Test and Evaluation Planning, Execution, and Analysis
  - Model and Simulation Verification, Validation and Accreditation
  - Systems Safety Engineering and Analysis

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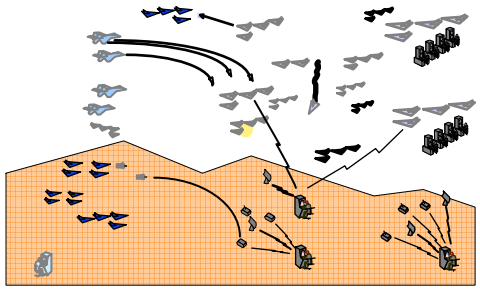
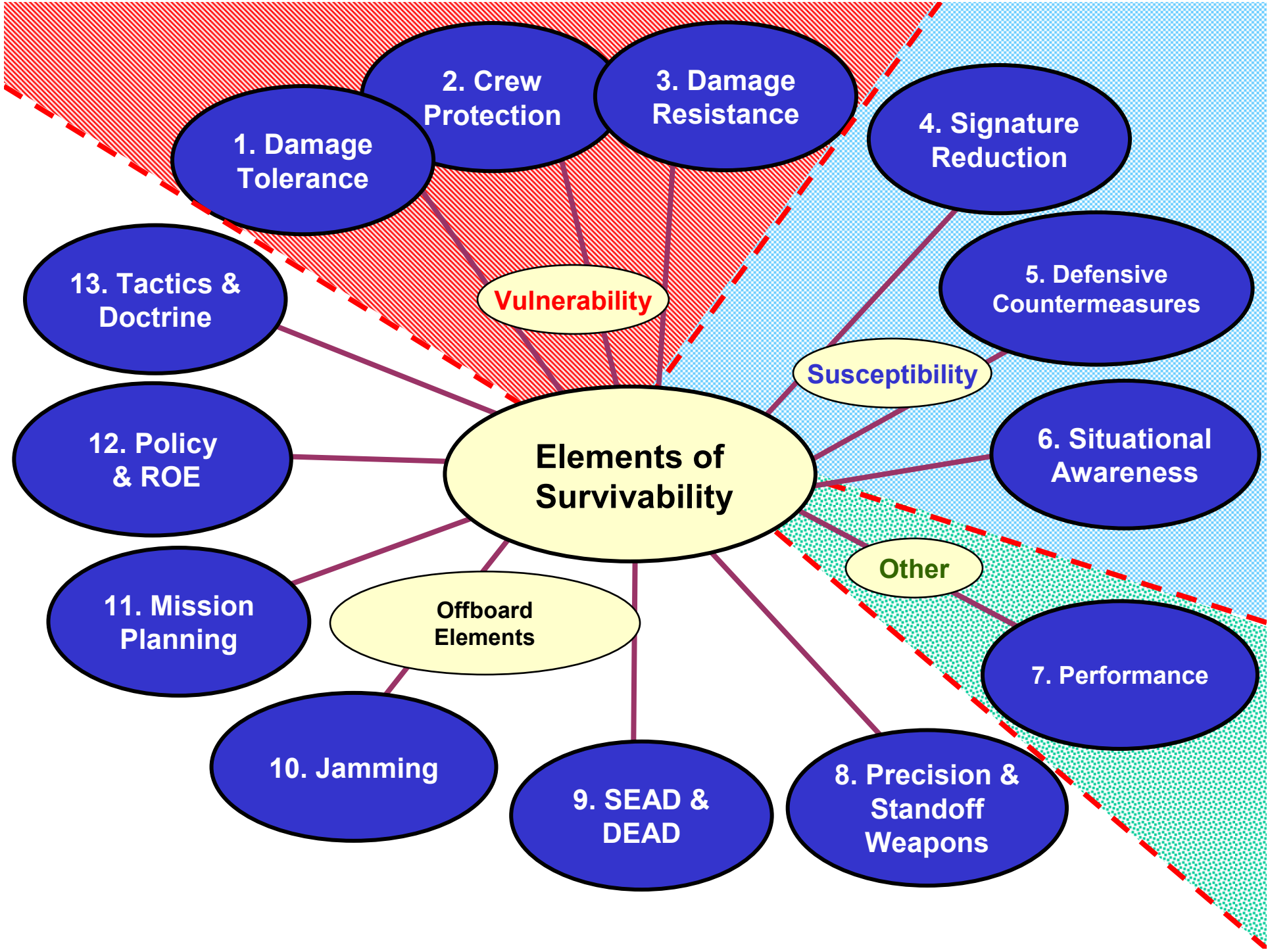
What does the Integrated Survivability Assessment Process Do?

- **Measures system survivability in the context of missions and scenarios**
  - **Ensures that mission and scenario vignettes "cover the waterfront" to avoid a point design**
- **Ensures consistent treatment of survivability if applied throughout the system acquisition lifecycle**
  - **Requirements development, AOA, spec compliance, LFT&E, OT&E, retrofits, SLEP, system mods, training applications…**
- **Enables trades of Survivability, Effectiveness, and Mission Metrics in 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
Offboard Elements
Elements of Survivability

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Developing an Integrated Survivability Assessment Process

- Develop a checklist of important survivability factors
- Define the operational context and environment
- Select and evaluate the metrics identified as important to integrated survivability assessment
  - Provide a modeling path to measure and quantify those metrics
  - Identify test range assets and processes to measure those metrics
- Identify assumptions, limitations, and deficiencies in both M&S and Test resources
  - And mitigation actions for deficiencies
- Provide for a path to validation of the modeling processes with available test range data
  - Model - test - model

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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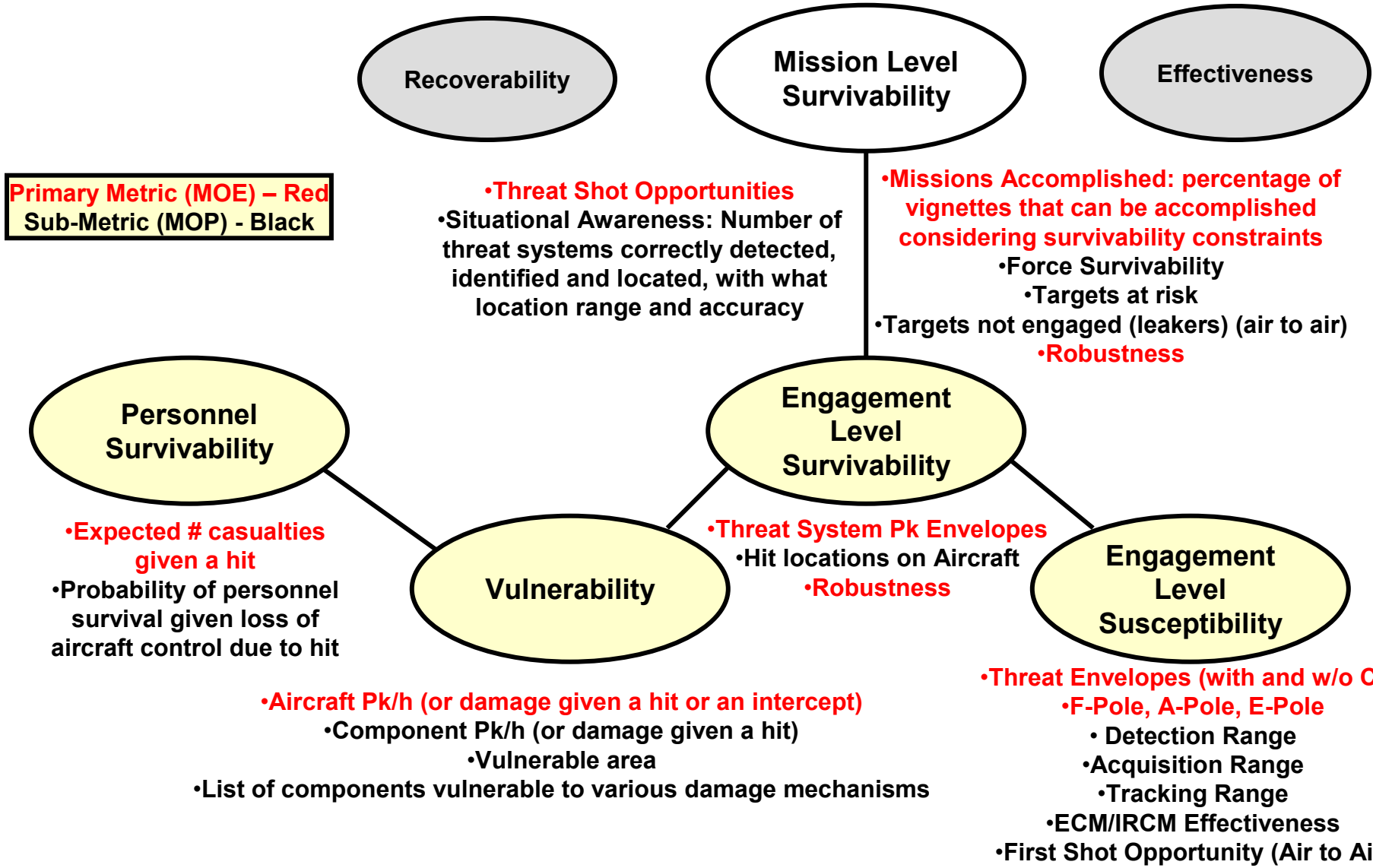
Survivability Metrics



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Metrics and the Checklist

Links in the Threat Kill Chain	ISA Metrics	Potential Survivability Enhancement Features Along the Kill Chain
Mission Survivability	Missions Accomplished; robustness	All features combine to support mission level survivability
Threat Suppression	Threat Shot opportunities; situational awareness (number, timeliness and accuracy of threats detected)	Tactics, Precision Guided Munitions, mission planning, low signatures, fighter escort, ARM, self defense weapons
Detection Avoidance	Threat Detection & Acquisition Envelopes	SOWs, Night Capability, on-board Electronic Attack (EA), stand-off EA, low signatures, good target acquisition, Terrain Following, Situational Awareness (SA), chaff, threat warning, tactics, mission planning
Engagement Avoidance	Threat Tracking envelopes; F-Pole, A-Pole, E-Pole; ECM effectiveness	SOWs, Onboard EA, Off-board EA, low signatures, good target acquisition, SA, chaff and flares, threat warning, speed and altitude, mission planning
Threat or Hit avoidance	Threat Intercept Envelopes; ECM/IRCM effectiveness	On-board EA, low signatures, chaff and flares, threat warning, speed and altitude, maneuverability, agility
Threat or hit tolerance	Threat system Pk envelopes; Aircraft Pk/h; Component Pk/h; VA; Vulnerable Components; Casualties given a hit; hit locations on aircraft	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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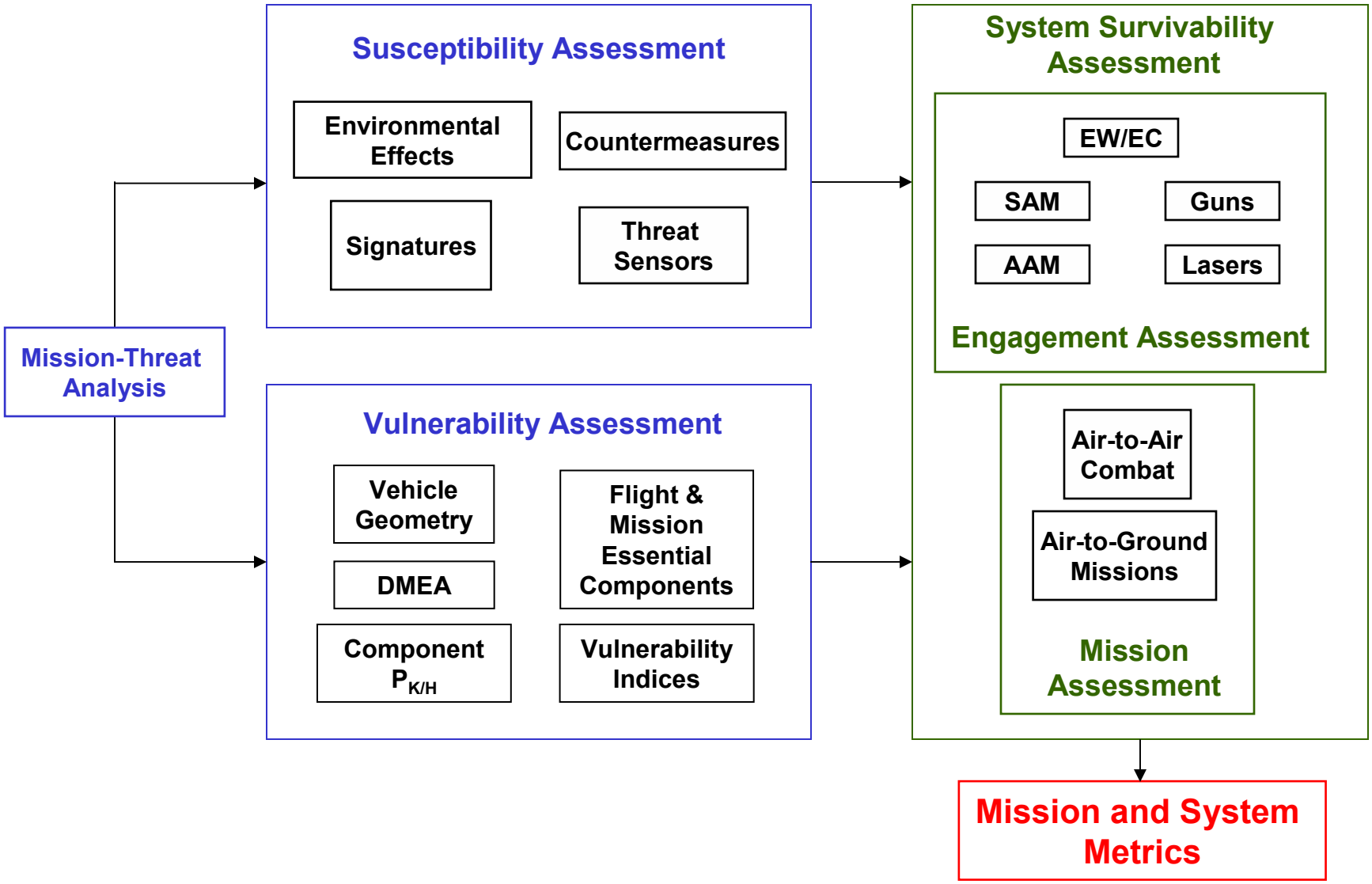
The Survivability Assessment Process



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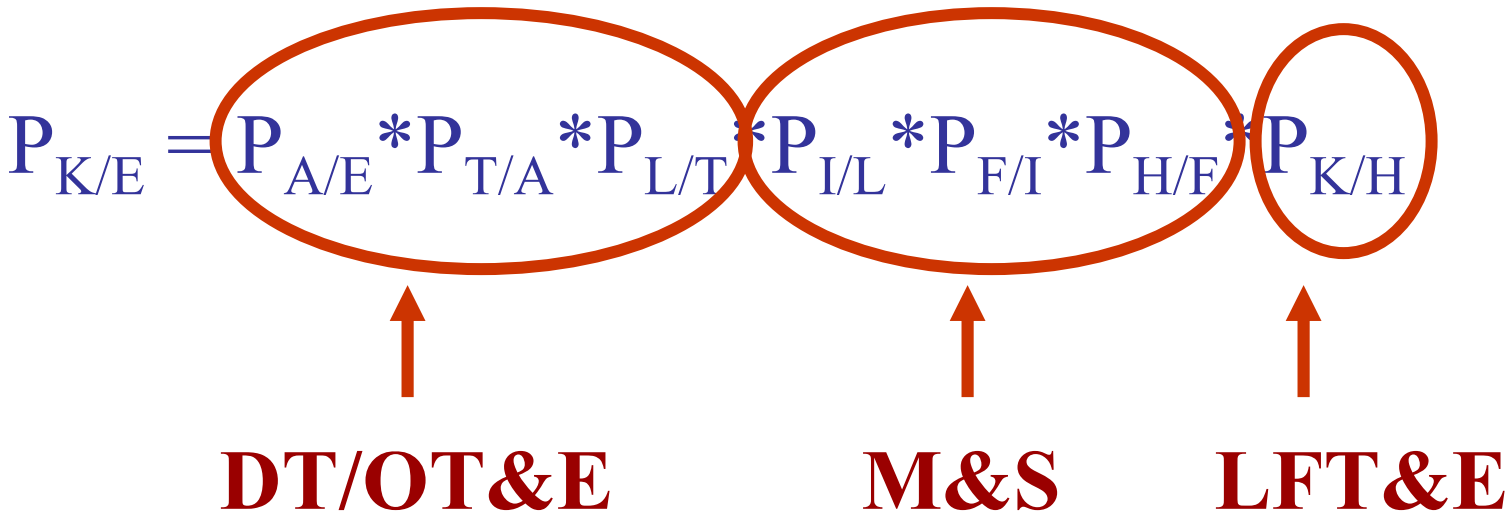
Data Sources for a Typical Survivability Assessment



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

I = Intercept
F = Fuzing
H = Hit

K = Kill

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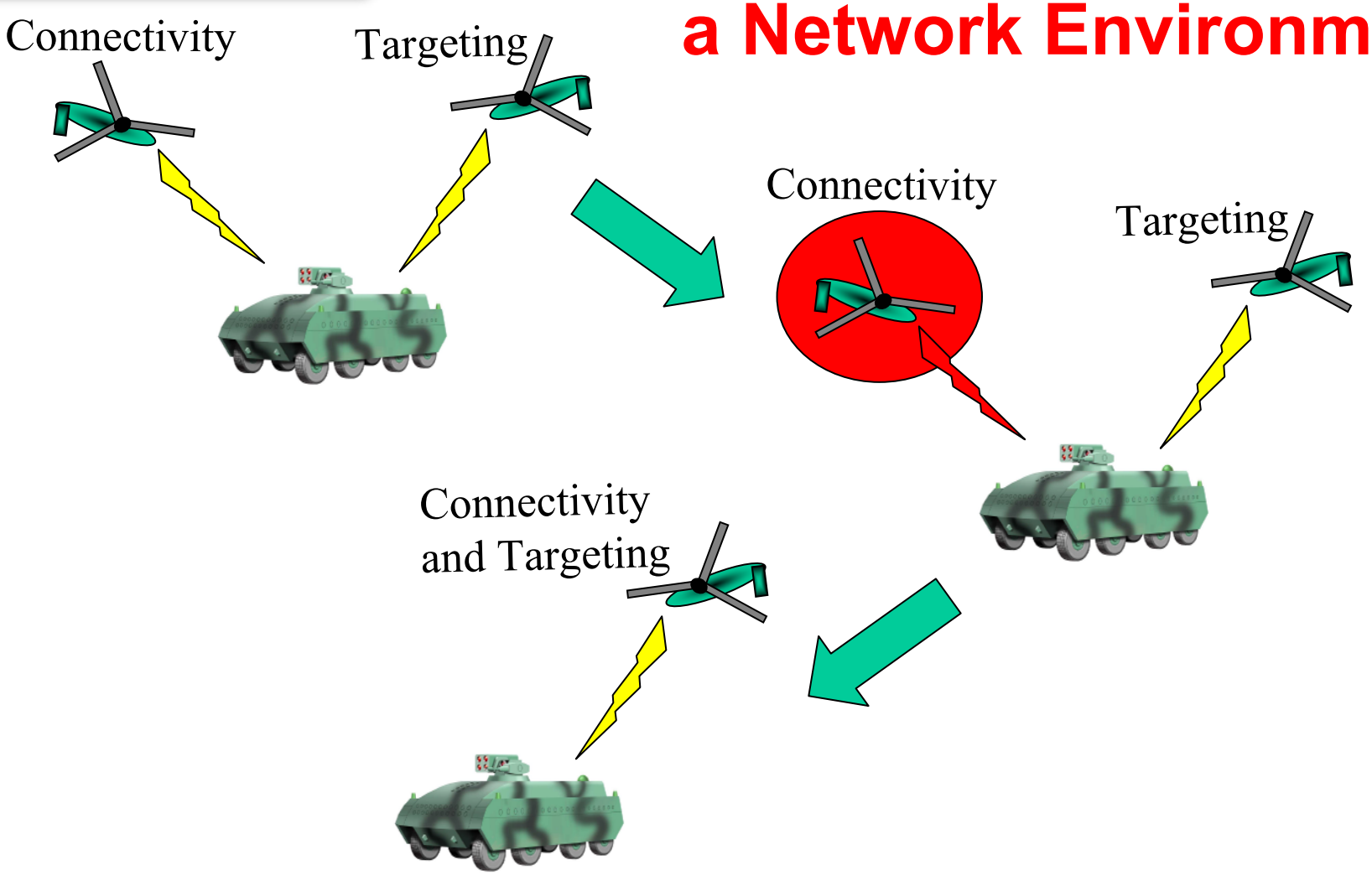
System Survivability in a Network Environment



How does loss of a UAS element affect the network?

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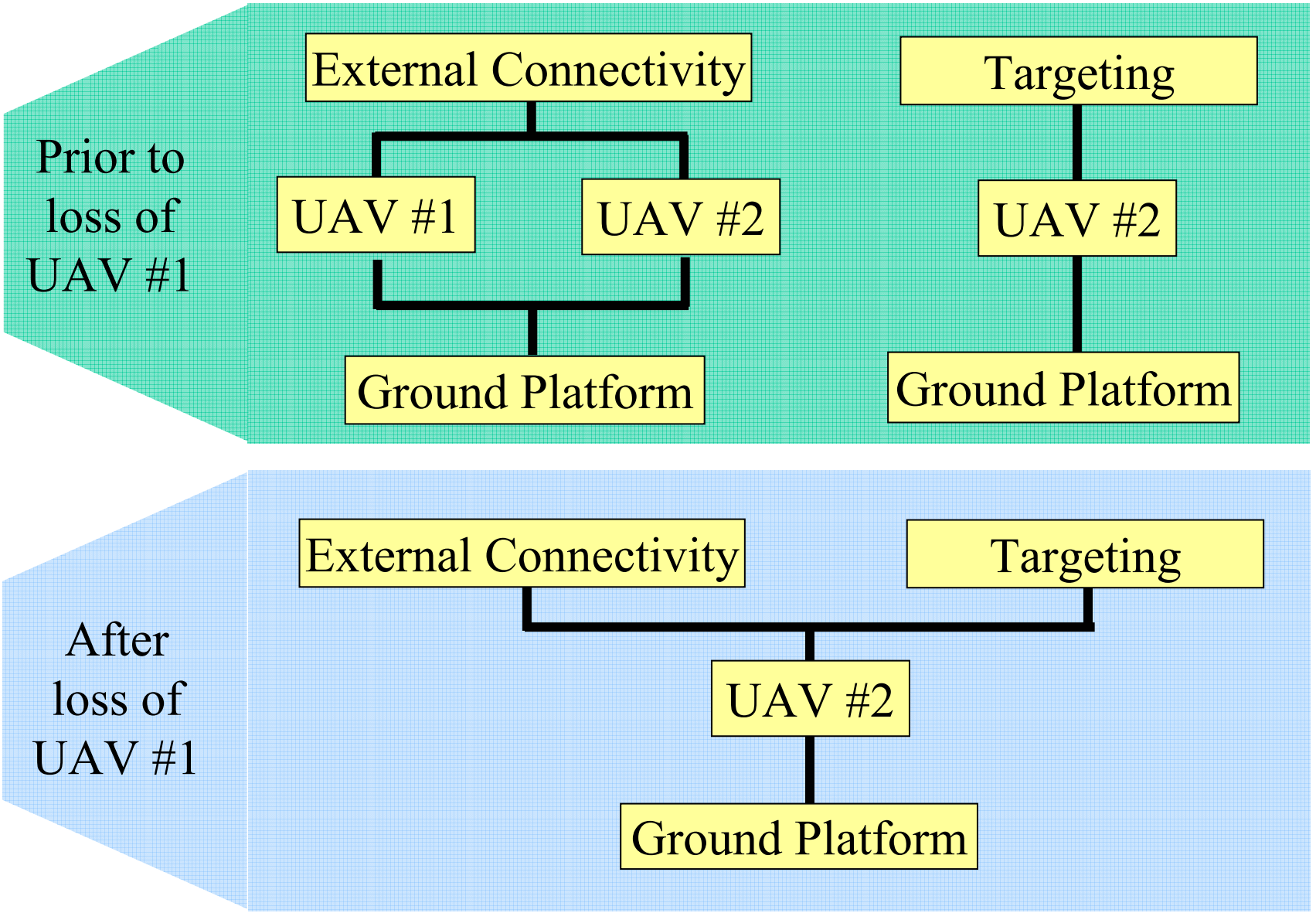
Network Fault Tree Approach



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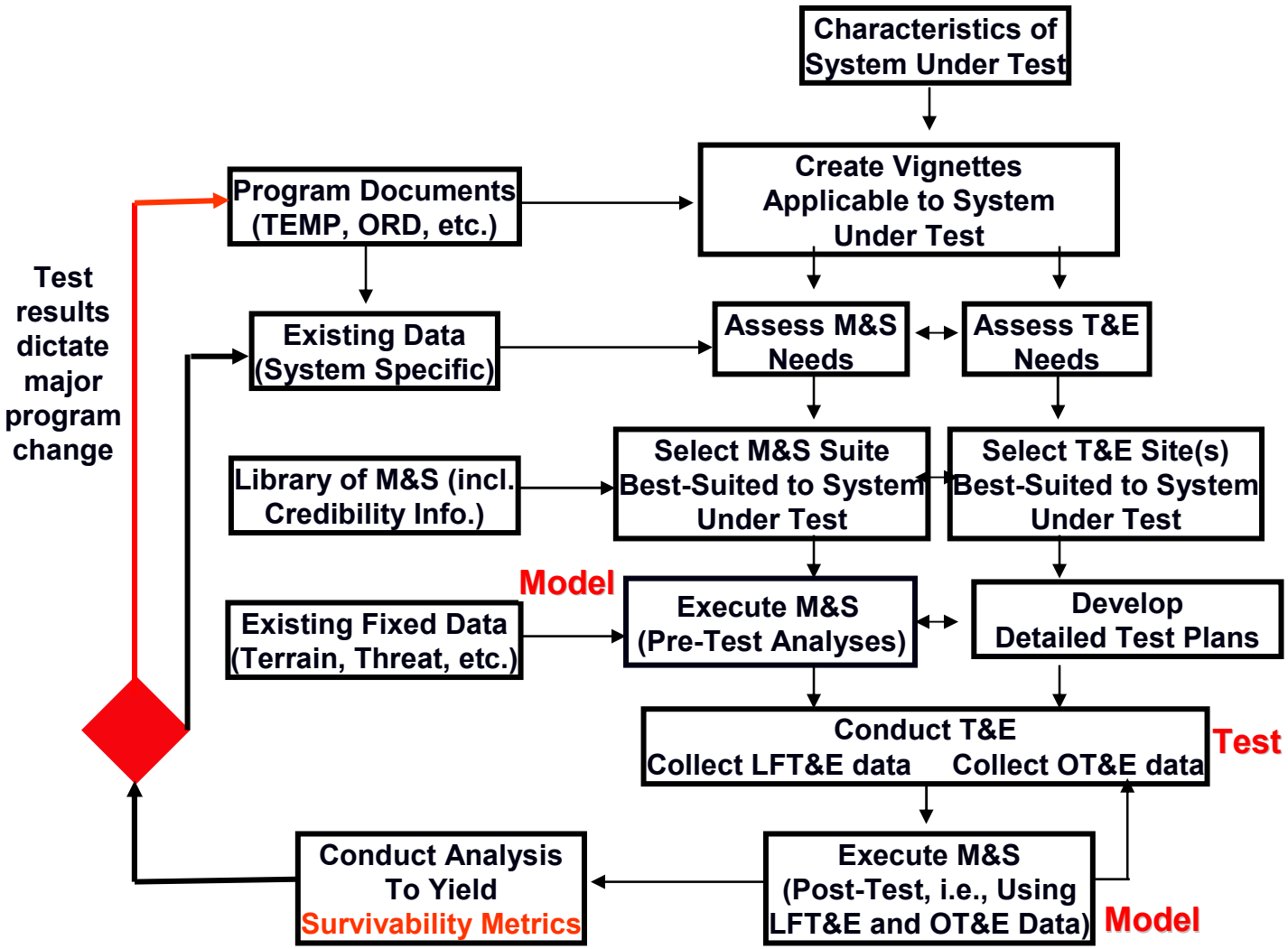
Integrated Survivability Assessment Process: Model-Test-Model Concept



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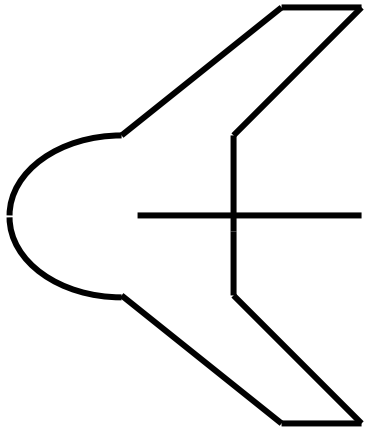
"Case Study" Example

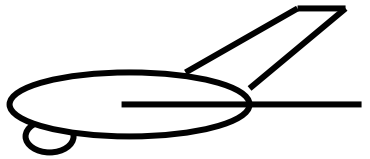
- **Unmanned Combat Aircraft System (UCAS) with the following characteristics:**

  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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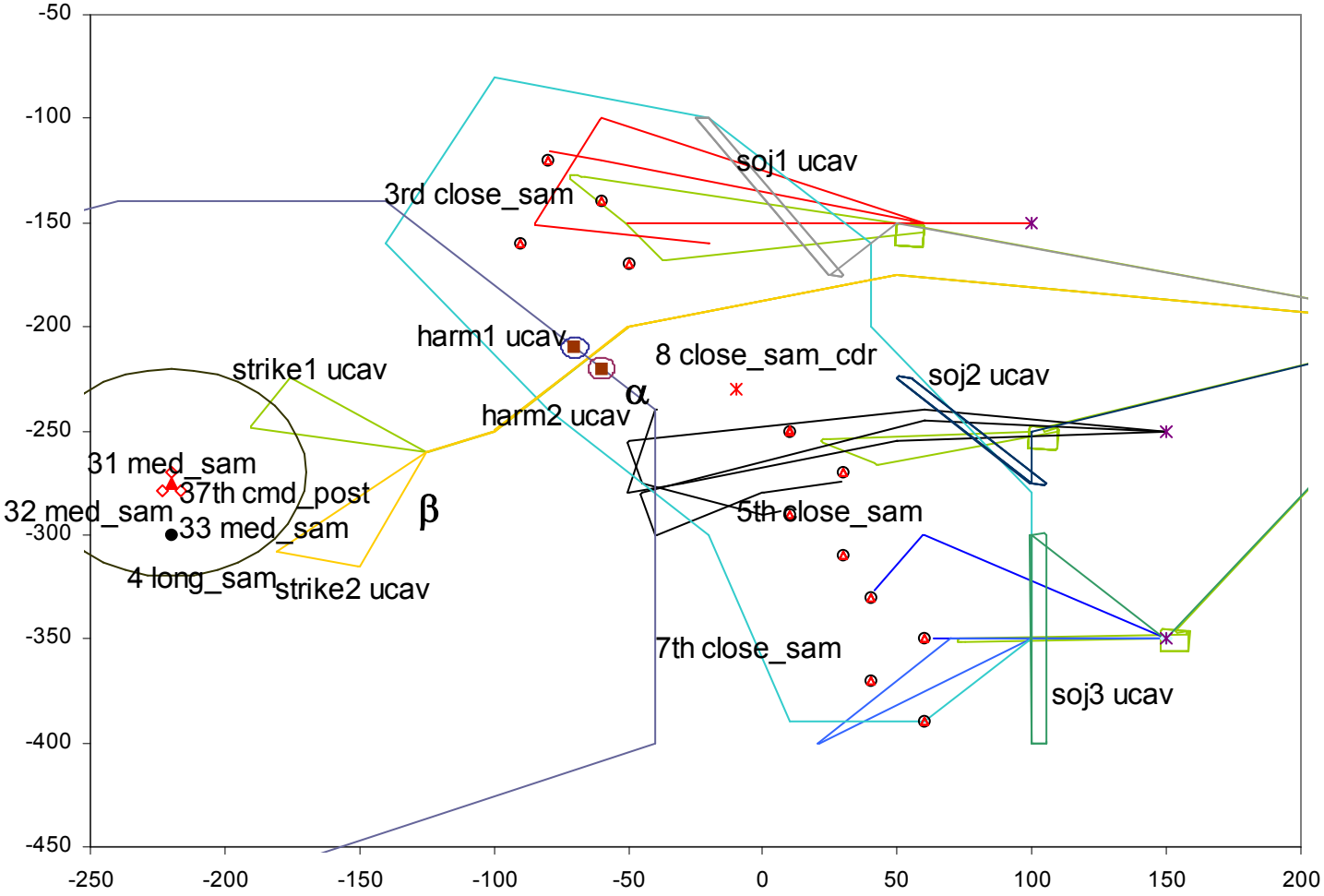
Example: SEAD/DEAD Vignette



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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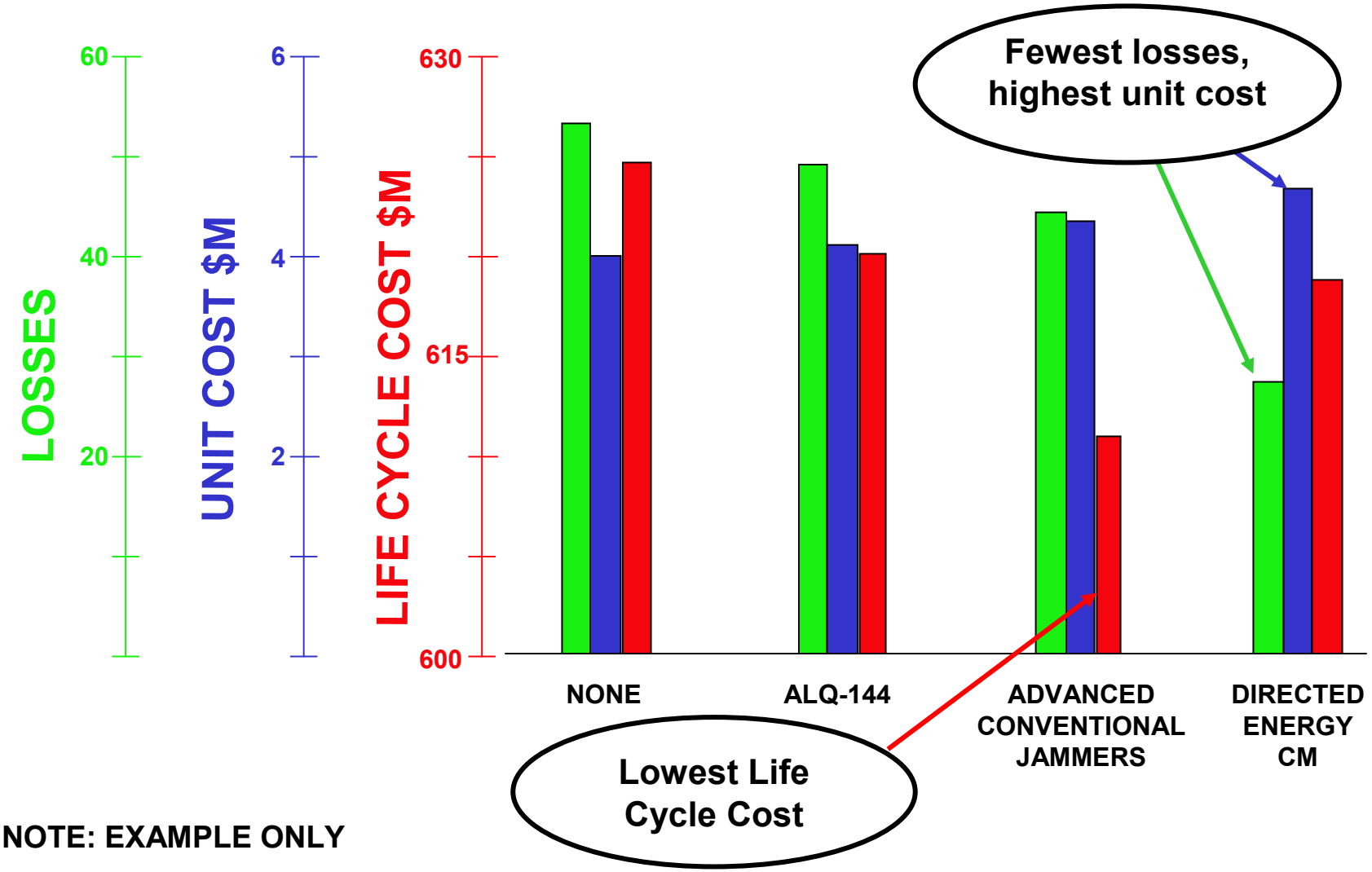
Example Integrated Survivability Results : Impact of IRCM Improvements on UAS



NOTE: EXAMPLE ONLY

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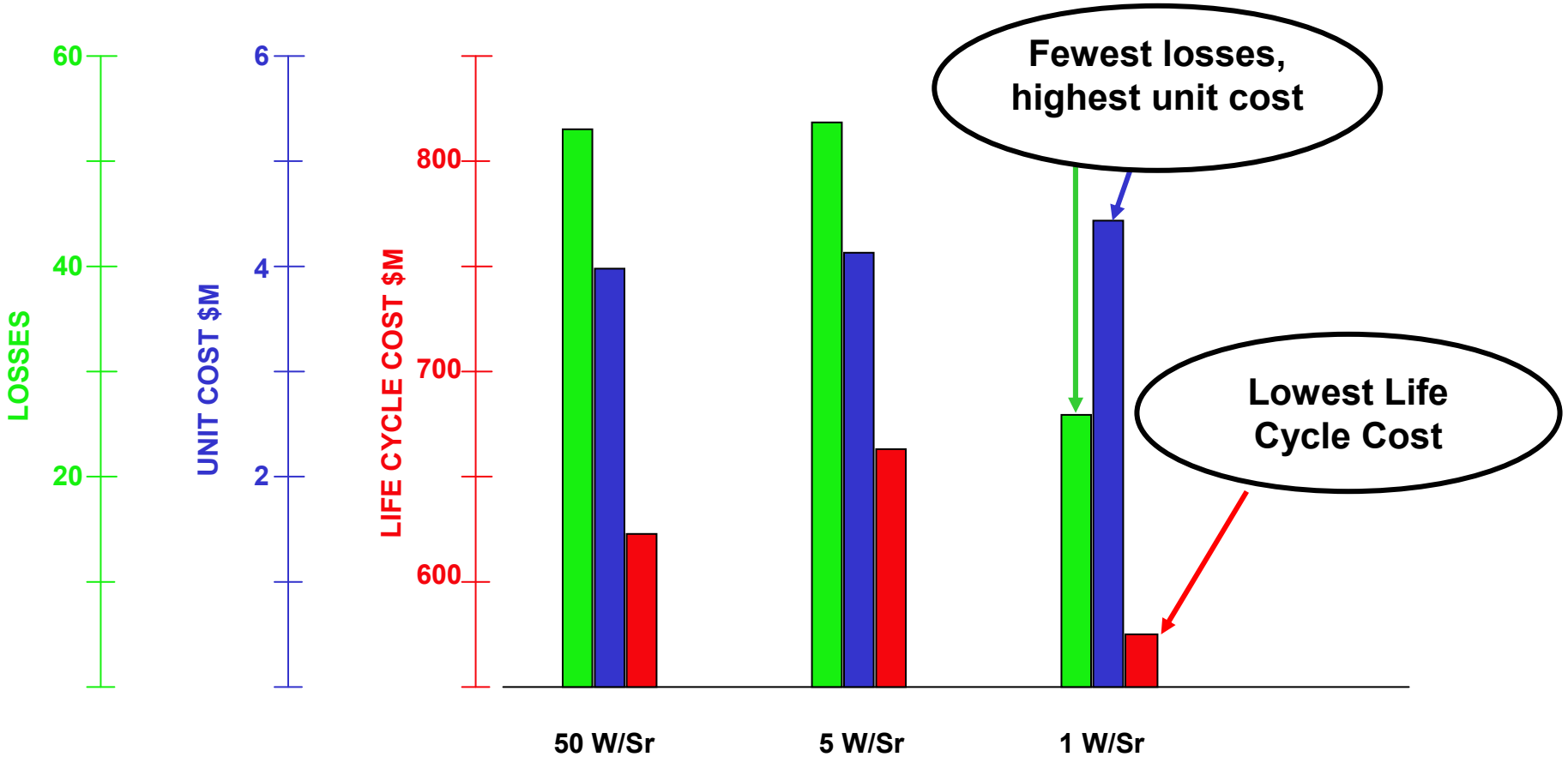
Example Integrated Survivability Result: Impact of IR Signature Reduction on UAS



NOTE: EXAMPLE ONLY

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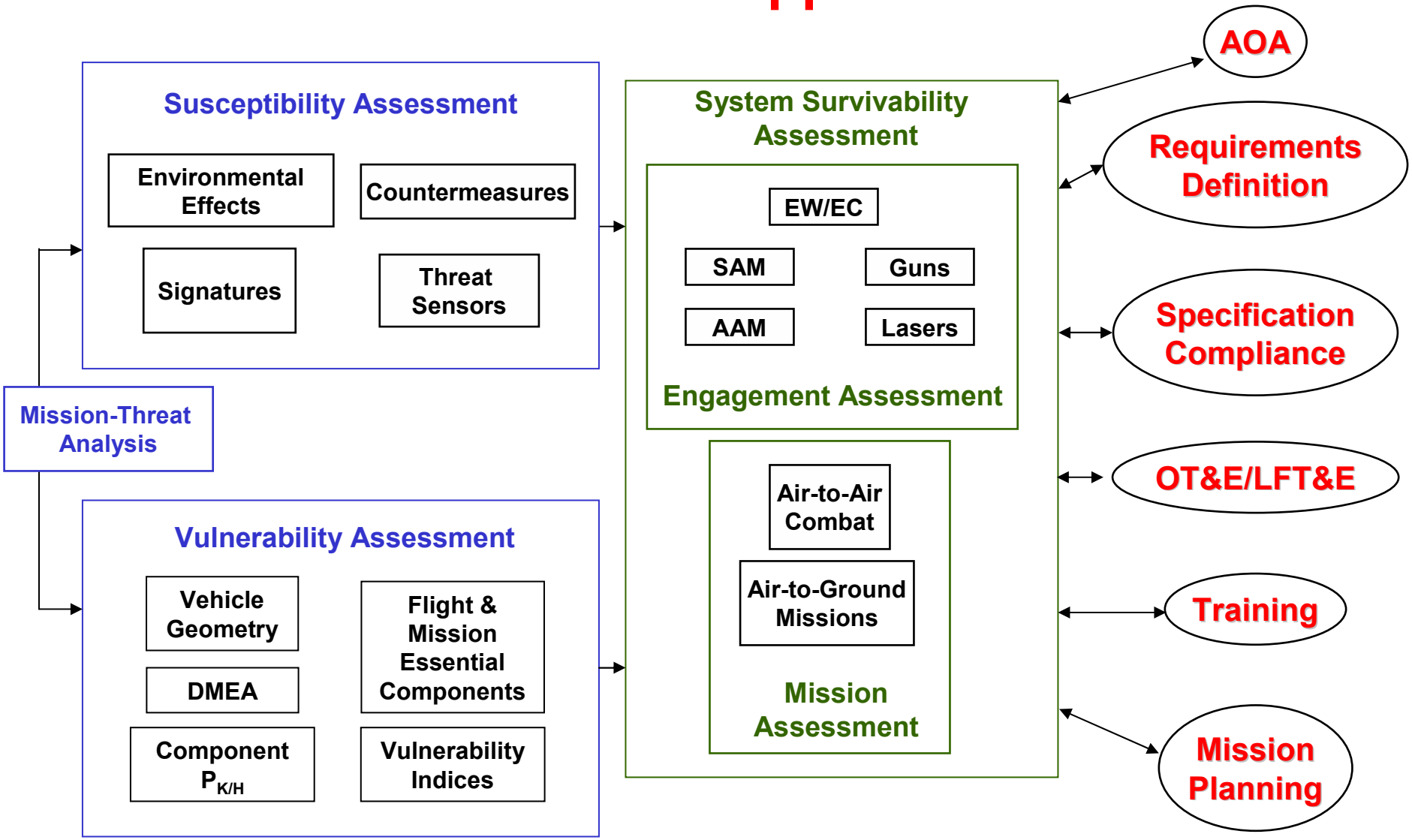
Integrated Survivability Assessment Applications



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Summary

- **Integrated Survivability Assessment incorporates survivability into the systems engineering process for all phases of system development**
  - **Supports both individual platform and network system assessment**
- **JASP has funded the development of a baseline ISA capability focused on air systems**
  - **ISA process is extensible to ground, shipboard and space systems as well**

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ISA Demonstrations

- JASP is co-funding demonstrations of the ISA process for two acquisition programs
- Multi-Mission Maritime Aircraft (MMA)
  - Demo began in FY04
- Aerial Common Sensor (ACS)
  - To begin in FY06

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Supplemental Material

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Example: SEAD/DEAD Vignette

- SEAD/DEAD mission
  - SOJ
  - HARM
  - Part of Battlefield Interdiction (Strike)
    - Command Post target
- Scenario:
  - Unclassified scenario taken from Joint Integrated Mission Model (JIMM) dataset
- Threats:
  - Surface-to-air RF and IR missiles only

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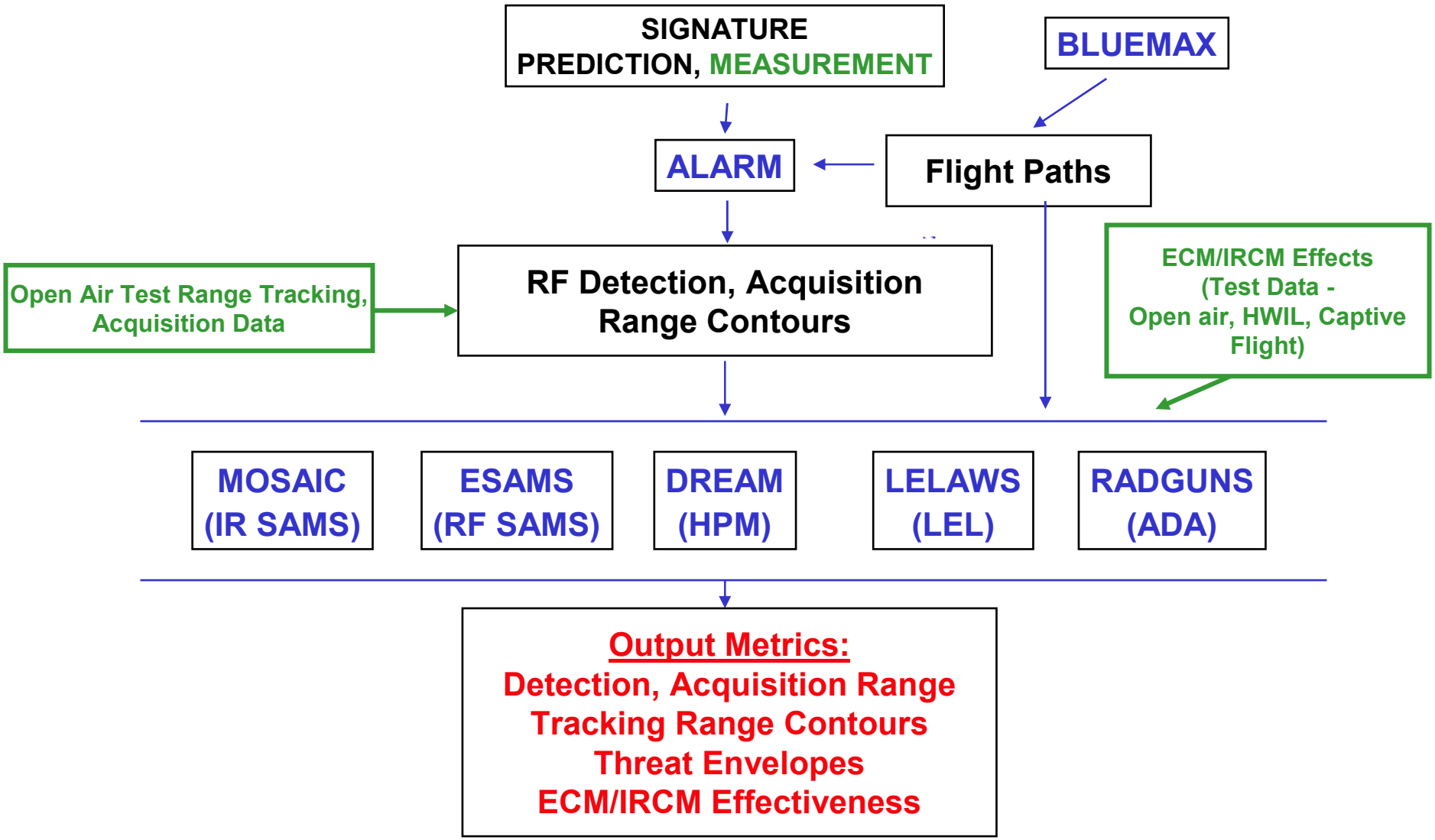
Single Threat Engagement Assessment



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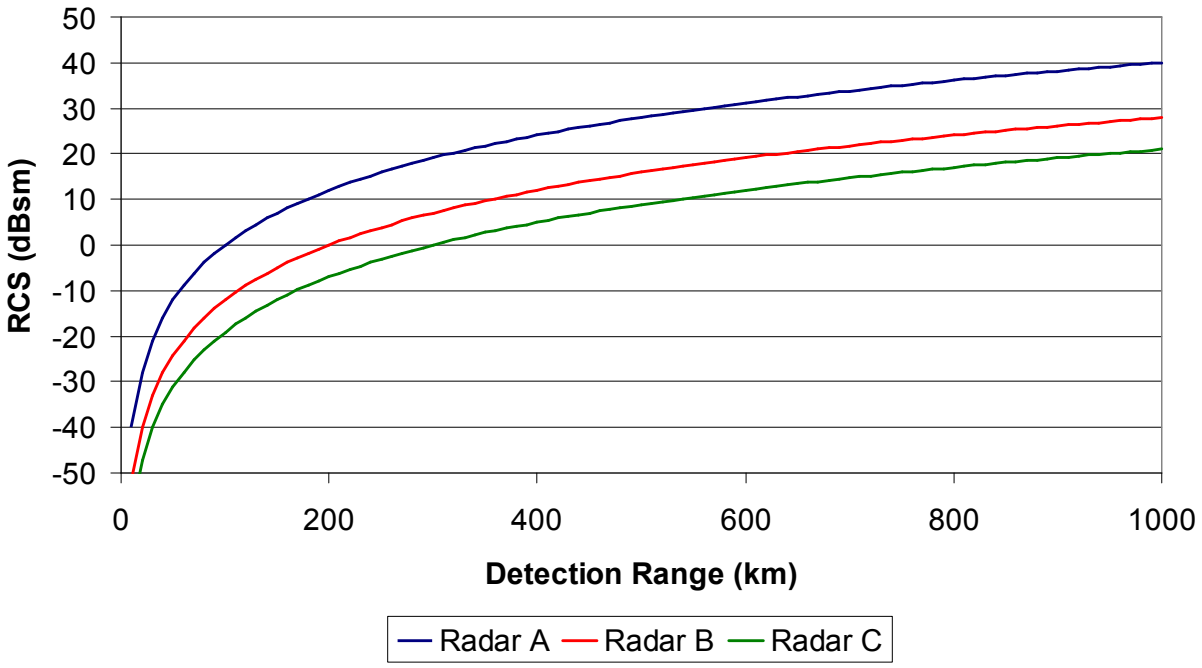
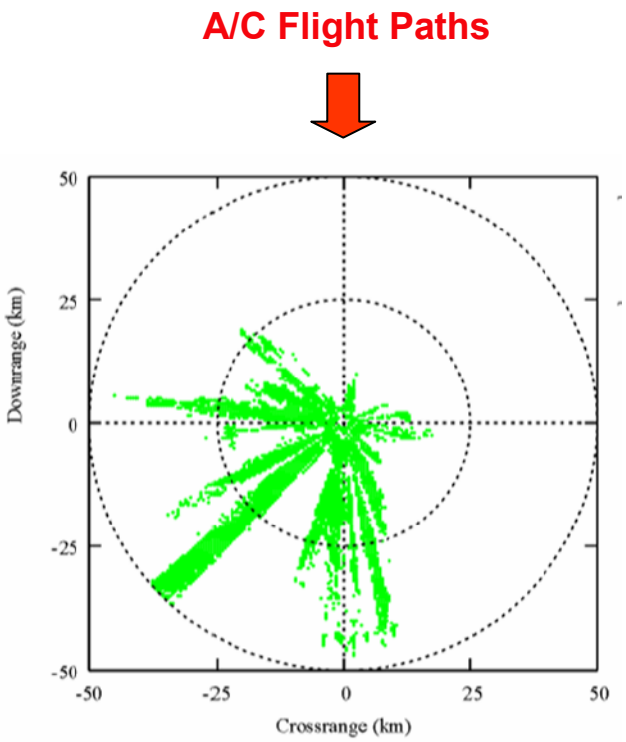
Example Susceptibility Results: Impact of RCS and Terrain on Detection

Detection range vs. RCS



Effects of Terrain Masking on Detection Contour



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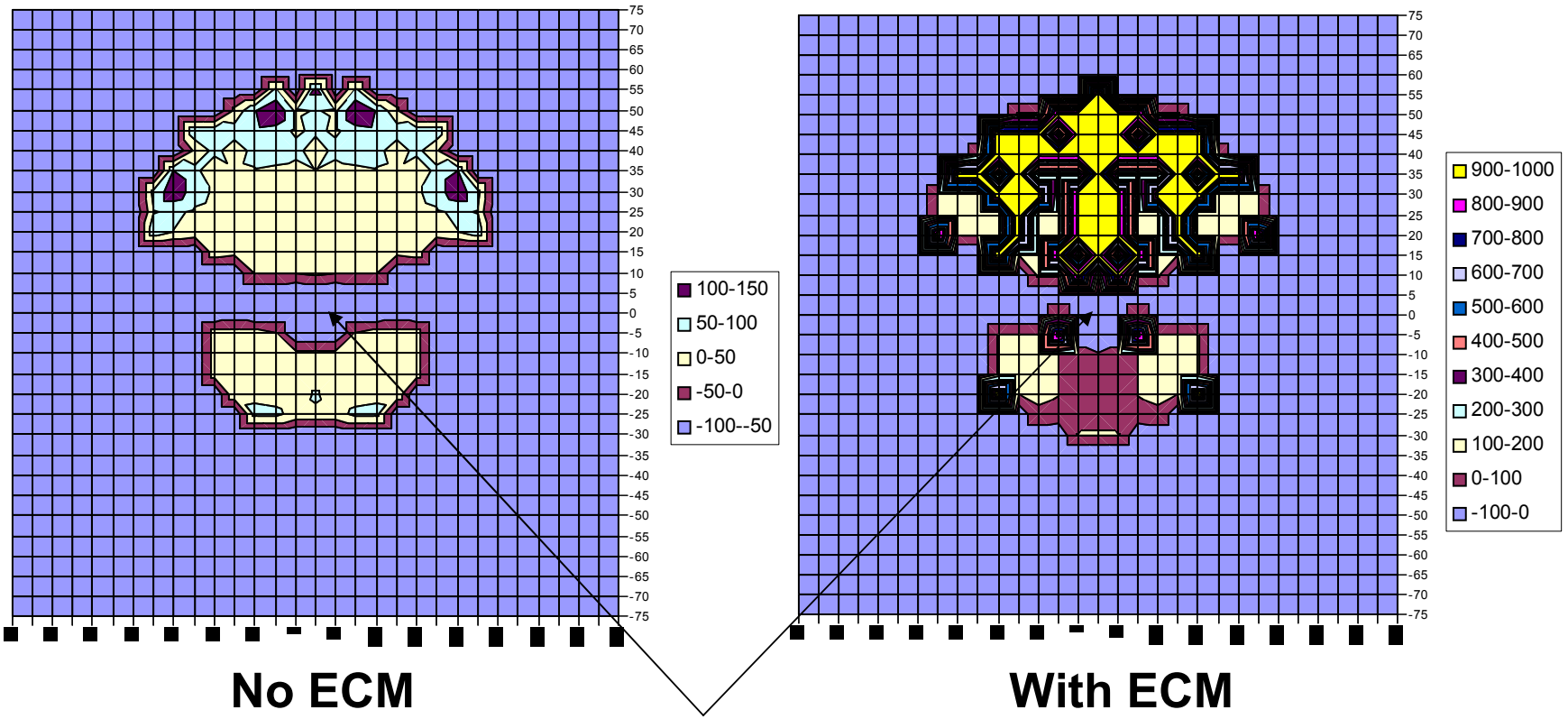
Example Results: Impact of ECM on Miss Distance

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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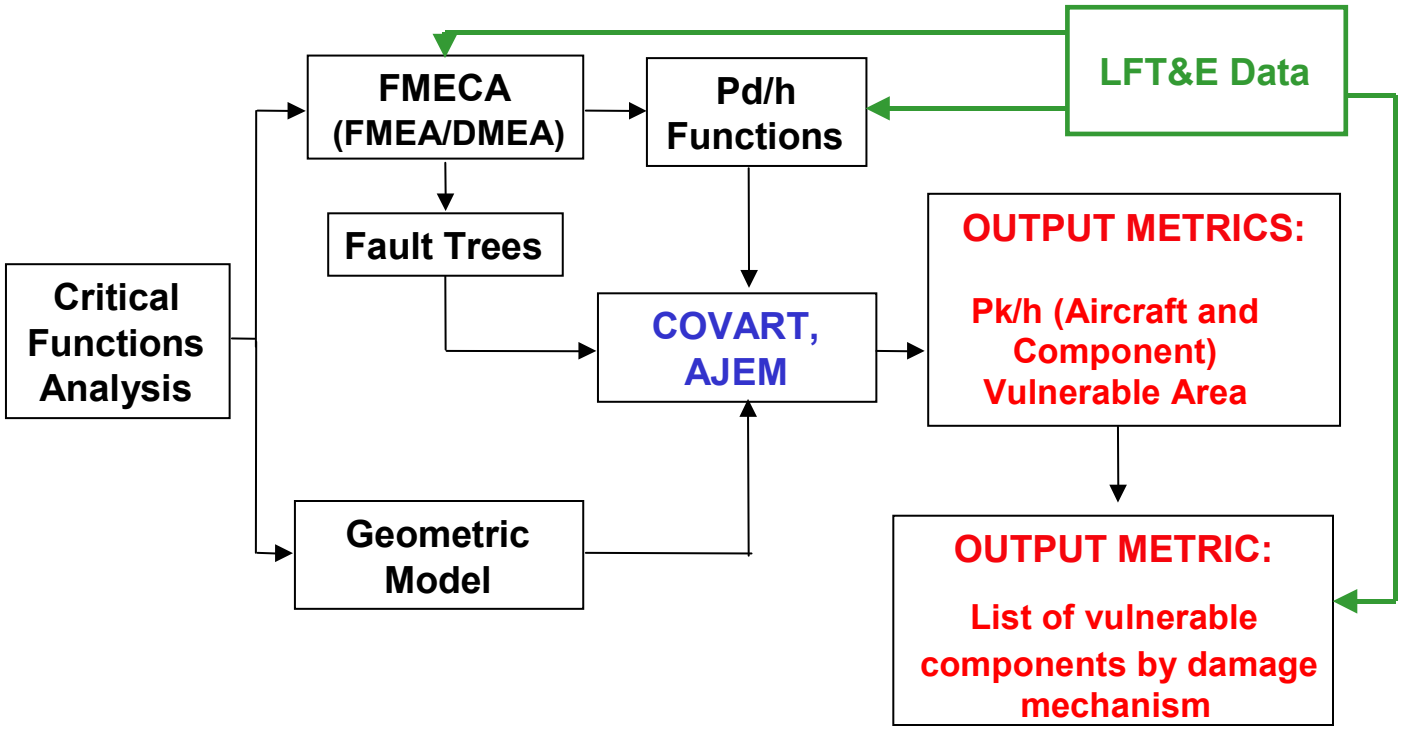
Vulnerability Assessment



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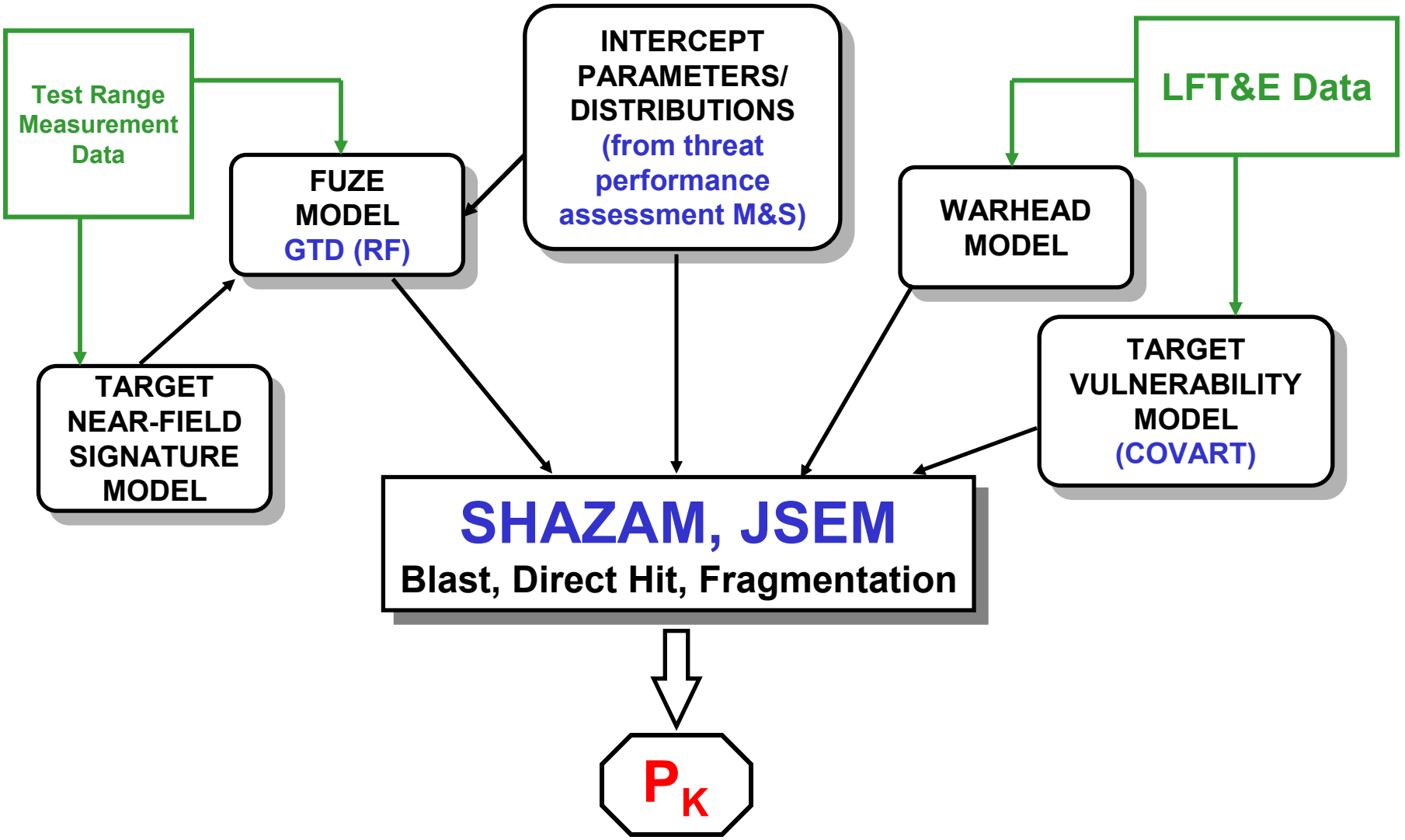
Threat Missile Endgame (Pk) Assessment



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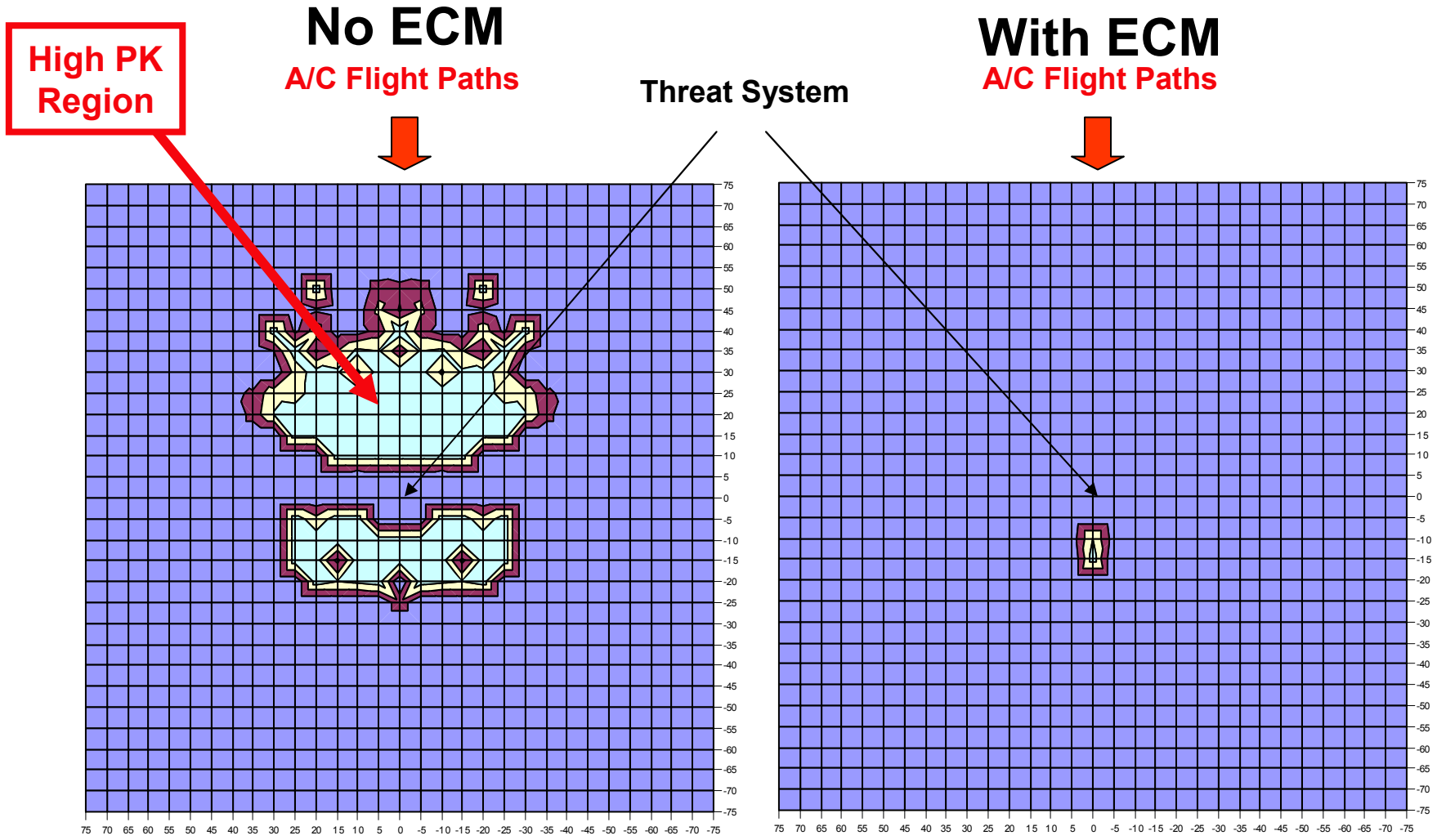
Example Engagement Survivability Results: Effect of ECM on PK



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Mission Survivability Assessment