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UNMANNED AERIAL VEHICLE SURVIVABILITY INFLUENCE ON SYSTEM LIFE CYCLE COST

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OBJECTIVE

To present a methodology for use in the Systems Engineering process that assists decision makers in identifying the unmanned aerial vehicle survivability alternative that provides the lowest life cycle cost while meeting the operational need.

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OUTLINE

- BACKGROUND
  - Systems Engineering
  - Survivability
  - Unmanned Aerial Systems

- METHODOLOGY DESCRIPTION
  - Basic Premise
  - Characteristics
  - Description

- EXAMPLE
  - Scenario Description
  - Vignette Snapshot
  - Results

- CONTRIBUTORS

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BACKGROUND
SYSTEMS ENGINEERING

DoD Directive 5000.1

Systems Engineering.Acquisition programs shall be managed through the application of a systems engineering approach that optimizes total system performance and minimized total ownership costs.

DoD Instruction 5000.2

Effective sustainment of weapon systems begins with the design and development of reliable and maintainable systems through the continuous application of a robust systems engineering methodology

Defense Acquisition Guidebook

Chapter 4 describes the systems engineering processes and the fundamentals of their Application to DOD acquisition.

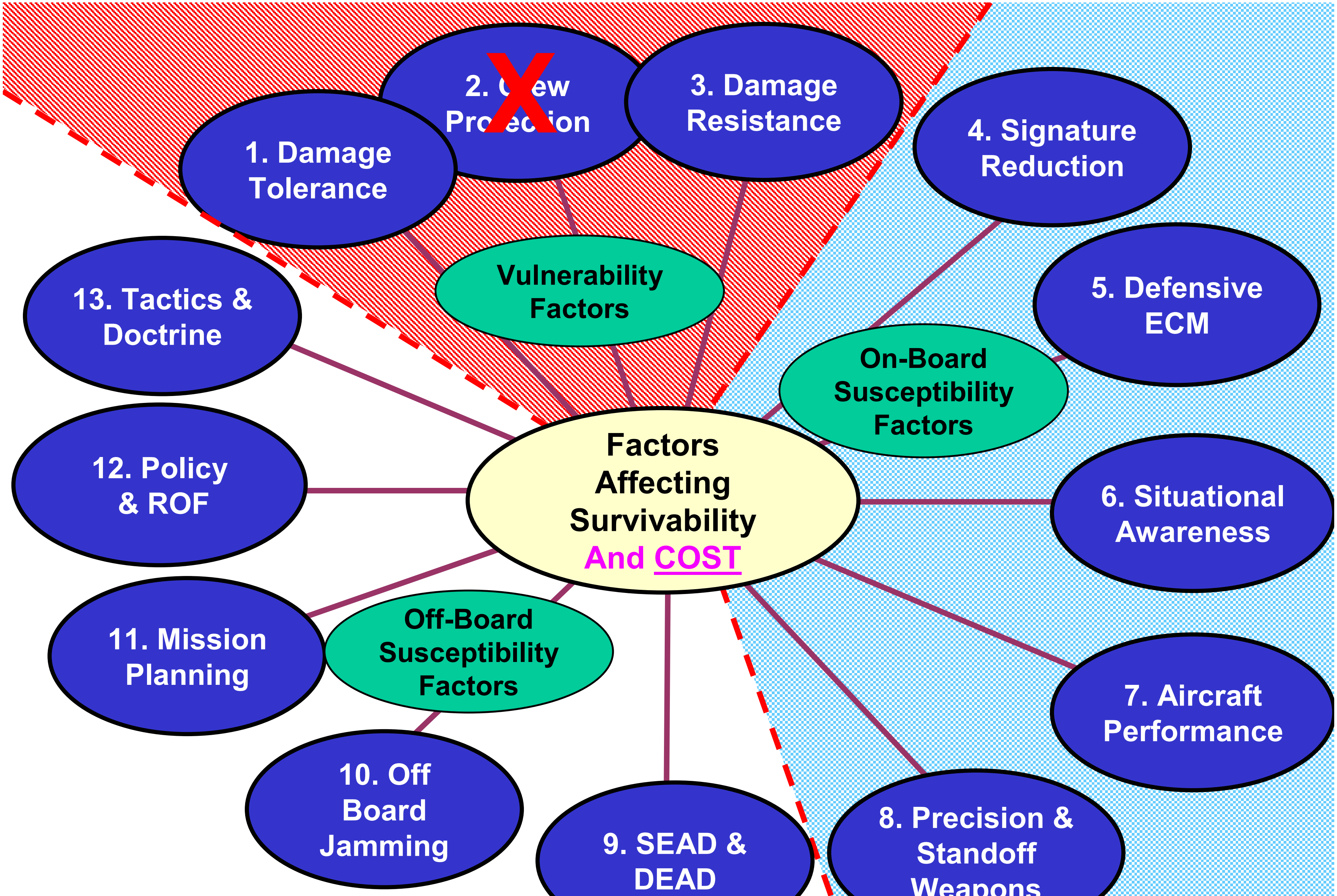
THE METHODOLOGY DESCRIBED IN THIS PRESENTATION WAS CONCEIVED TO ASSIST SURVIVABILITY EVALUATIONS WITHIN THIS PROCESS

BACKGROUND

WHAT IS SURVIVABILITY ?

- **Survivability is the capability of a system/platform to avoid and/or withstand a man-made hostile environment. Survivability is broken down into two subsets, susceptibility and vulnerability.**
  - **Susceptibility is the inability of an aircraft to avoid being hit by one or more damage mechanisms.**
  - **Vulnerability is the inability of an aircraft to withstand the damage sustained from man-made threats.**

$$\text{Probability of Survival} = 1 - \left(\text{Probability of Being Hit}\right)\left(\text{Probability of Being Killed Given a Hit}\right)$$



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BACKGROUND
SURVIVABILITY

- Every combat system has survivability characteristics
  - Influenced by mission/threat - system design/configuration - relationships to other systems

- Survivability characteristics have a strong influence on Total System Cost
  - Not enough survivability - lose assets and cannot complete mission
  - Unnecessary survivability - creates affordability issues

- Survivability is important to any warfighting system

  It must survive to perform the mission
  It protects the operator from harm
  It keeps the system affordable

ANY SYSTEMS LEVEL EVALUATION OF UAVs SHOULD INCLUDE A STRUCTURED, INTEGRATED ASSESSMENT OF SURVIVABILITY TO IDENTIFY AND DEVELOP THE BEST OVERALL CONFIGURATION

BACKGROUND

UNMANNED AERIAL SYSTEMS

Source: DoD UAS Roadmap 2005 - 2030

Dragon Eye/BAI Aerosystems; AeroVironment/Marine Corps

Weight:	4.5 lb
Length:	2.4 ft
Wingspan:	3.8 ft
Payload:	1 lb
Ceiling:	1000 ft
Radius:	2.5 nm
Endurance:	45-60 min

RQ-4 Global Hawk/Northrop Grumman/Air Force

Weight:	26,750 lb
Length:	44.4 ft
Wingspan:	116.2 ft
Payload:	1950 lb
Ceiling:	65,000 ft
Radius:	5400 nm
Endurance:	32 hr

THE TRADE SPACE FOR SURVIVABILITY IS LARGE AND GROWING

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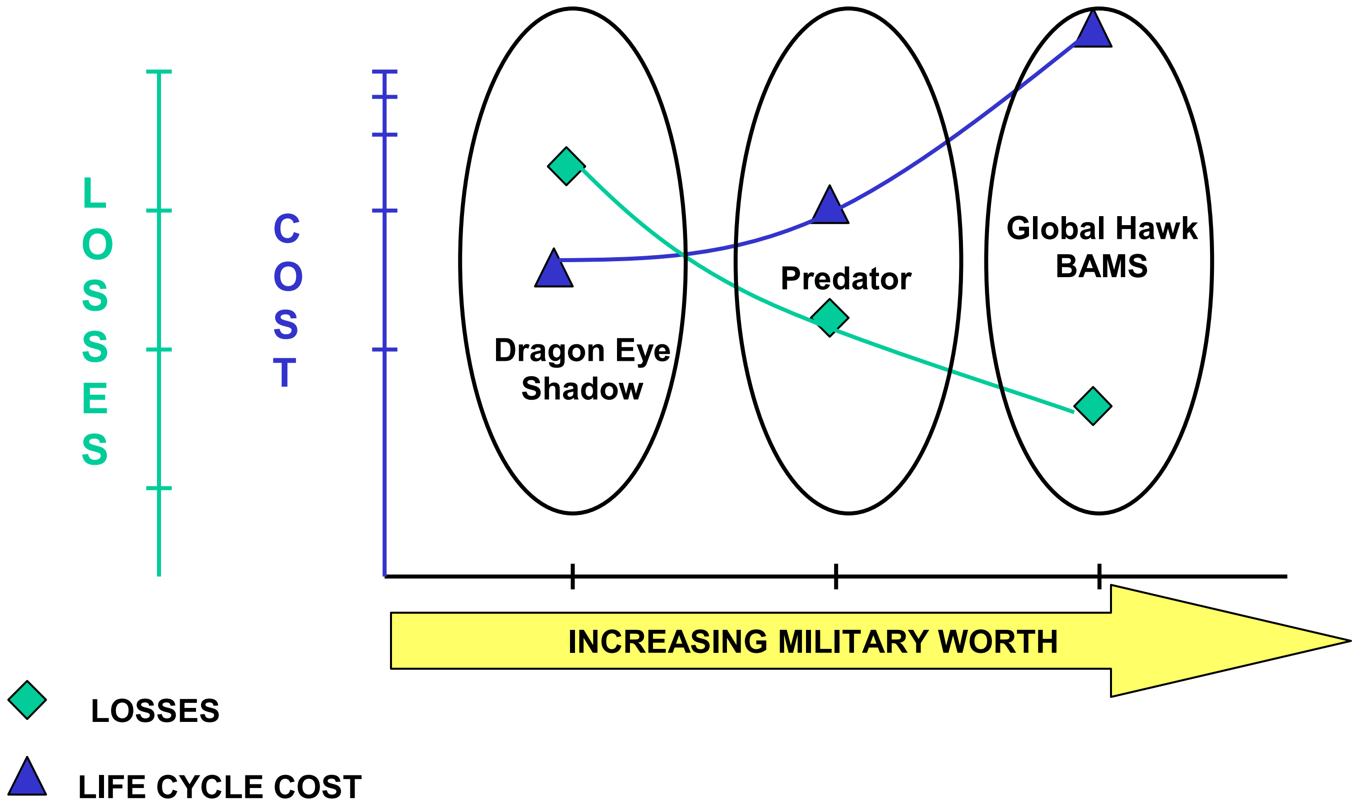
BACKGROUND
UNMANNED AERIAL SYSTEMS

Source: DoD UAS Roadmap 2005 - 2030

System	Aircraft Cost,FY04$*	Aircraft Weight, Lb*	Payload Capacity, Lb	System Cost FY04$	Number Acft/System
Dragon Eye	$28.5K	3.5	1	$130.3K	3
RQ-7A Shadow	$0.39M	216	60	$12.7M	4
RQ-2B Pioneer	$0.65M	307	75	$17.2M	5
RQ-8B Fire Scout	$4.1M	1765	600	$21.9M	4
RQ-5A Hunter	$1.2M	1170	200	$26.5M	8
MQ-1B Predator	$2.7M	1680	450**	$24.7M	4
MQ-9A Predator	$5.2M	3050	750**	$45.1M	4
RQ-4(Block 10) Global Hawk	$19.0M	9200	1950	$57.7M	1
RQ-4(Block 10) Global Hawk	$26.5M	15400	3000	$62.2M	1

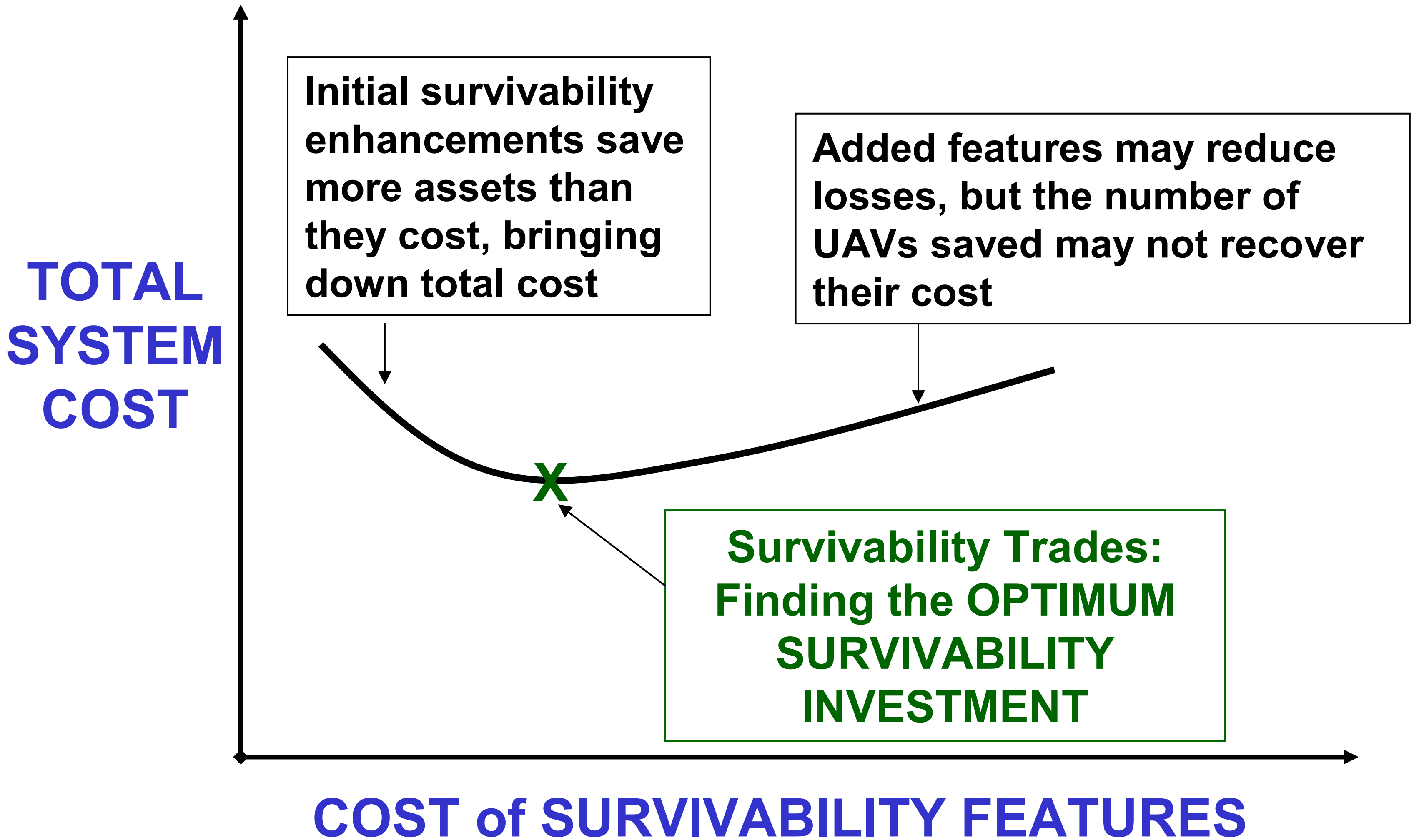
*Aircraft costs are minus sensor cost, and aircraft weights are minus fuel and payload capacities
** Internal payload weight capacity only

BACKGROUND
UNMANNED AERIAL SYSTEMS



- **As cost and military worth go up, reducing losses becomes key**
- **Cost <u>AND</u> military worth must be quantified to support survivability goals**

METHODOLOGY
BASIC PREMISE



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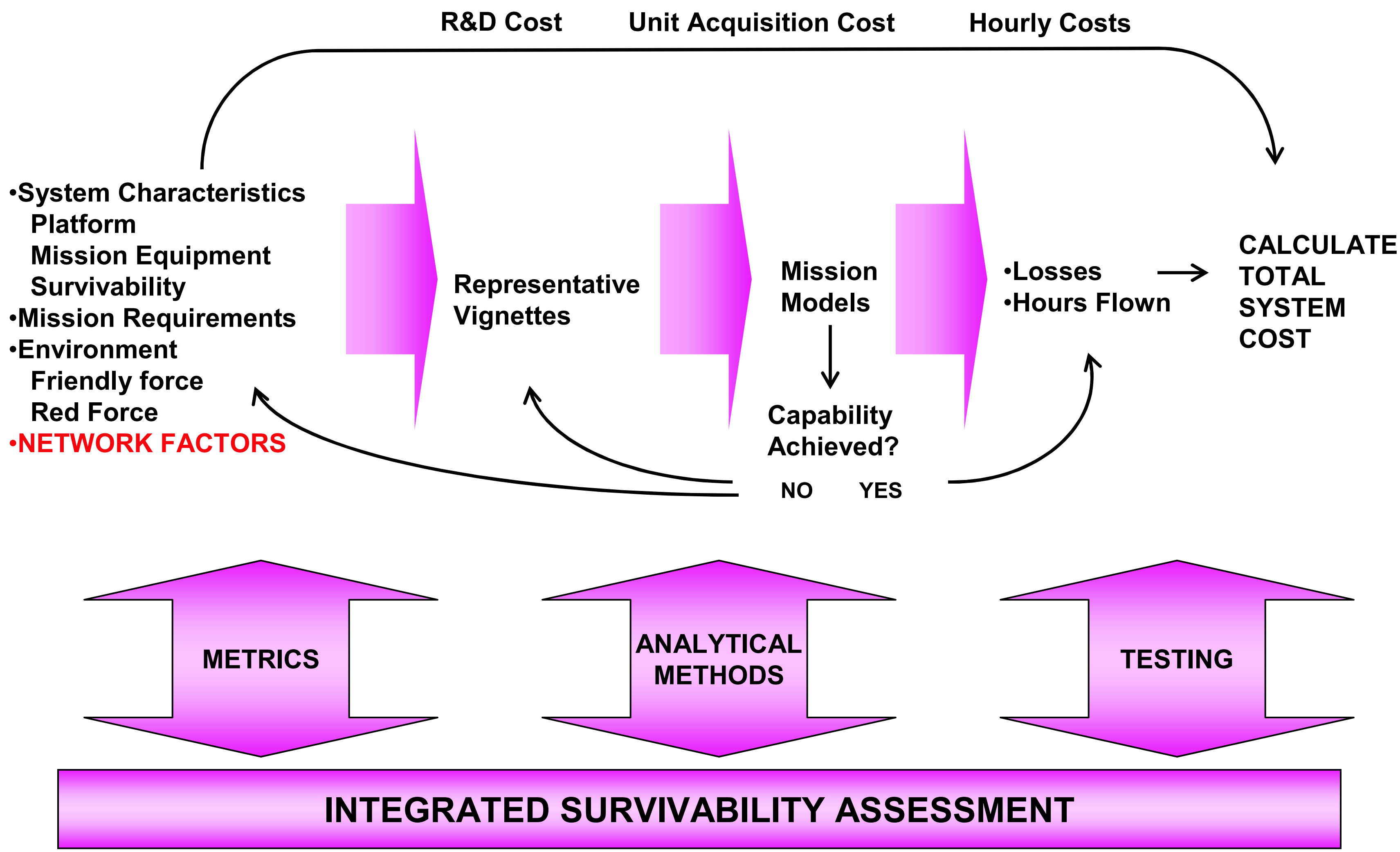
METHODOLOGY CHARACTERISTICS

- Encompass consideration of all aspects of survivability
  - Threat, Mission, Performance, Mission Equipment, Survivability Enhancements, Network Functions
- Executable within available time and resources.
- Account for cost implications during normal and combat conditions.
- Methodology supports decision-making even when little is known or when changes are encountered
  - Potential use as a capability evaluation tool
  - Parametric analysis around inputs that are "soft"
- Analysis allows building block approach
  - Build on what we have without starting over
  - Improve fidelity by evolution
  - What we know/don't know is always transparent

ARRIVE AT THE BEST TOTAL COST ESTIMATE POSSIBLE COMMENSURATE WITH THE INFORMATION, RESOURCES, AND TIME AVAILABLE.

METHODOLOGY DESCRIPTION



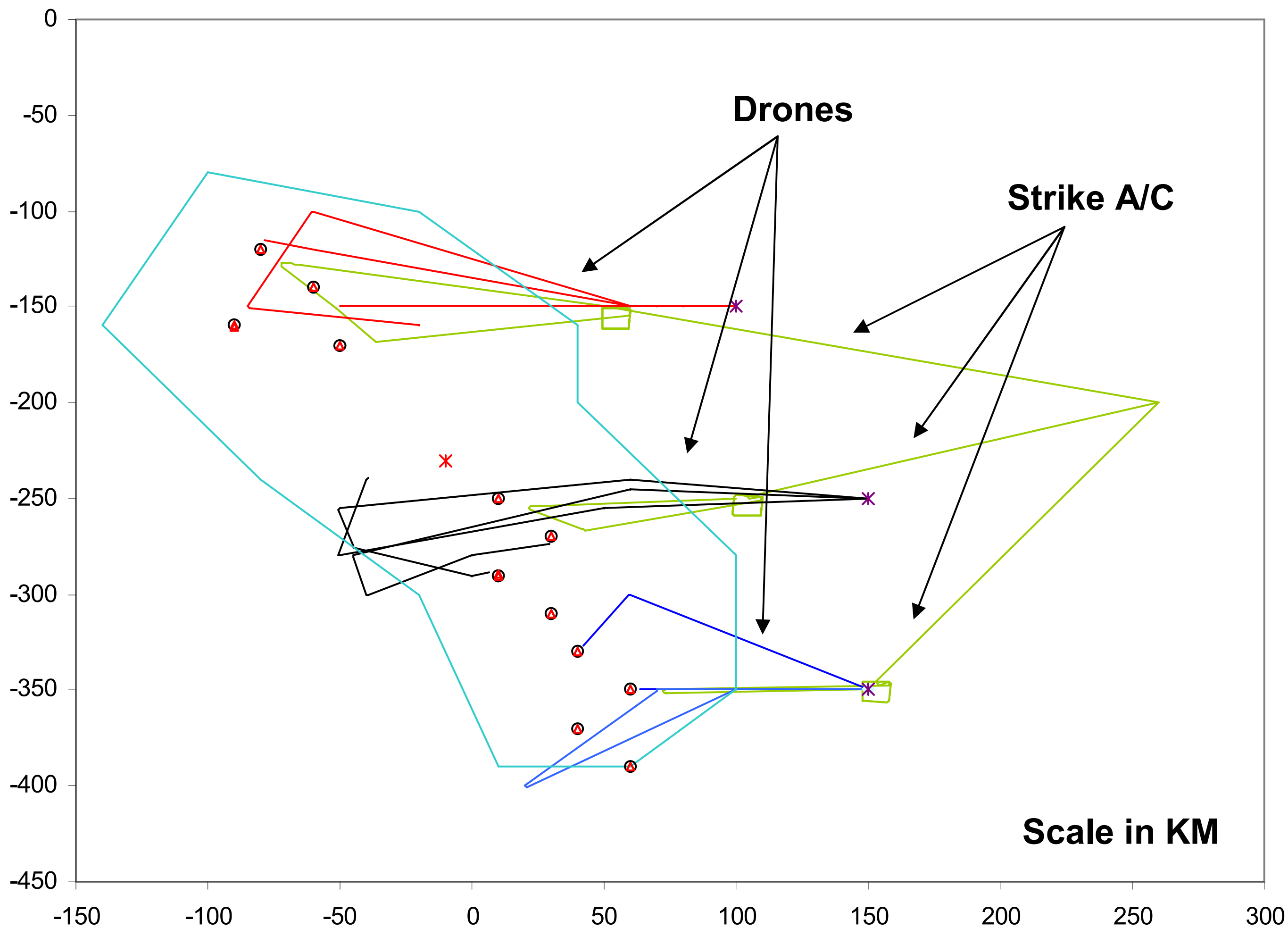
EXAMPLE
SCENARIO DESCRIPTION

The sample analysis involves VTUAVs on a surveillance mission to locate threat RF missile sites.

Threat - Three batteries of short range RF missiles
Each battery has three TELARs and a C2 vehicle. Batteries operate under strict control of the commander
One squad of three soldiers with each of the nine TELARs and C2 vehicles for a total of 36 MANPADS. Operate autonomously.

Friendly - Three VTUAV systems, each with three VTUAVs and a ground control station. The UAVs fly at 100kts at an altitude of 1050m. Each has an EO/IR sensor and an LDRF. When the ground target is detected, the info is transmitted to the ground station which sends an attack aircraft. The RF signature was held a 10 Sqm and the IR signature was varied from 500W/sr to 1 W/sr. A degrade to the missile pk of 25%, 50% and 75% was applied to simulate an IRCM.

EXAMPLE
VIGNETTE SNAPSHOT



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EXAMPLE
OVERALL RESULTS

Attrition results as a function of signature

SIGNATURE	RF Shots	IR Shots	RF hits	IR hits
500W/sr	2.43	17.10	0.93	4.33
50W/sr	2.80	16.50	0.87	4.50
5W/sr	2.33	16.87	1.00	4.63
1W/sr	1.93	6.43	1.00	1.73

Attrition results as a function of IRCM effectiveness

Pk Degrade	RF Shots	IR Shots	RF hits	IR hits
No Degrade	2.43	17.10	0.93	4.33
25%	2.57	18.50	0.93	3.87
50%	2.13	19.70	1.00	3.30
75%	1.97	21.70	0.97	2.00

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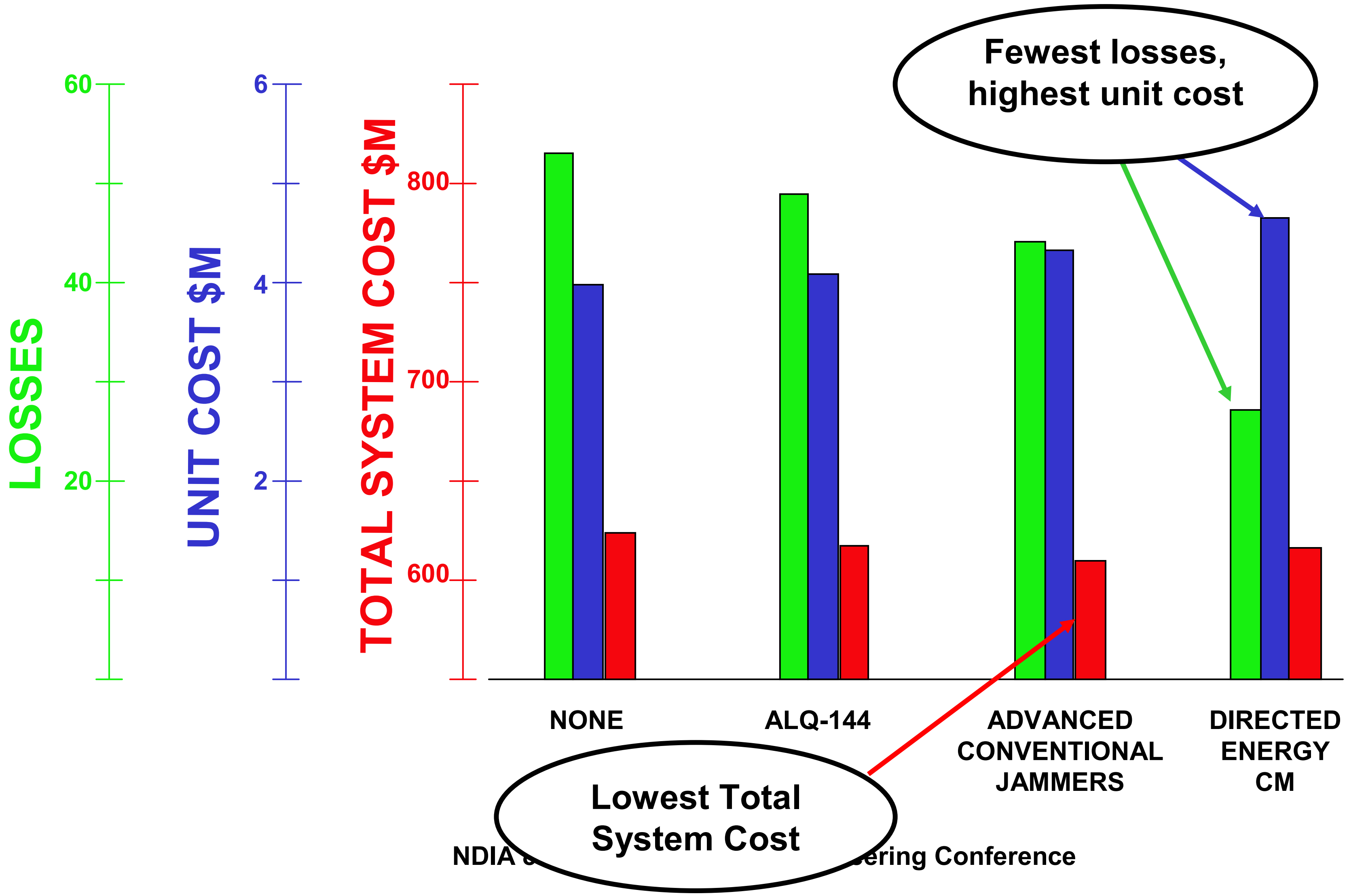
EXAMPLE
IRCM IMPROVEMENTS

	BASIC	ALQ-144	ADV JAMMERS	DIR ENERGY
Original Number of Mission Aircraft	9	9	9	9
Number of Mission Aircraft Lost	5.26	4.8	4.3	2.97
Mission Probability of Survival	0.41556	0.46667	0.52222	0.67000
Fleet Size	100	100	100	100
Number of Missions	90	90	90	90
Number of Losses	52.6	48	43	29.7
Number of Flight Hours/Mission	6	6	6	6
<u>Development Cost ($)</u>				
Basic Platform	8,000,000	8,000,000	8,200,000	8,400,000
Mission Package	2,000,000	2,000,000	2,000,000	2,000,000
Survivability Enhancements	0	500,000	1,000,000	1,500,000
Sub Total	10,000,000	10,500,000	11,200,000	11,900,000
	0			
<u>Unit Acquisition Cost ($)</u>				
Basic Platform	3,000,000	3,000,000	3,000,000	3,200,000
Mission Package	1,000,000	1,000,000	1,000,000	1,000,000
Survivability Enhancements	0	100,000	200,000	500,000
Sub-Total	610,400,000	606,800,000	600,600,000	609,590,000
<u>Hourly Operational Cost ($)</u>				
Basic Platform	300	300	300	300
Mission Package	50	50	50	50
Survivability Enhancements	0	10	10	10
Sub Total	189,000	194,400	194,400	194,400
TOTAL SYSTEM COST ($)	620,589,000	617,494,400	611,994,400	621,684,400

EXAMPLE
EFFECTS OF IRCM IMPROVEMENTS



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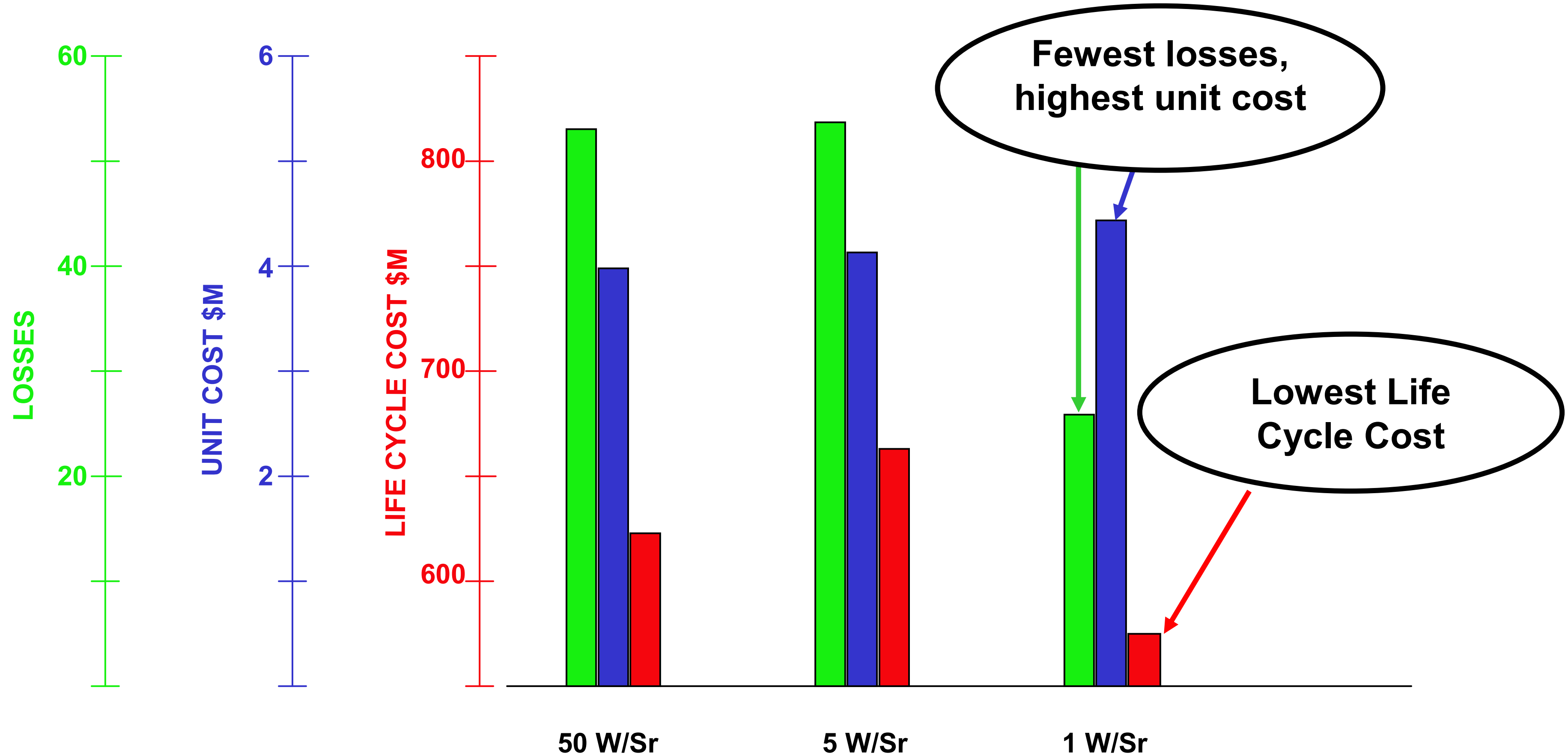
EXAMPLE
SIGNATURE REDUCTION

	50 W/Sr	5 W/Sr	1 W/Sr
Original Number of Mission Aircraft	9	9	9
Number of Mission Aircraft Lost	5.37	5.63	2.73
Mission Probability of Survival	0.40333	0.37444	0.69667
Fleet Size	100	100	100
Number of Missions	90	90	90
Number of Losses	53.7	56.3	27.3
Number of Flight Hours/Mission	6	6	6
Development Cost ($)			
Basic Platform	8,000,000	8,500,000	10,000,000
Mission Package	2,000,000	2,000,000	2,000,000
Survivability Enhancements	0	500,000	2,500,000
Sub Total	10,000,000	11,000,000	14,500,000
Unit Acquisition Cost ($)			
Basic Platform	3,000,000	3,000,000	3,200,000
Mission Package	1,000,000	1,000,000	1,000,000
Survivability Enhancements	0	100,000	200,000
Sub-Total	614,800,000	640,830,000	560,120,000
Hourly Operational Cost ($)			
Basic Platform	300	300	300
Mission Package	50	50	50
Survivability Enhancements	0	0	10
Sub Total	189,000	189,000	194,400
TOTAL SYSTEM COST ($)	624,989,000	652,019,000	574,814,400

EXAMPLE
EFFECTS OF IR SIGNATURE REDUCTION



NOTE: EXAMPLE ONLY

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QUESTIONS?