

**Assuring Advanced
Small Arms System Value
Utilizing
Cost As An Independent Variable
(CAIV)**

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Overview CAIV Application for Small Arms System Definition and Manufacturing Decisions

- Programmatic
- Technical
- Manufacturing
- Affordability

**Effective and Timely CAIV Application
Benefits System Life Cycle Management**

Are Requirements Defined Clearly?

Do Requirements Add Value?

- Operational
- Survivability
- Maintenance

Can Requirement Be Achieved By Other Means?

- Hardware vs. training
- Level of maintenance

Integration vs. Modularity Value?

- What is value of integration?
 - Complexity
 - Utility

Is Technology Ready? Does It Meet Objectives? When?

- Performance
- Design

Identifies Affordability Drivers

- Manufacturing
- Schedule

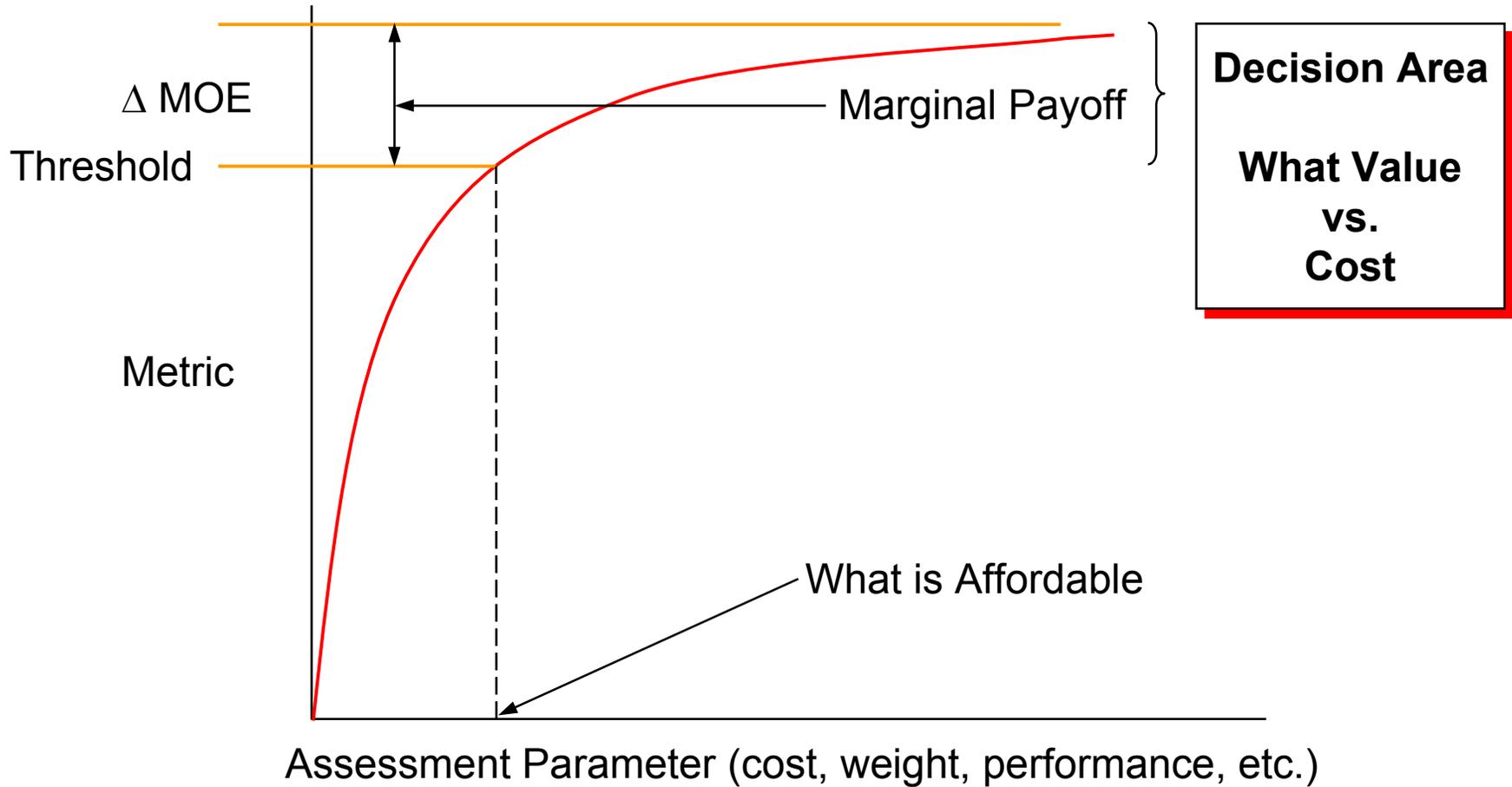
Legacy and Emerging Small Arms System Enhancements

- System design
- Performance enhancements
 - Baseline
 - Pre-planned
- Modularity functions
- Training
- Requirements validation

Decision process for
user
benefits/utility
and
affordability

- **Technology offers opportunity**
- **Transformation requires response**

CAIV Application = Value Decision



Earning “Best Value” — Establishing Marginal Payoff

- Performance
- Affordability
- Schedule
- Risk
- Maintenance
- Upgrades/technology insertion

**Effective Use of CAIV Provides “User Value” — Facilitates Fielding
— Provides Basis for Incremental Growth**

- OICW
- OCSW
- Legacy System Upgrades
- MOD Weapon System
- Bursting Munition System Integration
- Small Arms System Training
- Supportability Approaches
- Manufacturing Commonality
- Interoperability

Decisions

- Performance
- Schedule
- Cost

vs.

Payoff

- Operational
- Logistics
- TOC

OICW Applications

- System architecture
- P(I) value assessment
- Weight
- Functionality
- Supportability
- Training
- Land Warrior interface

Determining

- Operational Requirements Documents (ORD) compliance
- Unit Production Cost (UPC)
- Total Ownership Cost (TOC)



- Ensuring:
- Operational utility
 - Affordability

Superior 21st Century Soldier Effectiveness

- Integration vs. modularity
- Operational life with power source (type, technology, design)
- Functional levels and options
- Performance level vs. technology cost
- Design/performance vs. manufacturing cost
- Reliability advantage/cost vs. maintenance
- Hardware integration vs. training
- Product maturity vs. obsolescence

Select Priority Areas for CAIV Emphasis

Establish Measurable Metrics and Criteria

Objective: Measure of Effectiveness/Metric (MOEs) which characterize the design/performance

Example:

- P(I)
- P(CL)
- Power consumption
- Power capability
- Weight
- Ruggedness
- Functionality

Approach: Threshold and Objectives MOEs

- Evolving thresholds tied to milestones
- Objective (challenge level)
 - Measure similar parameters
 - Level requires major improvements, technology breakthrough, etc.

Measurable: Must be defined to be quantified

- Test
- Analysis
- Cost

MOE (1) Operational scenario assessment

- Number of rounds
- Exchange ratio

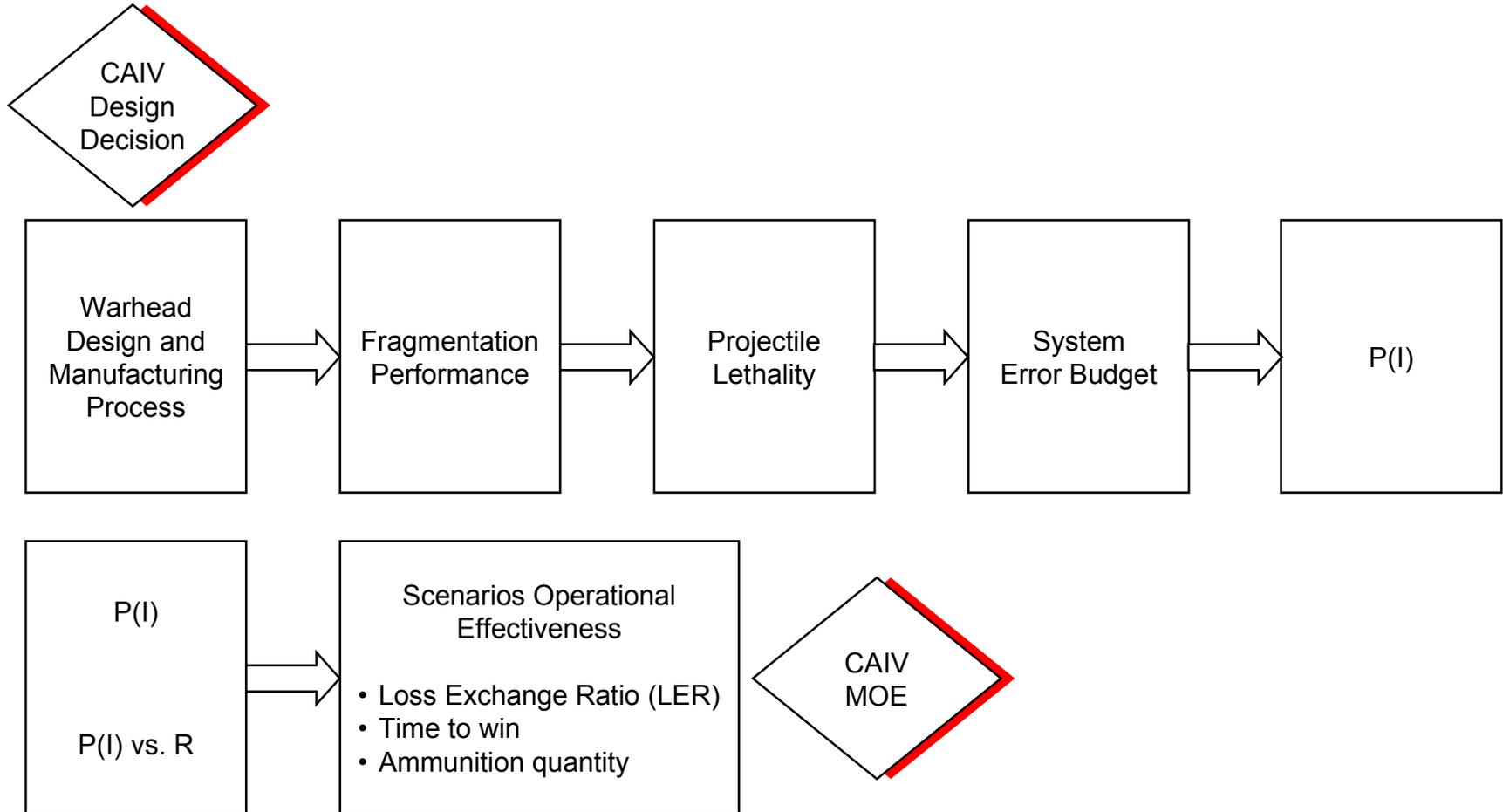
MOE (2) $P(I)$ = Probability of incapacitation

= f [(error budget)] [f (fuze parameters)] [f (warhead parameters)]
= determined in terms of $P(I)$ level [(e.g.) $P(I) = 0.5$ vs. 0.3]
 $P(I)$ at range [e.g., $R = 500$ vs. 300]

CAIV Questions

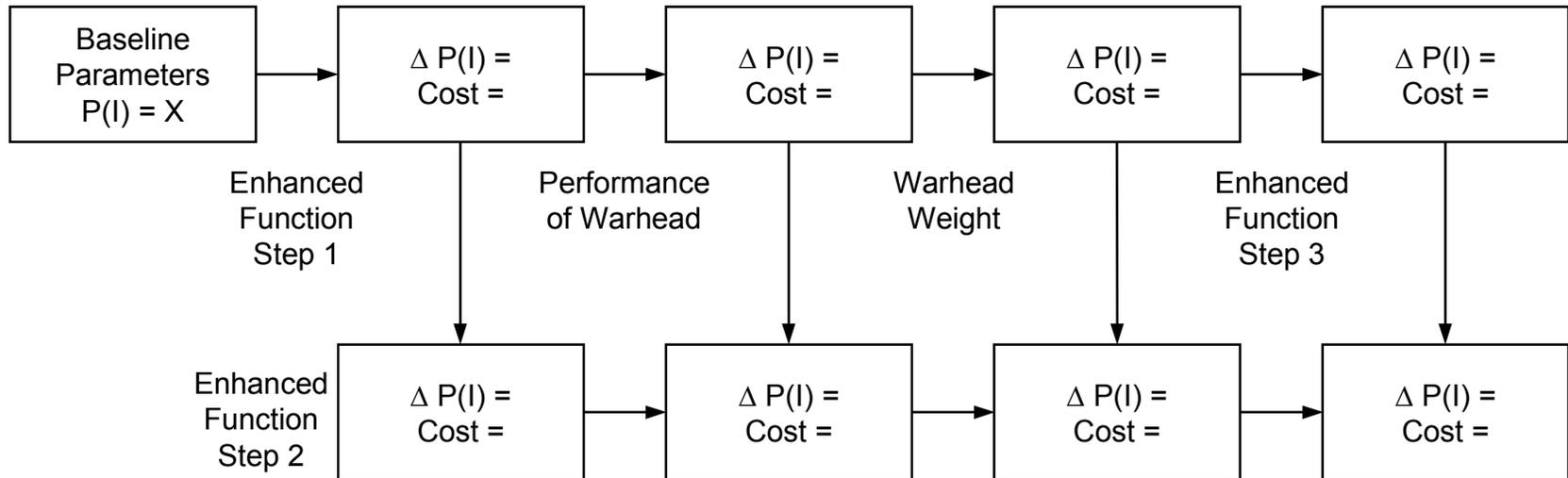
1. What is operational payoff?
2. What is the cost to reach $P(I)$ objective?
3. Address warhead parameters
 - Caliber
 - Warhead material
 - Error budget

- **What are associated costs?**
- **How does change affect outcome?**



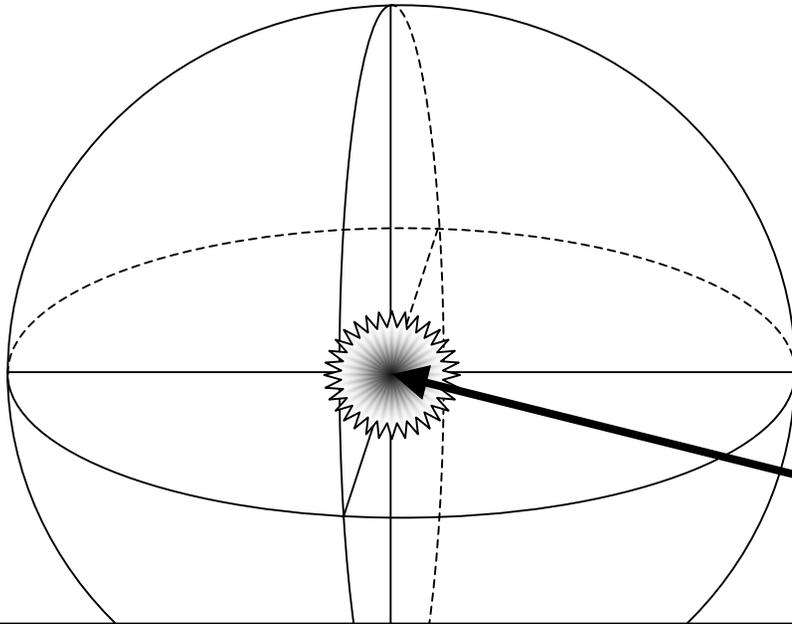
Relating CAIV MOEs to Design Parameters Realizes the Benefit

Establish Value of Incremental Changes



Evolving Best Value in Requirement and Design

Bursting Munition Lethality

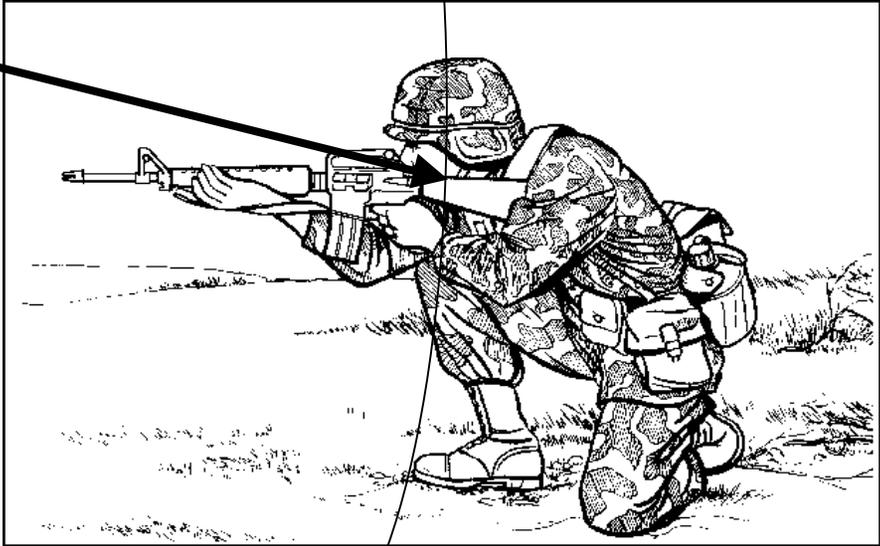


Steradians subtended by target decreases with distance from burst point to target

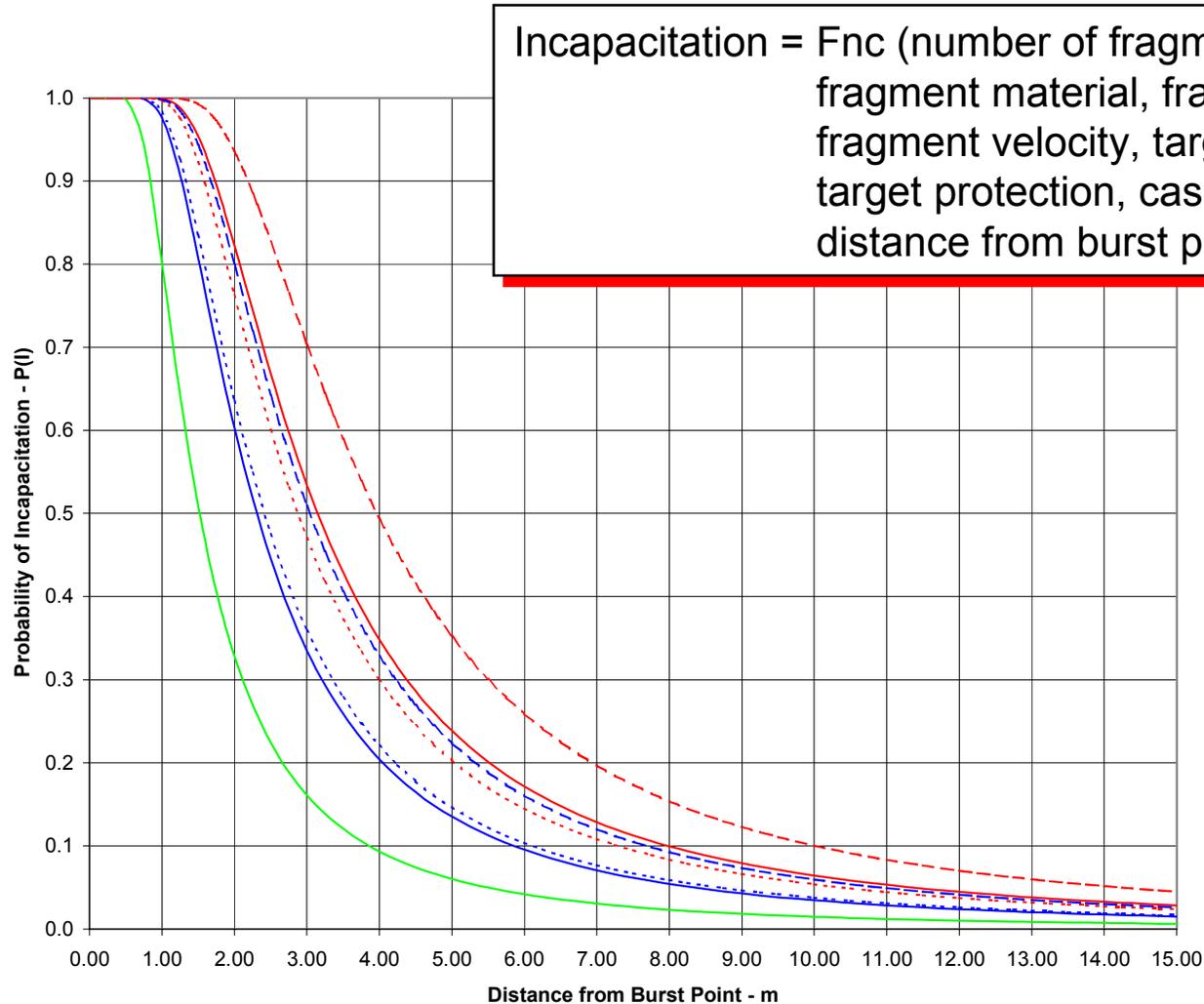
Fragment density measured in fragments per Steradian remains constant for given weapon detonation

Example:

$600 \text{ fragments} / 4\pi = 47.74 \text{ fragments per Steradian}$



Warhead Lethality Measure of Effectiveness



Bursting Munition Error Budget

3-D Error Space

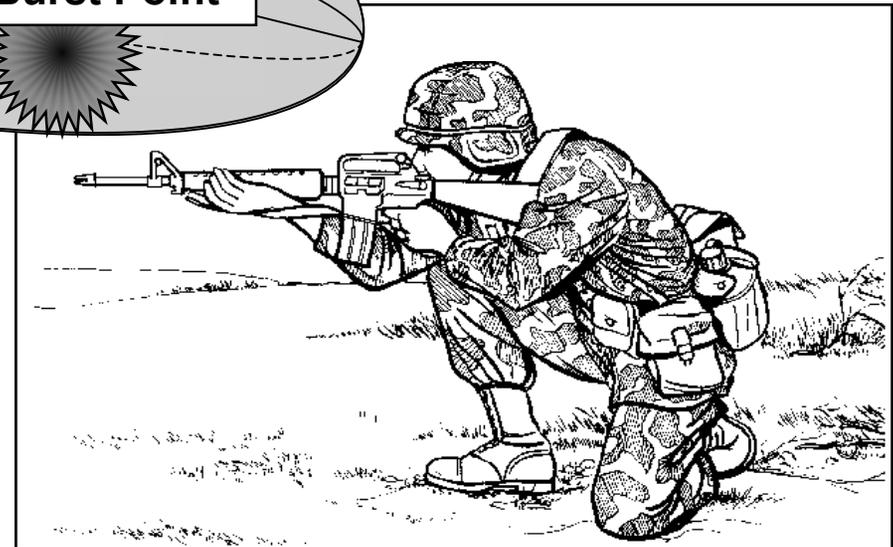
Random Burst Point

Occasion to Occasion Errors

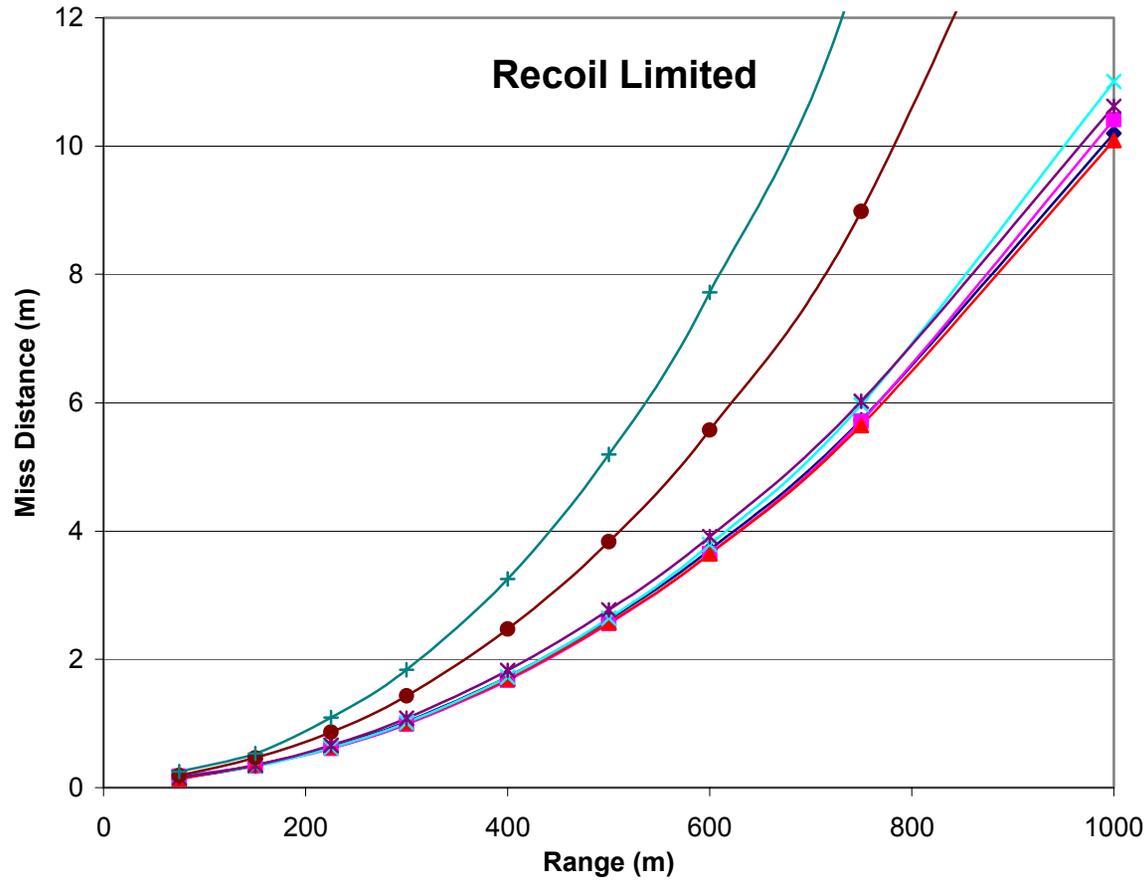
Errors in meters		Range - m								
		75	150	225	300	400	500	600	750	1000
Y Dispersion	mis									
Y Cart Angle	deg									
Y Site Angle	deg									
Weapon / Fire Control/Ammo										
Y Aiming	Table 2									
Man-in-the-Loop										
Random_H	WBX	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Muzzle Velocity	m/s									
Drag Variability	%									
Twist	deg									
Spin Damping	%									
mass_ixx	gm									
Clou_Cou	%									
d_ref	mm									
Z Dispersion	mis									
Ammo										
Z Cart Angle	deg									
Z Site Angle	deg									
Weapon / Fire Control/Ammo										
Z Aiming	Table 2									
Man-in-the-Loop										
Random_Z	WBZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Muzzle Velocity	m/s									
Drag Variability	%									
Twist	deg									
Spin Damping	%									
mass_ixx	gm									
Turns Count Accuracy	%									
d_ref	mm									
Ammo										
Site Angle	deg									
Weapon / Fire Control/Ammo										
Random_T	WBT	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total_T	TSD	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Random Errors

Errors in meters		Range - m								
		75	150	225	300	400	500	600	750	1000
Y Cross Winds	mps									
Environmental										
Y Boresight & Wind	mis									
Y Aimpoint Accuracy	Table									
Weapon / Fire Control										
Occasion to Occasion_H	OOX	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Z Range Winds	mps									
Z Air Temp	deg									
Z Air Pressure	mbar									
Environmental										
Z Boresight & Envr	mis									
Z Aimpoint Accuracy	Table									
Weapon / Fire Control										
Occasion to Occasion_Z	OOZ									
X Range Winds	mps									
X Air Temp	deg									
X Air Pressure	mbar									
Environmental										
Occasion to Occasion_T	OOT	0	0	0	0	0	0	0	0	0
X Laser Range Finder Error										
Weapon / Fire Control										
X Laser Ranging Error	0.00%									
Man-in-the-Loop										
Occasion to Occasion_R	REE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

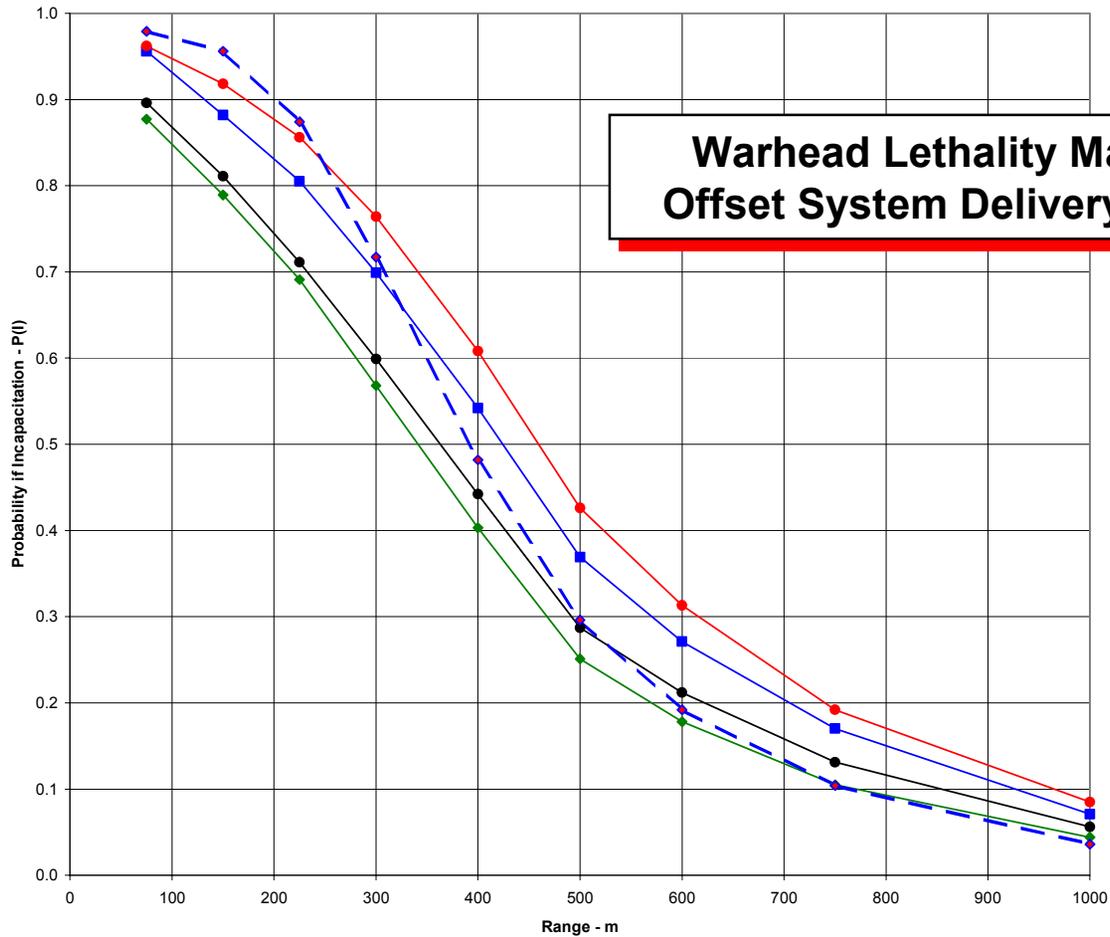


System Performance – Miss Distance



System Performance

Probability of Incapacitation

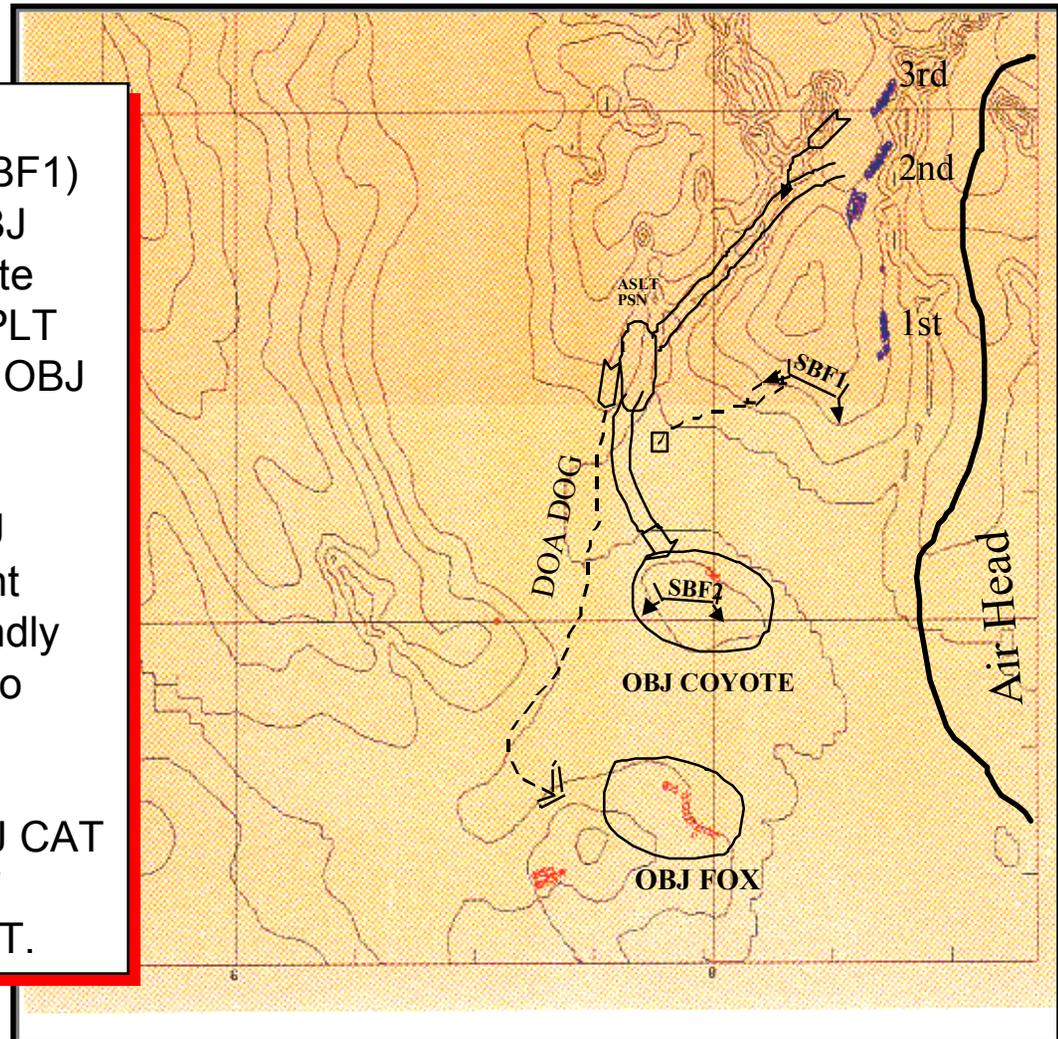


System Performance

CASTFOREM Force on Force Scenario

HRV 49A Concept of the Operation

1. 1st PLT establish support by fire 1(SBF1) to fix enemy vic OBJ COYOTE to facilitate movement of 2nd PLT and on order seize OBJ FOX.
2. 2nd PLT seize OBJ COYOTE to prevent interference of friendly forces' movement to OBJ FOX.
3. 3rd PLT seize OBJ CAT to facilitate 1st PLT assault on OBJ RAT.

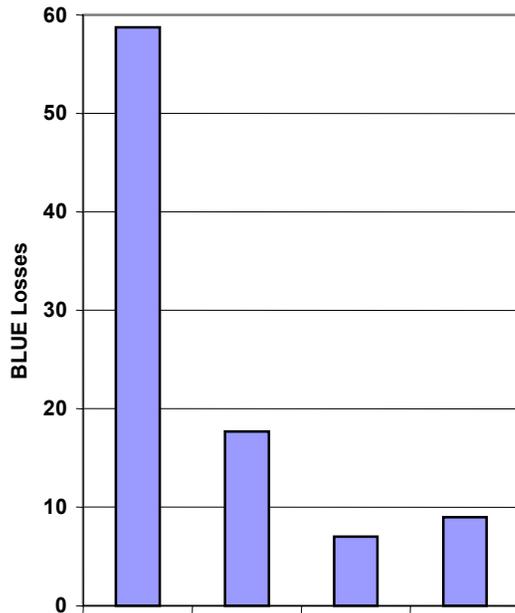


System Performance

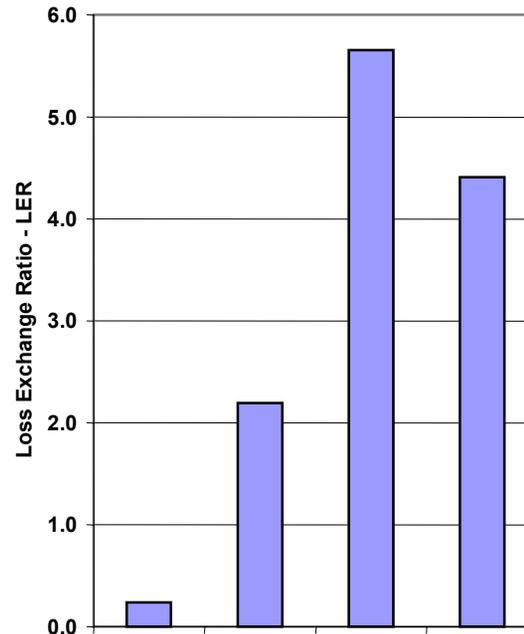
Force on Force Measures of Effectiveness

- Loss Exchange Ratio (LER) is not always the most significant metric
- Logistics costs (dollars and pallets) are decision drivers

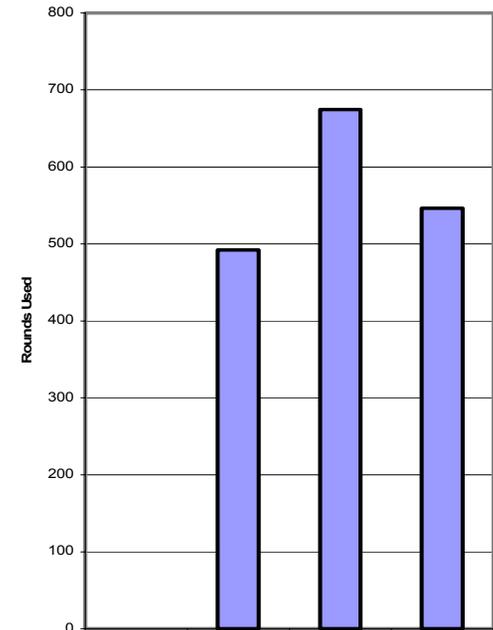
Blue Losses



Loss Exchange Ratio



Rounds Used



- Which projectile maximizes operational MOE?
 - P(I) level appropriate?
 - P(I) range appropriate?
- Which projectile is lowest cost?
- Is projectile cost increase offset with reduced logistics cost?
- Which approach minimizes schedule risk?

**Linking Performance, Design, Manufacturing, and Supportability
to Realize Schedule, Operational, and Affordability Advantages**

Operational MOEs

- Established by system effectiveness

Number of rounds

Range

P(I) sensitivity

Design/Performance

- Established from Fragmentation tests
Analysis
Manufacturing

P(I)

UPC

Logistics

- Established from supportability assessments

TOC

TOC sensitivity

Schedule

- Established by Risk assessment
Manufacturing planning

Schedule

UPC

TOC

MOEs and Costs Can Be Quantified and Tracked

Systems

1. System Integration vs. Modularity
2. Logistics/Maintenance Level
3. Weight vs. Schedule/Cost to Achieve Weight
5. P(I) Level
6. Range
7. Ruggedness

Weapon

1. Housing Material/Process
2. Barrel Material(s)
3. Harness/Connectors

TA/FCS

1. Sensor Performance
 - DVO
 - Video
 - Thermal
2. ASIC vs. COTS Processor
3. Laser Range Finder
 - Performance
 - Weight
4. Tracker/Laser Steering Integration
5. Alternatives to Maximize P(CL)
6. Power Management (Power Source vs. Life)
7. CIDDS
8. Training Module
9. Sensor Fusion

Ammunition & Fuze

1. HE Ammunition
 - Warhead Material
 - Warhead Fabrication
2. KE Ammunition
 - 5.5.6mm
 - Other
3. Fuze
 - ASIC vs. COTS
 - Fuze size vs. cost
 - Power source

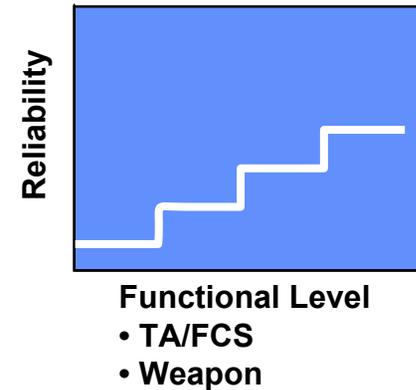
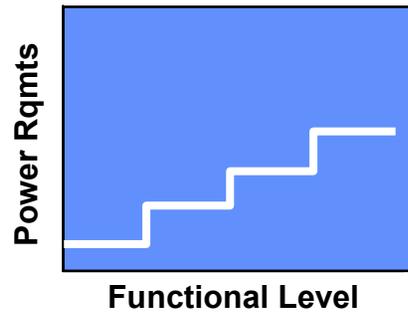
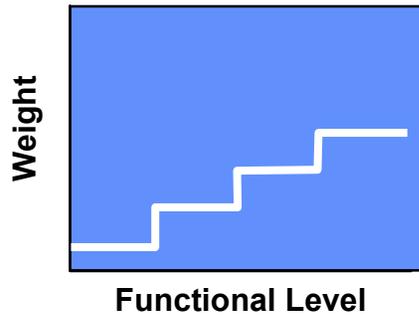
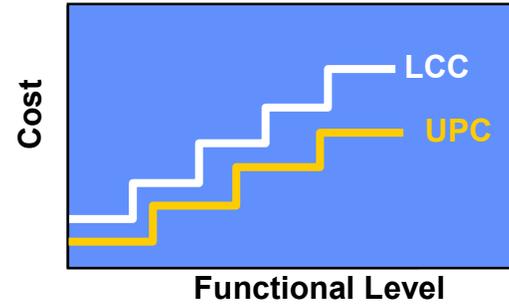
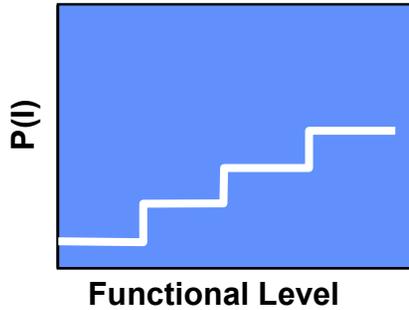
Training

1. Simulator Types
2. Training Rounds
 - TPS
 - Blank

CAIV Process Implementation Supports Design Process

System Functional Level Assessment

(Examples Only)



CAIV Link Functional Levels

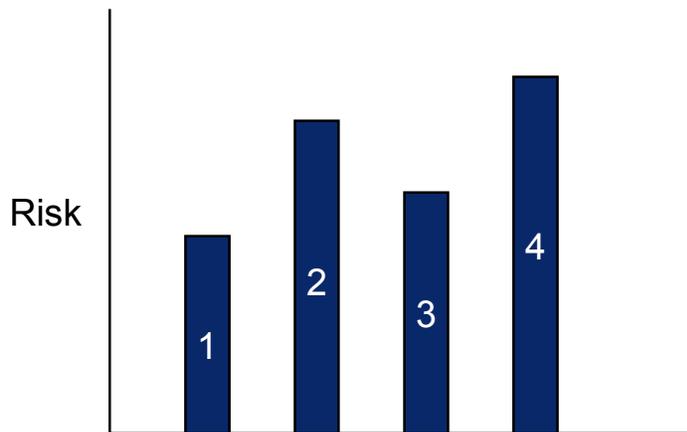
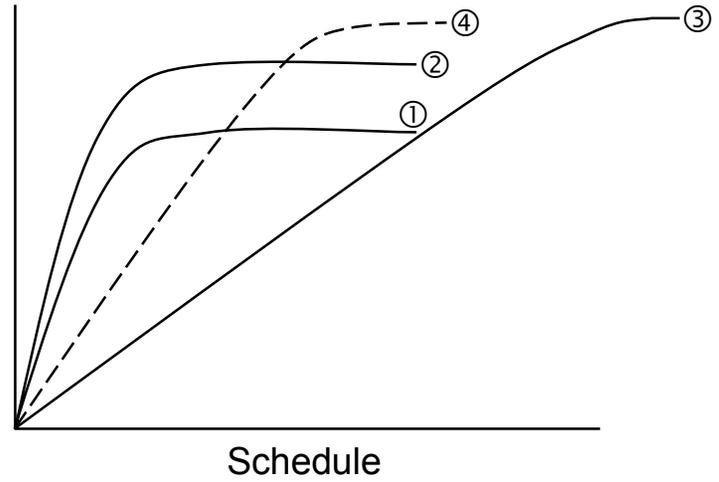
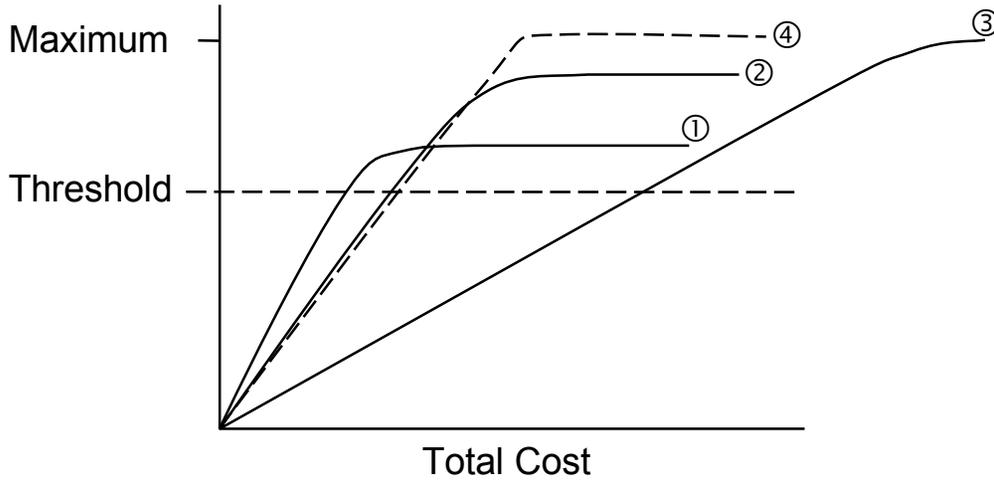
Cost As Independent Variable (CAIV) Is Not Only Dollars

Cost = Dollars = CAIV
= Weight = WAIV
= Reliability = ReAIV
= Schedule = SAIV
= Performance = PAIV
= Ruggedness = RgAIV

**Use CAIV Process to Independently Address Variables
and Drive Decisions**

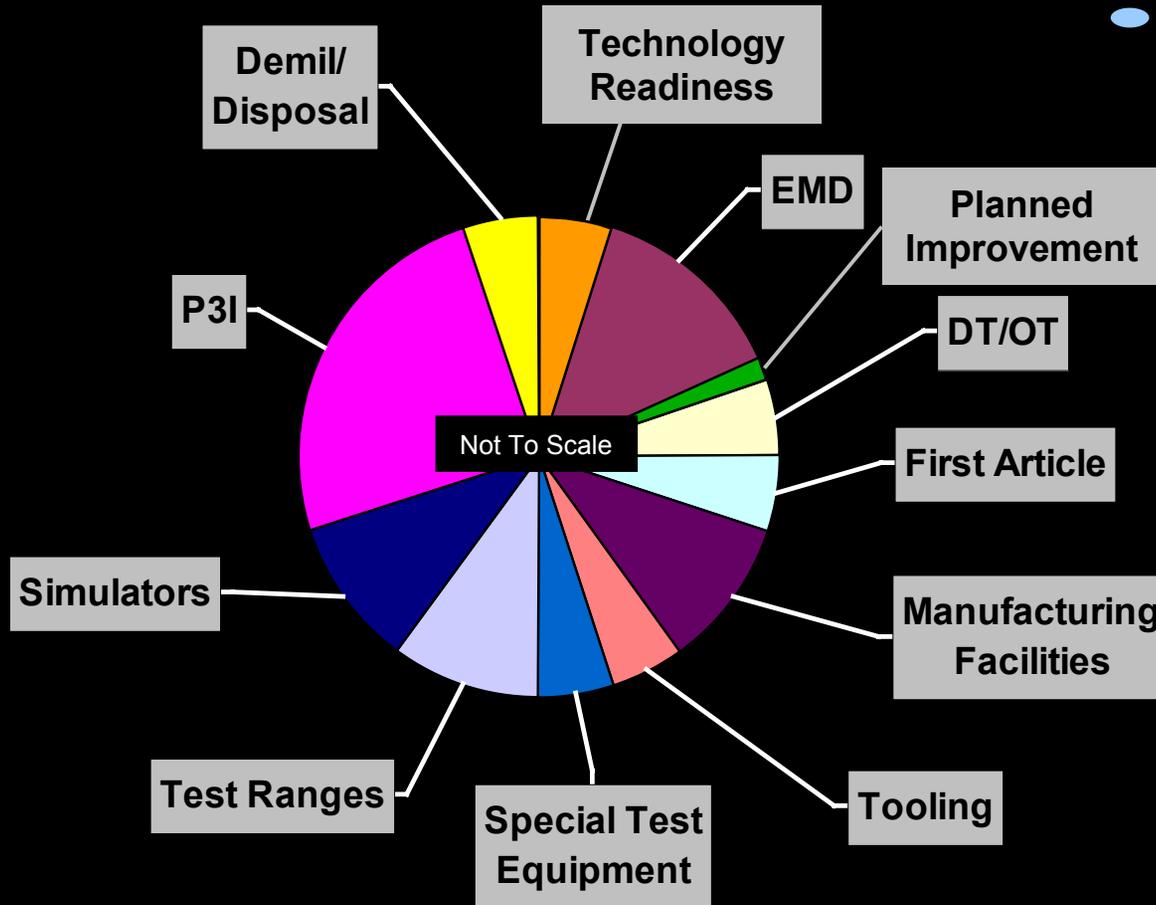
CAIV Alternative Example

Alternative Technologies

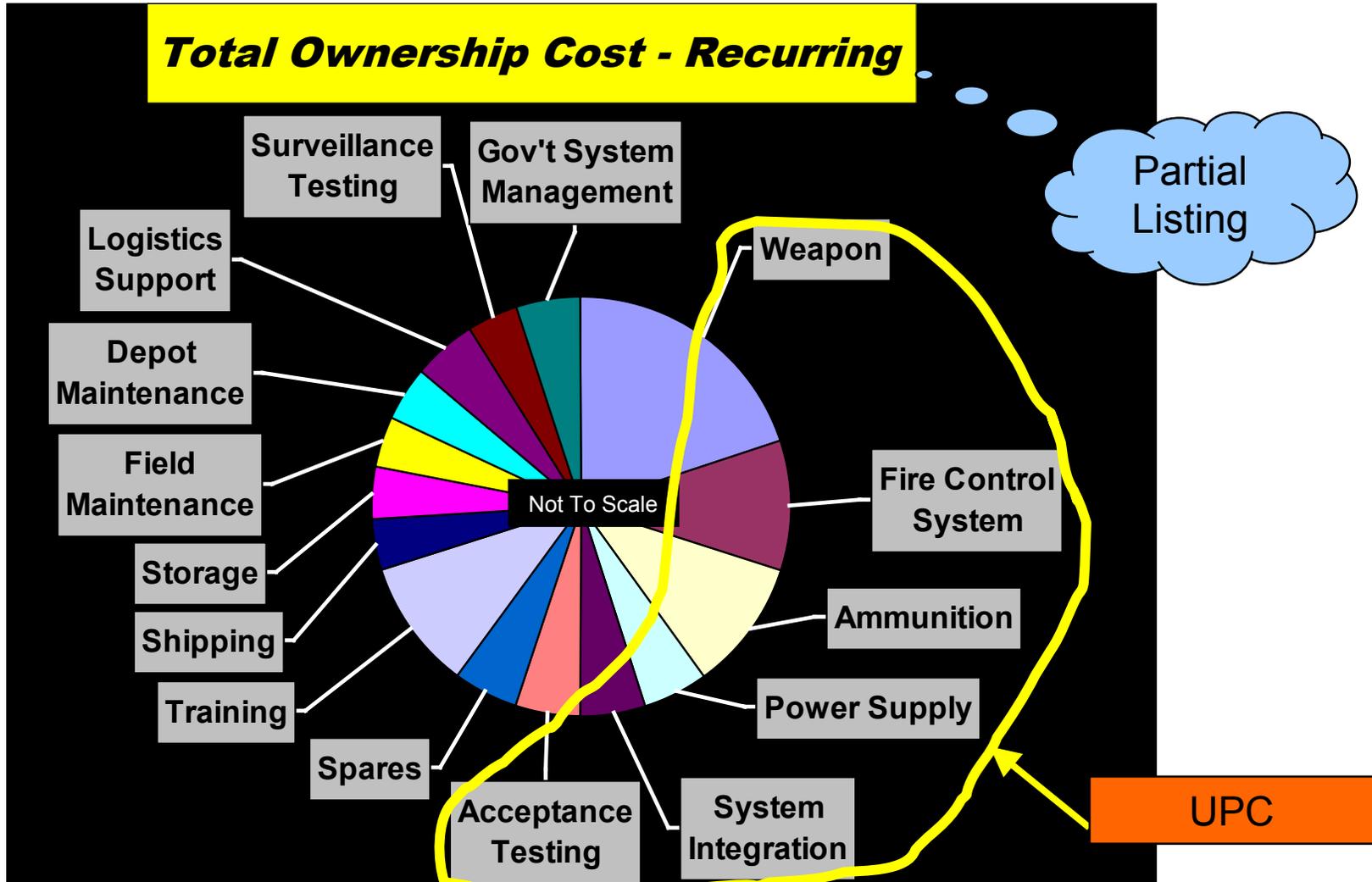


Decisions Based on Combined Rankings Ensure Benefits

Total Ownership Cost - Non-Recurring



Establishing and Tracking Costs Increases Fidelity



Select Critical Parameters — Assess Sensitivity

CAIV Decision Applications

**Requirement
Validation**

**Operational
Utility Value**

**Baseline System
Design/Performance
vs. Planned Product
Improvement**

**Technology
Readiness
and
Selection**

**Integration
vs.
Modularity**

Supportability
• Maintenance
• Reliability
• Logistics

**System
Operational Life
vs.
Obsolescence**

**Risk
Management**

**Manufacturing
Processes
and
Commonality**

**Total
Ownership
Cost**

- Focuses system requirements to real operational value
- Establishes value for all design/performance decisions
 - Decision rationale clarity
- Rank technology readiness
 - Applies DoD technology readiness levels
 - Emerging, COTS, mature
- Supports path to rapid development and fielding
 - Confidence in incremental enhancements
- Central element of risk management
 - Risk level
 - Risk mitigation
- Directs payoff to appropriate topics

**Individual and Crew Served Weapon Systems
Enhancement Realized Effectively, Affordably, and Timely**

Total Ownership Cost (TOC) Management

Concept

Proof of Principle

Development

Manufacturing

Deployment

Upgrade Insertion

CAIV Process Throughout Life Cycle

Implement Early for Maximum Impact

Track Milestones and Roadmaps

Update Regularly

Timely Decisions With Solid Rationale

- Effective application of “Cost As Independent Variable (CAIV)” process offers benefits for entire program life cycle

- CAIV application is not complex

- Requires rigorous:
 - Definition of metrics
 - Database development
 - Traceability

- CAIV links user objectives with affordability

- Complements Quality Functional Deployment (QFD)

Small Arms System Evolution — Ensured Through CAIV Application

- **Performance**
- **Utility**
- **Affordability**