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

14 August 2001
### Report Documentation Page

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<td>Broden, Dave; Giles, Pete</td>
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<td>NDIA (National Defense Industrial Association) 211 Wilson Blvd, STE. 400 Arlington, VA 22201-3061</td>
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| Abstract                                                                                           | |
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| Subject Terms                                                                                       | |
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Objectives

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
What Does CAIV Address?

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
CAIV Overview

Δ MOE Threshold

Metric

Assessment Parameter (cost, weight, performance, etc.)

What is Affordable

Marginal Payoff

Decision Area

What Value vs. Cost

Earning “Best Value” — Establishing Marginal Payoff
Why Utilize CAIV?

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

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

- 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

### 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
CAIV Examples

- 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
CAIV MOE Example

MOE (1)  Operational scenario assessment
• Number of rounds
• Exchange ratio

MOE (2)  
\[ P(I) = \text{Probability of incapacitation} \]
\[ = f[(\text{error budget})][f(\text{fuze parameters})][f(\text{warhead parameters})] \]
\[ = \text{determined in terms of } P(I) \text{ level } [(\text{e.g.}) P(I) = 0.5 \text{ vs. } 0.3] \]
\[ P(I) \text{ at range } [(\text{e.g.}) R = 500 \text{ vs. } 300] \]

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?
CAIV MOE Selection

CAIV Design Decision

Warhead Design and Manufacturing Process → Fragmentation Performance → Projectile Lethality → System Error Budget → P(I)

P(I) vs. R

Scenarios Operational Effectiveness
- Loss Exchange Ratio (LER)
- Time to win
- Ammunition quantity

Relating CAIV MOEs to Design Parameters Realizes the Benefit
CAIV Roadmap

Establish Value of Incremental Changes

Baseline Parameters
\[ P(I) = X \]

Enhanced Function Step 1
\[ \Delta P(I) = \text{Cost} = \]

Enhanced Function Step 2
\[ \Delta P(I) = \text{Cost} = \]

Performance of Warhead
\[ \Delta P(I) = \text{Cost} = \]

Warhead Weight
\[ \Delta P(I) = \text{Cost} = \]

Enhanced Function Step 3
\[ \Delta P(I) = \text{Cost} = \]

Evolving Best Value in Requirement and Design
Bursting Munition Lethality

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

Example:

600 fragments / $4\pi = 47.74$ fragments per Steradian

Steradians subtended by target decreases with distance from burst point to target.
Incapacitation = Fnc (number of fragments, fragment material, fragment mass, fragment velocity, target posture, target protection, casualty criteria, distance from burst point)
System Performance – Miss Distance

Recoil Limited

Range (m) vs. Miss Distance (m)
System Performance
Probability of Incapacitation

Warhead Lethality May Not Offset System Delivery Errors
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
CAIV Issues

• 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
CAIV Databases

Operational MOEs
• Established by system effectiveness
  Number of rounds
  Range
  P(I) sensitivity

Design/Performance
• Established from Fragmentation tests P(I)
  Analysis
  Manufacturing UPC

Logistics
• Established from supportability assessments TOC
  TOC sensitivity

Schedule
• Established by Risk assessment UTC
  Manufacturing planning TOC

MOEs and Costs Can Be Quantified and Tracked
CAIV Assessment Parameters

**Systems**
1. System Integration vs. Modularity
2. Logistics/Maintenance Level
3. Weight vs. Schedule/Cost to Achieve Weight
4. Power Management (Power Source vs. Life)
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. CIDDSS
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

- Weight
- Power Rqmts
- Reliability
  - LCC
  - UPC

- Functional Level
- Functional Level
- Functional Level
- Functional Level
- Functional Level
- Functional Level
- Functional Level

- TA/FCS
- Weapon
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
Decisions Based on Combined Rankings Ensure Benefits
Total Ownership Cost - Non-Recurring

- Demil/Disposal
- Technology Readiness
- EMD
- Planned Improvement
- DT/OT
- First Article
- Manufacturing Facilities
- Tooling
- Special Test Equipment
- Test Ranges
- Simulators
- Not To Scale

Establishing and Tracking Costs Increases Fidelity
TOC – Recurring Elements

Total Ownership Cost - Recurring

- Surveillance Testing
- Gov't System Management
- Logistics Support
- Depot Maintenance
- Field Maintenance
- Storage
- Shipping
- Training
- Spares
- Acceptance Testing
- System Integration
- Fire Control System
- Ammunition
- Power Supply
- UPC

Select Critical Parameters — Assess Sensitivity
CAIV Payoffs

• 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
Conclusions

• 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