Suitability . . . at what cost?

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Suitability . . . at what cost?

Typical IOT&E Evaluation Results:
- **EFFECTIVENESS**: approximately 90% success rate
- **SUITABILITY**: approximately 60 - 75% success rate

Typical Decision after IOT&E: Begin fielding ASAP, even **before** . . .
- Suitability problems are addressed
- Reliability is improved
- Maintenance procedures are mature
- Training is complete

Why field before addressing these problems? **Urgent Combat Need**

The QUESTION: How much does it cost us to do business this way?
Suitability . . . at what cost?

DAU Research Study Proposal

Investigate various types of systems
Total of 5 or 6, several from each service
Criteria:
  Recently fielded
  Evaluated to be Effective but not “fully” Suitable
Examine performance of systems wrt suitability
Determine suitability cost drivers
Evaluate suitability trends

Sponsor Decision: Start with one program, work from there . . . .

First Program Selected: STRYKER Family of Vehicles
Additional Study Candidates: TBD
STRYKER FAMILY OF VEHICLES
In service with the US Army

Legend

A. Infantry Carrier Vehicle   B. Command Vehicle   C. Mobile Gun System
D. Fire Support Vehicle      E. Medical Evacuation   F. Mortar Carrier
G. Engineer Squad Vehicle    H. Anti-tank Guided Missile I. NBC Reconnaissance
J. Reconnaissance Vehicle
Now, back to Suitability . . . 

ATEC Reliability Track Record

Demonstrated Reliability vs. Requirements for Operational Tests

**Only 41% Met Requirement**

1985-1990

**Only 20% Met Requirement**

1996-2000

Most Of Our Systems Fail To Achieve Reliability Requirements In OT

... And The Trend Appears To Be Continuing Downward

source: ATEC
LCC Distribution

LIFE-CYCLE COST

SYSTEM ACQUISITION

SYSTEM RESEARCH AND DEVELOPMENT

PRODUCTION

O&S

60%

30%

10%

20 YEARS
LCC Distribution

LIFE-CYCLE COST

SYSTEM ACQUISITION

Operations and Support

28%

72%

30 YEARS
Life Cycle Management

Design For Sustainment

Sustain The Design

65-80% of the Life Cycle Cost

Operations & Support (O&S)

Sustainment

O&S Costs Are Determined Early In The Acquisition Phase

USD(AT&L) FY 07 Strategic Goals (#4) Emphasize Sustainment Outcomes Throughout The Life Cycle Management Process
“As Government expenditures, those due to broken down chariots, worn-out horses, armor and helmets, arrows, and crossbows, lances, hand and body shields, draft animals and supply wagons will amount to 60% of the total.”

Sun Tzu (The Art of War, 6th Century B.C.)
Defense System Life Cycles

- B-52: 94 yrs
- SSN 688: 56 yrs
- F-15: 72 yrs
- F-14: 51 yrs
- CH-47: 71 yrs
- M-113: 59 yrs
- UH-1: 69 yrs
- KC-135: 86 yrs
- AIM-9: 86 yrs
- C-130: 93 yrs
- 2.5 Ton Truck: 94 yrs
- HEMTT: 44 yrs

SOURCE: John F. Phillips DUSD (L)
“PMs shall consider supportability, life cycle costs, performance, and schedule comparable in making program decisions.”
Emphasizes use of PBL (Performance-Based Logistics) for all weapons

Provides Specific Definitions (and Formulas) for the following metrics:
1. Ao (Operational Availability)
2. Mission Reliability
3. TLCS Cost per Unit of Usage
4. Cost per Unit of Usage
5. Logistics Footprint
6. Logistics Response Time
MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS
(ATTN: SERVICE ACQUISITION EXECUTIVES)

SUBJECT: Total Life Cycle Systems Management (TLCSM) Metrics

The Defense Business Board recommended to the Deputy Secretary of Defense that the Department aggressively pursue implementation of Performance-Based Logistics, for all its weapons, new and legacy.

In a memorandum dated August 16, 2004, my predecessor directed measuring performance in terms of Operational Availability, Mission Reliability, Cost per Unit of Usage, Logistics Footprint, and Logistics Response time. For consistency, this memorandum provides specific definitions of these metrics for use across the Department (attached). I direct their use as the standard set of metrics for evaluating overall TLCSM.

I also direct the TLCSM Executive Council to develop a “TLCSM Metrics Handbook,” with specific metrics, formulas and calculation methodologies. It will be used in performance-based contracts and for sustainment oversight. The handbook will also define supporting data requirements that should be incorporated into emerging logistics information systems.

The principal point of contact for administration of the handbook is Mr. Lou Kraiz, Assistant Deputy Under Secretary of Defense (Logistics Plans and Programs), 703-614-6527, Louis.Kraiz@osd.mil.

Attachment:
As stated
1. Endorsed Mandatory “MATERIEL AVAILABILITY” Key Performance Parameter (KPP) for all MDAPs and Select ACAT II and III
   With 2 Supporting Key System Attributes (KSAs):
   A. Materiel Reliability KSA
   B. Ownership Costs KSA

2. Endorsed ENERGY EFFICIENCY KPP for selected programs, as appropriate

3. Endorsed TRAINING KPP for selected programs, as appropriate

4. Did not endorse requirement for mandatory KPPs for these criteria:
   COST
   TIME and/or SCHEDULE
   SUSTAINMENT
   COALITION INTEROPERABILITY
   FORCE PROTECTION AND SURVIVABILITY
MEMORANDUM FOR: Under Secretary of Defense for Acquisition, Technology, and Logistics
Commander, US Joint Forces Command
Vice Chief of Staff, US Army
Vice Chief of Naval Operations
Vice Chief of Staff, US Air Force
Assistant Commandant of the Marine Corps

Subject: Key Performance Parameter Study Recommendations and Implementation

1. The Joint Requirements Oversight Council (JROC) approved the Key Performance Parameter (KPP) Study recommendations. The JROC endorses the implementation of a mandated Material Availability KPP with supporting key system attributes of material reliability and ownership cost for all Major Defense Acquisition Programs (MDAPs) and select ACAT II and III programs. The JROC also endorsed selectively applying an Energy Efficiency KPP and a System Training KPP, as appropriate.

2. To better ensure the correct KPPs are selected, the JROC endorsed the use of KPP reference sheets produced as part of this study. The KPP reference sheets will be used as an aid in the process of identifying and validating potential KPPs for any acquisition program.

3. Implementation of the study recommendations will be concurrent with the publishing of the next revision of CJCS 3170-series documents. The revision will incorporate the details of the execution and will be coordinated for final release by 31 October 2006. Specific JROC implementation due backs and approved recommendations are enclosed.

E. P. GIAMBASTIANI
Admiral, US Navy
Vice Chairman of the Joint Chiefs of Staff

Enclosures
JROC Approved* Mandatory Sustainment KPP and KSAs

• **Single KPP:**
  • **Materiel Availability** \(\frac{\text{Number of End Items Operational}}{\text{Total Population of End Items}}\)

• **Mandatory KSAs:**
  • **Materiel Reliability** (MTBF) \(\frac{\text{Total Operating Hours}}{\text{Total Number of Failures}}\)
  • **Ownership Cost** (O&S costs associated w/materiel readiness)

• **For mission success, Combatant Commanders need:**
  • Correct number of operational end items capable of performing the mission when needed
  • Confidence that systems will perform the mission and return home safely without failure

• **Ownership Cost** provides balance; solutions cannot be availability and reliability “at any cost.”

*JROC Approval Letter JROCM 161-06 Signed 17 Aug 06; Revised CJCS 3170 will put into Policy*
Proposed Life Cycle Sustainment Outcome Metrics

- **Materiel Availability (KPP*)**
  - A Key Data Element Used In Maintenance And Logistics Planning
- **Materiel Reliability (KSA*)**
  - Provides A Measure Of How Often The System Fails/Requires Maintenance
  - Another Key Data Element In Forecasting Maintenance/Logistics Needs
- **Ownership Cost (KSA*)**
  - Focused On The Sustainment Aspects Of The System
  - An Essential Metric For Sustainment Planning And Execution
  - Useful For Trend Analyses – Supports Design Improvements/Modifications
- **Mean Downtime**
  - A Measure Of How Long A System Will Be Unavailable After A Failure
  - Another Key Piece Used In The Maintenance/Logistics Planning Process
- **Other Sustainment Outcome Metrics May Be Critical To Specific Systems, And Should Be Added As Appropriate**

* Sustainment KPP & KSAs Included In Revised Draft CJCSM 3170

These 4 Life Cycle Sustainment Outcome Metrics Are Universal Across All Programs And Are Essential To Effective Sustainment Planning
DUSD AT&L Metrics Evolution

TLCSM Metrics (Nov 05)

- Operational Availability (Ao)
- Mission Reliability
- Total Life Cycle System Cost per Unit of Usage
  - Cost Per Unit of Usage
- Logistics Footprint
- Logistics Response Time (LRT)

Life Cycle Sustainment Metrics (Feb 07)

- Materiel Availability
  - Key Performance Parameter (KPP)
    (per Aug 06 JROC Memo)
- Materiel Reliability
  - New Key System Attribute (KSA)
    (per Aug 06 JROC Memo)
- Ownership Cost
  - New Key System Attribute (KSA)
    (per Aug 06 JROC Memo)
- No Corresponding New Metric
- Mean Down Time (MDT)
DAU Stryker Suitability Study

• Interim Progress Report #2
  – Objectives
  – Process
  – Progress & Plans
  – Findings & Observations
  – Data Analysis
  – Reliability Measurement Issue
  – Challenges
  – Recommendations
DAU Stryker Suitability Study

- Objectives
  - To conduct a research study to quantify the difference between projected O&S (associated with the RAM requirement) and the actual costs associated with the achieved level of operational suitability. That is, quantify the costs of not achieving adequate levels of operational suitability.
Process

• Phase 1 - Initial Program (Stryker)
  a. Understand the problem
  b. Define detailed study objectives
  c. Collect data
  d. Analyze data and build models
  e. IPR at T&E Conference - Hilton Head
  f. Acquire additional data as needed
  g. Draft report
  h. Finalize report

• Phase 2 - Analysis of 5 additional programs covering multiple types
Data Collection:

Phase 1 Sources
- Stryker PM Team (TACOM Warren, MI)
- AEC RAM Directorate (APG)
- OTC Reps (Ft. Hood)
- AT&L Rep
- IDA
- LMI
- GDLS CDRL Data
- Ft. Lewis Stryker Team
Findings & Observations

• Warfighters very satisfied with Stryker performance in-theatre
• Brigade Commanders extremely happy with ICLS
• High Operational Readiness Rates, but ORR is prioritized over support costs
• Op Temp in-theatre far exceeds planned usage rates (X10, X15, X30 ?)
• Operational Environment much different than expected
• Combat configurations add excessive weight to vehicle (affecting reliability and performance)
• Army did not buy Tech Data Pkg – “Prohibitively expensive” . . . risk to government
Findings & Observations

- Operational Readiness Rate not necessarily consistent with traditional \( A_o \) (Operational Availability)
  - RAM issues can be masked by ORR

- Mission Completion vs. Subsystem Failure
  - Possibly leads to overestimating system reliability due to non-reporting on individual subsystem (component) failures
  - Multi-mission vehicle – with subsystem failures, system can still perform alternate missions

- Reporting Criteria Issue:
  - ORR vs. MTBF of individual subsystems
Reliability Issues

• Reliability requirement as defined in ORD
  – 4.3.1.3. The Stryker (vehicle only, excluding GFE components/systems) will have a reliability of 1000 mean miles between critical failure (i.e., system aborts).

• Reliability issues and cost drivers found during DT/OT correlate well with fielded experience
Operational Environment

• **Field usage much harsher than planned**
  - e.g., higher tire pressure, roads, curbs, weight (armor, sandbags)

• **Mission Profile says 80% XCountry, 20% Primary Roads**
  - in-theater mission just the opposite . . . most missions in urban environment (police action) on paved roads

• **OpTempo very high (>10X)**
  - High OpTempo may improve reliability numbers, but beats up equipment
  - With low usage, seals can dry up, humidity can build up in electrical components

• **Changes in mission & configuration are putting excess stress on vehicle: armor/sandbags, over inflated tires, going over curbs**
  - replacing 9 tires/day (>3200 tires/yr)
  - wheel spindles developing fatigue cracks
  - drive shafts breaking
  - prescribed tire pressure is 80 PSI, however, with slat armor/sandbags – must maintain >95 PSI
  - 95 PSI is a logistics burden on operators
    • Must be maintained by the soldier (tire inflation system can’t do it)
    • Soldiers must check tire pressure more than 3 times per day to maintain 95 PSI
Tactical Considerations

• Slat Armor design (additional 5000 lb) is effective for many RPG threats, but negatively impacts circumference, weight and performance of Stryker
  – Causes multiple problems for safe and effective operation
    • Slat armor on rear ramp too heavy - greatly strains lifting equipment
      – Occasionally, crews must assist raising/lowering ramp
    • Bolts on rear ramp break off frequently with normal use
    • Slat armor bends with continued ops . . . can cover escape hatches and block rear troop door in ramp
    • Slat armor interferes with driver’s vision
    • Slat armor difficult for other traffic to see at night . . . Safety hazard in urban environment
    • Slat Armor prohibits normal use of exterior storage racks
  – Significantly impacts handling/performance in wet conditions
    • Adds excessive strain on engine, drive shafts, differentials
  – Impairs off-road ops
• Though not designed primarily for the urban fight (MOUT), Stryker is well-suited for it
  – Unlike M-1, Stryker is “ghostly” quiet . . . tactical advantage
• Stryker overall OIF performance significantly better than HUMVEE, BRADLEY or M-1 in this environment
Stryker Fleet Readiness

ORR vs Strykers Fielded
As Of: 20 Feb 2007

1470 Fielded
ORR = 97%

Strykers Fielded
ORR

Number Fielded

ORR Percentage
Operational Readiness Rate (ORR)

• Contractual requirement: ORR > 90%
  – Does not include GFE (base vehicle configuration only)

• Stryker consistently above requirement
  – Current ORR 97% (20 Feb 07)

• Cost-plus-fixed-fee contract motivates GDLS to meet ORR . . . .
  – However, contract does not incentivise controlling costs . . . risk to government
  – Example – to repair cracked hyd res in power pack, whole power pack is replaced in field
Cost Per Mile (CPM)

- CPM is a planning tool used to project future budget requirements
- No specific value of CPM required by contract
- Govt/Kr both calculate CPM independently, and use results to negotiate parts cost forecasts to determine purchasing requirements
- For this research project, DAU is doing our own independent computation of CPM (garrison and deployed units) to validate other data and our methodology
Cost Per Mile (CPM) Estimates

- CPM estimate - $17.19 (GAO 04-925, including labor, parts & repair)
- CPM estimate - $18.78 (Stryker R-TOC Brief)
- CPM estimate - $18.23 (based on M113 methodology w/Stryker adjustments)
- CPM estimate - $14.53 (based on initial 4 month deployment data)

- CPM estimate (GDLS) - $13.52 garrison
  $ 8.88 deployed
- DAU CPM estimate – $ 13.30 garrison
  $  7.95 deployed

- Note 1 - We need to understand the basis for these estimates more thoroughly (assumptions, models, configurations, limitations . . . )
- Note 2 - Figures above are averages across all variants (deployed or garrison)
- Note 3 - CPM higher for garrison than deployed stryker ???

  Why? A. While deployed, non-essential maintenance can be delayed until absolutely necessary . . . intervals between reported failures increases, CPM decreases
  B. Maintenance more accessible/available in garrison – follow the book closer
  C. Higher mi/day deployed . . . less labor/mi
Other Findings . . . cont.

• Stryker initial deployment/fielding was extremely accelerated to meet urgent combat need
  – Result was that Army was doing these things concurrently:
    • Testing
    • Producing
    • Fielding
    • Conducting combat operations

• The threat and the operational environment were different than anticipated
Other Findings . . . cont.

- Immature Maintenance Procedures- many procedures have not been validated in IETMs (interactive electronic tech manuals) lead to:
  - “Tribal System Maintenance” from experienced crews (“. . . that new book isn’t any good . . . . . . . . . . this is the way it worked on the M113, so do it like this”)

- With Kr support to maintain vehicles, soldier crews develop “rental car mentality” . . .
  - Lack of ownership mentality . . . overly dependent on contractor
  - Sometimes they forget the basics (oil check)
  - One vehicle lost because pre-mission checks were ignored
DATA ANALYSIS

Phase 1 – March 2007
Data Collected

• CDRL A003 (Aug 2006)
  – Parts Consumption Report (for ~ 1 yr)
  – Good quality data (possibly some errors in mileage or dates)

• CDRL A004 (Aug 2006)
  – Repairable Items Repair Cost Summary
  – Most repair items have estimates or quotes
Cost Per Mile Analysis

\[
\text{Cost Per Mile} = \frac{\text{Labor} + \text{Replacement Parts} + \text{Part Repair}}{\text{Total Vehicle Mileage}}
\]

Labor: $4.73M per brigade (average value)
Replacement Parts: from CDRL A003 Consumption Report
Part Repair: No historical data for many parts
  - Variability in Part Repair
  - Existing data from CDRL A004
    (Repairable Items Repair Cost Summary)
Vehicle Mileage: Does not exist for all vehicles
  - Questionable accuracy
Determining the Average Repair Cost

• Repair Cost data only exists for ~ 26% of total consumable parts
  – Determine the Average Repair Costs for Repairable Parts listed in CDRL A004*
  – Determine Average Scrap Rates for Repairable Parts listed in CDRL A004

• For remaining consumables (~74%):
  – Use Parametric Models developed from CDRL A004 data

* CDRL A004 Repairable Items Repair Cost Summary)
Repair Costs Parametric Model

- Data from CDRL A004
- Uncertainty for parts or assemblies costing more than $50k
- Repair of Powerpack set to 30%
- Did not factor in warranty items
Scrap Rate Parametric Model

- Model Used For Parts not in CDRL A004
- High statistical variance for some parts due to small sample size
- 100% data points ignored in the model
Total Vehicle Mileage

\[
\text{Cost Per Mile} = \frac{\text{Labor} + \text{Replacement Parts} + \text{Part Repair}}{\text{Total Vehicle Mileage}}
\]

Vehicle Mileage: Does not exist for all vehicles
Questionable accuracy

- Extreme values discarded.
- Miles/day calculated for every vehicle in the database
- Average miles/day from the database assumed to apply to all Brigade vehicles
Estimating Miles Per Day

For each vehicle

Earliest Part Consumption (date & mileage)

Latest Part Consumption (date & mileage)

Vehicle miles per day $\sim \frac{\text{Miles}_L - \text{Miles}_E}{\text{Day}_L - \text{Day}_E}$

- Miles/day computed for each vehicle
- Downtime not factored into the estimation.
Vehicle Miles Per Day From A003
(CONUS)

Maximum Limit For CONUS
Estimating the Repair Cost per Mile

For each vehicle

- Above computation over estimates cost/mile because it doesn't include any mileage before the first or after the last part consumption.
- The error is a function of the number of failures (i.e., as the failures increase, the error decreases).
- Numerical simulations were performed to develop a correction factor to be applied to the computed repair costs per mile.
Correction Factor for the Estimated Repair Cost Per Mile

\[ y = -3 \times 10^{-5}x^4 + 0.0014x^3 - 0.0271x^2 + 0.2383x + 0.0918 \]

\[ R^2 = 0.9971 \]
CONUS Cost Per Mile

- **CPM based on vehicles with:**
  - Maximum total miles < 5,000
  - Maximum Miles/Day < 100

- **Models:**
  - Parametric Repair Cost Model
  - Parametric Scrap Rate Model
  - Cost per Mile Correction

- **Assumptions**
  - 300 Strykers Per Brigade (all operational)
  - Power Pack repair = 30% unit cost
CONUS Cost/Mile
ICLS Labor, Replacement Parts, Part Repair

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>No. Vehicles</th>
<th>Repair Cost in Computation</th>
<th>Total Mileage in Computation</th>
<th>Spares/ Repair Parts Cost/mile</th>
<th>Miles Per Day</th>
<th>Total CPM</th>
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<tbody>
<tr>
<td>ICV</td>
<td>345</td>
<td>$1,581,641</td>
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<td>$7.25</td>
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<td><strong>$7.39</strong></td>
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<td><strong>$13.30</strong></td>
</tr>
</tbody>
</table>

Assumptions: Each vehicle < 5k total miles, < 100 miles/day average, 30% repair cost for Power Pack
Deployed Cost Per Mile

• CPM based on vehicles with:
  – Maximum total miles < 20,000
  – Maximum Miles/Day < 400

• Models:
  – Parametric Repair Cost Model
  – Parametric Scrap Rate Model
  – Cost per Mile Correction

• Assumptions
  – 300 Strykers Per Brigade (all operational)
  – Power Pack repair = 30% unit cost
## Deployed Cost/Mile

ICLS Labor, Replacement Parts, Part Repair

<table>
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<tr>
<th>Vehicle Type</th>
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<td><strong>All vehicles</strong></td>
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<td><strong>$13,984,989</strong></td>
<td><strong>2,075,310</strong></td>
<td><strong>$6.74</strong></td>
<td><strong>35.59</strong></td>
<td><strong>$7.95</strong></td>
</tr>
</tbody>
</table>

- Model assumes $4.73M per brigade
- Higher miles/day for Deployed vehicles results in lower Total Cost Per Mile

Assumptions: Each vehicle < 20k total miles, < 400 miles/day average, 30% repair cost for Power Pack
Sensitivity Analysis (CONUS)

- Using an Overall Average Repair Cost (based on CDRL A004) Instead of the Parametric Models drops the CPM by 2%
- Increasing the limit on Miles Per Day (from 100 to 300) drops the CPM by 3%
- Increasing the limit on Maximum Miles (from 5,000 to 10,000) drops the CPM by 4%
Challenges

• Validity of comparisons
• Baseline assumptions
• Missing Data
• Quality of data
Recommendations

- Continue Research
  - Complete Stryker analysis
- Feedback from sponsor
- Feedback from community
- Determine path ahead
- Develop methodology for conducting suitability studies on other systems
- Look at other programs for comparison
  - Other services, other types of systems