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Understanding The Combined Influence On Ownership Cost Of Reliability, Maintainability, Component Packaging, Commonality, and Support Process Performance

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Background

- Importance of reliability to ownership cost has been studied and documented for many years*
- Other aspects such as maintainability, commonality, component packaging, and cycle time also studied, although less frequently*
- Each studied more or less in isolation
- Not as well understood is the relative and combined importance of five dimensions
  - Reliability
  - Maintainability
  - Component packaging, e.g. choice of line replaceable modules (LRMs) versus Line Replaceable Units (LRUs)
  - Commonality, and
  - Performance of the support process

*References on slide 17

Purpose of Presentation

- Using data representative of a complex ground platform electronics subsystem, examine the relative importance of the five dimensions from the perspective of ownership cost
- Show how plausible improvement in a dimension, or combination of dimensions, affects ownership cost
- By characterizing what amounts to a trade space analysis can help inform the allocation of constrained test and evaluation resources

Data

- **System**: high technology electronics used on mobile ground platforms, with two types of LRUs
  - LRU A: $81K each, 5 per system, mean time between failure (MTBF) = 4,000 hours; comprising 7 types of SRUs;
  - LRU B: $70K each, 2 per system, MTBF = 4,650 hours; comprising 9 types of SRUs
- **Equipment density**: 3,645 platforms total
- **OPTEMPO**: 141 hours per month per system for 20 year service period
- **Support system**: two-level maintenance with nominal performance characteristics (e.g., 4-hour troubleshoot, remove, and repair; 45-day turn-around on LRU maintenance; cost of repair at sustainment level = 22% of production unit cost)
- **Caveats**: data constructed for this analysis by analogy with systems fielded and in design, representative of such systems, but not data from any specific system

Method

- Used Logistics Support Activity (LOGSA) Cost Analysis Strategy Assessment (CASA) model as primary tool
- Added spares holding cost manually—not addressed in CASA*
- For LRU vs. LRM comparison, used results of recent study by Army Material Systems Analysis Agency (AMSAA) for Future Combat Systems (FCS) program to parametrically adjust CASA spares cost
  - CASA not well structured for such a comparison
  - AMSAA analysis used Selected Essential-item Stock for Availability Method-Life Cycle Cost (SESLCC) model
  - CASA and SESLCC calculated spares costs for LRU case are comparable, hence parametric adjustment is reasonable approach**

*Holding costs include cost of capital, losses due to obsolescence, other inventory losses, storage costs

**Model descriptions in backup

Limitations on Analysis

- Examined sum of classic operations and support (O&S) and field-level spares cost
- Did not address RDT&E or production costs other than spares
- Did not address sustainment (wholesale) level spares costs or support equipment costs
- Treated sustainment-level repair costs as material costs (i.e., labor implicit in material)
- Since time frames for all analysis are identical did not discount
- Did not examine changes in unit cost, which "usually" decreases as failure rate decreases

Quantification of Dimensions

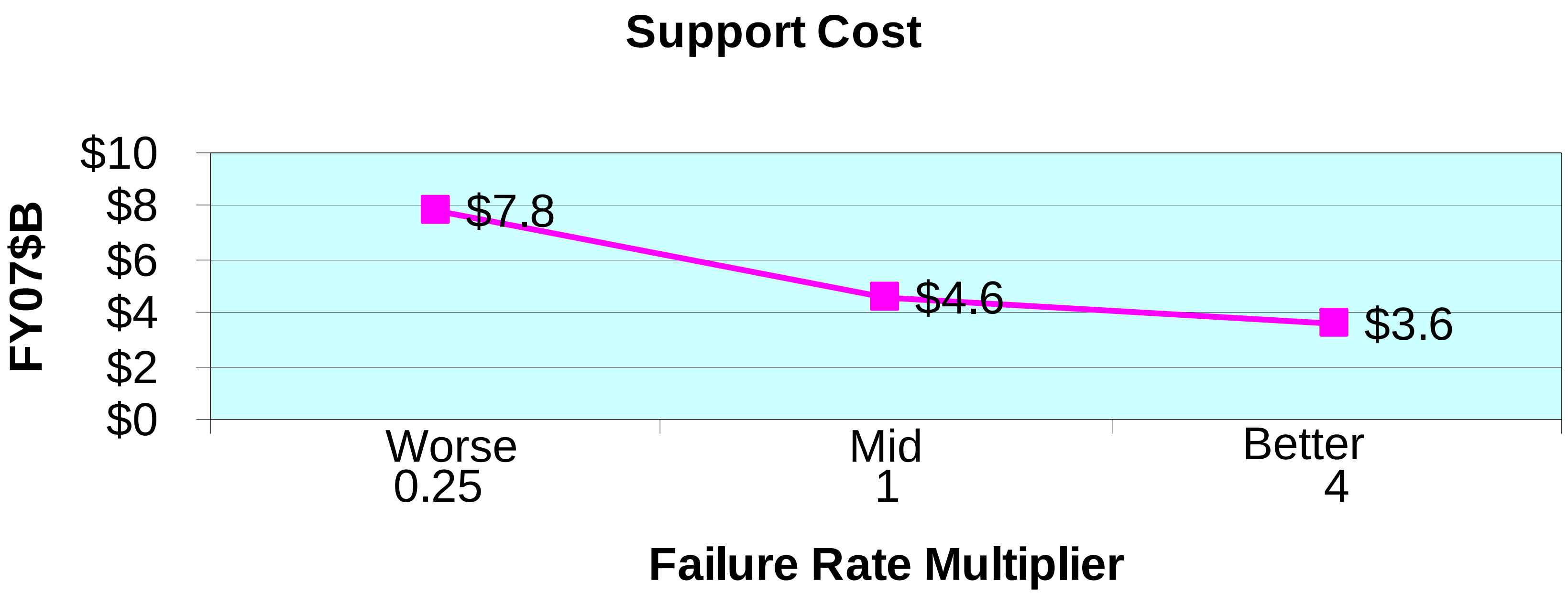
Dimension	Operationalized As	Units
Reliability	Failure rate (1/ MTBF)	Failures per 1,000 hours
Maintainability	Mean time to repair (MTTR)	Hours
Component Packaging	LRU format or LRM format	NA
Commonality	Number of distinct configurations of functionally equivalent systems	Count
Performance of support system	Turn-around time from field to depot and back	Days

Experimental Design

Dimension	Worse	Mid	Better
Failure rate (system level, per 1,000 hours)	6.7 4*mid	1.7	0.4 0.25*mid
MTTR (hours)	16 4*mid	4	1 0.25*mid
Packaging		LRU	LRM
Commonality (number of different configurations)	8 (8*nominal)	4 & 2 (4 & 2*nominal)	1
Turnaround time (days)	180 4*mid	45	11 0.25*mid

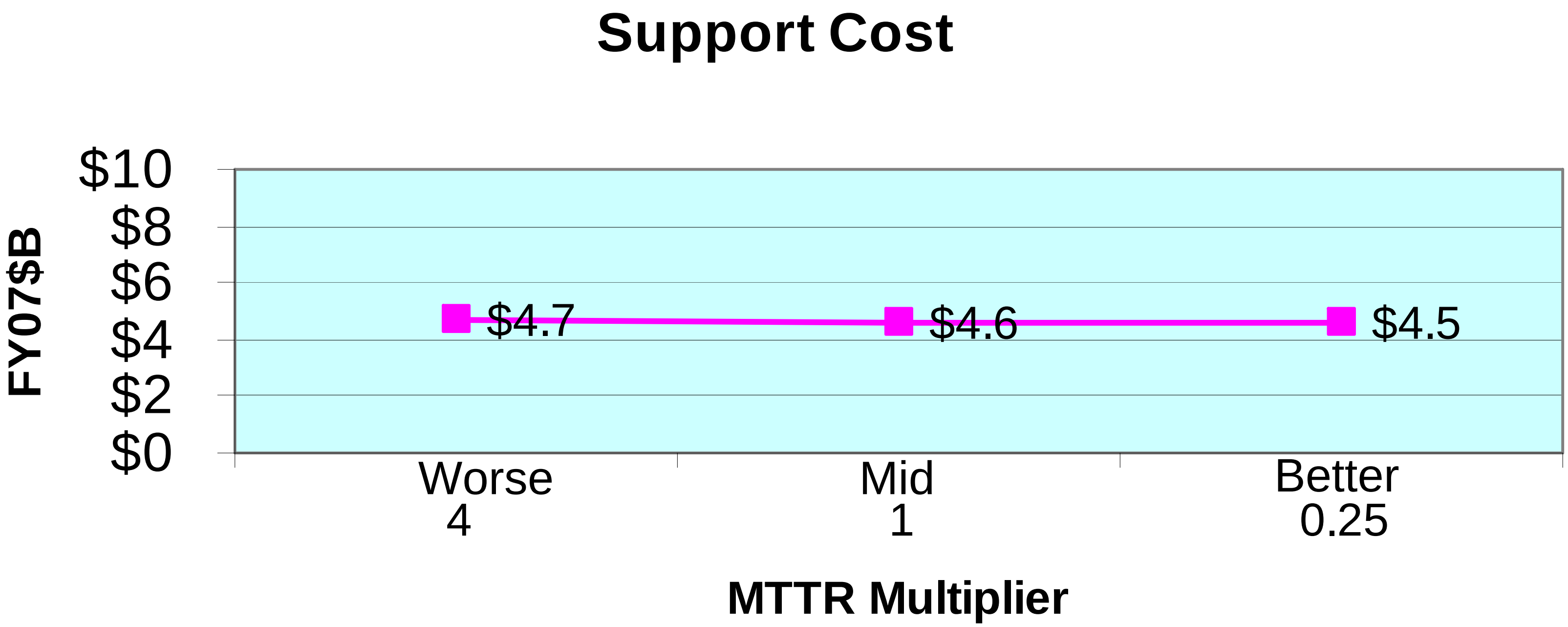
Nominal; base case

Reliability Results



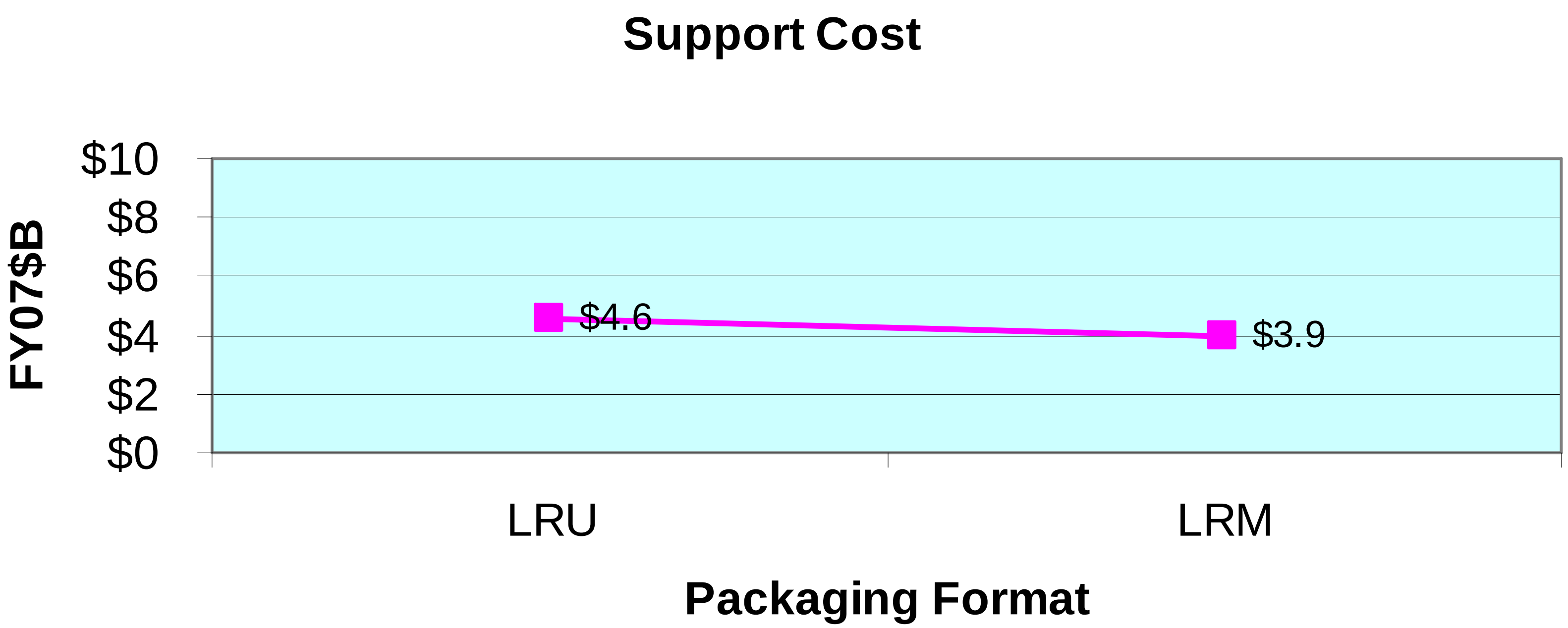
2.19:1 change in support cost

Maintainability Results



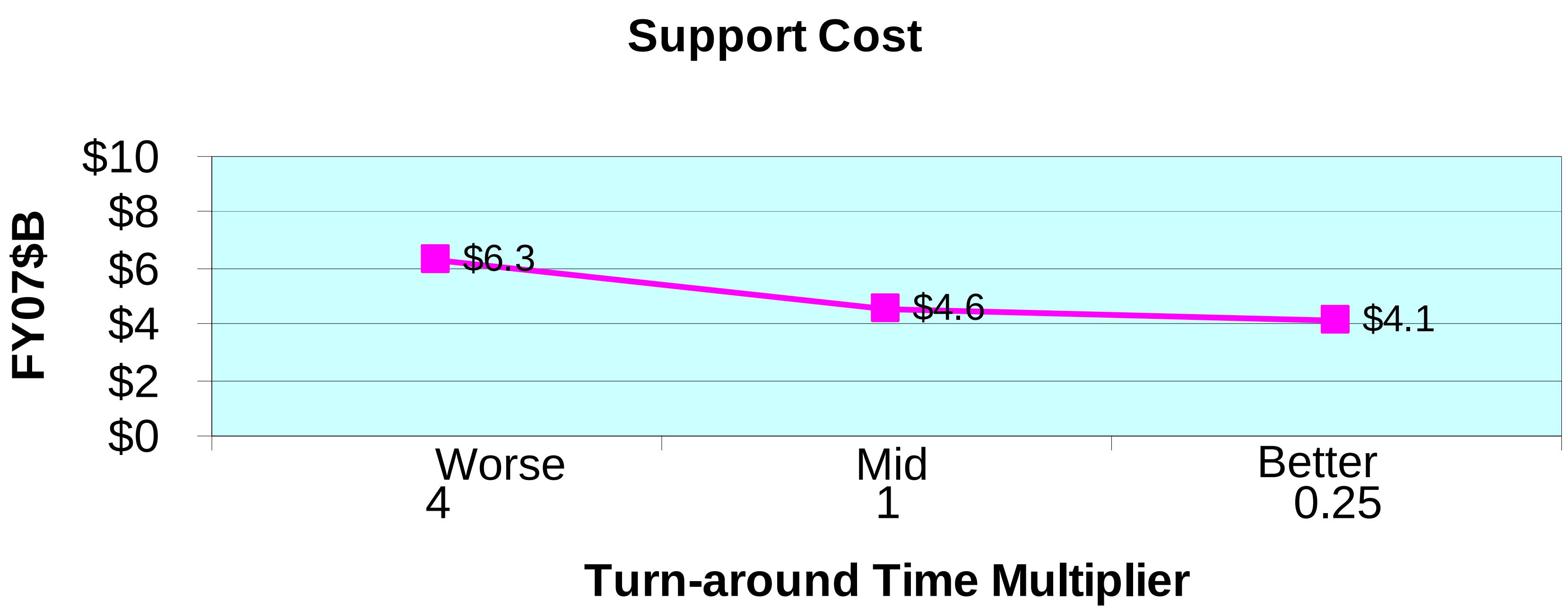
1.03:1 change in support cost
Affects field labor, not spares
But other reasons for maintainability

Component Packaging Results



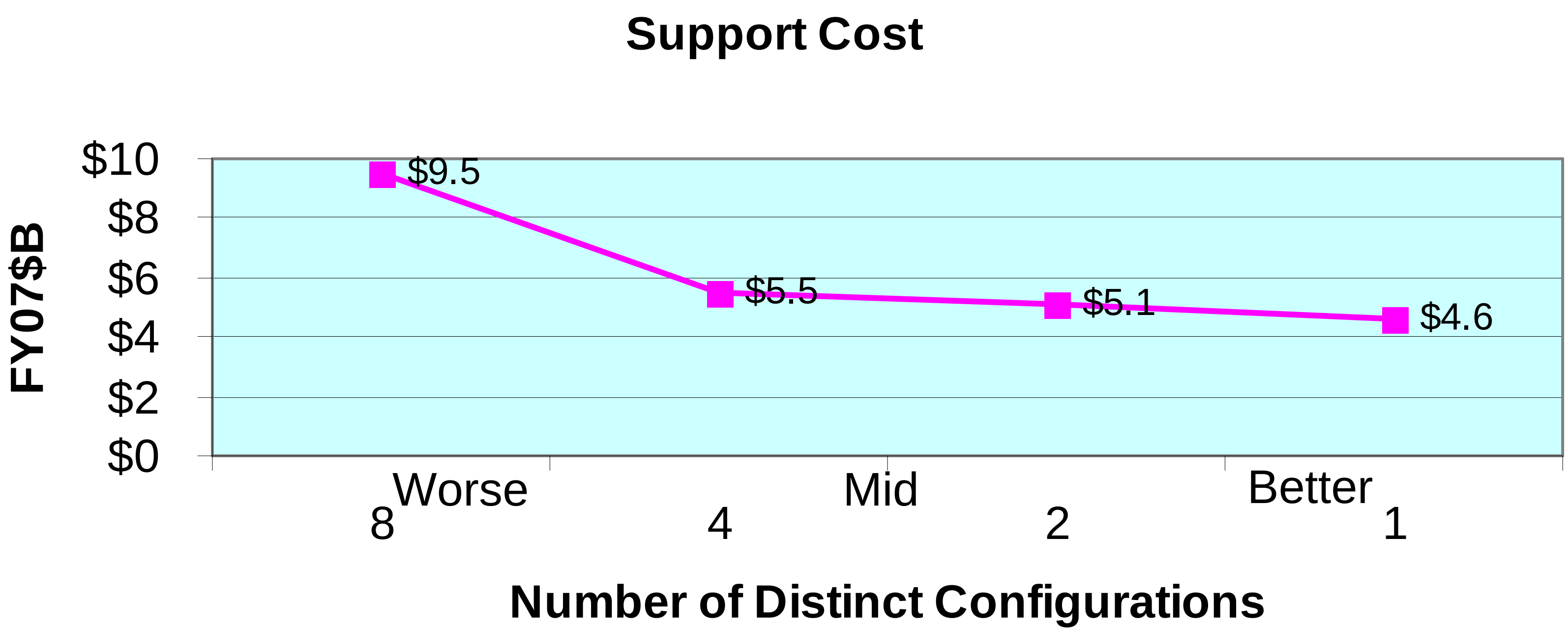
1.17:1 change in support cost

Support System Performance Results



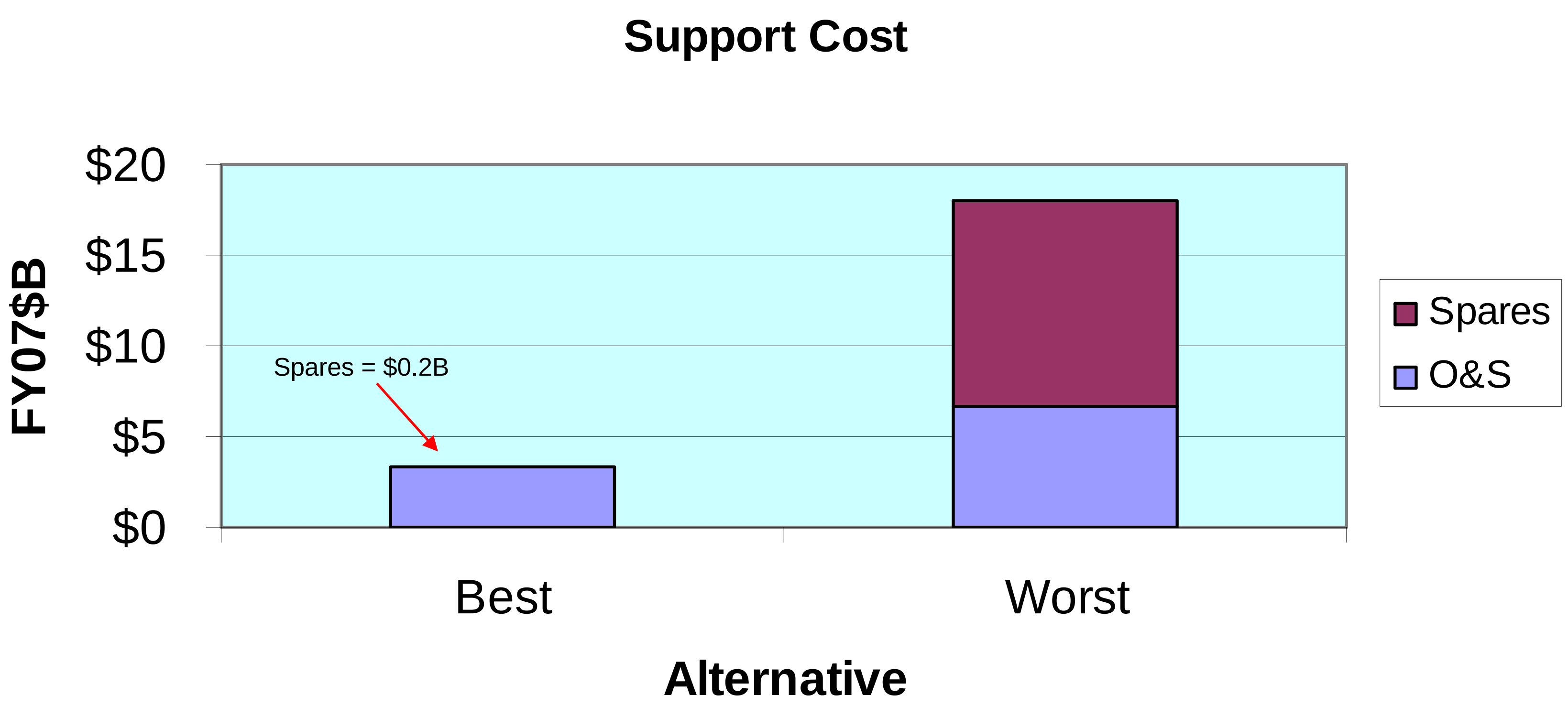
1.53:1 change in support cost

Commonality Results



2.07:1 change in support cost

All Worst Case and All Best Case



5.3:1 change in support cost

Evaluation

(Over Range Examined, Given Characteristics of System Examined)

- Order of impact
  - Reliability (2.19:1)
  - Commonality (2.07:1)
  - Support system performance (1.53:1)
  - Packaging (1.17:1)
  - Maintainability (1.03:1)
- Worst-to-best comparison: > 5.3:1 change in support cost

Interpretation

- All dimensions except maintainability strongly affect support cost
  – All except maintainability affect labor and spares
  – Maintainability affects labor
- Comparing best combined case to worst combined case potential for > 5:1 change in support cost
  – Largest impact comes from design choices: reliability, commonality, packaging
  – Confirms notion that early design decisions “lock in” support cost
  – Since unit cost normally decreases as failure rate decreases, may be underestimating
- Results intended to be representative of complex, high density electronics system on mobile ground platforms
- Less complex, lower density systems in other environments likely to have similar trends but different magnitudes

Selected References

1. Dwight E. Collins, “Logistic Support Cost Commitments for Life Cycle Cost Reduction.” LMI, June 1977. (An early but certainly not the only early look at reliability, maintainability, and cost)
2. Mark I Knapp and Joseph W. Stahl, “Assessment of Avionic Equipment Field Reliability and Maintainability as Functions of Unit Cost,” Presentation to the 16th Annual Department of Defense Cost Analysis Symposium, October 4-7, 1981 (Established a direct log/log relationship between unit cost and failure rate)
3. James A. Forbes, Donald W. Hutcheson, and Beirn Staples. “Using Technology to Reduce Cost of Ownership.” LMI LG404RD4, April 1996 (Showed the relative contribution to ownership cost of reliability and maintainability. Sized the potential for ownership cost return on investment in reliability-related technologies, compared relative return on reliability to maintainability)
4. Dennis L. Zimmerman, et al., “Quantifying and Trading Off the Benefits of Reducing Order and Shipping Times.” LMI LG501R1, September 1997 (Examined cost benefit of support system performance improvement)

backup

Models Compared

Cost Analysis Strategy Assessment (CASA) Model

- Accounting model with embedded spares algorithms*
- Developed by Defense Systems Management College
- Maintained by Army Logistics Support Activity
- Calculates the total cost of ownership including research, development, test, and evaluation (RDT&E); acquisition and production; operations and support; and disposal

*CASA 2002 embedded documentation (March 2003)

Selected Essential-item Stock for Availability Method (SESAME) Model**

- Army standard initial provisioning model. Optimizes the mix and placement of spares to achieve an end item operational availability (Ao) requirement or the maximum Ao for a dollar goal input
- Maintained by Army Material Systems Analysis Agency.
- SESAME becomes SESLCC model when augmented with additional logic to capture other support costs.
- Does not address RDT&E or production other than spares

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