Space Exploration Logistics Workshop
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Group F
Spares Management

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Session Overview

- **Spares Management Scope**
  - A discussion that covers the ‘what, where, when, how many, and how-to’ issues of spares management for exploration missions

- **Goals**
  - Identify and define the impact of spares management issues on the three different exploration mission types

- **Organization**
  - Identify the important issues (starter list + attendee participation)
  - Pick the “top 3” issues/topics relevant to each exploration mission type
  - Discuss potential impacts, mitigations and opportunities, early tests/demonstrations, and interfaces to other systems
Discussion Points

- Design of systems for reliability
- Commonality and re-configurability
- Forecasting failure rates
  - Low density of each ORU
  - Large MTBF
  - Experiential updating (Bayesian techniques?)
  - Multiple lots, sources, and/or blocks
- Level-of-repair analysis
  - Optimal number of repair echelons (O, I, D)
  - Optimal repair-in-space rate
  - Design of ORUs for in-space maintenance
- In-space transportation/storage of spares
Discussion Points

- **Sparing-to-availability (single-echelon)**
  - POS
  - Functional availability
  - Risk-based (PRA required)

- **Optimal multi-echelon distribution of spares inventory**

- **Optimal procurement strategies**
  - Lifetime buy
  - Hedging against supply/demand uncertainty
  - EOQ

- **Managing condemnations**
  - Optimal triage
  - Cannibalization
  - Cost of repairs vs. buy new

- **Inventory tracking/data management**
Issues - Short Lunar Mission

1. Issue:
   Predicted Impact:
   Potential Mitigation:
   Testing Methods:
   Impact on Other Systems:
   Possible Solution(s):

2. Issue:
   Predicted Impact:
   Potential Mitigation:
   Testing Methods:
   Impact on Other Systems:
   Possible Solution(s):

3. Issue:
   Predicted Impact:
   Potential Mitigation:
   Testing Methods:
   Impact on Other Systems:
   Possible Solution(s):

See “Common to All Missions”
1. Issue:
   Predicted Impact:
   Potential Mitigation:
   Testing Methods:
   Impact on Other Systems:
   Possible Solution(s):

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3. Issue:
   Predicted Impact:
   Potential Mitigation:
   Testing Methods:
   Impact on Other Systems:
   Possible Solution(s):

See “Common to All Missions”
Issues – Mars Mission

1. Issue:
   Predicted Impact:
   Potential Mitigation:
   Testing Methods:
   Impact on Other Systems:
   Possible Solution(s):

2. Issue:
   Predicted Impact:
   Potential Mitigation:
   Testing Methods:
   Impact on Other Systems:
   Possible Solution(s):

3. Issue:
   Predicted Impact:
   Potential Mitigation:
   Testing Methods:
   Impact on Other Systems:
   Possible Solution(s):

See “Common to All Missions”
Issues –

Common to all Missions

1. Issue: Logistics Engineering is ignored in the Design Phase
   Predicted Impact: Inability to spare and maintain, support costs and risk will soar
   Potential Mitigation: Do Logistics Engineering in the design phase or buy more spares
   Testing Methods: Use simulation and modeling for sparing to availability
   Impact on Other Systems: Individual Missions and short term performance will be sub-optimal while life-cycle will be “more optimal”
   Possible Solution(s): Program Authority must impose logistics considerations in the design phase – “Top Down” Emphasis

2. Issue: Loss of Supplier and Product Line Viability
   Predicted Impact: reduced parts availability and increased cost due to increased demand uncertainty and long lead times
   Potential Mitigation: firm and constrained mission duration
   Testing Methods: Sensitivity analysis and analytical or simulation modeling
   Impact on Other Systems: NA
   Possible Solution(s): A. Consolidation to the organic supply base B. Standardize Interface and Function to allow for upgrade/technology insertion
3. Issue: Lack of integrated hardware/software design and maintenance strategies and policies
   Predicted Impact: Overly rigid designs drive costs up; and dramatically increases risk of catastrophic mission failure
   Potential Mitigation: Increased operational workarounds
   Testing Methods: Efficiency figures of merit
   Impact on Other Systems:
   Possible Solution(s): A. Implementation of a condition-based maintenance policy B. Identify optimal level of repair in space C. Increase use of embedded diagnostics or external testers
Other Points not Developed

- **Is modularity worth it**
  - Decision factors
    - High $ value
    - Critical Items/wear out items
    - Consumables (critical)
    - Fast technology upgrades
  - Decision on a case by case basis
  - Is any level of repair applicable to modular items
  - Impact on demand patterns/needs

- **Increased demands because of obsolescence “failures”**
  - Condition based maintenance
  - Shift in levels of risk (e.g. prevention of failures)
Other Points not Developed

- **Procurement of Spares**
  - Trade Off in $ between spares, provisioning, & technology refresh
  - Probabilistic Estimate of when/How many to buy
  - Full reparable or component of reparable
    - Testing for Compatibility
    - Built in diagnostics
    - Lead time to impact

- **Demand Forecasting**
  - No commonality in standards, types, crew, hazards, STTE requirements in design
  - Goals rather than standards might be unsupportable

- **Focus shift from SCM to provisioning D for S/M/R, sparing to availability etc, doctrine (level of repair & LORA)**