

Modeling, Simulation and Analysis for Life Cycle Decision Making

Nadine E. Miner, Ph.D., Liliana Andrade, Steven Handy
and Kimberly Welch

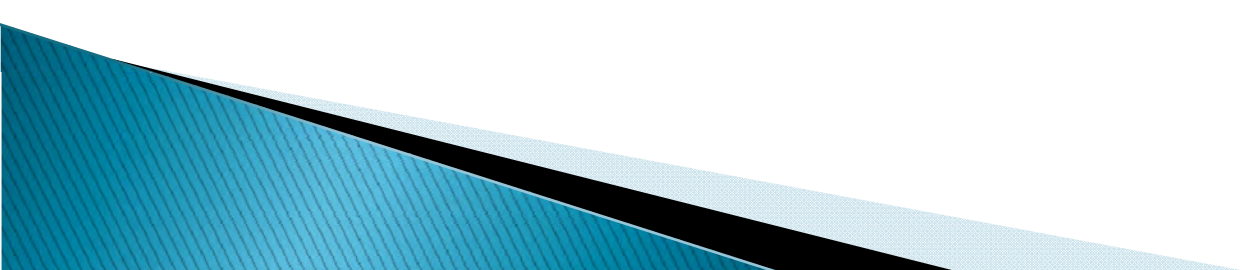
Sandia National Laboratories
Albuquerque, NM 87185
neminer@sandia.gov
(505)844-9990

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Outline

- ▶ Motivation for Modeling, Simulation and Analysis (MSA) for Life Cycle Decision Making
- ▶ Sandia's System of System Analysis Toolset
- ▶ MSA during different Life Cycle Phases
 - Design Phase
 - Fielding Phases
 - Program Improvement Phases
 - Recap/Reset/Retirement Phase
- ▶ Conclusions



Motivation for Life Cycle MSA

- ▶ Too often MSA efforts throughout a program lifecycle are disjoint and adhoc
 - MSA efforts become difficult and costly
 - Long-term benefit of life cycle MSA reduced
- ▶ Benefits of Life Cycle MSA
 - Initial model development investment is leveraged across lifecycle
 - Model accuracy is increased as life cycle phases progress
- ▶ MSA can assist decision makers in:
 - Setting feasible design requirements
 - Mission and logistics planning
 - Force structure configuration
 - Recap/Reset/Retirement decision making

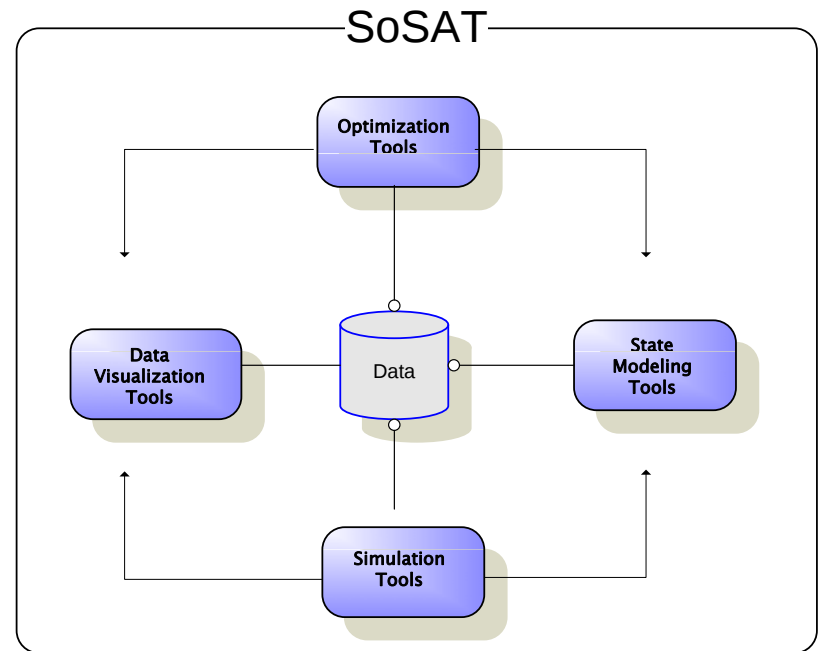
System of Systems Analysis Toolset (SoSAT) Background

- ▶ SoSAT (System of Systems Analysis Toolset) is a suite of software tools:
 - State Model tool
 - Stochastic simulation tool
 - Advanced data visualization tools
 - Reliability, spares, and supply optimization tools
- ▶ Initially designed to provide DoD and supporting organizations the capability to analyze a System-of-Systems (SoS) and its various platforms
 - Supporting multiple US Army Future Combat Systems (FCS) trade studies
 - Influencing military system design decisions
 - Performing Assessment of Sustainment/Reliability Key Performance Parameters
 - Operational Availability (Ao)
 - Self-Sustainment (Spares, Ammo, Water, Fuel)
 - Footprint Reduction
 - US Army Program Executive Office of Ground Combat Systems (PEO GCS) is using SoSAT for Fleet Management and Modernization Planning initiative
 - Participating in formal Verification, Validation & Accreditation effort with Army Organizations

SoSAT Simulation v2.0 Released February 2010

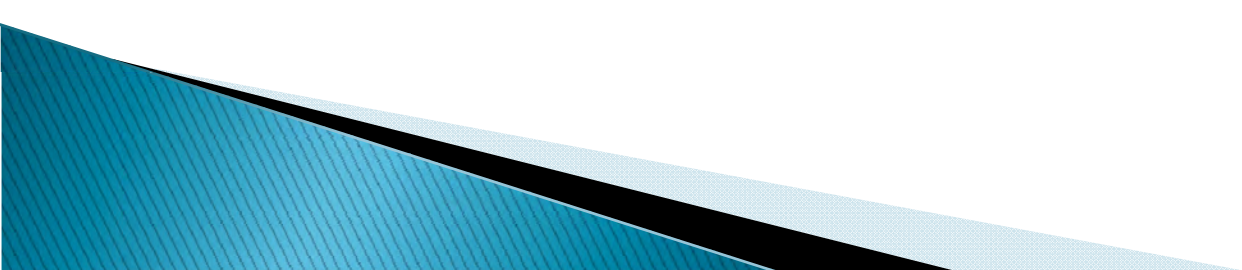
SoSAT Capabilities

- ▶ SoSAT provides analysts the capability to:
 - Simulate *any or all* of a system of systems (SoS) organizational structure
 - Simulate multiple mission segments for a SoS
 - Provide data to assess SoS performance objectives
 - Support business decisions and trade-offs
- ▶ Basic Modeling Features
 - System element reliability failures
 - Consumable usage and depletion
 - Maintenance activities including any required spares or services
 - Supply reorder for consumables and spare inventories
- ▶ Advanced Modeling Features
 - Combat Damage Modeling
 - Network Modeling
 - Prognostics and Health Management
 - Time-Based changes to model attributes (External Conditions)
 - System Referencing (interdependencies)
- ▶ Active Model Development
 - Network & human modeling capability
 - Enterprise Modeling incorporation



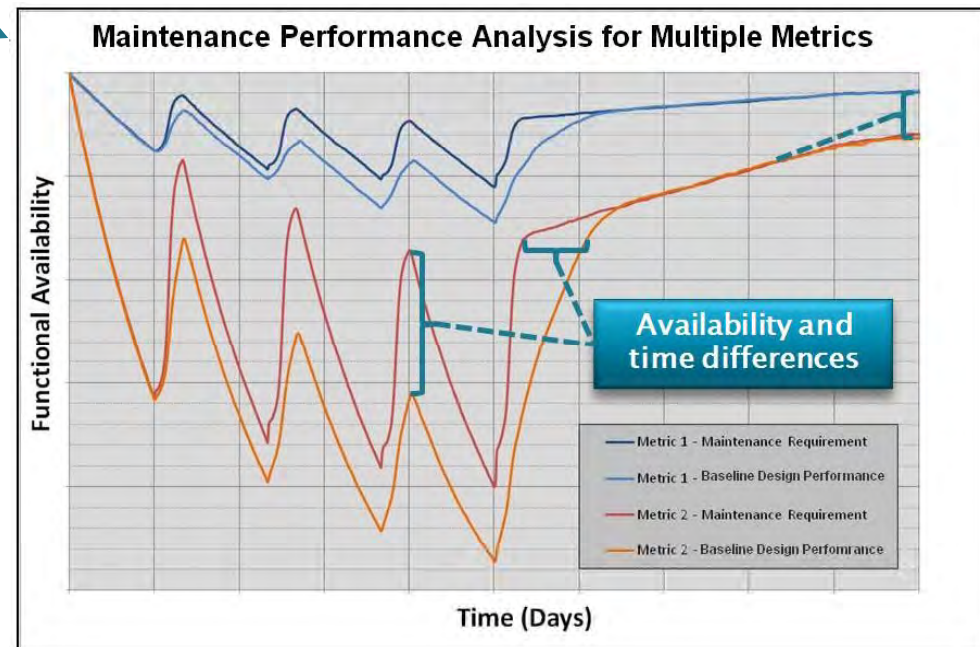
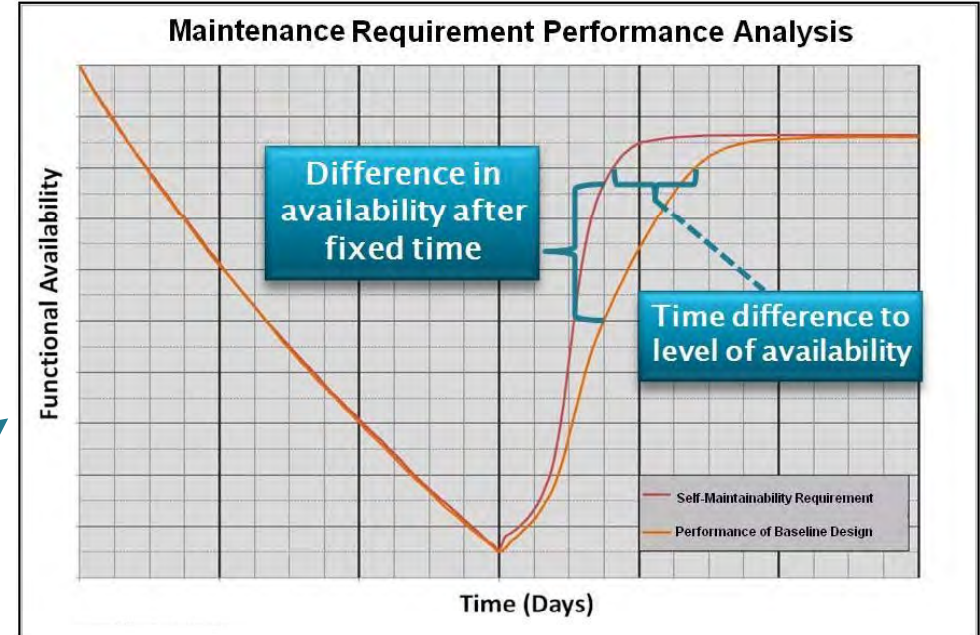
Design Phase MSA

- ▶ Evaluate system's ability to meet performance specifications and requirements, such as:
 - Operational Availability (Ao)
 - System maintainability and reliability
 - Cost
- ▶ Develop initial system of systems models
 - Leverage this investment throughout life cycle
- ▶ Use MSA to validate feasibility of design requirements
- ▶ Example: Maintainability Requirement



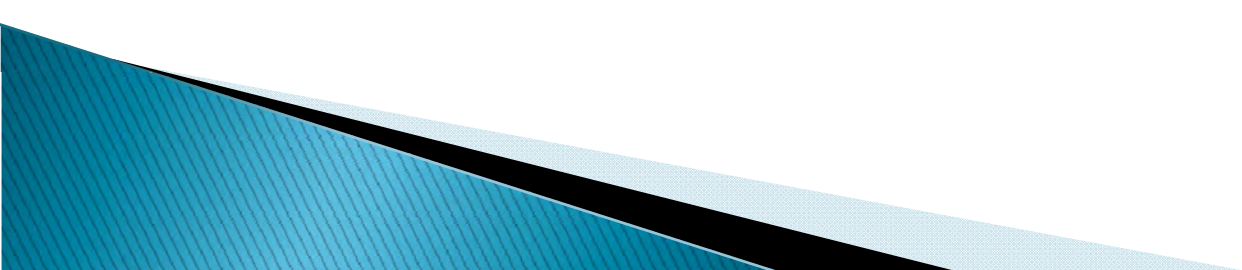
Maintenance Impact Study Overview

- ▶ **Objective:** Quantify impacts of not meeting the maintainability requirement for manned vehicles
- ▶ Metrics of Interest
 - Functional Availability over time
 - Time to recover after mission
- ▶ Model Scenarios
 - Single mission followed by long recovery
 - Multiple missions with short recovery followed by long recovery
- ▶ Major factors influenced by design
 - Reliability
 - Maintainability
 - Time to repair
- ▶ Other factors outside of design control
 - Spare availability
 - Number of maintenance resources
 - Competition for resources by other platforms
 - Platform utilization



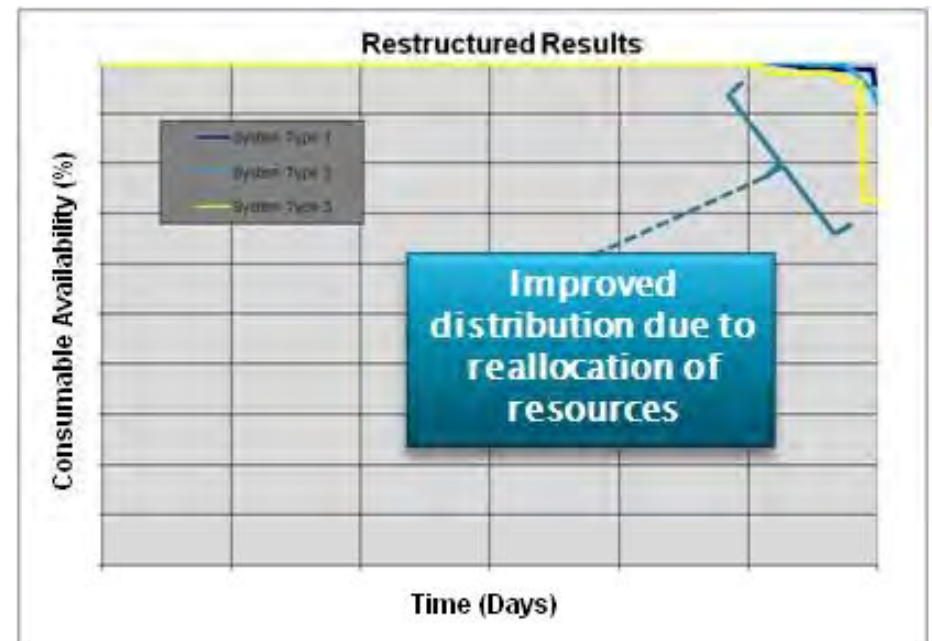
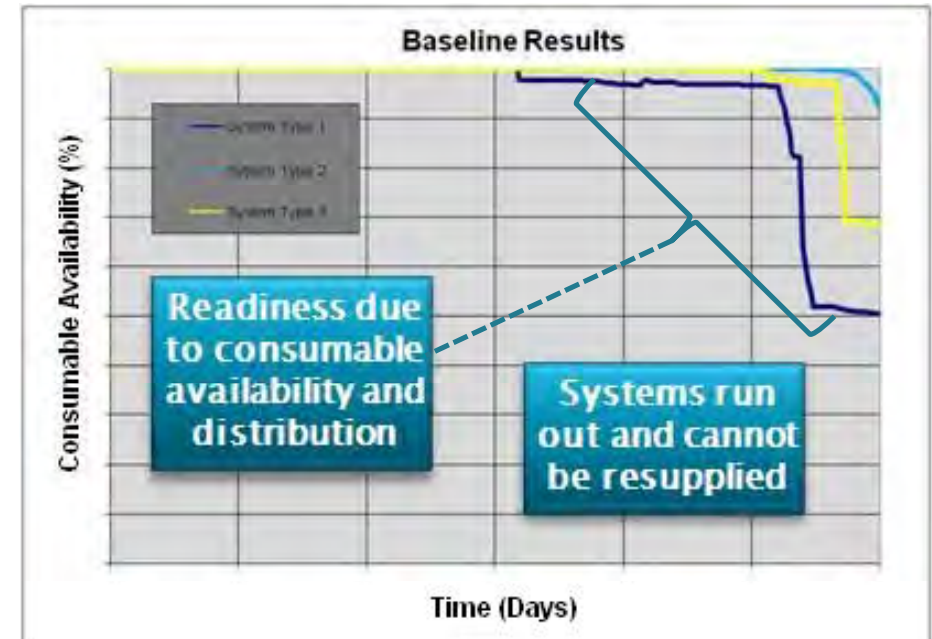
Fielding Phases

- ▶ MSA can assist in evaluating Operational Availability of fielded systems using existing models for:
 - Mission planning
 - Force structure configuration
 - Logistics planning
- ▶ Update models based on deployment strategies and field data
 - Fine tune model in terms of logistics supply chain, troop and system deployment decisions
- ▶ Example: Consumable Distribution Analysis



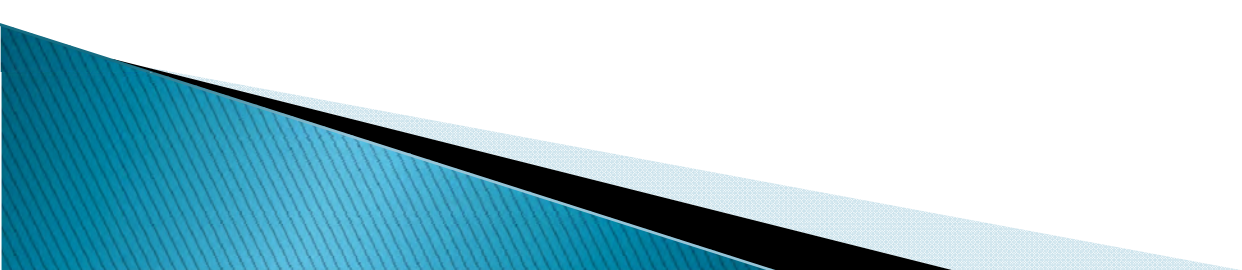
Consumable Distribution Study

- ▶ **Objective:** Determine number and location of distribution resources to sustain organization over mission
 - Minimize consumables within organization
 - Minimize distribution platforms
 - Evaluate distribution concepts of operations
 - Include reliability effects
- ▶ **Model Scenarios**
 - Single mission
 - Baseline –original distribution structure
 - Restructured – same number of distribution resources with different distribution locations
- ▶ **Study Findings**
 - Reliability and sustainment of distribution resources can have a large impact
 - Variable consumption rates over mission should be included to examine distribution performance



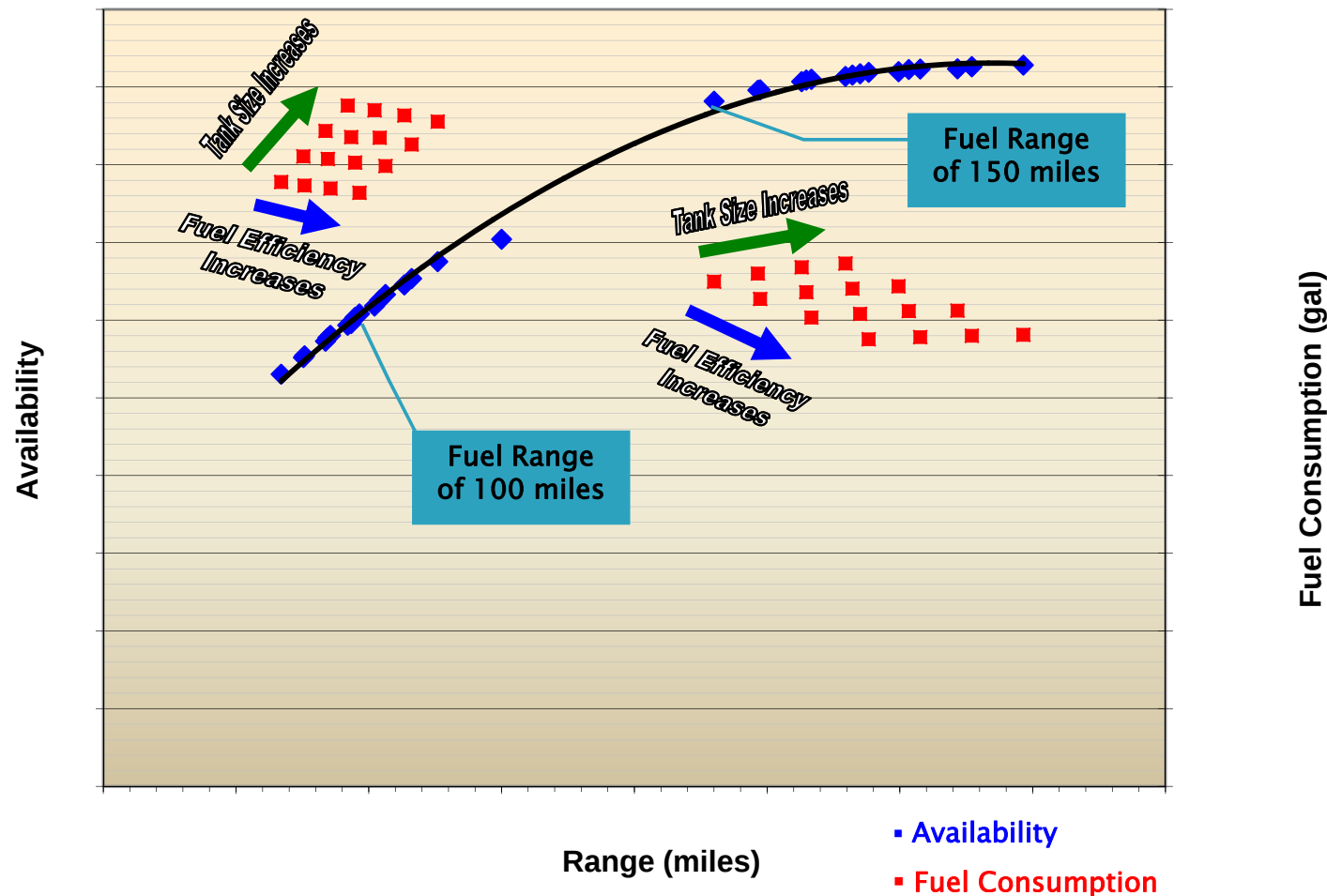
Program Improvement Phases

- ▶ Continuous pressure to improve performance of fielded systems is a reality
- ▶ There is a desire to reap potential benefits by deploying new technology advances
- ▶ MSA can assist decision makers in evaluating the effect deployment of new technologies will have on fielded systems
- ▶ Example: Engine upgrade evaluation



Engine Upgrade Evaluation Example

Engine Selection Based on Fuel Range Impacts

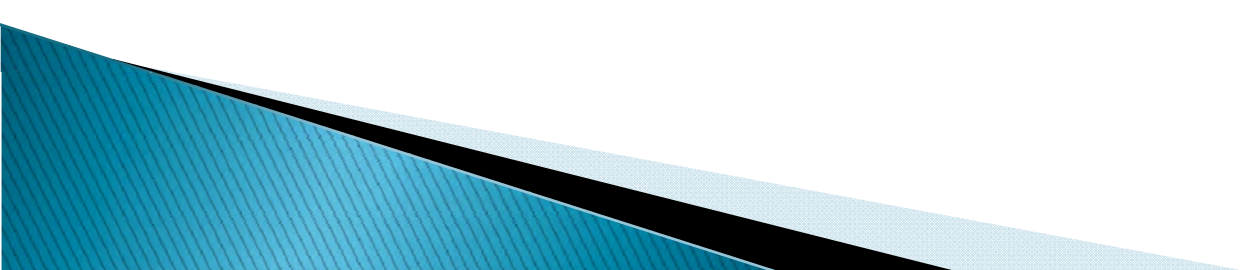


- ▶ This example measures a new 100 mile fuel range engine against a 150 mile range engine
- ▶ Each engine is analyzed with varied changes in tank size and fuel efficiency
- ▶ Availability and fuel consumption are the metrics used for this analysis

Goal: Evaluate new engine technology against operational metrics

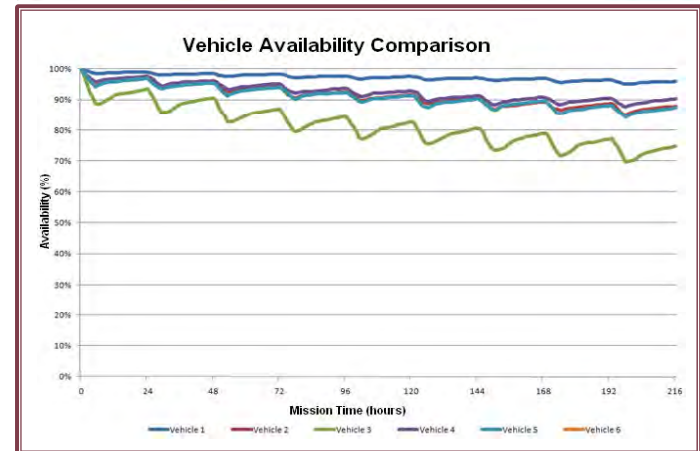
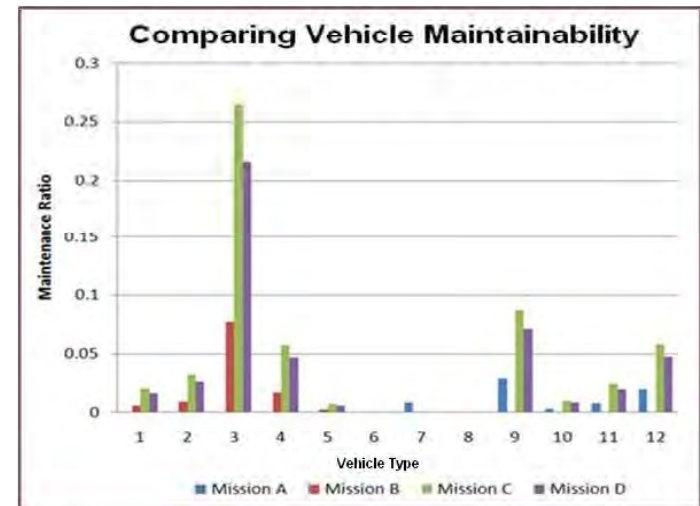
Retirement Phase

- ▶ MSA can assist decision makers in determining which systems to remove from field operations by evaluating contribution of system on overall SoS performance
 - Quantitative analysis of various performance attributes across the fleet of vehicles
 - Qualitative assessments of relative importance of each performance attribute
- ▶ Optimization and planning tools can also assist in formulating a retirement schedule
- ▶ Example: Fleet Management Analysis

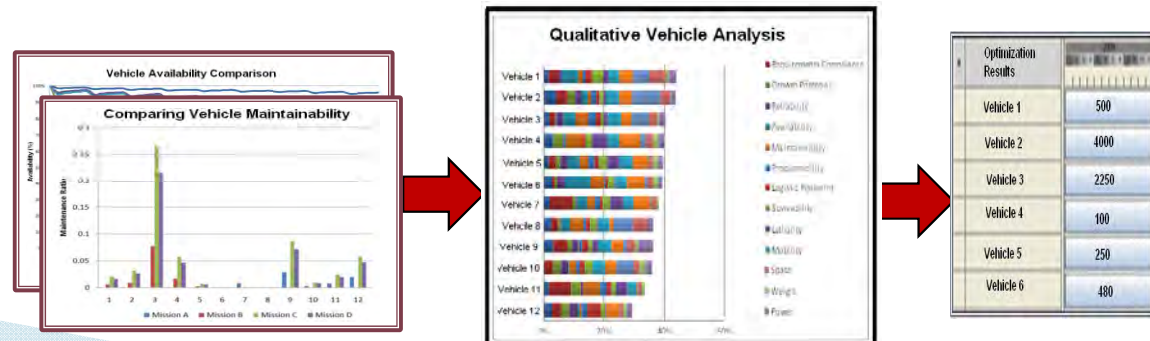


Fleet Management Analysis

- ▶ **Objective:** Develop analysis framework to support decisions concerning the management of a large fleet of vehicles
- ▶ Use MSA to evaluate vehicle/fleet performance parameters
 - Maintainability
 - Availability
- ▶ Multi-objective fleet management optimization
 - Proper fleet composition and allocation for future requirements
 - Decisions about vehicle recap/reset/retirement
- ▶ Model constraints
 - Budget
 - Force structure requirements
 - Theatre or mission requirements
 - Vehicle Performance requirements
- ▶ Key Outputs
 - Number of vehicles by type to purchase or recap/reset/retire over time
 - Allocation of vehicles to theaters or missions based on performance



Optimization and Decision Analysis Framework



Conclusions

- ▶ Benefits from early investment in model development and MSA are gained throughout a system's life cycle
 - ▶ MSA can save millions by helping to set realistic design requirements
 - ▶ Continuous model refinement and use of simulation and analysis during system field use provides on-going benefits
 - ▶ MSA can further assist decision makers by providing quantitative evidence to support program improvement and phase-out decisions
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