SAND2009-0327P

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Reliability Analysis & Optimization Programs

Bruce Thompson
Manager
System Readiness & Sustainment Technologies
Sandia National Laboratories (SNL)
Albuquerque, NM 87185
(505) 284-4949 bmthomp@sandia.gov

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

Technologies & Customer Base

System Readiness & Sustainment Technologies

Readiness & Sustainment Technologies

- Complex Systems Modeling & Simulation
- Life Cycle & Total Ownership Costs Analyses
- Design for Reliability/Maintainability
- Prognostics & Health Management (PHM)
- Integrated Logistics Support
- Technology Management Optimization
- Asset Acquisition & Mission Planning
- Risk Assessment & Risk Management

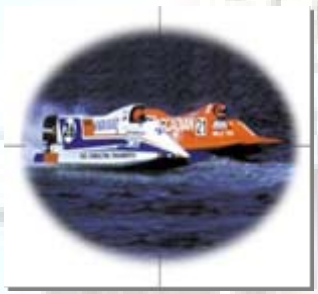
Technologies Support Broad Customer Base

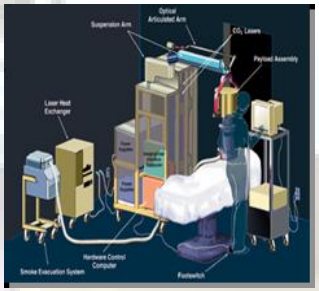

Defense


Machine Tool


Wind Energy


Semiconductor


Boating


Health Care


Petroleum


Aviation


Automotive


Nuclear Power


Coal-Fired Power


Power Electronics

Tools & Technologies Validated Through Broad Use

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System Analysis & Optimization Capabilities

System Readiness & Sustainment Technologies

- ***ProOpta™* – A Life Cycle Analysis & Optimization Decision Support Tool**
  - Can be used to optimize design trades & resource allocations across weapon systems
  - Capability for optimizing multiple performance objectives over multiple weapon systems
  - Ability to optimize new technology insertions and fleet upgrades & retrofits
- ***Support Enterprise Model (SEM)* – An Enterprise-Scale Modeling & Simulation (M&S) Decision Support Tool**
  - Integrated modeling of a worldwide support system
  - Ability to model affects of dynamic changes throughout life cycle
  - Can optimize support structures and operations across enterprise
- ***Technology Management and Optimization (TMO)* – A Technology Management Tool for facilitating and optimizing technology insertion**
  - Include management of obsolescence, diminishing manufacturing sources and tech refresh
  - Allows for a proactive vs. reactive approach for tech refresh
  - New approach for optimal tech refresh & tech insertion over systems life cycle
- ***System-of-Systems Analysis Toolset (SoSAT)* – A System of Systems (SoS) M&S Tool for analyzing integrated system-of-system scenarios**
  - Accounts for a portfolio of systems
  - Allows linkages and shared functionality across systems
  - Capability for evaluating impact of new technology insertions at a SoS level

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ProOpta™ Life-Cycle Analysis Tool

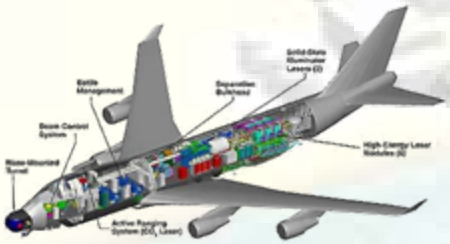
System Readiness & Sustainment Technologies

SNL's Unique *ProOpta*™ Systems Analysis & Optimization Software

Ensure that your system's reliability & readiness objectives will be met early in the design

Use of *ProOpta*™ during the design phase can help ensure that system performance objectives are met and that potential problems are identified and solved before prototypes are built.

Semiconductor Industry Design-for-Reliability Program



Airborne Laser (ABL) Reliability Optimization Program

Optimize the allocation of your system's requirements to ensure system performance at minimal costs

Use of *ProOpta*™ during the development & demonstration phase of a system can help ensure system requirements are optimally allocated to subsystems & components.

Optimize your system's upgrades & life extension for enhanced readiness & sustainment

When system upgrades and life extension are being considered, *ProOpta*™ supports cost-benefit trade studies to optimize upgrade life extension strategies.

Apache Recapitalization (RECAP) Program

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Petroleum Industry

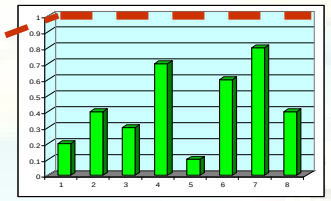
System Readiness & Sustainment Technologies

Analyzed & Optimized the Reliability & Quality of Directional Down-Hole Drilling Systems used by British Petroleum (BP)

Questionnaire

Factor	Phase 1 - Concept / Feasibility
1.1	Specific goals for the equipment are established - they are developed with consideration given to their attainability, the support and resources required to attain them, their acceptance by those involved in meeting them, and how they will be measured. Q1.1: How do you establish goals for new equipment and what is the basis on which they are determined?
1.2	Once the goals are established, a program plan is developed to meet the goals. It defines the activities, resources, schedule, procedures, and organizational interfaces required to meet the equipment goals. Q1.2a: Does your company develop a program plan for equipment and if so, can you describe how it was developed and implemented? Q1.2b: Can we get a copy of the program plan?
1.3	Only technologies that have attained a minimum technology readiness level are considered for inclusion in equipment design. Q1.3: Can you describe your company's processes for determining when a new technology is ready for consideration?

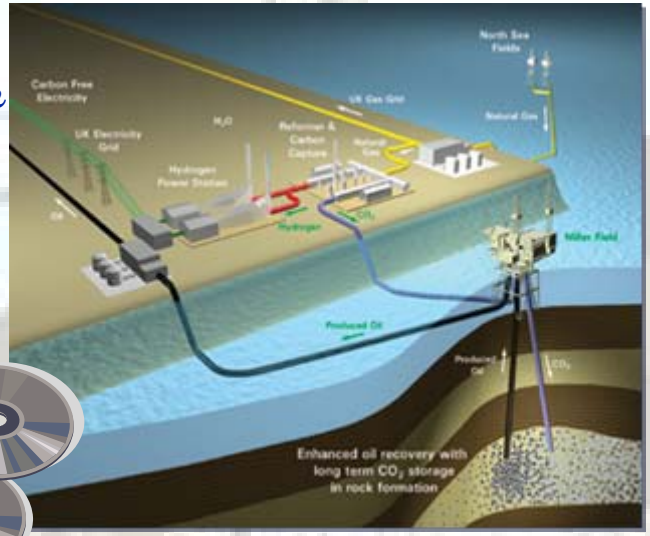
Hypothetical *"Best in World"* Scores



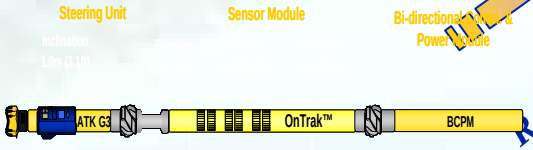
Halliburton

Assessment Model

Reliability and Quality per Product Stage

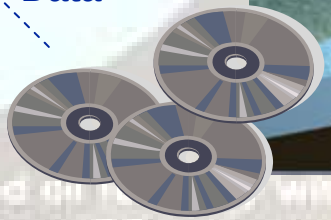


AutoTrak®G3



Reliability and Quality Control Questionnaire Responses

Data



BAKER HUGHES

The Assessment Methodology

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Customer/Supplier Dynamics

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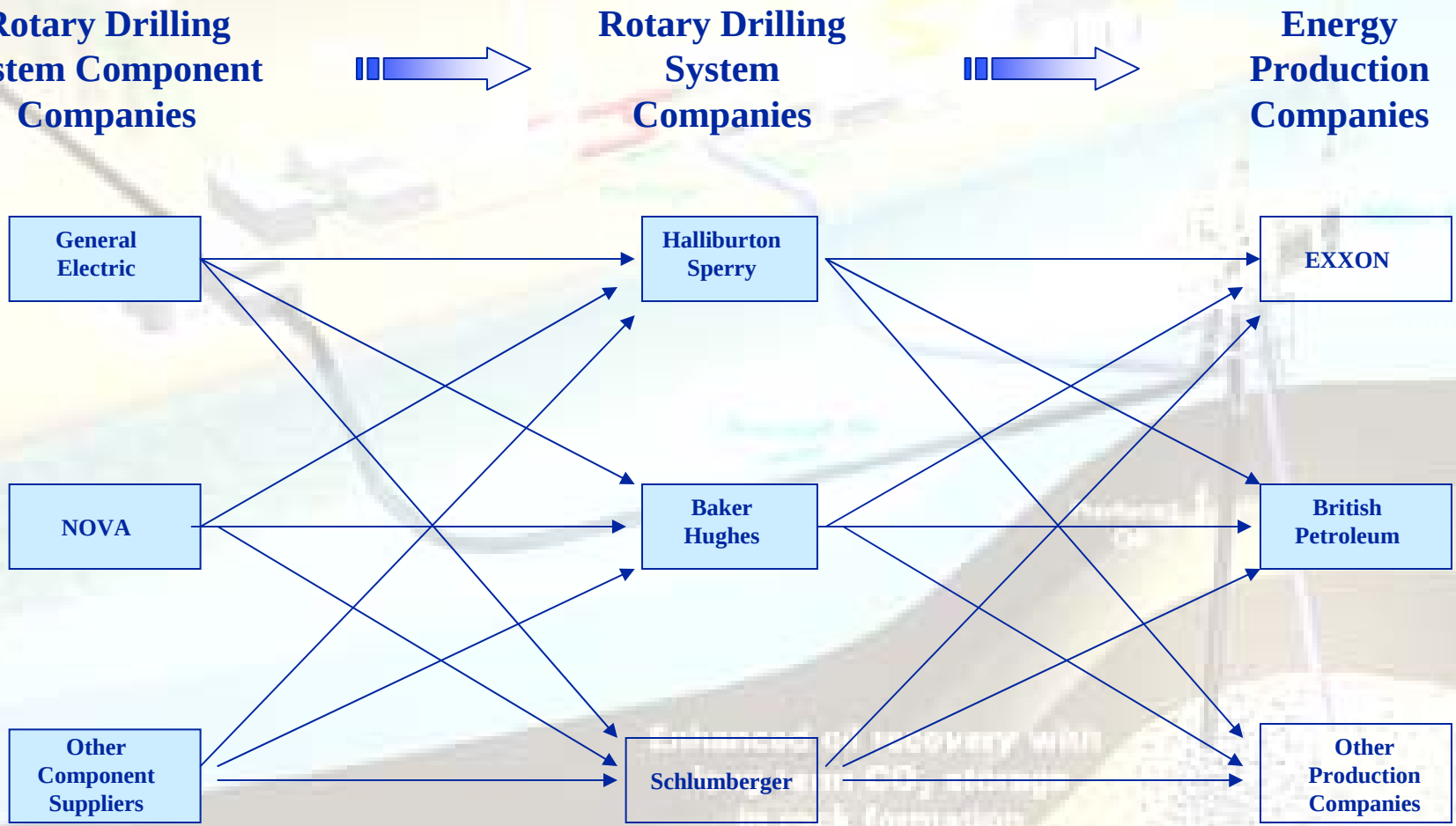
The "System" for our Project…



Baker Hughes AutoTrak® G3

System Readiness & Sustainment Technologies

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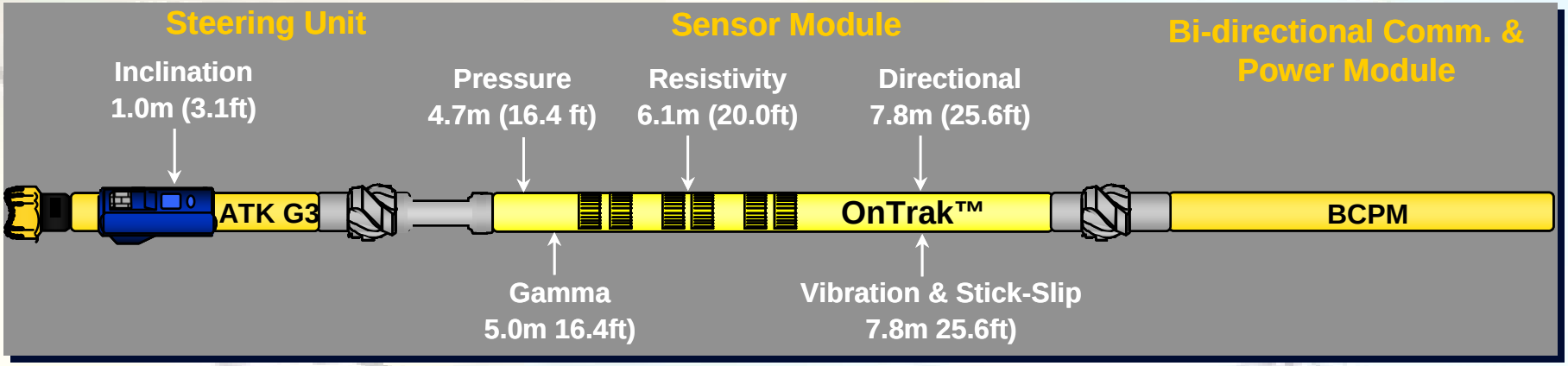
The Focus…



…AutoTrak® G3

Analyzed & Optimized the Reliability & Quality of Baker-Hughes Rotary Closed Loop Drilling System used by British Petroleum (BP) in their directional drilling programs

bp

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Baker Hughes AutoTrack® G3

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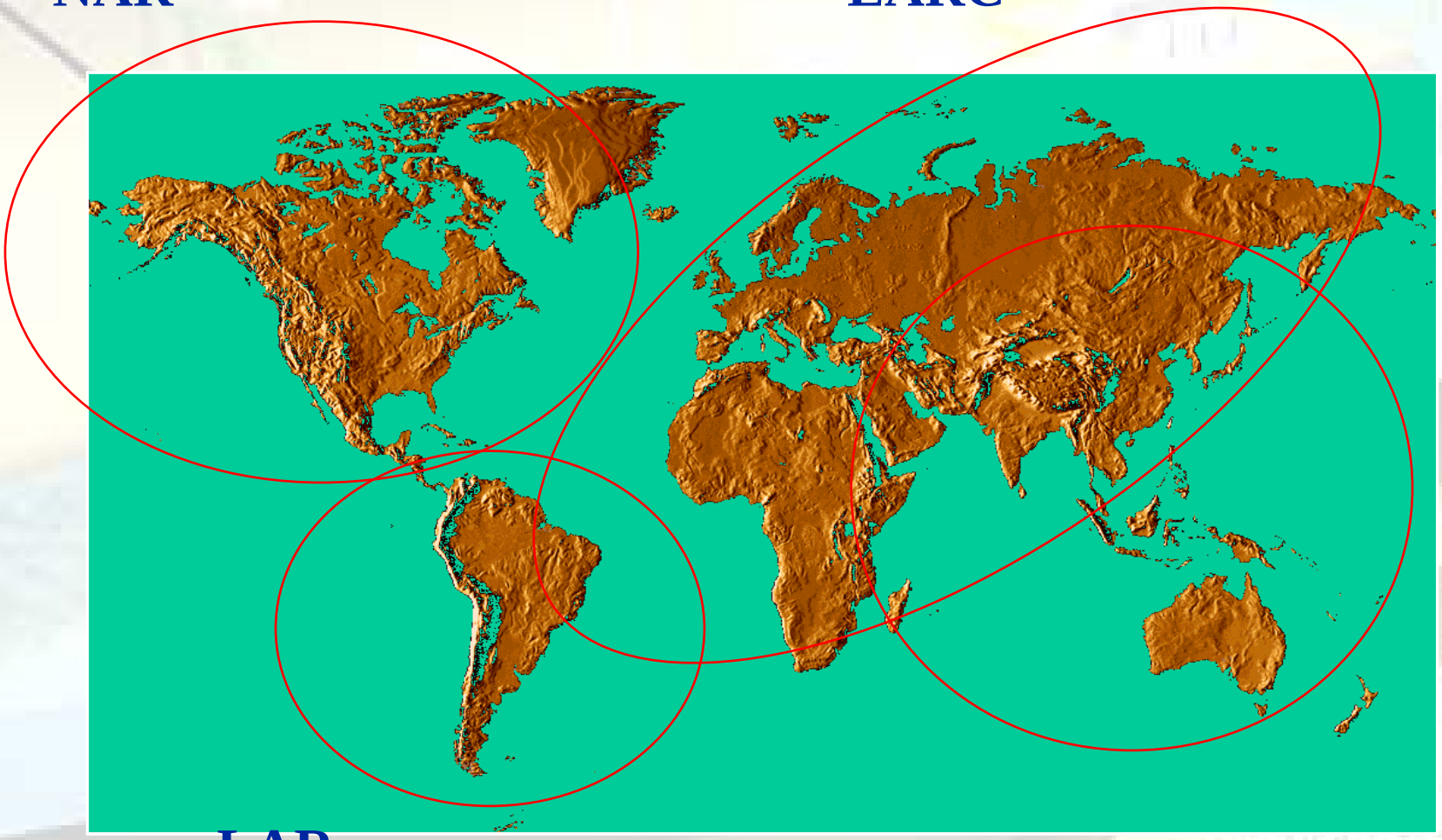
World-Wide Reliability Network



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Baker Hughes AutoTrack® G3

System Readiness & Sustainment Technologies

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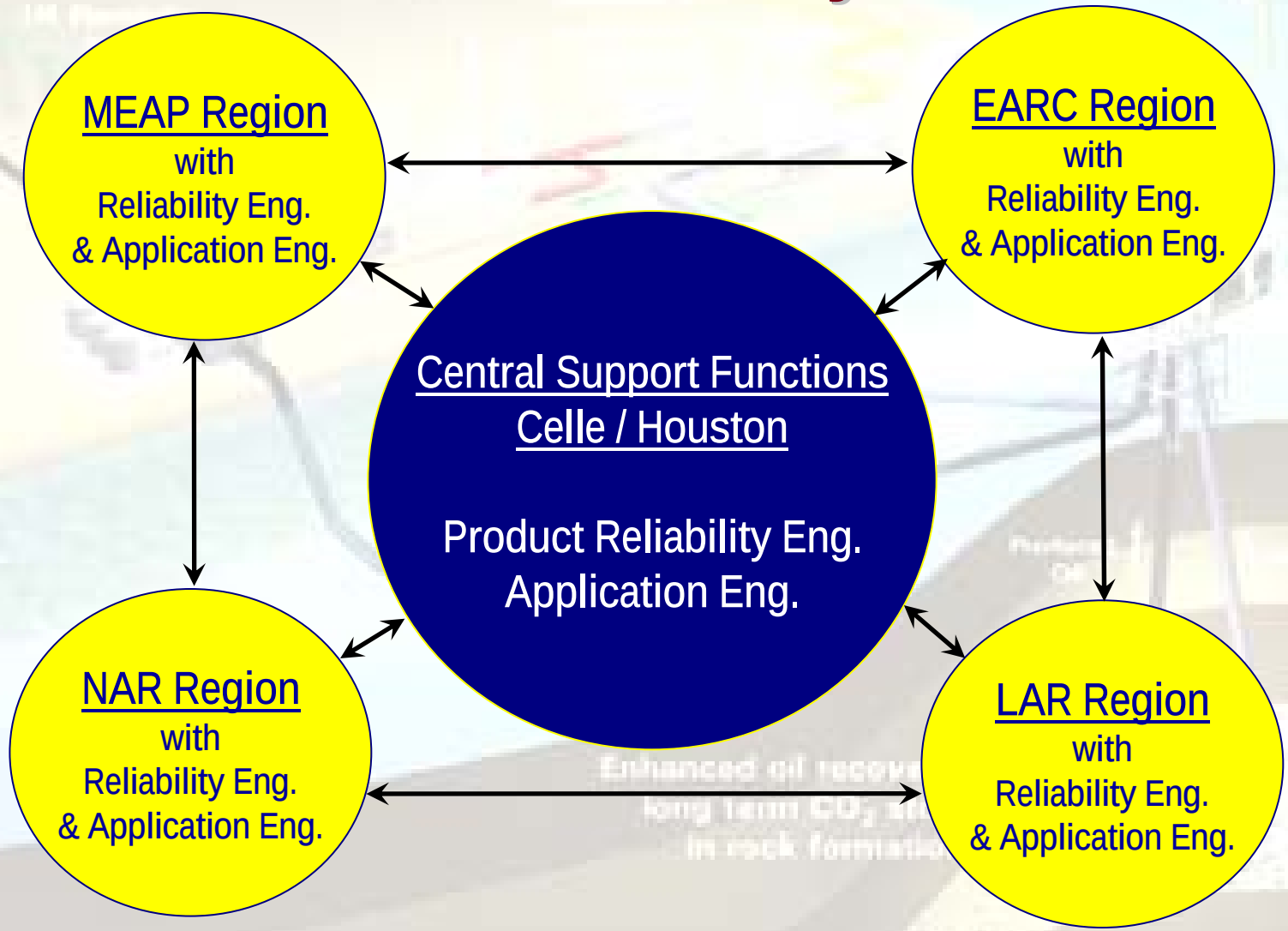
World-Wide Reliability Network



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Support Enterprise Model (SEM)

System Readiness & Sustainment Technologies

A Unique Modeling, Analysis and Optimization Decision Support Tool

Integrated Modeling of Worldwide Support System

- Operations
- Supply/Repair Chain
- Transportation

Benefits

- Real-time strategic planning
- Dramatic risk mitigation
- Unparalleled resource management

Dynamic Changes Throughout System Life Cycle

- Fleet build up & retirement
- Site activation/closure
- Deployment/Surge

Total Support System Performance & Cost

- Full on/off system support activities
- Prognostics & Health Management
- Global optimization across enterprise

Capability to Model A Complex Worldwide Support System!

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SEM: How Used on JSF Program

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- **JSF used SEM during Proposal & CDP to:**
  - Demonstrate Performance-based Logistics (PBL) capabilities
  - Determine JSF Life-cycle Costs (LCC)
- **JSF is using SEM during SDD phase to:**
  - Enable determination of 'best value' JSF business approach (BA)
  - Verify effectiveness of Autonomic Logistics System
  - Analyze impact of Prognostics & Health Management (PHM)
- **JSF will use SEM during production and operation phases to:**
  - Assess performance/cost during implementation of JSF BA solution
  - Monitor performance/cost for global JSF fleet sustainment throughout life cycle

F-35 Lightning II
Enterprise Modeling & Simulation

LM Anticipates >$9B in Savings & Risk Reduction from use of SEM on JSF

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Sandia PHM Research

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- **Nuclear Power Plant "Smart" Equipment**
  - DOE Nuclear Energy Research Initiative (NERI) with MIT, etc.
  - Introduce PHM to selected power plant equipment
- **Manufacturing Facility PHM**
  - DOE funded program
  - Implement PHM in manufacturing facility
- **Machine Tool PHM**
  - DOE funded program
  - Implement PHM on SNL machine tools
- **F-16 Accessory Drive Gearbox (ADG)**
  - Joint program with LM Aero
  - Extend replacement intervals
- **Airborne Laser (ABL)**
  - Program with MDA and Industry
  - Implement PHM on fluid flow systems (COIL)
- **MEMS-Based PHM for Internal Combustion Engines**
  - Predict failures in internal combustion engines and other rotating machinery
  - Low footprint PHM hardware & software solution

Power Plant PHM


Manufacturing Facility PHM


Machine Tool PHM


F-16 ADG PHM


Airborne Laser (ABL) PHM

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TMO Technology Management Optimization Tool

System Readiness & Sustainment Technologies

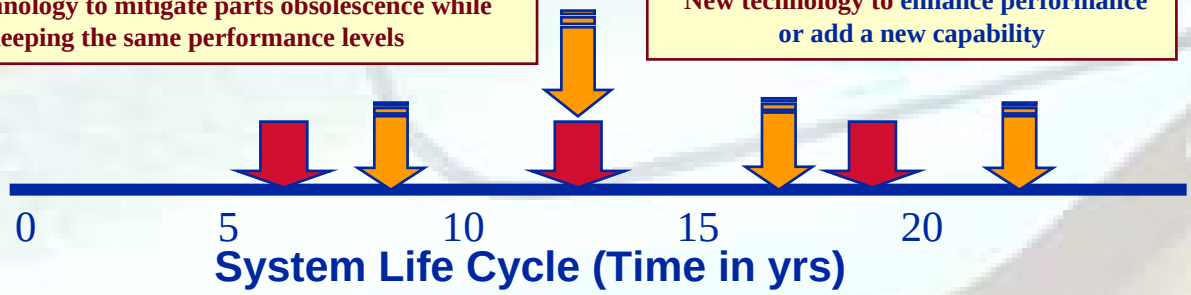
- **Problem:** Identify the most effective set of technology management actions over a given set of time periods

- **TMO:** Optimization based planning tool that finds the set of technology management actions over specified set of time periods that maximize system performance within given constraints

Tech Refresh
New technology to mitigate parts obsolescence while keeping the same performance levels

Tech Insertion
New technology to enhance performance or add a new capability

TMO determines the optimal set of Technology Management activities based on user-defined objectives and constraints



Drivers

Parts obsolescence
Diminishing manufacturing
Increase life of system
New system performance upgrades
New system requirements
Reduction of total ownership costs

Legend
Tech Refresh Points
Tech Insertion Points

Conceptual Tech Refresh/Insertion Points

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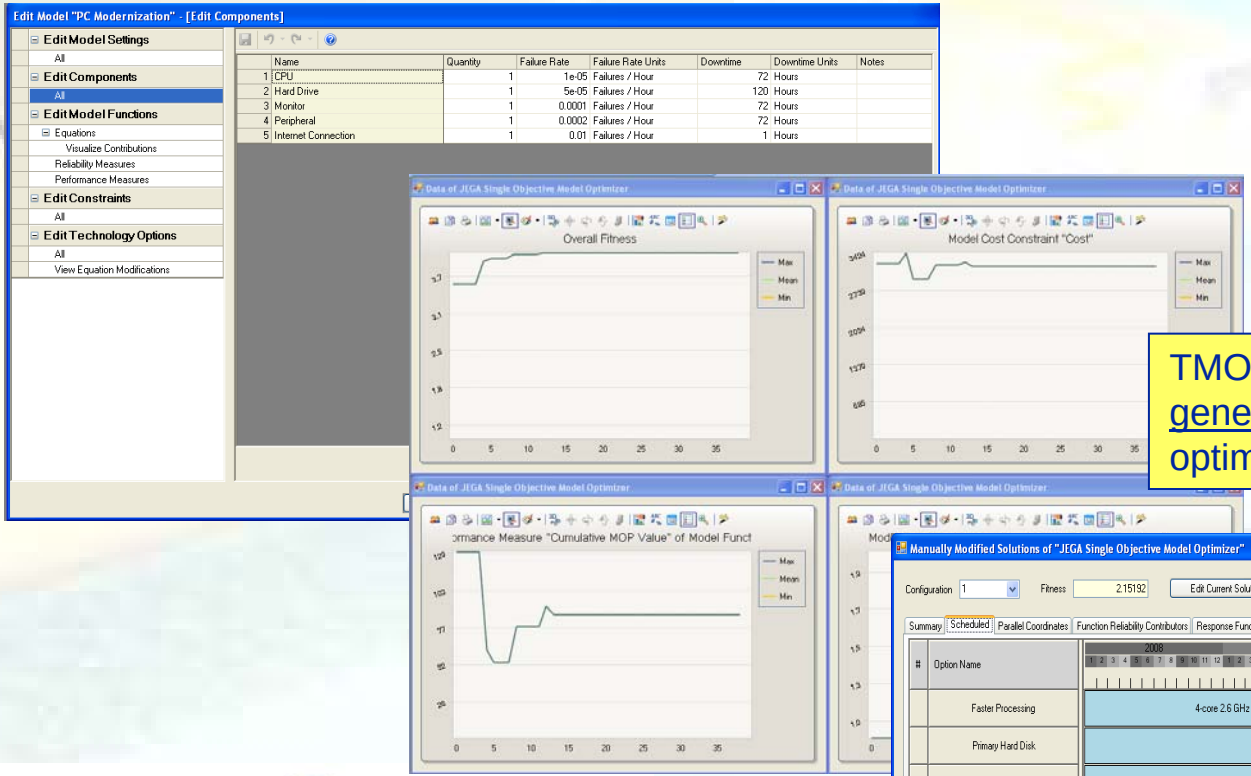
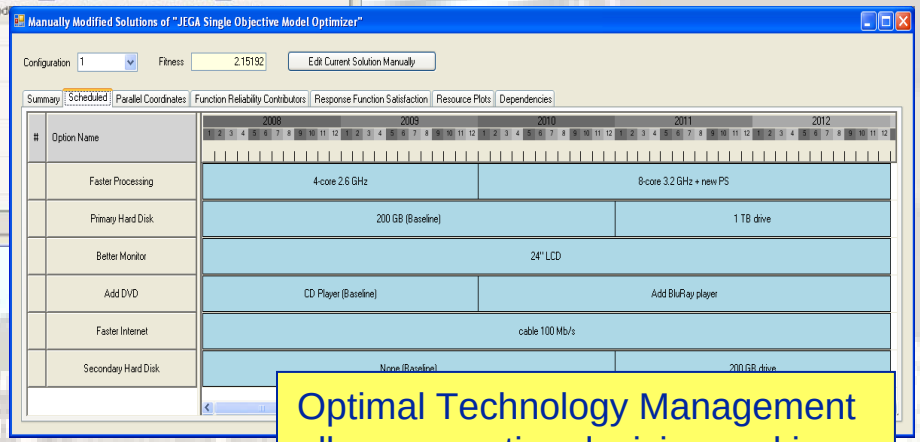
Running TMO

TMO input data can include reliability measures (availability, MTBF, etc.), performance measures (targeting accuracy, range, etc.), and system constraints (cost, weight, size, etc.)



TMO uses a robust suite of genetic algorithms to solve the optimization problem



Optimal Technology Management allows proactive decision-making and saves money

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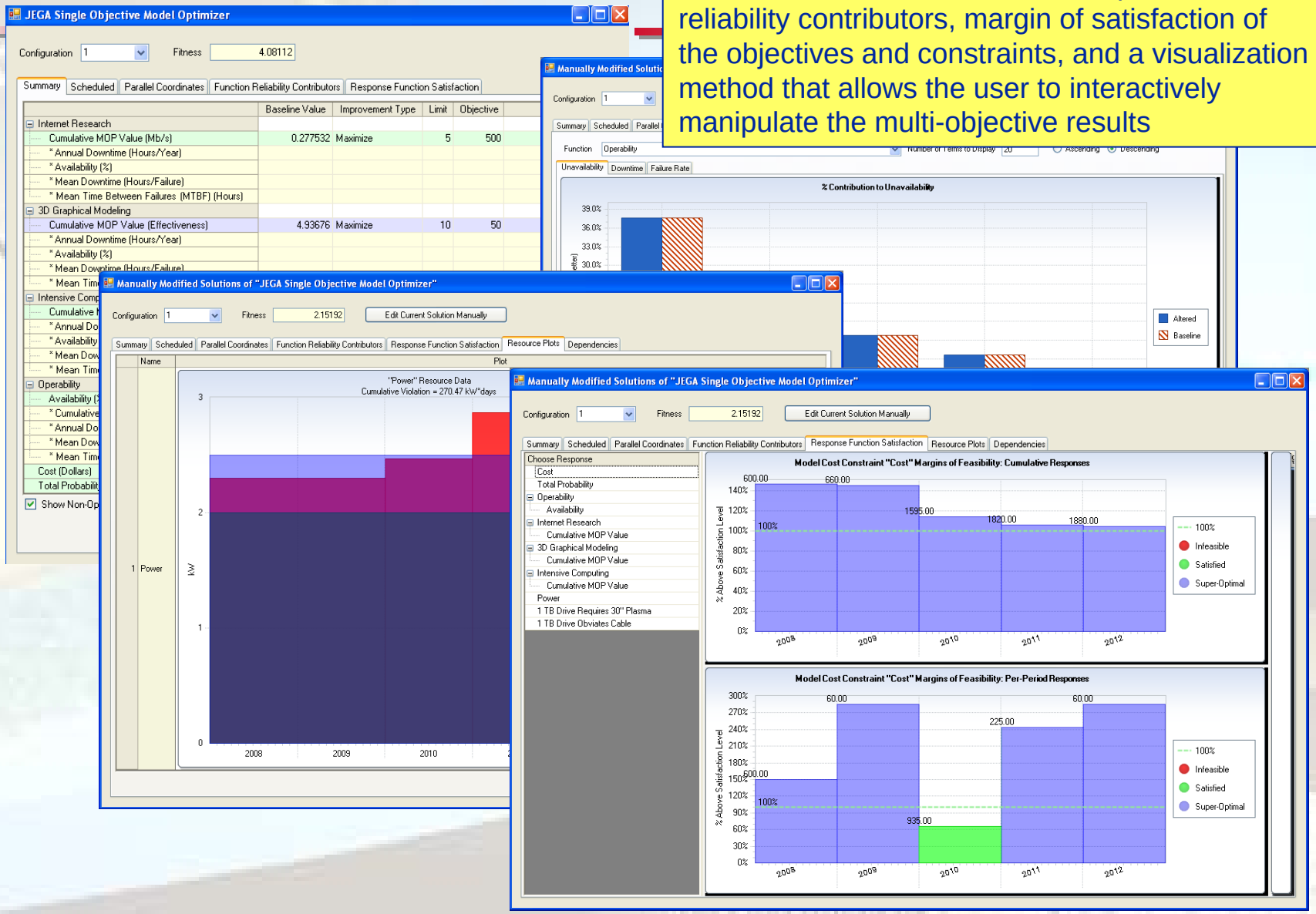
TMO Results

In addition to a schedule, TMO output includes reliability contributors, margin of satisfaction of the objectives and constraints, and a visualization method that allows the user to interactively manipulate the multi-objective results



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What Distinguishes TMO

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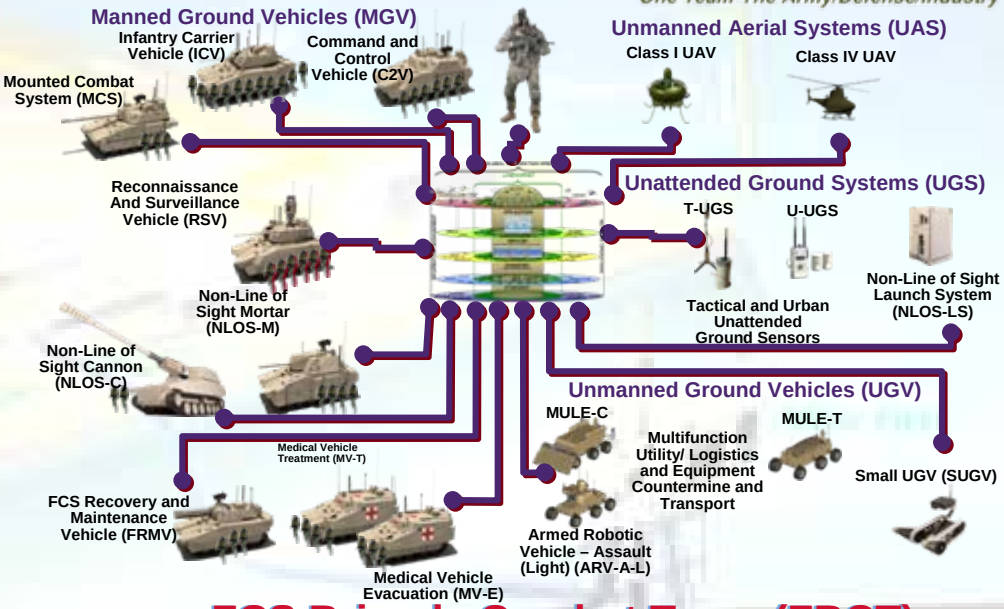
- TMO includes time period and time horizon in its optimization—allowing creation of an optimal Tech Management schedule
- TMO can consider dependencies between Tech Management options
- TMO has the flexibility to handle multiple, diverse Tech Management options at the same time
  - e.g., maintenance manpower requirements can be compared to upgrading the reliability of certain components
- TMO allows user-defined objectives and constraints, including scheduling risk

Support to Army's FCS Program

System Readiness & Sustainment Technologies

PROGRAM MANAGER FCS BRIGADE COMBAT TEAM
One Team-The Army/Defense/Industry

- **Challenges:**
  - New System-of-Systems (SoS) concept of warfighting
  - Lack of SoS analytics to make decisions
  - Critical SoS M&S capabilities needed for program success



FCS Brigade Combat Team (FBCT)

- **SNL's System-of-Systems Analysis Toolset (SoSAT)**
  - Provides unique SoS M&S capability currently not availability
  - Supporting FCS Readiness/Sustainment Requirements
  - Also supporting GCS Current Force modernization

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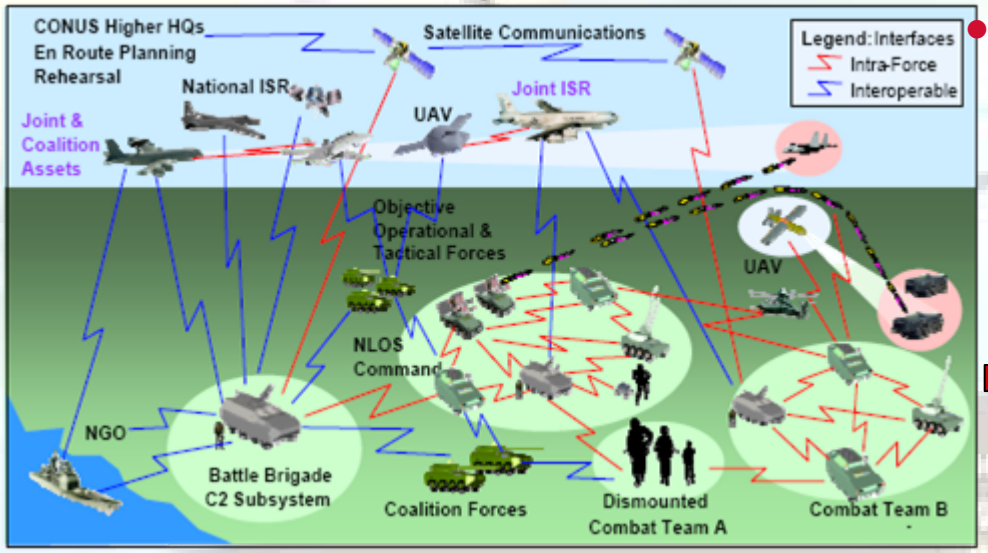
System of Systems Analysis Toolset (SoSAT)

System Readiness & Sustainment Technologies

PROGRAM MANAGER FCS BRIGADE COMBAT TEAM
One Team-The Army/Defense/Industry

- Single model for multiple MOEs/MOPs
- Multiple states (not just functional or failed)
- Incorporates shared functionality between systems
- Includes external factors (weather, terrain, threats,…)
- State model for every system/platform

SoS Simulated Scenario



- **Utilizes:**
  - Unique State Modeling Concepts for every system
  - State-of-Art SoS Simulation Framework
  - Customized Optimization Algorithms
- **Provides Capability for Analyzing:**
  - Systems as well as Systems-of-Systems
  - Combat capabilities (pre, post, during campaigns)
  - SoS metrics at various levels of BCT hierarchy
  - Impacts of PHM/CBM+
- **Flexibility to Include:**
  - Complex supply & support networks
  - Stochastic treatment of combat damage
  - Human performance (maintainers, warfighters, …)

- *Time-Dependent State Changes*
- *SoS MOEs*
- *Sensitivity Trades*
- *Optimization Analyses*
- *….*

Integrated methodology provides unique capabilities for SoS analysis

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Thank You

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- **Questions?**

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