OPTIMIZING A WORLDWIDE MAINTENANCE AND LOGISTICS SUPPORT NETWORK

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Outline

- Motivation
- Problem Definition
- Modeling Issues
- Modeling Approach
- Modeling Challenges
- Future Enhancements

Motivation

- Performance-Based Logistics – a new government contracting paradigm
- Lots of data but little information
- Need for a way to tie support system design and resource levels to projected performance

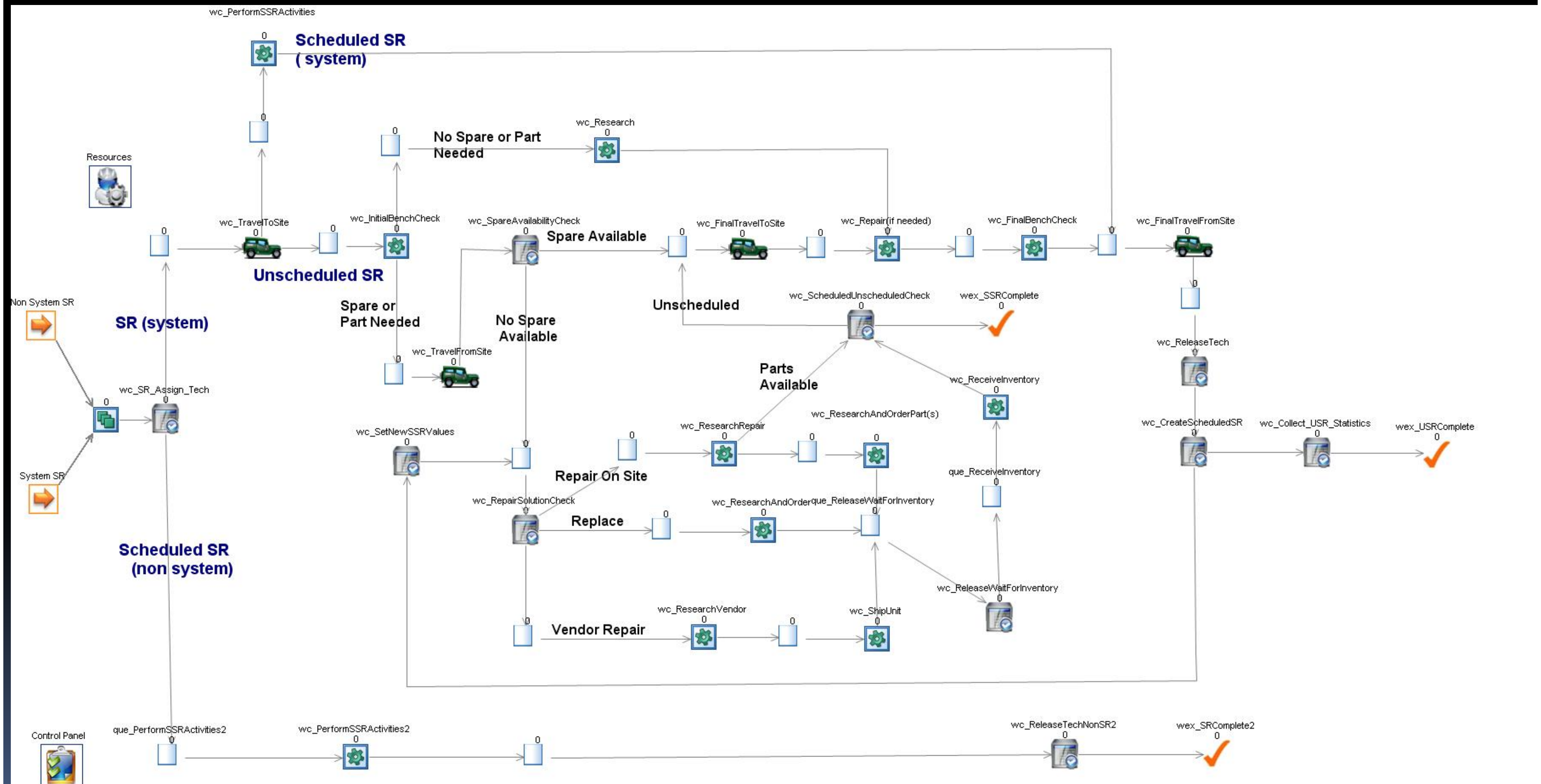
Problem Definition

- Several hundred "systems" fielded at approximately 50 locations worldwide.
- Repair, part replacement, and system maintenance managed from 6 repair sites.
- Technicians with various skill mixes (Up to 10 labor categories) located at repair sites.
- Approximately 1200 parts managed, with spares inventories currently maintained at repair sites.

Problem Definition (cont)

- Repair Sites receive unscheduled service requests indicating part or system failure
- Service requests are classified as mission critical or non-mission critical.
- Service request indicates particular failed component (well, most of the time)
- Technicians are dispatched to repair/replace broken components and return the system to full service

Problem Definition (Process Flow)



Problem Definition (objectives)

- Determine labor requirements
- Inventory Management
- Estimate cost and performance
- Usability
- System Optimization

Modeling Issues

- Incomplete data
- Information security
- Maximize profit (based on Award Fee structure)
- Tradeoff analysis (service vs. cost)
- Evaluate tactical planning scenarios
- Evaluate strategic planning scenarios
- Estimate risk (solution variability)
- Account for uncertainty (input variability)

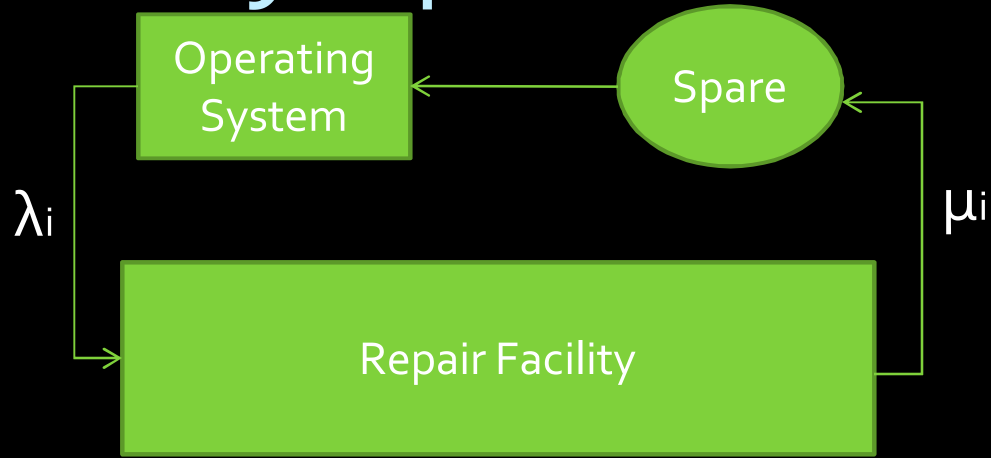
Modeling Approach

- Interface: MS Excel
- Front-end: Data analysis, forecasting, and Bayesian inference (custom low level code)
- Inventory optimization via greedy implementation of spare parts allocation model (custom low level code)
- Core: Discrete-event simulation (Simul8)
- Optimization wrapper: Optquest

Modeling Challenges (data analysis)

- Designing data extraction and augmentation components and process flow
- Computing relative part failure rates from limited and incomplete data→bayesian inference for multinomial distributions
- Creating “blended” forecasts that mix data from similar repair sites, site types (e.g CONUS, OCONUS, Deployed), and system versions → decomposition, exponential smoothing, and averaging

Modeling Challenges (Inventory Optimization)



- Based on “Optimal Spare Parts Allocation” model of Barlow and Proschan.
- Assume that the (exponential) arrival/failure rate for component ***i*** is the total service request generation rate at the repair facility multiplied by relative failure probability of component
- Assume that the (exponential) repair rate for ***i*** is based on the length of the longest process : ordering a new part (conservative since we are talking mission critical here)
- Greedy algorithm adds 1 additional unit of component ***i*** to inventory that will provide greatest increase in expected fill rate per purchase dollar:

$$FillRate = \sum_{i=1}^{k} \lambda_i \sum_{j=0}^{n_i-1} \frac{(\lambda_i \mu_i)^j}{j!} e^{-(\lambda_i \mu_i)} \left(\sum_{i=1}^{k} \lambda_i \right)^{-1}$$

Modeling Challenges (Simulation)

- Vast amount of "under-the-hood" simulation code to:
  - Automate building of model structure based on input data - variable numbers of components such as repair sites, inventory sites, labor categories, part families, and parts managed
  - manage Excel table based model data/parameters
  - compute and display custom PBL metrics

Modeling Challenges (Optquest)

- Integrating with Simul8 while maintaining dynamic model building within the simulation model
- Performance:
  - we have over 100 discrete decision variables (labor qty by repair site and category)
  - This could require thousands of simulation trials of multiple runs each to fully optimize
  - Each 1 year simulation run takes over a minute
  - You do the math

Modeling Challenges (Optquest – cont)

- Performance Solutions
  - Critical to limit problem size through tight variable bounds, liberal use of constraints (the more constraints the better), and a good starting solution
  - Can select "current best" solution at any point in the optimization
  - May be able to use parallelization
  - May be able to use a shorter simulated time(3to 6 months versus 1 year) and/or warm-up period (1 or 2 weeks versus 1 month).
- Objective function – PBL provides a nice way to weight the various performance metrics into a single value:

Award Fee = w1*Availability Score+ w2*Cost/System Score+ w3*Turn Around Time (MC) Score + W4*TurnAroundTime(NMC) Score+ w5*Footprint Score

Possible Enhancements

- Data mining to define part families by demand clusters
- Automated construction of Optquest model files (constraints, etc)
- Generic simplified version for extension to similar support scenarios but different systems – some of which may have very limited historical data