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Using Simulation and Analysis to Explore Enterprise Logistic Systems Vulnerabilities

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Presentation Outline

- Supply Chain Vulnerability
- Enterprise Modeling Capabilities
- Notional Analysis Example

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Motivation

- The international Cargo Security Council reports that cargo theft costs Americans $60 billion per year[1]
- Thefts in the United States range from $5M container thefts in Norfolk, VA to $600M worth of stolen goods in Los Angeles in 2000[2]
- Military logistic tails in war are a risk to personnel and divert major assets from fighting

Source: [1] “Cargo Security: A Partnership to Secure the Transportation Industry”, Lt. Colonel David B. Binder, Florida Department of Transportation Motor Carrier Compliance Office.
[2] “Supply Chain Vulnerability”, Dick McCormick, Pinkertons.

Supply Chain Vulnerability

- A study by the Cranfield School of Management[1] defines the following:
  - Modern supply chains are not simply linear chains or processes; they are complex networks
  - Resilience is 'the ability of a system to return to its original state or move to a new, more desirable state after being disturbed"
- Supply chain vulnerability involves a complex network of systems that must adapt to adverse conditions that arise from risks both within and outside the enterprise system

Source: [1] "Building the Resilient Supply Chain", Martin Christopher and Helen Peck, Cranfield School of Management.

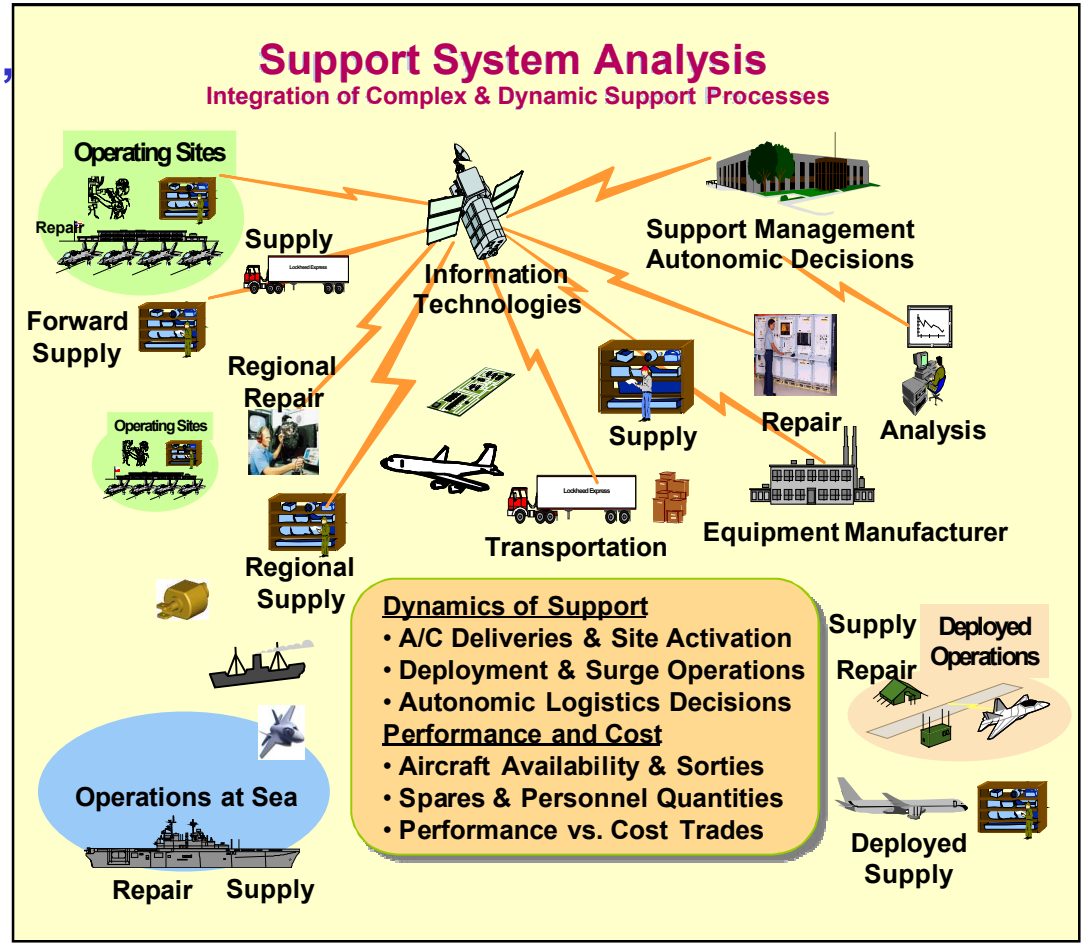
Methods and Tools for Supply Chain Vulnerability

- **Mapping tools are used on supply chain network representations to identify key characteristics**
  - **Pinch points and Critical Paths**
  - **Risk areas that could be caused by long lead times, single source supply, low visibility, and other issues**
- **Principals of management**
  - **Risk awareness of supplier**
  - **Supply chain collaboration**
- **Current tools lack the capability to measure impact of solutions or strategies on enterprise level metrics**

Supply Chain Vulnerability assessment should include the impact on the overall enterprise

Enterprise Modeling Capabilities

- Sandia has developed logistics modeling, analysis, and decision support tools
- Provides *integrated* modeling of supply chain and repair chain activities for a worldwide support system:
  - Demand generation
  - Field Level maintenance tasks
  - Part storage and inventory management
  - Support equipment and personnel usage
  - Unit repair activities and production at OEMs
  - Transportation, surge, and deployment



Links Sustainment System Performance to Readiness

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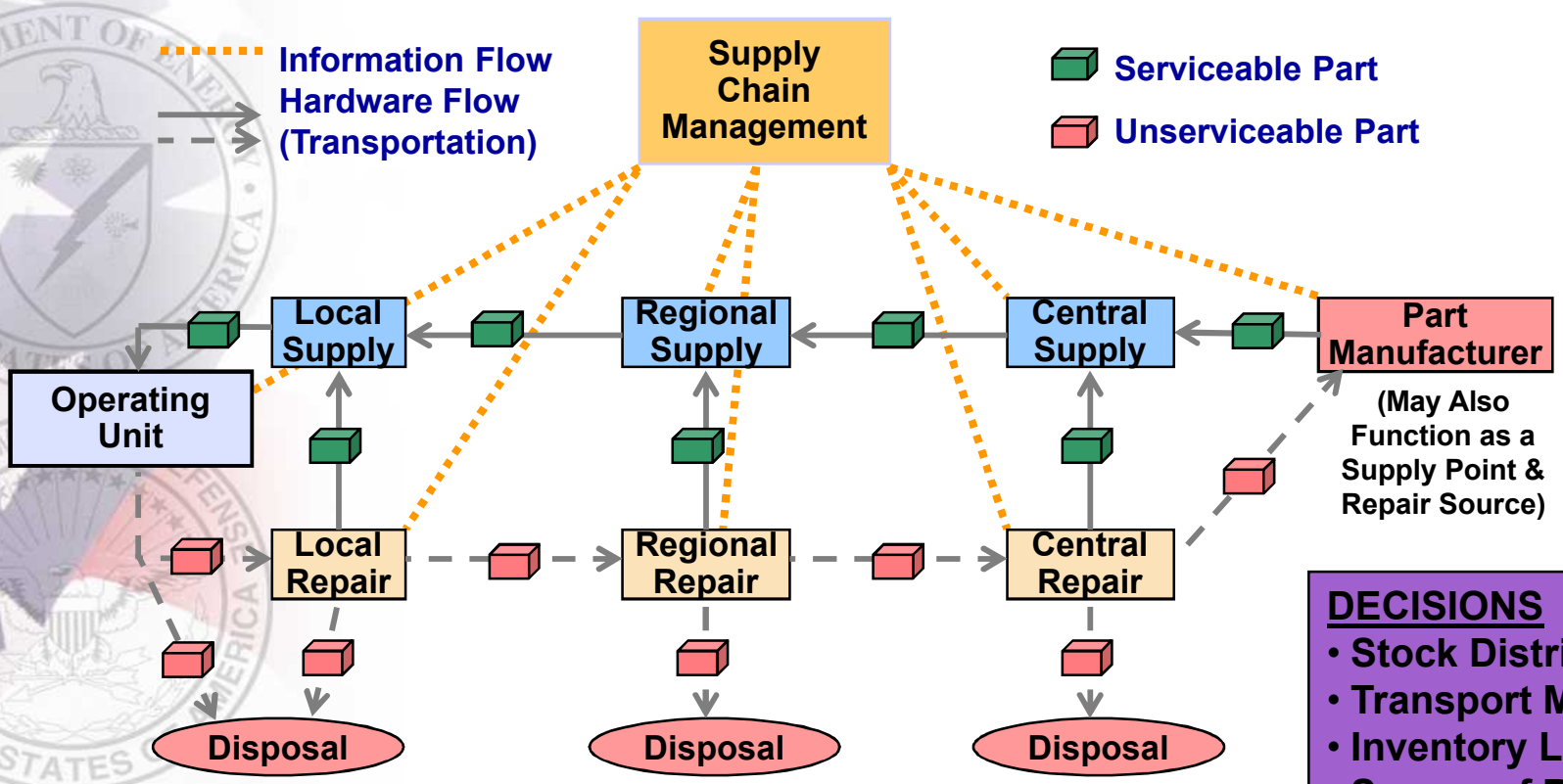
Modeling and Simulation Capabilities

- **Modeling of Supply/Repair Chain Processes**
  - Global operations with arbitrary multi-echelon supply/repair capabilities
  - Integrated supply, repair, manufacturing, and transportation processes
  - System usage schedules (generating demands)
- **Analysis of Dynamic Changes Throughout the Life-cycle**
  - System delivery schedules
  - Transition from “normal” to deployed/surge operations
  - Changes in inventory controls, quantity/location of resources
  - Disruptions in Site operations and Transportation modes
- **Analysis of Support System Performance, Resource Requirements, and Costs**
  - System Availability, Mission Capable Rate
  - Supply fill rates, response times
  - Spares, personnel, support equipment, and transportation requirements
  - Cost indicators (investment and operating costs)

Multi-Level Supply Chain



DECISIONS

- Stock Distribution
- Transport Methods
- Inventory Levels
- Source of Repair
- Repair Capability
- Manning Levels
- Support Equipment

Process Flow and Hierarchy Can Vary for Each Part and Operating Location

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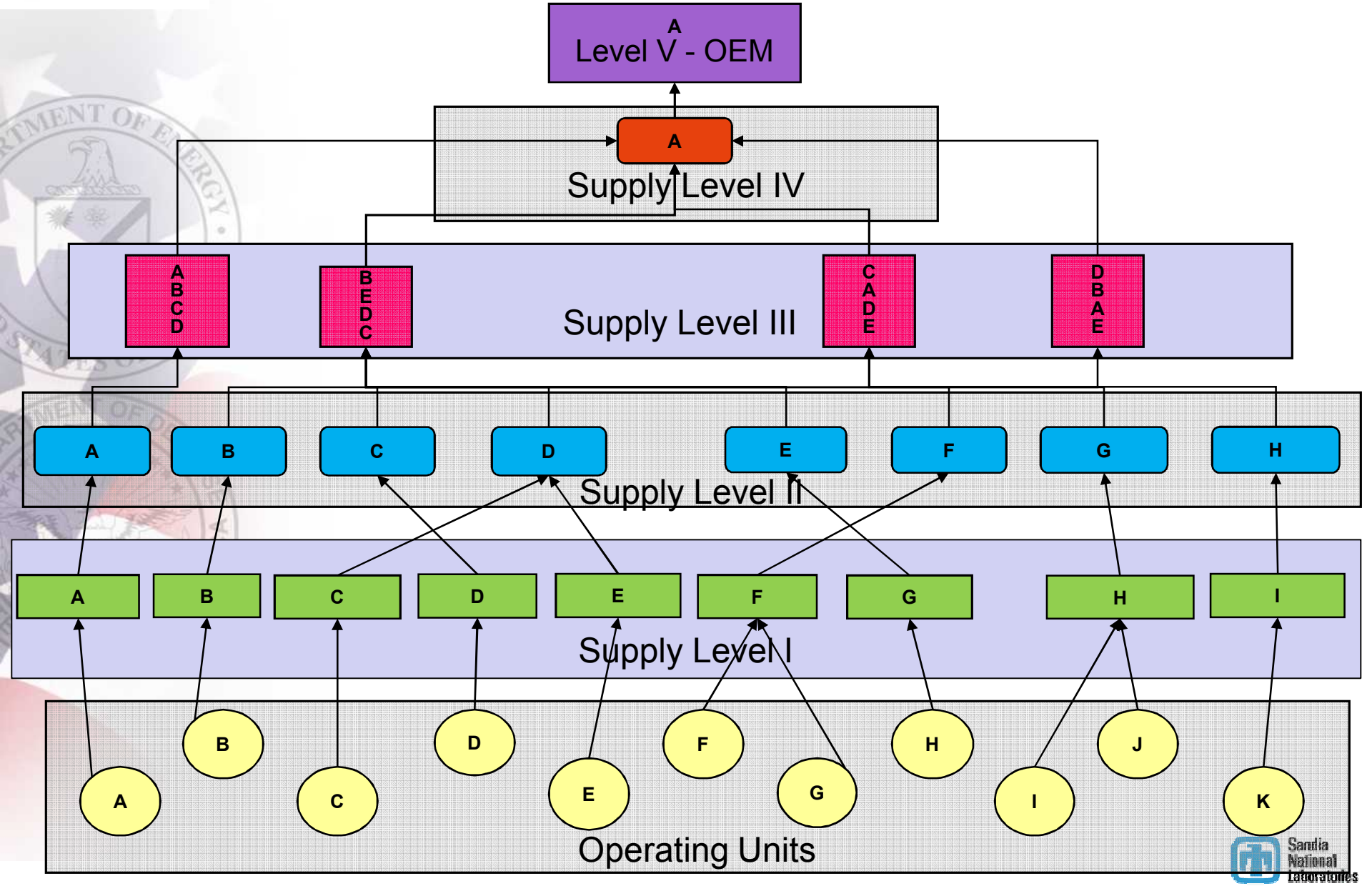
Notional Enterprise Experiments

- Two experiments were performed to test the stability of the enterprise supply chains
  - Experiment 1 modeled a robust enterprise
    - No transportation cost or delay time difference between supply levels
    - Expected minimal impact from disruptions
  - Experiment 2 enterprise less robust, but still stable
    - Significant difference in delay time and cost for transportation between supply levels
- Several scenarios were run for each experiment
  - Baseline scenarios served as comparison against other scenarios
  - Scenarios modeled disruptions of one or more sites for a period of time (assumption of 5-8 months recovery) over a 10 year simulation run

Goal: Identify vulnerabilities and analyze the effects of supply chain disruptions on Enterprise performance metrics

Example Enterprise Supply Requisition Chain



Experiment 1 Results

- **Scenarios in Experiment 1 had minimal impact on the Enterprise performance**

Experiment 1				
Trial	Model	Description	Mission Capable Rate (%)	Total Cost
1	Baseline Scenario	Baseline Model	85.80	$ 7,396,184
2	Scenario_1	Baseline with Additional Level IV Warehouse Entity	85.77	$ 7,385,511
3	Scenario_2	Baseline with Additional Level IV Warehouse and Original Level IV Supply Center disrupted	85.78	$ 7,384,614
4	Scenario_3	Baseline with Level III supply site disrupted for 5 months during 10 year run	85.80	$ 7,398,183
5	Scenario_4	Baseline with Level III supply site out for 5 months during 10 year run	85.74	$ 7,438,565
6	Scenario_5	Baseline with Level II supply site out for 3 months during 10 year run	85.80	$ 7,380,762
7	Scenario_6	Baseline with multiple sites out over 10 years	85.83	$ 7,355,087

All scenarios show an approximately 85% MCR with similar total costs

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Experiment 2 Design

- **Two additional scenarios in Experiment 2 attempt to further stress the Enterprise**

Experiment 2		
Trial	**Model**	**Description**
1	Baseline Scenario	Baseline Model
2	Scenario_1	Baseline with Additional Level IV Warehouse Entity
3	Scenario_2	Baseline with Additional Level IV Warehouse and Original Level IV Supply Center disrupted
4	Scenario_3	Baseline with Level III supply site disrupted for 5 months during 10 year run
5	Scenario_4	Baseline with Level III supply site out for 5 months during 10 year run
6	Scenario_5	Baseline with Level II supply site out for 3 months during 10 year run
7	Scenario_6	Baseline with multiple sites out over 10 years
8	Scenario_7	Baseline with a Level III supply site out for 5 months every 2 years during the 10-year simulation
9	Scenario_8	Multiple sites out (Level IV sites)

Experiment 2 Results

- **In this experiment the important metrics include:**
  - Average Mission Capable Rate
  - Total transportation costs
  - Average weekly supply delay time (during disruption and normal operations)
- **Scenarios 7 and 8 result in significantly larger supply delay times during interruption periods**
  - Demonstrates that the supply level III and level IV sites disrupted may be weak points or areas of focus for vulnerability

Experiment 2 Results					
Trial	Model	Average Mission Capable Rate (%)	Total Cost	Average Weekly Supply Delay during Disruption periods	Average Weekly Supply Delay during normal operations
1	Baseline Scenario	83.15	$ 5,764,354		161.57
2	Scenario_1	83.11	$ 5,764,071	N/A	239.80
3	Scenario_2	83.14	$ 5,756,578	304.84	231.68
4	Scenario_3	82.68	$ 5,760,967	216.05	160.76
5	Scenario_4	83.00	$ 5,779,048	615.52	219.05
6	Scenario_5	83.29	$ 5,746,279	199.90	226.48
7	Scenario_6	83.18	$ 5,728,234	203.47	231.17
8	Scenario_7	82.59	$ 5,804,698	613.89	185.00
9	Scenario_8	80.58	$ 5,629,131	1,279.79	238.07

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Summary

- **Understanding Supply Chain vulnerabilities is vital in today's world**
  - To be adequately prepared to protect critical assets
  - To mitigate risk in Military Operations
- **Simulation modeling and analysis provides the ability to better comprehend complex enterprise systems and their weaknesses**