712CD
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An Experiment in Theater Sustainment using the Joint Analysis System

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WORKING GROUP: B, N, 33
COMPOSITE GROUP:
SPECIAL SESSION 1: TUTORIAL:
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An Experiment in Theater Sustainment using the Joint Analysis System

Lockheed Martin Corporation Suffolk, VA

Approved for public release, distribution unlimited

An Experiment in Theater Sustainment using the Joint Analysis System (U)

Paul J. Bross
Center for Innovation

Richard Madson
L&MR LMIC - IS&GS
• L&MR LMIC tasked to develop the integrated architecture for DoD logistics
• Mobility workshops were conducted to scope effort
  – Resulting focus: Theater Transportation and Distribution
• Value Engineering sessions conducted to confirm validity of focus
• Operational DoD Architecture Framework views developed
• Operational analysis of the architecture using JAS (was JWARS)
  – Increment 0 - “Proof of Principle”
  – Series of discovery experiments to determine the capability of JAS to address Logistics and Materiel Readiness (LMR) issues.
  – Issues include both operational outcome effects and lower-level metrics focused specifically on logistics functions.
  – Data generated by JAS output not study quality, however may be used to shape subsequent studies.
OMEGA® Engineering Framework Competencies

Framework competencies for Best Value Solutions

OMEGA® Engineering Framework Tailored for Capability Based Assessment (CBA) of L&M

Cycle Repeated for each level of Capability Based Assessment

Exercising a framework for Best Value Solutions
Area of Interest: Agile Sustainment with focus on the seams between strategic delivery into theater and transfer of materiel and supplies to the end user.
**Joint Data Support (JDS) Assessment**

JAS tool provides most breadth:
- Force-on-Force
- C4ISR
- Mobility & Logistics
- WMD
Joint Analysis System (JAS)

- **A high-fidelity Campaign wargame simulation**
  - sponsored by the JFCOM - Joint Forces Command (J9)
  - jointly developed by CACI, Inc. and PROSOFT
- **Intended to provide high fidelity to all forms of battle**
  - Land
  - Air
  - Sea
  - Undersea
  - Space, not at high fidelity
  - Amphibious
  - Airborne
  - Chemical warfare
  - TBM / TBM defense
  - Special Operations
- **Strong emphasis on Transportation & Logistics**
  - Strategic Mobility and Intra-Theater Logistics
- **An agent-based simulation**
- **Platforms:**
  - PC-based application, with either a PC- or Sun-based Oracle server.
  - Can export data to Excel, Access, or XML.
  - Usually runs on a DoD SECRET system, scenario / data classified. Can run Unclassified.
- **JAS continues to evolve**
  - Current version is “Release 2.0”
C4ISR-centric, Joint Campaign-Level Model with Integrated Strategic Mobility, Theater Logistics, and Joint Warfighting

Each Functional Area …

- Planning
  - User Inputted rules or events
  - Decision logic implemented in code

- Execution
  - Controlled via C2 logic / rules
  - Includes Movement / Maneuver / Combat

- Adjudication
  - Results of interactions, e.g. kills and detections

Note: TPFDD = Time-Phased Force Deployment Data
**JAS Transportation and Logistics**

**Inter-theater transportation (Strategic Mobility)**
- From Continental US to another region Point of Debarkation (APOD, SPOD)
- Input Time-Phased Force Deployment Data (TPFDD) defines transportation requirement

**Intra-theater transportation**
- Theater Point of Debarkation (POD) to Tactical Assembly Area (TAA) location

Map showing Notional Air Route and Notional Sea Route with a focus on BSE and Road Network.
• JAS requires a very detailed transportation and logistics plan for the scenario
  – For each unit, scenario must specify when, where, and how it will arrive in the theater
  – JAS models the capabilities of each seaport, aircraft, road, etc.

**Inter-theater transportation**

- **Deployment Flow Scheduler**
  - Loading of ships
  - Loading of aircraft
  - Routes
  - Departure Times
  - Arrival times

**Intra-theater transportation**

- **Theater Scheduler**
  - Admin Move Orders
  - Commander’s Inputs
  - Installation requests
  - POD to destination shipping requirements
  - Sustainment stockpiles
  - Network status

- **Execution**
  - Supply requests
  - Conversion of generic items
  - Distribution systems operated by component commander
  - Movement on network

- **Adjudication**
  - Resource attrition due to attacks
  - Inventory levels
Design Memo for OA Modeling of Joint Deployment and Distribution Enterprise (JDDE) with JAS

Increment 0 – Proof of Principle

- **Series of discovery experiments** to determine the capability of JAS to address Logistics and Materiel Readiness (LMR) issues.
- Issues include both operational outcome effects and lower-level metrics focused specifically on logistics functions.
- Data generated by JAS **output not study quality**, however may be used to shape subsequent studies.
- Base Case scenario is derived from a US Joint Forces Command (JFCOM) scenario based on the Unified Quest series.
Increment 0 – Study Variables

Operational Dependent Variables:
- Time to Achieve Objective
- Time spent inactive due to supply shortage
- Time to gain Air Superiority
- Percent sorties not flown due to logistics
- Time SLOC last opened and not closed again by Red forces
- Percent of time SLOC is open
- Percent of TBMD launches leaking through defenses
- Loss Exchange Ratio (LER)

Logistical Dependent Variables:
- Available Days of Supply
- Lift capacity shortfalls
- Total number of supply requests delivered by common user assets
- Percent of lift assets used per day per task force

Control Variables (constant during Inc0):
- Time to load, unload, process
- Command and control structure for logistics planning
- Command and control structure for lift asset management
- All other JAS factors, including weather, terrain, etc.

Independent Variables
- Days of Supplies: Class III – Fuel, Class V – Ammo, and Bulk Cargo – all other classes (food, medical, maintenance, …)
  - UD: number of Unit Days of Supply to be held by operating BSEs and Brigade-level headquarters elements
  - SD: number of Days of Supply to be held by SSAs and other logistics echelons rearward of operating Brigades
- Quantity of Transport Assets
  - AT: number of Air Transport assets available for intra-theater transportation
  - GT: number of Ground Transport assets available for intra-theater transportation
- Quality of Transport Assets
  - JH: mix of intra-theater aircraft representing C130J or C130H lift capacity
  - FT: mix of ground intra-theater trucks representing the future truck system or the existing fleet
**Phase I: Develop the study base case scenario**
- Complete the orders and routing inputs necessary to implement the remainder of the campaign after the Air Superiority phase.
- Establish and document the base case set of control variable settings.

**Phase II: Initial Discovery Runs**
Begin with all values set at the base case levels. Using the UD variable as an example the process is expected to proceed as follows:
- Assume the base case value for UD is 15 Days of Supply (DOS)
- Run 5 replications of UD = 15
- Generate two variations above base case ⇒ UD = 20, 25 and run 5 replications each
- Generate two variations below base case ⇒ UD = 5, 10 and run 5 replications each
- For each UD setting for each individual replication (1-5), calculate the Dependent Variables and the mean of each.
- Plot the results
- Based on the timing considerations previously noted it is expected that completing the initial set of calculations for variables UD, SD, AT, and GT will take approximately one month unless we have greater access to the lab facilities and that there are no problems encountered during the JWARS runs.

**Phase III: Force Mix Discovery Runs**
Based on Phase II results:
- Determine the mixture of settings to use for the comparisons of the C130J vs. C130H and the Future truck system vs. the legacy trucks.
- Determine whether to conduct as two separate pair-wise comparisons (aircraft/trucks only) or a factorial experiment with all combinations represented in a formal full factorial design.
Tools to Support Analysis:

- JAS - Campaign analysis model
- Hyperion Intelligence tool (BRIO) - Data gathering and analysis tool used during the Design and Setup, Analysis, and Report generation phases
- Design-Ease – Statistical package and experimental design analysis
JAS Battle Space Entity (BSE) - Assets

BSE Assets

Asset Overview

Asset Platform Characteristics
JAS Consumption Sustainment Guidance

**Days of Supply**

**UD** – (Land Units/Brigade Rear)

**SD** – (Division/Corps/Army Rear)

- **UD**: the number of Unit Days of Supply to be held by operating BSEs and Brigade-level headquarters elements
- **SD**: the number of Days of Supply to be held by SSAs and other logistics echelons rearward of operating Brigades
BRIO Query Process

**Instrument Queries**

BRIO Query of Instrument Data

**Data Results**

Pivot Table of BRIO Query Results

**Computational Results**

Computational Results of BRIO Query
Vehicle-Missions by Type

Cargo Movement by Type

Cargo/Vehicle-Mission Rate

Graphic Presentation of BRIO Query Metric Generation

Cargo Movement per Vehicle-Mission Ratio

Day of War
Design of Experiments (DoE) Statistical Package (Design Ease Ver-6)

DOE Layout

Normal Plot of Residuals

DOE Normality Assumption Check

DOE Outlier Check

Statistical Package

DOE Outlier Check

Outlier T

Studentized Residuals

Run Number

UNCLASSIFIED
Loss Exchange Ratio (LER) of Troop Losses
By Unit Distribution (UD)

**Cargo Vehicles**

Factor Plot

**Fighting Vehicles**

Factor Plot

**Troops**

One Factor Plot

LER = Red Loss / Blue Loss

Not Statistically Significant

Statistically Significant

A: UD

UNCLASSIFIED
Loss Exchange Ratio (LER) of Troop Losses
By SSA Distribution (SD)

LER = Red Loss
Blue Loss
Loss Exchange Ratio (LER) of Troop Losses
By Air Transport Variations (AT)

LER = Red Loss / Blue Loss

Statistically Significant
A: AT

Not Statistically Significant
A: AT

Cargo Vehicles
Fighting Vehicles
Troops

Not Statistically Significant
A: AT
Loss Exchange Ratio (LER) of Troop Losses
By Ground Transport Variations (GT)

**Cargo Vehicles**

**Fighting Vehicles**

**Troops**

LER = Red Loss
Blue Loss

**Statistically Significant**

**Not Statistically Significant**
# Summary of Metrics

<table>
<thead>
<tr>
<th>Metric Name</th>
<th>Description</th>
<th>Status</th>
<th>Comments</th>
<th>Associated JWARS Instrument(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Lift Assets Available by Type</td>
<td>By Type</td>
<td>C</td>
<td>Common User and C-130J</td>
<td>Air Unit Status Report</td>
</tr>
<tr>
<td></td>
<td>By Mode</td>
<td>C</td>
<td>Air and Ground (separate queries for air and ground)</td>
<td>TLT CU Unit Vehicle Inv</td>
</tr>
<tr>
<td>Total Lift Capacity Available</td>
<td>By Type</td>
<td>C</td>
<td>Common User and C-130J</td>
<td>Air Unit Status Report</td>
</tr>
<tr>
<td></td>
<td>By User</td>
<td>C</td>
<td>Air and Ground (separate queries for air and ground)</td>
<td>TLT CU Unit Vehicle Inv</td>
</tr>
<tr>
<td>Total Number of Requests</td>
<td>By Type</td>
<td>C</td>
<td></td>
<td>TLT Req Sust Sngl Ship</td>
</tr>
<tr>
<td>Percent of lift assets utilized</td>
<td>Per day</td>
<td>P</td>
<td>Cargo to Vehicle Ratio and number of trucks per mission</td>
<td>TLT Road Trans Creation</td>
</tr>
<tr>
<td></td>
<td>Per campaign</td>
<td>P</td>
<td>could not connect inventory with usage to get percentage</td>
<td>TLT Road Trans Content</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TLT Road Trans Departure</td>
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<tr>
<td>Starting Days of Supply (DOS) at:</td>
<td>Combat Units</td>
<td>C</td>
<td>This is an Excel file showing DOS for all scenarios</td>
<td>JWARS: Land Consumption Sustainment</td>
</tr>
<tr>
<td></td>
<td>SPOD/APOD</td>
<td>C</td>
<td></td>
<td>Command Guidance</td>
</tr>
<tr>
<td></td>
<td>Installations</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SSA</td>
<td>C</td>
<td></td>
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</tr>
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<td></td>
<td>Installations</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SSA</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lift Capacity Shortfalls</td>
<td>Planes</td>
<td>C</td>
<td>Returns cargo not delivered by air and ground</td>
<td>TLT Cu Cargo Dlv Shrtf</td>
</tr>
<tr>
<td></td>
<td>Trucks</td>
<td>C</td>
<td></td>
<td>TLT TA Trans Cgo Not Loaded</td>
</tr>
<tr>
<td>LER Ground</td>
<td>Direct Fire</td>
<td>C</td>
<td>Direct Fire adjudication</td>
<td>ADJ Direct Fire KVS</td>
</tr>
<tr>
<td></td>
<td>Indirect Fire</td>
<td>C</td>
<td>Indirect Fire adjudication</td>
<td>ADJ Indirect Fire KVS</td>
</tr>
<tr>
<td></td>
<td>Air to Ground</td>
<td>C</td>
<td>Air to Ground Fire adjudication</td>
<td>ADJ A2G Fire KVS</td>
</tr>
<tr>
<td>LER Air</td>
<td>Air to Air</td>
<td>C</td>
<td>Air to Air (only for UD scenarios)</td>
<td>Air ATO Gen, Air ATO Exec Order Sch</td>
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<tr>
<td></td>
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<td>C</td>
<td>Surface to Air (only for UD Scenarios)</td>
<td>ADJ S2A KVS, Adj A2A KVS</td>
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<td>TBM Percent Leakage</td>
<td>TBM Launched</td>
<td>C</td>
<td>Brio query has data for TBM Launch and Leak</td>
<td>TBM MSL Launch</td>
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<tr>
<td></td>
<td>TBM Leaked</td>
<td>C</td>
<td>Excel File has percentage (only C-130 and Baseline scenarios)</td>
<td>Tbm Leaker</td>
</tr>
<tr>
<td>Time to Objective</td>
<td>Ground Units</td>
<td>C</td>
<td>Time it took TF Longstreet to reach each of its three objectives</td>
<td>JWARS video playback</td>
</tr>
</tbody>
</table>
## Analysis of Increment 0 Metrics

### Metrics

<table>
<thead>
<tr>
<th>Metrics</th>
<th>Phase II</th>
<th>Phase III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days of Supply</td>
<td>Baseline</td>
<td>Quantity</td>
</tr>
<tr>
<td>UD</td>
<td>SD</td>
<td>GT</td>
</tr>
<tr>
<td>Total Ground Lift Assets Available by Type</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Total Air Lift Capacity Available</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Total Number of Requests</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Cargo to Vehicle Ratio</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Days of Supply (DOS) at:</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Lift Capacity Shortfalls</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>LER Ground</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>LER Air</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Time to Objective</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>TBM Percent Leakage</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

### Depth and Breadth in Analysis
Operational Analysis Lessons Learned

- Proof of Principle
  - Not study quality data
  - Demonstrated relative comparisons vice absolute results
- Pre-determined successful baseline “seeds” not always successful with variations/changes
- Used JAS Release 1.6-SR2.15-RCS, did not transition to JAS Release 2.0
- Focused scenario to generate potential logistic opportunities
- Setup to ensure logistics plays reasonably
- Limited air routes did not provide significant pulsing of Quality of Intra-Theater Air Transports activity
- DOE requires scheduling of computing assets for production runs
  - 5 reps w/ 5 conditions for 5 combination »»» 125 runs
  - BRIO export required scheduling considerations
  - Multi-processing capability was essential
Desired JAS Logistics Enhancements / Refinements

1. Capability to use different load/unload times for cargo carrying assets such as trucks at different echelons. For example, Army 5-ton trucks carrying materials from Division to Brigade to have different loading parameters than the same asset moving cargo from Brigade to Battalion. This might also be satisfied with a “transfer” variable at the echelon without affecting the asset data.

2. Capability for inter-theater response to sustainment requests without having to go through a pre-planned TPFDD.

3. Capability to integrate inter- and intra-theater transportation and logistics planning. For example, a sensitive munition being brought straight from CONUS to the requestor where the APOD/SPOD is chosen with a view to available assets in theater for the onward movement of the shipment or shipped direct to the requesting BSE.

4. Expand the Land Sustainment visibility to all classes of supply instead of just Class III and Class V.

5. Permit replacement of Class VII pacing items.

6. Add an abstract maintenance capability by a mean-time-to-repair function to permit rough repair of damage.

7. Break casualty data into Item level bins such as damaged/killed and people into wounded/killed.

8. Permit the creation and repair of infrastructure (such as bridges, port berths, etc.) during the play of the game. In the case of “new” installations, have them properly recognized for arc/node and other calculations. [This may mean having to “reinitialize” some environmental parameters during a run.]

9. Capability to have cargo re-directed while in transit based on user priorities.

10. Capability to reconstitute units. [May be a blend of repair/replace]
Conclusions and Recommendations

- Demonstrated the OMEGA® framework and DoD provided tools (JAS) can be used collaboratively to evaluate logistics enterprise architecture alternatives
  - Modifications to the DoDAF schema & JAS descriptions were required to model and perform operational driven assessment of the JDDE architecture (JIC)

- Although JAS fell short in several areas, the team recommends using OMEGA® & JAS for modeling and simulation of the proposed JDDE Architectures
  - Identified shortfalls and recommend JAS modifications
  - Explore federating JAS with other models for work-arounds
  - Input M&S determined MOO & MOE into OMEGA®’s Value Model to “grade” JDDE alternatives

- Working with JFP LMIC and JAS Program Office to develop logistic enhancements in support of Experimentation

- Recommend follow-on analysis activities