Dynamic Multi-level Modeling Framework (DMMF)
Results of the Feasibility Study

NDIA M&S Committee

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DoD Modeling & Simulation Coordination Office
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Agenda

• Genesis of DMMF
• Problem
• Approach
• Technology Outreach
• Challenges
• Recommendation
Dec 2011 briefing to ASD(R&E)

Objective:
“Single common framework”

Select Panel of Experts
PEO-STRI
JHU-APL
RAND
SRI
IDA
SERC
MITRE
Problem Statement

- Determine how an analysis capability with the following characteristics can be developed:
  - A single framework (or small number of frameworks)
  - Engineering to Theater level models
  - Allows composability to quickly reconfigure analysis, address range of options
  - Multi-level modifiable inputs
  - For use by senior DoD decision makers
  - Operable from the desktop or a single location
Panel of Experts

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
<th>Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Gary Allen</td>
<td>PEO-STRI</td>
<td>Campaign/Mission Computer software</td>
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<tr>
<td>Dr. Jim Coolahan</td>
<td>JHU-APL</td>
<td>Mission/Engagement/Engineering Computer software, interoperability</td>
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<tr>
<td>Dr. Paul Davis</td>
<td>RAND</td>
<td>Campaign/Mission Applications areas, composability</td>
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<tr>
<td>Mr. David Hanz</td>
<td>SRI</td>
<td>Engagement/Engineering Computer software</td>
</tr>
<tr>
<td>Dr. William Rouse</td>
<td>Georgia Tech</td>
<td>Socio-Technical Applications areas</td>
</tr>
<tr>
<td>Mr. Fred Hartman</td>
<td>IDA</td>
<td>Campaign/Mission Applications areas</td>
</tr>
<tr>
<td>Mr. Edward Skees</td>
<td>MITRE</td>
<td>Engagement/Engineering Computer software</td>
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- **Off-sites**
  - 30 May - 1 June: Fact finding
    - Technical outreach
    - DoD model composability assessment
  - 8-10 August: Report writing session

- **Meetings**
  - Weekly meeting with IDA
  - Weekly update to PDASD(R&E)
  - Weekly teleconference with panel
## Technology Outreach

<table>
<thead>
<tr>
<th>Organization</th>
<th>Format</th>
<th>Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Boeing-Virtual Warfare Center</td>
<td>Demonstration</td>
<td>Architecture Framework for Network Enabled Systems (AFNES)</td>
</tr>
<tr>
<td>John Hopkins University-Applied Physics Lab</td>
<td>Meeting</td>
<td>Warfare Analysis Laboratory</td>
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<tr>
<td>(JHU-APL)</td>
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<tr>
<td>MITRE</td>
<td>Conference</td>
<td>Service-oriented Architecture</td>
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<tr>
<td>*Analytical Graphics, Inc. (AGI)</td>
<td>Demonstration</td>
<td>Systems Tool Kit-based framework</td>
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<tr>
<td>Warp IV</td>
<td>Demonstration</td>
<td>Open unified technical framework architecture</td>
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<tr>
<td>Innovative Management Concepts (IMC)</td>
<td>Demonstration</td>
<td>Joint resource allocation model</td>
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<tr>
<td>Lockheed (Owego)</td>
<td>Meeting</td>
<td>Data conditioning capability</td>
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<tr>
<td>Center for Army Analysis (CAA)</td>
<td>Meeting</td>
<td>Army engagement/mission modeling methods</td>
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<tr>
<td>Korean Battle Simulation Center (KBSC)</td>
<td>Meeting</td>
<td>Theater M&amp;S support to exercises</td>
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<td>USAF/A9 (United States Air Force Studies and</td>
<td>Meeting</td>
<td>Air Force “T” analysis method</td>
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<tr>
<td>Analysis)</td>
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<tr>
<td>ARA (Applied Research Associates)</td>
<td>Meeting</td>
<td>Electronic warfare, and cyber</td>
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<td>Alion Science and Technology</td>
<td>Demonstration</td>
<td>SmartMoves</td>
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<tr>
<td>TASC (The Analytic Sciences Corporation)</td>
<td>Meeting</td>
<td>Enterprise capability-based</td>
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<td>SURVIAC (Survivability/Vulnerability Information</td>
<td>Meeting</td>
<td>Integration tools and processes</td>
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<td>Analysis Center)</td>
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<tr>
<td>Adventium (Adventium Enterprises, LLC)</td>
<td>Meeting</td>
<td>Intra-level tool integration</td>
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</tbody>
</table>

* Exemplars due to advanced development of multilevel modeling techniques and existence of DoD customers for their frameworks
Example 1
Boeing Virtual Warfare Center
St. Louis, MO

* Analytic Framework for Network Enabled Systems (AFNES)
  - AFNES offers integration and visualization for the engagement and mission level models and simulations
  - Further analysis is required to explore what is necessary to incorporate engineering and campaign level models and simulations
  - Arrangements are being made with Boeing to have a demonstration copy of AFNES loaded onto a computer at M&SCO

*Figures uses with permission of Boeing Virtual Warfare Center
Example 2
Analytical Graphics, Inc. (AGI)
Exton, PA

Systems Took Kit (STK*)-based framework**

- AGI vision is to support all levels of analysis (Engineering to Campaign)
- Current assessed capability at the Engagement/Engineering levels
- Simulations are based on engineering performance, and data is fed up to higher level models
- Offers engineering and engagement level simulations coupled with a high-end visualization capability
- Future analysis will explore application at mission and campaign levels of analysis
- CAPE currently uses STK

* Formerly Satellite Toolkit
**Figures used with permission of AGI
Challenges

Art v. Science

Key influences

- Force resilience, political will
- Joint training, morale
- System performance, Unit-level training
- Physical law
Challenges

• Technical
  – Timescales
  – Modularity and decomposition
  – Interoperability and composition
    – Horizontal and vertical
    – New and legacy models

Model 1
Lower level
Higher resolution

\[
  \begin{bmatrix}
    a_{11} & \cdots & a_{1n} \\
    \vdots & \ddots & \vdots \\
    a_{m1} & \cdots & a_{mn}
  \end{bmatrix}
\]

Transform

\[
  \begin{bmatrix}
    b_{11} & b_{12} & b_{13} \\
    b_{21} & b_{22} & b_{23} \\
    b_{31} & b_{32} & b_{33}
  \end{bmatrix}
\]

Model 2
Higher level
Lower resolution

n \times m output to 3x3 input

Inter-model Transforms
Syntactically correct
Semantically meaningful

Model 3
Lower level
Higher resolution

Statistical output to single-valued input

Model 4
Higher level
Lower resolution
Challenges

• **Analytical**
  – Model and/or simulation selection
  – Engineer and analyst selection

• **Process**
  – Analysis and reporting
  – Orienting and selecting an analytic approach before modeling
  – Obtaining and connecting models, data, transformations

• **Organizational/Cultural**
  – Long term ownership-cost and performance
  – Sharing of intellectual property
  – Standards to support reuse
  – Business model that supports rapid identification and acquisition of M&S resources
Architecture Model

- Enterprise, Infrastructure layers assumed given
- DMMF focus on Information, Application, Business layers
Feasibility

• Results of technical outreach
  – e.g., Boeing, AGI

• Current practice
  – Interlevel functions performed by SMEs

• Suitability of legacy models
  – May be limited due to semantic compatibility of inputs and outputs

• DMMF Future