Dynamic Multi-level Modeling Framework (DMMF)

Results of the Feasibility Study

National Defense Industrial Association
16th Annual Systems Engineering Conference

October 30, 2013

Dr. Gary Allen
U.S. Army, PEO-STRI

Fred Hartman
Institute for Defense Analysis

Frank Mullen
DoD Modeling & Simulation Coordination Office
Agenda

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

Objective:
“Single common framework”

Select Panel of Experts
PEO-STR
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
  - Define an architecture as close to a complete solution as possible
## 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>Johns Hopkins University-Applied Physics Lab (JHU-APL)</td>
<td>Meeting</td>
<td>Warfare Analysis Laboratory</td>
</tr>
<tr>
<td>MITRE</td>
<td>Conference</td>
<td>Service-oriented Architecture</td>
</tr>
<tr>
<td>*Analytics Graphics Inc. (AGI)</td>
<td>Demonstration</td>
<td>Systems Tool Kit-based framework</td>
</tr>
<tr>
<td>Warp IV</td>
<td>Demonstration</td>
<td>Open unified technical framework architecture</td>
</tr>
<tr>
<td>Innovative Management Concepts (IMC)</td>
<td>Demonstration</td>
<td>Joint resource allocation model</td>
</tr>
<tr>
<td>Lockheed (Owego)</td>
<td>Meeting</td>
<td>Data conditioning capability</td>
</tr>
<tr>
<td>Center for Army Analysis (CAA)</td>
<td>Meeting</td>
<td>Army engagement/Mission modeling methods</td>
</tr>
<tr>
<td>Korean Battle Simulation Center (KBSC)</td>
<td>Meeting</td>
<td>Theater M&amp;S support to exercises</td>
</tr>
<tr>
<td>USAF/A9 (United States Air Force Studies and Analysis)</td>
<td>Meeting</td>
<td>Air Force “T” analysis method</td>
</tr>
<tr>
<td>ARA (Applied Research Associates)</td>
<td>Meeting</td>
<td>Electronic warfare, and cyber</td>
</tr>
<tr>
<td>Alion Science and Technology</td>
<td>Demonstration</td>
<td>SmartMoves</td>
</tr>
<tr>
<td>TASC (The Analytic Sciences Corporation)</td>
<td>Meeting</td>
<td>Enterprise capability-based</td>
</tr>
<tr>
<td>SURVIAC (Survivability/Vulnerability Information Analysis Center)</td>
<td>Meeting</td>
<td>Integration tools and processes</td>
</tr>
<tr>
<td>Adventium (Adventium Enterprises, LLC)</td>
<td>Meeting</td>
<td>Intra-level tool integration</td>
</tr>
</tbody>
</table>

* Exemplars due to advanced development of multilevel modeling techniques and existence of DoD customers for their frameworks
* AFNES: Analytic Framework for Network Enabled Systems

- AFNES offers integration and visualization for the engagement and mission level models and simulation
- Engineering data are attached to engagement/mission entities

*Figures used with permission of Boeing Virtual Warfare Center
Example 2
Analytic Graphics, Inc (AGI)
Exton, PA

**MSAF: Modeling, Simulation & Analysis Framework***

- AGI vision is to support all levels of analysis (Engineering to Campaign)
- 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

*Figures used with permission of AGI*
Challenges

Key influences

Material
- Industrial capacity

Human
- Political will
- Strategic vision
- Military leadership
- Morale
- Force resilience

Logistics
- Joint/Combined training

System performance
- Unit-level training

Force resilience

Modeling Framework

Region of applicability

Physical law
Challenges

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

Model 1
Lower level
Higher resolution

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

Model 2
Higher level
Lower resolution

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

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

Statistical output to single-valued input

n x m output to 3x3 input
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
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**