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Space-Oriented Capabilities of SEAS for AFSPC

Presentation to 73rd MORS Symposium
United States Military Academy
22 June 2005

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Purpose of Study

- Assess SEAS for its ability to address AFSPC's space-oriented analyses
- Discover, be aware of, and appreciate SEAS' strengths and weaknesses
- Understand to which questions and studies SEAS could be effectively applied
  - Mission-level
  - Campaign-level

Purpose of Our Presentation

- Make you aware of our findings
- Have an active discussion of the strengths and weaknesses of our work
  - This is a working group after all
- Solicit your inputs and comments which will possibly (and not necessarily surprisingly) be:
  - Parochial
  - Biased (this is not a negative word)
  - Passionate

Findings

- SEAS is more of a modeling environment than a model
- Each SEAS model (implementation of a new scenario) requires much building from scratch
- As such, the quality of the model is highly dependent upon:
  - The modelers' SEAS proficiency
  - The modelers' understanding of combat warfare
  - The analysts' ability to engage in scenario development

More Findings

- As such, there is little validity or accreditability transferred forward from past models/studies, as is common for most other combat warfare models (Legacy)
- There are differences between how Legacy and SEAS models are constructed

Legacy Approach

- Legacy models usually built on consensus of user community with pre-stated and agreed-upon:
  - Requirements
  - Algorithms
  - Processes
  - Approaches
  - Implementation

Legacy Pros & Cons

- Pros
  - Understood and agreed-upon representation of warfare, systems, scenarios, and processes
  - Results more readily accepted by community
  - The buy-in process occurs up front
- Cons
  - Less flexibility and responsiveness when changes are required

SEAS Approach

- SEAS models usually built by small, self-contained group of modelers
  - In close conjunction with study sponsor/tasker and analysts

SEAS Pros & Cons

- Pros
  - Tighter feedback loop for model development & refinement
  - More intimate understanding of client's requirements
  - Relatively easy to learn
  - Analyst has access to model implementation
  - Excellent at exploratory analysis
  - Well-suited to smaller (mission-level) scenarios

SEAS Pros & Cons

- Cons
  - Usually takes more time in development
    - Scenario implementation must be accomplished anew
  - Little broad-based (peer) review
  - Extremely dependent on developer's understanding of combat warfare
    - Ground, air, and space
  - Validation and accreditation harder

Exploratory Analysis & Agent Based Models

- SEAS has been described as an agent-based model (ABM)
- Is it really?

Is SEAS an ABM?

- Could be . . .
- Its architecture is surely designed for it
- ABMs were designed to elicit emergent behavior
  - Depends on how the modeler codes the agents' rules of behavior and action
- There are two ends of this behavior spectrum:
  1. Developer models warfare with few constraints on the agents
     - Agents produce previously unknown or unobserved behavior from which the analyst derives new understandings
  2. Developer tightly scripts agent behavior to MSFD actions
     - Agents don't diverge from generally expected behavior of combat entities and do conform to military doctrine

Is SEAS an ABM?

- We conclude implementations of SEAS for the space community to date haven't been
  - And this is a good thing
  - We want our combat warfare model to:
    - Conform to approved doctrine
    - Agree with Joint Staff-propagated Analytic Guidelines
  - We don't want our combat warfare model to:
    - Have brigades or wings autonomously develop new approaches to warfare

Ability of SEAS to Represent Desired Capabilities

- Since SEAS models are built study by study, “you can model anything you want”[1]
- There is a difference between
  - What has been modeled by someone, somewhere, sometime, and
  - What could be modeled

A Conclusion on Scope of Use of SEAS

- We’re comfortable using SEAS at the mission level
  - Models and scenarios represent the whole of the question

- Can SEAS be used at the campaign level?

Campaign-Level???

- Maybe . . .
- Limited by time to build model
  - Not inconsiderable
- Limited by amount of computing power
- If those limits exist, one needs to “Slice”
- Slicing
  - Building a smaller representation of the full scenario
  - Ensure operationally correct proportions of components (wings, brigades, sensors, C2, etc)
  - More tractable for building scenario
- But . . .

Is Slicing a Valid Technique?

- We found no (pure) analytic precedent
- Limited academic foundation
- No standard procedure for slicing
  - No algorithm or heuristics for how to slice
- How do we answer our question?

Follow-On Work

- Conduct a second phase of our work
  - Determine for ourselves if slicing is valid for campaign-level scenarios
- Two approaches

Approach 1

- Use a common scenario description (MSFD) and two independent teams
  - Team 1: create a full, campaign-level representation of the scenario
  - Team 2: independently create a sliced representation of the same scenario
    - Force thinning & independent agent rules
- Simulate
- Compare results

Approach 1 Results

- Likely outcome: differences will exist in results
- We'll need to make iterative changes in sliced model to obtain similar results as full scenario
- What do we gain?
  - Understanding of steps required to replicate
  - Distilled into heuristics or guidelines for future use
  - An academic precedent that says at least that slicing is possible

Approach 1 Results (cont)

- Issues
  - It will be difficult to build two independent teams who are each qualified to construct these two scenarios
  - We will essentially be guaranteed differences
  - May have too many degrees of freedom
    - Thinning proportions
    - Agents' rules

Approach 2

- Again use a common scenario description (MSFD) and two independent teams
- Team 1 again creates a full, campaign-level representation of the scenario
- Team 2 independently chooses units for inclusion in the sliced scenario
  - **Can** use agent rules extracted from Team 1's full model
- Simulate
- Compare

Approach 2 Results

- Likely outcome:
  - Again, differences will exist in results
  - But this approach removes one dimension of variation
  - Different results will be more directly explained by proportions of units included in the sliced scenario
- Again make iterative changes in sliced model to obtain similar results as full scenario

Approach 2 Results (Cont)

- We'll again need to iterate making changes in sliced model to obtain similar results as full scenario
- What do we gain?
  - The same understanding of:
    - Steps required to replicate the results of a full scenario
    - Creation of heuristics/guidelines
  - An academic precedent that says (at least) that slicing is possible
- Issues
  - Less clear academic independence

What's Next?

- Accomplish our follow-on work
  - Suggestions/inputs very welcome
- Share our results with SEAS Users Group
- Present to this Working Group next summer

Let’s Talk