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Standard Form 298 (Rev. 8-98)  
Prescribed by ANSI Std Z39-18
VALIDATION METHODOLOGY for AGENT-BASED SIMULATION
ABOUT ABSVal

• WHICH SIMULATIONS are the target of interest
  ▪ Directly applicable to IW problem set
  ▪ In addition to ISAAC, Pythagoras, MANA, consider decision rules, knowledge-based systems, cellular automata, population dynamics

• Discussion about VV&A
  ▪ Goal of validation: Match Tool to Application
    • Conservation of Vagueness: definition of “match”

• DoD definitions & Processes
  ▪ Looking at UK MOD, AIAA, ASME, NASA, DOE

• Two phases
  ▪ This phase: What we need to know to evaluate an ABS
  ▪ Next Phase: Experiment with methods
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Schism

• Agent-based simulations use modular rules and local reasoning to produce realistic and/or interesting emergent aggregate behavior.
  - Surprise is good**

• Successful simulation testing (core to face/results validation) based on demonstrating credibility across the range of potential input.
  - Surprise not good**

** Refined later in this talk
Questions

• What activities can I reasonably support with my ABS?
• What are the limits?
• What caveats are necessary?
• Compared with traditional simulation solutions, how are my results to be used?
• How can I make credibility statements about a simulation that is out of my (top-down) control?
  ▪ Value of training experiences
  ▪ Value of analytical results

• Can I support the scientific method with this ABS?
ABSVal Products

• General, institutionally acceptable processes and criteria for assessing the validity of an agent-based simulation used as part of a DoD-level analysis
  ▪ What information?
  ▪ What assurances and endorsements?
  ▪ What desirable qualities?
Benefit

- Increased awareness of the value of analysis results supported by agent based simulation(s)
- [Potential] Increased credibility of results
- [Potential] More valuable agent-based simulations
- [Potential] Responsible analytical application of ABS by OA professionals
- [Potential] Civilization of the discourse concerning ABS-generated analysis results

Benefactors: HBR, VVA, All Military Organizations using ABS, Analysis, Planning, Experimentation, Training, Acquisition, …
# First Principles

## GOAL OF SIMULATION
- a)Aggregate effects you understand
- b)Calculate probability of simultaneous/sequential events
- c)Challenge user’s intuition**

## DATA
- a)Model exists because of the data
- b)Data exists because of the model
- c)Accuracy, precision
- d)Covering the possible truths
- e)Propagating uncertainty & model sensitivity analysis

## SEEING THE INSIDE AND OUTSIDE
- a)Depict agent’s behavior
- b)Depict aggregation methods
- c)Serial aggregation (building blocks)
- d)Prose, pictures, diagrams, tests
- e)Visualization of outcomes, trends, cause-effect

## VALIDATION SURROGATES
- a)History of successful uses
- b)Credible believers
- c)Large, mature user community
- d)Transparency
- e)Relative validity
- f)(Over-?) Fitting historical data
What abstractions, data values, shortcuts, tricks, intentional oversights, modifications to expectations, code changes were required?
Representation

• Dynamic Influence
  ▪ 1st-order effect
  ▪ Direct influence
  ▪ Relevant over large interval
  ▪ Plausibly relevant over limited interval
  ▪ Possibly influential
  ▪ Minor detail
  ▪ No relevance

• Distillation
  ▪ Include only the highly-relevant dynamics
  ▪ Aggregation of effects
  ▪ Referent often loose/missing

Completeness vs. Parsimony
Statistical Methods

*Balance Predictiveness vs. Parsimony*

• $x_i$’s are the levels of dynamics included/excluded (capacities)
• $Y$ is the response variable (utility)
• $Y = f(x_1, x_2, ..., x_n)$

$$DI = \frac{\text{SSE}_{\text{with/df}}}{\text{SSE}_{\text{without/df}}}$$

Qualitative assessment meets Critical Values

Goals

• Understanding the meaning of *Valid Enough*
• Techniques for uncovering validation shortcomings
  ▪ in the presence of a weak referent
• Expressing validation boundaries
• Being conservative with VV&A resources
• Framework
  ▪ transparent, traceable, repeatable, communicate-able
In Sum

• Achieve the Goals of Simulation Validation for ABS
  ▪ Concentrate on analytical applications
  ▪ Test-case-driven & practical
  ▪ Institutional acceptability
  ▪ Vast collection of potential partners