In Search of the Grand Challenge

by Michael Macedonia, Chief Scientist, STRICOM

At the last Simulation Interoperability Standards Organization (SISO) Workshop, Dell Lunceford, the director of the Army Modeling Simulation Office (AMSO), called for the Modeling and Simulation (M&S) community to ponder the Grand Challenges (GC) of M&S. This meeting spawned as many Grand Challenge ideas as there were people in the crowded Orlando hotel room, and soon spilled over to a new e-mail reflector list. Ernie Page described this effort on the SISO GC e-mail reflector as "attempting to define a strategic vision for M&S research, development and investment" (*www.sisostds.org/*).

This is a great topic to ponder and probably worthy of a National Academy of Sciences study. I can see many possibilities presented by M&S, but Grand Challenges translate into questions such as—where should we be putting our research resources to garner big gains that can transform M&S or use M&S to great benefit?

This question is a regular discussion item at the US Army Simulation, Training, and Instrumentation Command (STRICOM) in Orlando, Florida. STRICOM uses a "balanced score card approach" to prioritize research. However, it is a constrained agenda because part of the model is the limited funding we receive.

So this begs the question as to what I perceive as the Grand Challenges, regardless of resource constraints. Below is an incomplete list of some of my favorites and why:

- QuickSim—this is Jim Dunnigan's idea. Dunnigan *(www.jim.dunnigan.com/)*, one of the great modern wargamers, has pointed out that in an era when we are swimming in information, we do not have military simulations that take advantage of real time news and web databases. For example, if the Commander-in-Chief of Central Command (CINCCENT) is faced with a crisis in the Indian Ocean, he should be able to rapidly create a matching scenario in a wargame that has its database automatically populated with both current and historical information. Commanders-in-chief primarily need high level information and deal in both political and military worlds. They also need their simulations to give them rapid insight to emergent issues such as terrorism or economic stability (e.g., the price of oil). QuickSim would always be running, incorporating the latest changes of the world's state into the game.

- Urban Operations—Military Operations in Urban Terrain (MOUT) show up on lots of people's lists, primarily because we do not have good models or simulations for urban combat. The world is quickly being urbanized over the next twenty years. It is safe to assume that CINCS and service commanders have to plan and train for these environments. However, urban areas have physical attributes (e.g., city blocks) that deny use of long range sensors and fires, slow the operational tempo to a crawl, limit communications, and impose the need to deal with non-combatants.

Fighting in cities is a three-dimensional problem. This calls for very different kinds of tactics and operational concepts than what traditional models assume. Moreover, a commander's instincts are to avoid cities, and few contemporary American commanders have extensive experience in them.

There are a number of efforts to tackle this problem. SAIC in Orlando *(www.asset.com/orl/disaf/home.html)* has made lots of progress in simulating urban environments in a special version of ModSAF. They have been able to incorporate urban models (such as sewer systems and skyscrapers) developed by the Institute for Defense Analysis into ModSAF and simulate urban operations. Army Research Institute (ARI) is building an After-Action Review capability for this type of simulation combined with instrumented live MOUT training. However, we still have a long way to go.

- General Models of Human Behavior—This is, in a sense, the Holy Grail of artificial intelligence (AI) since AI is an attempt to model and simulate human behavior with the result that we can be fooled into believing that a computer "thinks." To a limited degree, AI is starting to fulfill this promise. On the low end of the scale, we have computers that beat grandmasters in chess and checkers. On the other end, we have examples of computers that can have a limited dialogue with a human in a specific context, and exhibit emotion *(www.ict.usc.edu/misreh.html)*.

Also intriguing is the idea to use very simple models of human behavior, which—in the aggregate—give us insight into the behavior of a population. Two examples are the commercial game, The Sims *(www.thesims.com)* which allows you to play God over a group of families, and the agent-based model Aspen *(www-aspen.cs.sandia.gov/index.html)*, which looks at the impact of individual choices on economics.

However, the ideal would be to model command decision making for simulations that attempt to represent command and control (C2) systems. Though the technical behavior of command and control equipment are well documented and implemented in many models, we still cannot replace human decision makers, with exception to the lowest levels of combat simulation. What we need are synthetic humans that can "think," plan, and act as part of a C2 system, and agent-based simulations that provide insight into how information operations can impact large military and civilian infrastructures.

- Holodeck —If we can generate synthetic people, then the Holodeck in Star Trek is 5-10 years away. In the virtual simulation world, we can see rapid progress being made in

more ▸

POC: Michael Macedonia, 12350 Research Parkway, Orlando FL 32826-3276
▸ E-mail: *Michael_Macedonia@stricom.army.mil*

new computer graphics techniques, such as image-based rendering and high-resolution displays. Similar advances will likely be made in spatial audio. The key is to integrate a wide variety of technologies in order to deliver a seamless, virtual experience of the world.

The Holodeck is a transforming technology. This is because a key problem of making simulation compelling to decision-makers is that we often lack the ability to let them experience the problem. Moreover, we expect to face future possibilities that none of us has experience with. For example, few American soldiers have direct experience in urban warfare. MOUT facilities are one form of simulation that allows them to experience the problems first hand. But the facilities are extremely small (a handful of buildings) and expensive. The Holodeck could let us build virtual cities inhabited by virtual humans. They would enable commanders the ability to explore and experience a wide variety of issues related to urban warfare and provide a training environment for future operations.

This list could go for several more pages. For example, at some point in the future I would like to discuss the problems of medical simulation and the challenges of modeling the human body. However, I encourage you to join the Grand Challenge e-mail list and let us all know about your views.

First International Conference on Grand Challenges for Modeling and Simulation

to be held in conjunction with the 2002 SCS Western Multiconference, January 27-31 2002, Riverwalk Sheraton, San Antonio, TX, USA

General Chair: W. H. (Dell) Lunceford, U.S. Army Model and Simulation Office, E-mail: Wendell.Lunceford@hqda.army.mil
Program Chair: Ernest H. Page, The MITRE Corporation, E-mail: epage@mitre.org

One of the better aspects of human nature is our drive to seek out and conquer challenges. We seem imbued with a desire to formulate problems of the highest degree of difficulty and then to relentlessly pursue their solution. The identification and pursuit of Grand Challenges has been a hallmark of the high-performance computing arena for over a decade. In recent years, many other technical communities have defined Grand Challenge problems for their disciplines. While Grand Challenges themselves provide a useful focal point for research and development activities within a discipline, perhaps more important is the community dialogue that surrounds the formulation of Grand Challenge problems.

We seek to stimulate a dialogue among the community of modeling and simulation (M&S) researchers and practitioners regarding what our community is, and where it is and ought to be going, through the creation of the First International Conference on Grand Challenges for Modeling and Simulation. We welcome and encourage participation from all application domains within which M&S plays a significant role.

I. Guidelines

Authors are encouraged to submit papers that describe and propose Grand Challenge problems for M&S. Problems may be formulated that are specific to an application domain, e.g. modeling of financial markets, or they may be formulated as general modeling and simulation technology problems. In either case, authors are encouraged to describe their problem within the context of an M&S life cycle. For example, one may view a generic life-cycle for M&S as being depicted of four phases:

- understanding the system to be modeled
- representing the system as a model
- executing the model of the system
- drawing conclusions from the model

We anticipate that Grand Challenges are definable in any of these phases. In the "understanding the system to be modeled" phase, for example, many of the difficulties in modeling human behavior are resident. In general, this phase tends to encompass areas for which little supportive theory exists upon which to base our modeling efforts. Challenges related to the representation of systems as models are also conceivable. Identifying suitable abstractions is critical to addressing problems of scalability. Issues of scalability are also prevalent in the execution phase, e.g., massively parallel computation. Finally, we have long been aware of the many weaknesses in our ability to apply rigorous statistical methods to many applications of modeling.

II. What Constitutes a Grand Challenge?

We recognize that the concept of proposing Grand Challenges invariably generates controversy. There is a certain degree of inherent subjectivity surrounding the formulation of what is or is not a Grand Challenge. We suggest that a Grand Challenge problem exhibits at least the following characteristics:

1. The problem must be demonstrably hard to solve. Ideally, the problem requires (demonstrably) several orders-of-magnitude improvement in our capability in one or more areas.
2. The problem must not be known to be unsolvable. If it probably cannot be solved, then it cannot be a Grand Challenge. Ideally, quantifiable measures that indicate progress toward a solution are also definable.
3. The solution to a Grand Challenge problem must have a significant economical and/or social impact.

Authors should clearly demonstrate how the Grand Challenge problems they propose meet the criteria suggested here. Authors who disagree with the suggested criteria may suggest additional/alternative criteria and relate their proposals to those criteria, but should also provide a compelling argument in favor of their suggested criteria. Very often the assumptions upon which the classical techniques are based (e.g., independent, identical distribution, stationarity, and so forth) are violated in the context of the systems that we model. Does an initiative such as Simulation-Based Acquisition (SBA), which seems to imply the need for very high degrees of confidence in our models, suggest Grand Challenges in this area?

III. Deadlines and Requirements for Paper Submission

All papers will be subject to peer-review. Only original papers written in English that have not been previously published and are not currently submitted for possible publication elsewhere, will be accepted. Submission deadlines are as follows (these dates are tentative, refer to the URL below for possible updates):

Abstract submission: June 1, 2001
Notification of suitability: June 10, 2001
Full paper submission: July 1, 2001
Notification of acceptance: August 15, 2001
Final submission: September 30, 2001

Paper submission and review will be handled online using the WIMPE system developed by David Nicol. For complete details regarding paper submission (length, formatting, and so forth) or to register to be a referee for the conference, see *http://ms.ie.org/page/GC.html*