Topics, Structure, and Delivery of the New Certified Modeling and Simulation Professional Examination

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Systems Engineering Division
Modeling & Simulation Committee
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UAHuntsville
Center for Modeling, Simulation, and Analysis
Acknowledgements

- **Sponsors**
  - National Training and Simulation Association
  - The Boeing Company

- **Guidance**
  - Modeling & Simulation Professional Certification Commission (exam structure)
  - SimSummit (body of knowledge outline)

- **Contributors**
  - John A. Sokolowski, Ph.D. (question review)
  - Joshua Ciardelli, Glenn Nesbitt, Justin Watson (software)
  - William F. Waite (topics and sources)
  - David C. Gross, Ph.D. (topics and sources)
Presentation outline

- Introduction
  - CMSP certification
  - CMSP renewal
- Examination content
  - Topics
  - Questions
  - Examination instances
- Examination delivery
  - Process
  - Web system
Introduction
CMSP certification background

- Professional certification, in general
  - Indicator of individual expertise and competence
  - Milestone in maturation of professional discipline
  - Exists for law, medicine, project mgt, finance, ...

- Professional certification, for M&S
  - Certified Modeling and Simulation Professional (CMSP) instituted in 2001
  - Approximately 200 people designated as CMSPs
CMSP certification renewal

- **Renewal**
  - Initiated by M&SPCC 2009
  - Performed by volunteers and contracted

- **Renewal goals**
  - Exam topical coverage of M&S Body of Knowledge
  - Exam questions updated to reflect M&S advances
  - Exam questions drawn from authoritative sources
  - Two types of certification
  - Updated and enhanced examination web delivery
Certification types

User/Manager

1. Employ and explain key terms, definitions, and concepts in modeling and simulation.
2. Apply important principles of modeling and simulation practice, including simulation ethics, business considerations, and related communities of practice.
3. Understand and work effectively within typical and important uses of modeling and simulation, including application areas and domains of use.
4. Identify, assess, and select relevant simulation technologies, including modeling paradigms and implementation architectures, for a specific application.
5. Determine whether the use of simulation is, or is not, appropriate for a specific application.
6. Plan, initialize, and execute simulation runs or trials to satisfy project requirements.
7. Analyze, interpret, and apply the results of simulation runs in the context of an application.
8. Manage aspects of projects involving the use or development of simulation models and systems.

Developer/Technical

1. Employ and explain key terms, definitions, and concepts in modeling and simulation.
2. Apply important principles of modeling and simulation practice, including simulation ethics, business considerations, and related communities of practice.
3. Understand and work effectively within typical and important uses of modeling and simulation, including application areas and domains of use.
4. Design and develop simulation models of various types, including mathematical, logical, structural, and conceptual.
5. Identify the underlying mathematical issues associated with many simulation models, including numerical evaluation algorithms, digital discretization, and numerical precision.
6. Implement simulation models as executable software and verify those implementations.
7. Validate simulation models using suitable methods and assess the suitability of a model for a specific application.
8. Design and implement technical infrastructures needed to support simulation systems.
Examination content
New examination, topics and subtopics

- **Intent:** coverage of M&S body of knowledge
- **Structure:** 8 topics, 54 subtopics
- **Content**
  - Initially based on SimSummit M&S BoK Index
  - Revised per expert recommendations
  - Revised per source availability and topic testability
1. Concepts and context
   1.1 Fundamental terms and concepts
   1.2 Categories and paradigms
   1.3 History of M&S
2. Applications of M&S
   2.1 Training
   2.2 Analysis
   2.3 Experimentation
   2.4 Acquisition
   2.5 Engineering
   2.6 Test and evaluation
3. Domains of use of M&S
   3.1 Combat and military
   3.2 Aerospace
   3.3 Medicine and health care
   3.4 Manufacturing and material handling
   3.5 Logistics and supply chain
   3.6 Transportation
   3.7 Computer and communications systems
   3.8 Environment and ecology
   3.9 Business
   3.10 Social science
   3.11 Energy
   3.12 Other domains of use
4. Modeling methods
   4.1 Stochastic modeling
   4.2 Physics-based modeling
   4.3 Structural modeling
   4.4 Finite element modeling
   4.5 Monte Carlo simulation
   4.6 Discrete event simulation
   4.7 Continuous simulation
   4.8 Human behavior modeling
   4.9 Multi-resolution simulation
   4.10 Other modeling methods
5. Simulation implementation
   5.1 Modeling and simulation life-cycle
   5.2 Modeling and simulation standards
   5.3 Development processes
   5.4 Conceptual modeling
   5.5 Specialized languages
   5.6 Verification, validation, and accreditation
   5.7 Distributed simulation and interoperability
   5.7 Virtual environments and virtual reality
   5.8 Human-computer interaction
   5.9 Semi-automated forces
   5.10 Stimulation
6. Supporting tools, techniques, and resources
   6.1 Major simulation infrastructures
   6.2 M&S resource repositories
   6.3 M&S organizations
7. Business and management of M&S
   7.1 Ethics and principles for M&S practitioners
   7.2 Management of M&S projects and processes
   7.3 M&S workforce development *
   7.4 M&S business practice and economics *
   7.5 M&S industrial development *
8. Related communities of practice and disciplines
   8.1 Statistics and probability
   8.2 Mathematics
   8.3 Software engineering and development
   8.4 Systems science and engineering

* Sources sought for these subtopics.
Question counts and sources

- Counts
  - Total: ~2000 new questions
  - Per subtopic: min ≥ 20, mean ~40, max > 100

- Sources
  - Each question directly based on specific source
  - Published, peer-reviewed, publicly available
  - Yes: journal papers, conference papers, books
  - No: Wikipedia, briefings, unpublished reports
  - > 175 different sources
  - List of sources available
Question format and attributes

• Format
  ▪ ~75% multiple choice (one correct, three incorrect)
  ▪ ~25% True–False
  ▪ Diagrams, images, mathematical formulas used

• Question attributes
  ▪ Question and answers
  ▪ Unique question number
  ▪ Source, including page number
  ▪ Author
  ▪ Subtopic
  ▪ Certification type (User/Mgr, Dev/Tech, Core)
  ▪ Difficulty (1–5)
## Example question, with attributes

<table>
<thead>
<tr>
<th>Question number</th>
<th>8.545</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Which of the following is <em>not</em> a use of simulation?</td>
</tr>
<tr>
<td>Correct answer</td>
<td>Justify decisions already made based other criteria</td>
</tr>
<tr>
<td>Incorrect answer</td>
<td>Describe and analyze the behavior of a system</td>
</tr>
<tr>
<td>Incorrect answer</td>
<td>Ask and answer “what if” questions about a system</td>
</tr>
<tr>
<td>Incorrect answer</td>
<td>Help in designing new systems</td>
</tr>
<tr>
<td>Type</td>
<td>Core</td>
</tr>
<tr>
<td>Difficulty</td>
<td>2 (Easy)</td>
</tr>
<tr>
<td>Topic</td>
<td>1.1 Fundamental terms and concepts</td>
</tr>
<tr>
<td>Page number</td>
<td>3</td>
</tr>
<tr>
<td>Question author</td>
<td>M. Petty</td>
</tr>
</tbody>
</table>
### Example question, with attributes

<table>
<thead>
<tr>
<th>Question number</th>
<th>6.20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>In simulating a physical system governed by partial differential equations, _________ can be used to facilitate estimation of derivatives.</td>
</tr>
<tr>
<td>Correct answer</td>
<td>Fourier analysis</td>
</tr>
<tr>
<td>Incorrect answer</td>
<td>The Graham-Schmidt process</td>
</tr>
<tr>
<td>Incorrect answer</td>
<td>The downhill-simplex method</td>
</tr>
<tr>
<td>Incorrect answer</td>
<td>Gauss-Jordan elimination</td>
</tr>
<tr>
<td>Type</td>
<td>Developer/Technical</td>
</tr>
<tr>
<td>Difficulty</td>
<td>5 (Very difficult)</td>
</tr>
<tr>
<td>Topic</td>
<td>4.2 Physics-based modeling</td>
</tr>
<tr>
<td>Page number</td>
<td>530</td>
</tr>
<tr>
<td>Question author</td>
<td>W. Colley</td>
</tr>
</tbody>
</table>
### Example question, with attributes

<table>
<thead>
<tr>
<th>Question number</th>
<th>9.78</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Which of the following terms best describes use of models and simulation by the military, for the purposes of obtaining insight into the cost and performance of military equipment?</td>
</tr>
<tr>
<td>Correct answer</td>
<td>Requirements and acquisition</td>
</tr>
<tr>
<td>Incorrect answer</td>
<td>Exploration of advanced technologies and concepts</td>
</tr>
<tr>
<td>Incorrect answer</td>
<td>Training</td>
</tr>
<tr>
<td>Incorrect answer</td>
<td>Geo-navigation</td>
</tr>
<tr>
<td>Type</td>
<td>User/Manager</td>
</tr>
<tr>
<td>Difficulty</td>
<td>3 (Moderate)</td>
</tr>
<tr>
<td>Topic</td>
<td>3.1 Combat and military</td>
</tr>
<tr>
<td>Page number</td>
<td>38</td>
</tr>
<tr>
<td>Question author</td>
<td>S. Barbosa</td>
</tr>
</tbody>
</table>
Question quality control

- Initial
  - Authoritative sources
  - Check by question development team leader
- Independent
  - Review by external review team
  - Questions revised per review team feedback
- Long-term
  - Examination delivery software tracks correct/incorrect
  - Problematic questions reviewed and clarified
Examination instance

- Examination instance generation
  - Unique instance generated for each candidate
  - Candidate selects certification type
  - Candidate selects excluded subtopics
  - Questions selected randomly within selections

- Examination instance
  - 100 questions
  - All from selected certification type, or Core
  - At least 10 questions per topic
  - No questions from excluded subtopics
  - Average difficulty min 2.5, max 3.5
Examination delivery
Examination delivery process

- Candidate applies and pays fee
- Administrator creates account for candidate
- Candidate selects certification type, exclusions
- System generates examination instance
- System give candidate web access to instance
- Candidate answers 100 questions over 14 days
- Candidate submits completed examination
- System scores examination
- Administrator notifies candidate of result
Examination delivery system

- **Web site**
  - Implementation: PHP, JavaScript, MooTools AJAX, HTML, Subversion
  - Features: administration, question search, statistics
- **Question database**
  - Questions and attributes: mySQL
  - Import: MS Word, text
  - Export: HTML, text
Summary
Summary

- CMSP: professional certification for M&S
- Renewed exam
  - Topical coverage of M&S Body of Knowledge
  - Questions traceable to authoritative sources
- Examination delivered via custom web system
Future work

- Questions developed for missing subtopics
  - 7.3 M&S workforce development
  - 7.4 M&S business practice and economics
  - 7.5 M&S industrial development
- Clarify and correct problematic questions
- Add new questions as M&S BoK evolves
End notes

• Details

• Contact information
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  ▪ 256-824-4368, pettym@uah.edu

• Questions?
End