**Modeling and Simulation Body of Knowledge (M&S BoK)** - **Index**

**Draft Version 11**  
(In this revision, major changes have been done  
updated and © by: Dr. [Tuncer Ören](http://www.site.uottawa.ca/~oren/) - 2012-04-02   (yyyy-mm-dd)

(The format is especially chosen to reveal the structure and the content of the M&SBOK index)

**Please also consider**:

[Modeling and Simulation Body of Knowledge Index:   
An Invitation for the Final Phases of its Preparation](http://scs.org/magazines/2010-10/index_file/Files/Oren_Waite.pdf),   
M&S Magazine of SCS, Vol. 1, Issue 4 (October 2010), by Tuncer Ören and Bill Waite

Publication and Presentations of Dr. Tuncer Ören on [M&SBOK](http://www.site.uottawa.ca/~oren/pubsList/MSBOK.pdf)

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**Part 1. Background**

(Preliminary, Introduction, Terminology, Comprehensive View)

|  |  |
| --- | --- |
| * 1. **Preliminary** | |
|  | M&SBOK Development [Project](http://www.site.uottawa.ca/~oren/MSBOK/MSBOK-project.htm) |
|  | [Version History](http://www.site.uottawa.ca/~oren/MSBOK/versions.htm) and Milestone Reports |
|  | [Members](http://www.site.uottawa.ca/~oren/MSBOK/revCom.htm) of the Review Committee |
|  | [Recommendations](http://www.site.uottawa.ca/~oren/MSBOK/revComRecs.htm) by Members of the Review Committee |
| * 1. **Introduction** | |
|  | Some [Vision Quotations](http://www.site.uottawa.ca/~oren/MSBOK/quotations.htm) |
|  | High level Recognition of M&S      - US Congressional Modeling and Simulation [Caucus](http://forbes.house.gov/Biography/mscaucus.htm)      - US [House Resolution 487](http://thomas.loc.gov/cgi-bin/query/z?c110:hres487:) (2007 July 16) |
|  | - [M&S in China](http://www.scs.org/newsletters/2010-01/index_file/NewsDevelopment.htm) |
|  | [Stakeholders](http://www.site.uottawa.ca/~oren/MSBOK/stakeholders.htm) and Possible Interests for M&SBOK |
|  | - M&S [Associations and Organizations](http://www.site.uottawa.ca/~oren/links-MS-AG.htm)      - For a comprehensive World Medical Simulation Centre Database         click [here](http://www.bmsc.co.uk/sim_database/centres_canada.htm) then select the region on the map |
|  | - [Individuals, Certified Simulationists](http://www.site.uottawa.ca/~oren/MSBOK/individuals.htm)     - Workforce Development      - Professional Certification for:  --CMSP (Certified Modeling and Simulation Professional) designation:  [M&SPCC](http://www.simprofessional.org/index.html) – M&S Professional Certification Commission |
|  | [Professional Concerns](http://www.site.uottawa.ca/~oren/MSBOK/proConcerns.pdf)  (**P**rofessionalism, **A**chievements, **P**rogress, and **C**hallenges) |
|  | Why an M&SBOK? Rationale and Possible Usages - Some [Views](http://www.site.uottawa.ca/~oren/MSBOK/views.htm) |
|  | M&SBOK: [Early and Contemporary Studies](http://www.site.uottawa.ca/~oren/MSBOK/MSBOK-Studies.pdf) |
|  | Presentation Formats of: [Other BOK studies](http://www.site.uottawa.ca/~oren/MSBOK/refs-byTopics.pdf), as well as M&S BOK studies |
| * 1. **Terminology** | |
|  | [Background](http://www.site.uottawa.ca/~oren/MSBOK/terminology-background.pdf): Definitions of "Definition" |
|  | Some [M&S Definitions](http://www.site.uottawa.ca/~oren/MSBOK/defs-definitions.pdf): On Internet:  From Defense-Related Sources and From Civilian Sources, Suggested in this Study |
|  | Ören, T.I. (2011). [The Many Facets of Simulation](http://www.scs.org/magazines/2011-04/index_file/Files/Oren(2).pdf) through a Collection of about 100 Definitions. SCS M&S Magazine, 2:2 (April), pp. 82-92. |
|  | Ören, T.I. (2011). [A Critical Review of Definitions](http://www.scs.org/magazines/2011-07/index_file/Files/Oren-July-11(2).pdf) and About 400 Types of Mode and Simulation. SCS M&S Magazine, 2:3 (July), pp. 142-151. |
|  | Collections of Special Terms |
|  | - An Inventory of [over 8400 M&S Terms](http://www.site.uottawa.ca/~oren/MSBOK/terms-concepts.pdf) |
|  | - Terms and Concepts Related with [Simulation and Similarity](http://www.site.uottawa.ca/~oren/MSBOK/terms-sim-sim.htm) |
|  | - Terms Related with [Experiment, Experience and Training](http://www.site.uottawa.ca/~oren/MSBOK/terms-experiment.pdf) |
|  | M&S Dictionaries |
|  | - List of [M&S Dictionaries](http://www.site.uottawa.ca/~oren/SCS_MSNet/MSdictionaries.htm) |
|  | - M&SNet's [M&S Dictionary Project](http://www.site.uottawa.ca/~oren/SCS_MSNet/simDic.htm) |
|  | -- version 1: English-French-Turkish (over 4000 terms) |
|  | -- version 2: English-French-Italian-Spanish-Turkish                          (over 10 000 terms, in preparation) |
|  | -- version 3: English-Chinese (about 9000 terms, in press) |
|  | Ontology-Based Dictionaries |
|  | - Ontology-Based Dictionary of [V&V](http://www.site.uottawa.ca/~oren/MSBOK/terms-ob-dic-VV.htm) (rationale and an example) |
|  | - Ontology-Based Dictionary of [Understanding](http://www.site.uottawa.ca/~oren/pubs-pres/2007/pub-ADS-07-understanding) |
|  | - Ontology-Based Dictionaries of Other M&S Terms |
| * 1. **Comprehensive View** | |
|  | ***Challenges and Benefits of a*** [Comprehensive and Consolidated View](http://www.site.uottawa.ca/~oren/MSBOK/MS-big-picture.htm) of M&S  [Different perspectives](http://www.site.uottawa.ca/~oren/MSBOK/MS-big-picture-perceptions.pdf),  [Domain-independent Application Areas](http://www.site.uottawa.ca/~oren/MSBOK/catSimApps.pdf)  Ören, T.I. (2010). Simulation and Reality: The Big Picture. (Invited paper for the inaugural issue) International Journal of Modeling, Simulation, and Scientific Computing (of the Chinese Association for System Simulation - CASS) by the World Scientific Publishing Co. China. [Vol. 1, No. 1](http://www.worldscinet.com/ijmssc/01/0101/S17939623100101.html), 1-25. (Based on the keynote speech of the 2009 International Simulation Multiconference of SCS and SISO, July 13-16, 2009, Istanbul, Turkey.)  Ören, T.I. (2009). [Modeling and Simulation: A Comprehensive and Integrative View](http://media.wiley.com/product_data/excerpt/12/35274078/3527407812.pdf). In L. Yilmaz and T.I. Ören (eds.). Agent-Directed Simulation and Systems Engineering. Wiley Series in Systems Engineering and Management, Wiley-Berlin, Germany, pp. 3-36  [Simulation and Reality: The Big Picture and Challenges](http://www.site.uottawa.ca/~oren/MSBOK/MS-IMSc-2009_keynote.pdf)  Keynote of [ISMC'09](http://www.scs.org/confernc/summersim/summersim09/cfp/summersim09.htm) (International Simulation Multiconference)  Sponsored by SCS and SISO, 2009 July 13-16, Istanbul, Turkey  Ören, T.I. (2007). [The Importance of a Comprehensive and Integrative View of Modeling and Simulation](http://www.site.uottawa.ca/~oren/pubs-pres/2007/pub-0706-SCSC-BigPicture.pdf). Proceedings of the Summer Simulation Conference. San Diego, CA, July 15-18, '07. |

**Part 2. M&S BOK Core Areas**

                    Science / Methodology, Types of simulation, Life cycles of M&S, Computers & Computation, Technology, Infrastructure, Reliability, Ethics, Maturity,  
                    History, Trends, Challenges, and Desirable Features, Enterprise

|  |  |  |  |
| --- | --- | --- | --- |
| * 1. **Science / Methodology** | | | |
|  | **Data** | | |
|  |  | [Issues](file:///C:\Users\Tuncer\Documents\WebSites-maintained%20by%20TIO-2009-08-24\site\MSBOK\core-sci-data.pdf) | |
|  |  | ([types of data and terms related with data](file:///C:\Users\Tuncer\Documents\WebSites-maintained%20by%20TIO-2009-08-24\site\MSBOK\terms-data.pdf))                                 (over 260 terms) | |
|  |  | Variables ([types of variables and terms related with variables](file:///C:\Users\Tuncer\Documents\WebSites-maintained%20by%20TIO-2009-08-24\site\MSBOK\terms-variables.pdf))     (over 160 terms) | |
|  |  | -- Input Variables ([types of inputs and terms related with inputs](file:///C:\Users\Tuncer\Documents\WebSites-maintained%20by%20TIO-2009-08-24\site\MSBOK\terms-inputs.pdf)) (over 110 terms) | |
|  |  | Values ([types of values and terms related with values](file:///C:\Users\Tuncer\Documents\WebSites-maintained%20by%20TIO-2009-08-24\site\MSBOK\terms-values.pdf))                 (over 90 terms) | |
|  | **Models & Modeling Formalisms** | | |
|  | **Models** ([types of models and terms related with models](file:///C:\Users\Tuncer\Documents\WebSites-maintained%20by%20TIO-2009-08-24\site\MSBOK\terms-models.pdf))                  (over 1100 terms) | | |
|  | Issues: Reusability, Interoperability, Composability, Dynamic composability | | |
|  | Conceptual models and Conceptual modeling | | |
|  | Taxonomy of simulation models | | |
|  | Modeling formalisms (list of modeling formalisms) | | |
|  | Modeling physical systems  (By Prof. Dr. Fançois [Cellier](http://www.inf.ethz.ch/personal/fcellier/index_engl.html) (in [English](http://www.inf.ethz.ch/personal/fcellier/Lect/MMPS/Ppt/mmps_ppt_engl.html), in [German](http://www.inf.ethz.ch/personal/fcellier/Lect/MMPS/Ppt/mmps_ppt.html), in [Spanish](http://www.inf.ethz.ch/personal/fcellier/Lect/MMPS/Ppt/mmps_ppt_cast.html)) | | |
|  | Modeling qualitative systems | | |
|  | **Model Building** | | |
|  | Modeling | | |
|  | Model composition (and dynamic model composition) | | |
|  | **Model-base Management** | | |
|  | Model search, semantic model search | | |
|  | Model integrity | | |
|  | **Model Parameters and Parameter-base Management** | | |
|  | Parameters, Auxiliary parameters | | |
|  | Deterministic parameters, Stochastic parameters | | |
|  | **Model Characterization** (Descriptive model analysis) | | |
|  | for Model comprehensibility | | |
|  | -- Model documentation (static and dynamic documentations) | | |
|  | -- Model ventilation (to examine its assumptions, deficiencies, limitations, etc.) | | |
|  | for Model usability | | |
|  | -- Model referability | | |
|  | **Model Evaluation** (Evaluative Model Analysis) | | |
|  | Model evaluation with respect to: | | |
|  | **A Modeling Formalism** (Consistency of model representation) | | |
|  | Evaluation of: | | |
|  | (Static structure of: component models, Coupled models, Models of system of systems) | | |
|  | (Dynamic structure of: state transitions, Output function(s), | | |
|  | Structural change, Dynamic coupling) | | |
|  | Model robustness | | |
|  | **Another Model** (Model Comparison) | | |
|  | Structural model comparison | | |
|  | -- Model *verification* | | |
|  | (Types of and techniques and tools for model verification) | | |
|  | -- Model checking (for homomorphism, isomorphism, endomorphism) | | |
|  | -- Model equivalencing | | |
|  | Behavioral model comparison (under same or different scenarios) | | |
|  | **Real System** (For Analysis Problems) | | |
|  | **Technical System Specifications** (For Design and Control Problems) | | |
|  | Model qualification (model realism, model adequacy, model correctness analysis) | | |
|  | Model *validity* | | |
|  | (Types of and techniques and tools for model validity) | | |
|  | **Goal of the Study** | | |
|  | Model relevance (domain of intended application(s),; range of applicability of a model) | | |
|  | **Model Transformation** | | |
|  | Types of model transformation (copying, reduction, pruning, simplification, elaboration, | | |
|  | isomorphism, homomorphism, endomorphism) | | |
|  | **Experimentation** ([Main issues related with experimentation](http://www.site.uottawa.ca/~oren/MSBOK/core-sci-exp.pdf))     (types of experimentation and terms related with experimentation) (over 100 terms) | | |
|  |  | | Statistical Design of Experiments |
|  |  | | Computer-Aided Systems for Design of Experiments |
|  |  | | Computer-Aided Systems for Execution of Experiments |
|  |  | | Data compression techniques (deterministic, stochastic) |
|  |  | | Analysis of simulation data |
|  | **Model Behavior** (Main issues related with model behavior)     (types of model behavior and terms related with behavior)  (over 120 terms) | | |
|  |  | | Types of Model Behavior |
|  |  | | Generation of Model Behavior |
|  |  | | Processing of Model Behavior |
|  |  | |  |
| **2.2 Types of Simulations** (types of simulation and terms related with simulation)  (over 850 terms) | | | |
|  |  | |  |
| **2.3 Life Cycles of M&S** | | | |
|  | **for Experimentation** | | |
|  | **to Gain Experience for Training** to enhance | | |
|  |  | | motor skills (virtual simulation: simulators, virtual simulators) |
|  | **to Gain Experience for Training** to enhance: | | |
|  |  | | decision-making and communication skills  (constructive simulation - serious games: business gaming, war gaming, peace gaming) |
|  | **to Gain Experience for Training** to enhance: | | |
|  |  | | operational skills (live simulation) |
|  | **for Entertainment** (simulation games) | | |
|  |  | |  |
| **2.4 Computers & Computation** | | | |
|  | Impact of Computers | | |
|  |  | | Digital, hybrid, analog; mobile |
|  |  | | Extreme scale computers (petascale simulation, exascale simulation) |
|  | Synergies **Soft Computing** and M&S | | |
|  |  | | Fuzzy logic and simulation |
|  |  | | Neural networks and simulation |
|  | Synergies of **Artificial Intelligence & M&S** | | |
|  |  | | |
|  |  | | |
|  | **Agent-Directed Simulation** | | |
|  |  | | Agent simulation (and agent-initiated simulation) |
|  |  | | Agent-supported simulation |
|  |  | | Agent-based simulation |
|  |  | |  |
| **2.5** [**Technology**](http://www.site.uottawa.ca/~oren/MSBOK/core-technology.pdf) | | | |
|  | M&S languages  M&S tools and environments  Computer-Aided Problem Solving Environments  (for Modeling, Model Processing, Program Generation, Experimentation, and Problem Solving) | | |
|  |  | |  |
| **2.6** [**Infrastructure**](http://www.site.uottawa.ca/~oren/MSBOK/core-infrastructure.pdf) | | | |
|  | [Standards](http://www.site.uottawa.ca/~oren/MSBOK/refs-standards.pdf)  Code of Best Practice  Lessons Learned  Resource Repositories | | |
|  |  | |  |
| **2.7** [**Reliability**](http://www.site.uottawa.ca/~oren/MSBOK/core-reliability.pdf) **& QA of M&S and types of:** | | | |
|  | Errors (types of errors and terms related with errors)                            (over 200 terms) | | |
|  | Validation (types of validation and terms related with validation)             (over 50 terms) | | |
|  | Verification  (types of verification and terms related with verification) | | |
|  | Built-in Quality Assurance | | |
|  | Failure Avoidance | | |
|  |  | |  |
| **2.8 Ethics** | | | |
|  |  | | (at [SCS](http://www.scs.org/ethics/)) (at [Tuncer Ören's site](http://www.site.uottawa.ca/~oren/SCS_Ethics/ethics.htm)) |
| **2.8** [**History**](http://www.site.uottawa.ca/~oren/MSBOK/core-history.pdf) | | | |
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| **2.10** [**Trends, Challenges, and Desirable Features**](http://www.site.uottawa.ca/~oren/MSBOK/core-trends-challenges.pdf) | | | |
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| **2.11** [**Enterprise**](http://www.site.uottawa.ca/~oren/MSBOK/core-enterprise.pdf) | | | |
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| **2.12** [**Maturity**](http://www.site.uottawa.ca/~oren/MSBOK/core-maturity.pdf) | | | |
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**Part 3. M&S BOK:**

**Supporting Domains (Independent of the Application Areas)**Supporting Science Areas  
Supporting Engineering Areas  
Supporting Management Areas

Mutual Contributions of M&S

|  |  |
| --- | --- |
| **3.1 Supporting Science Areas** | |
|  | Systems Science |
|  | Physics |
|  | Differential Equations |
|  | Numerical Analysis |
|  | Probability |
|  | Statistics |
|  | Queuing Theory |
|  | Computer Science |
|  | Artificial Intelligence |
|  | Software Agents and [Agent-based models](http://www.agent-based-models.com/ABM_Lab/Home.html) |
| **3.2 Supporting Engineering Areas** | |
|  | Systems Engineering |
|  | Software Engineering |
|  | Visualization |
| **3.3 Supporting Management Areas** | |
|  | Enterprise Management |
|  | Project Management |
|  | Product Management |
| **3.4 Mutual Contributions of M&S with:** | |
|  | Systems Engineering, Systems Science |
|  | Software Engineering, Artificial Intelligence, Software Agents |
|  | Optimization |
|  | Education |
|  |  |

**Part 4. References**

(See also: M&S BoK [Sharepoint](http://www.sim-summit.org/BoK07/BoK_SharePoint.htm)of SimSummit**)**

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| M&S Portals | |
| Social Network - [Ning](http://simulation.ning.com/) by Prof. Dr. Gabriel Wainer | |
| M&S [Blogs](http://blogsearch.google.ca/blogsearch?hl=en&ie=UTF-8&q=simulation&btnG=Search+Blogs) | |
| Google [News on Simulation](http://news.google.ca/?hl=en&q=simulation&ie=UTF-8&client=blogsearch) | |
|  | |
| References by Authors | |
| References by Application Areas | |
| References by Topics including: | |
|  | **Body of Knowledge** |
|  | - BOK of Other Areas |
|  | - M&SBOK - Early Studies & Other Contributions |
|  | - M&SBOK - Recent Contributions     - Dr. Tuncer Ören's publications and activities on M&SBOK |
|  | **M&S** |
|  | - Master Plans |
|  | - Dictionaries |
|  | - Epistemology |
|  | - Ontologies |
|  | - Taxonomies |
|  | - Standards |
|  |  |
|  | - Composability |
|  | - Reusability |
|  | - Interoperability |
|  | - Conceptual Models |
|  | **M&S &** |
|  | - Systems Engineering |
|  | - Simulation Professionals & Needed Qualifications |
|  |  |