**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)

**Index**

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| --- | --- |
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| Part 4. References: | M&S Portals, M&S Blogs, Google News on Simulation References by Authors, Application Areas, Topics |

**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%282%29.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%282%29.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, TurkeyÖren, 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%3A%5CUsers%5CTuncer%5CDocuments%5CWebSites-maintained%20by%20TIO-2009-08-24%5Csite%5CMSBOK%5Ccore-sci-data.pdf) |
|  |  |    ([types of data and terms related with data](file:///C%3A%5CUsers%5CTuncer%5CDocuments%5CWebSites-maintained%20by%20TIO-2009-08-24%5Csite%5CMSBOK%5Cterms-data.pdf))                                 (over 260 terms) |
|  |  | Variables ([types of variables and terms related with variables](file:///C%3A%5CUsers%5CTuncer%5CDocuments%5CWebSites-maintained%20by%20TIO-2009-08-24%5Csite%5CMSBOK%5Cterms-variables.pdf))     (over 160 terms) |
|  |  |     -- Input Variables ([types of inputs and terms related with inputs](file:///C%3A%5CUsers%5CTuncer%5CDocuments%5CWebSites-maintained%20by%20TIO-2009-08-24%5Csite%5CMSBOK%5Cterms-inputs.pdf)) (over 110 terms) |
|  |  | Values ([types of values and terms related with values](file:///C%3A%5CUsers%5CTuncer%5CDocuments%5CWebSites-maintained%20by%20TIO-2009-08-24%5Csite%5CMSBOK%5Cterms-values.pdf))                 (over 90 terms) |
|  | **Models & Modeling Formalisms** |
|  | **Models** ([types of models and terms related with models](file:///C%3A%5CUsers%5CTuncer%5CDocuments%5CWebSites-maintained%20by%20TIO-2009-08-24%5Csite%5CMSBOK%5Cterms-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 languagesM&S tools and environmentsComputer-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 PracticeLessons LearnedResource 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) |
|  |  |  |
| **2.10** [**Trends, Challenges, and Desirable Features**](http://www.site.uottawa.ca/~oren/MSBOK/core-trends-challenges.pdf) |
|  |  |  |
| **2.11** [**Enterprise**](http://www.site.uottawa.ca/~oren/MSBOK/core-enterprise.pdf) |
|  |  |  |
| **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

|  |
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| **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 |
|  |  |