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

This site reflects the work of:

the **SCS Technical Committee on M&S Body of Knowledge Index** (Tiger Team*)*

founded in 2016 with the authorization of Prof. Lin Zhang, the then President of the [SCS](http://scs.org/)

(The Society for Modeling & Simulation International)

updated by Dr. Tuncer [Ören](http://www.site.uottawa.ca/~oren/): 2017-04-18

ISO 8601: (yyyy-mm-dd)

* The [members](http://www.site.uottawa.ca/~oren/MSBOK/TT.pdf) of the Committee
* The **basic agreement** to develop the M&S Body of Knowledge Index
* **Status**:
	+ Part 1 is under scrutiny [2017-04-18 -

**Index**

|  |  |
| --- | --- |
| Part 1. Background: | Preliminary, Terminology, Comprehensive View of M&S |
| Part 2. M&SBOK: | Core Areas |
| Part 3. M&SBOK: | Supporting Domains |
| Part 4. References: | M&S Portals, M&S Blogs, Google News on Simulation References by Authors, Application Areas, Topics |

**Part 1. Background**

* 1. Preliminary
	2. Terminology
	3. Comprehensive View of M&S

|  |  |
| --- | --- |
| **1.1** | **Preliminary** |
|  | 1.1.1 | [Recommendations](http://www.site.uottawa.ca/~oren/MSBOK/ComRecs.pdf) by Members of the Technical Committee |
|  | 1.1.2 | Some [Vision Quotations](http://www.site.uottawa.ca/~oren/MSBOK/quotations.pdf) |
|  | 1.1.3 | High level Recognition of M& |
|  |  | 1.1.3.1 | US Congressional Modeling and Simulation [Caucus](http://soling.syr.edu/DestinyUSA/UpdateDocs/MSCaucus.htm) |
|  |  | 1.1.3.2 | US [House Resolution 487](https://www.congress.gov/bill/110th-congress/house-resolution/487) (introduced by [Rep. Forbes, J. Randy [R-VA-4]](https://www.congress.gov/member/j-forbes/F000445) 2007 June 14) |
|  | 1.1.4 | [Stakeholders](http://www.site.uottawa.ca/~oren/MSBOK/stakeholders.pdf) and Possible Interests for M&SBOK |
|  |  | 1.1.4.1 | M&S [Associations and Organizations](http://www.site.uottawa.ca/~oren/links-MS-AG.pdf) |
|  |  | 1.1.4.2 | For a comprehensive World Medical Simulation Centre Database click [here](http://www.bmsc.co.uk/) then select the region on the map (Maintained by [BMSC](http://www.bmsc.co.uk/) – Bristol Medical Simulation Centre)) |
|  |  | 1.1.4.3 | [Individuals, Certified Simulationists](http://www.site.uottawa.ca/~oren/MSBOK/individuals.pdf) |
|  |  | 1.1.4.4 | Workforce Development |
|  |  | 1.1.4.5 | Professional Certification for **CMSP** (Certified Modeling and Simulation Professional) designation: [M&SPCC](http://www.simprofessional.org/index.html) – M&S Professional Certification Commission |
|  | 1.1.5 | [Professional Concerns](http://www.site.uottawa.ca/~oren/MSBOK/proConcerns.pdf) (**P**rofessionalism, **A**chievements, **P**rogress, and **C**hallenges) |
|  |  | 1.1.5.1 | Why an M&SBOK? Rationale and Possible Usages – Some [Views](http://www.site.uottawa.ca/~oren/MSBOK/views.htm) |
|  |  | 1.1.5.2 | [Other BOK studies](http://www.site.uottawa.ca/~oren/MSBOK/refs-otherBOKs.pdf) and their presentation formats |
|  | 1.1.6 | M&SBOK  |
|  |  | 1.1.6.1 | [Early Studies](http://www.site.uottawa.ca/~oren/MSBOK/refs_MSBOK.pdf) |
|  |  | 1.1.6.2 | Tuncer Ören’s [publications and activities on MSBOK](http://www.site.uottawa.ca/~oren/pubsList/MSBOK.pdf) |

|  |  |
| --- | --- |
| **1.2** | **Terminology** |
|  | 1.2.1 | [Background](http://www.site.uottawa.ca/~oren/MSBOK/terminology-background.pdf): Definitions of "Definition" |
|  | 1.2.2 | **Definitions** of simulation: |
|  |  | 1.2.2.1 | Ören, T.I. (2011). [The Many Facets of Simulation through a Collection of about 100 Definitions](http://scs.org/wp-content/uploads/2016/12/2011-04-Issue06-6.pdf). SCS M&S Magazine, 2:2 (April), pp. 82-92. |
|  |  | 1.2.2.2 | Ören, T.I. (2011). [A Critical Review of Definitions and About 400 Types of Mode and Simulation](http://scs.org/wp-content/uploads/2016/12/2011-07-Issue07-7.pdf). SCS M&S Magazine, 2:3 (July), pp. 142-151. |
|  | 1.2.3 | Collections of Special Terms |
|  |  | 1.2.3.1 | An Inventory of [over 8400 M&S Terms](http://www.site.uottawa.ca/~oren/MSBOK/terms-concepts.pdf) (Currently, the list that I maintain has over 12 500 terms) |
|  |  | 1.2.3.2 | Terms and Concepts Related with [Similarity](http://www.site.uottawa.ca/~oren/MSBOK/terms-similarity.pdf) |
|  | 1.2.4 | [M&S Dictionaries](http://www.site.uottawa.ca/~oren/MSBOK/MSdictionaries.pdf) |
|  | 1.2.5 | Ontology-Based Dictionaries |
|  |  | 1.2.5.1 | Ontology-Based Dictionary of [V&V](http://www.site.uottawa.ca/~oren/MSBOK/terms-ob-dic-VV.htm) (rationale and an example) |
|  |  | 1.2.5.2 | Ontology-Based Dictionary of [Understanding](http://www.site.uottawa.ca/~oren/pubs-pres/2007/pub-ADS-07-understanding) |

|  |  |
| --- | --- |
| **1.3** | **Comprehensive View of M&S** |
|  | 1.3.1 | **Challenges and Benefits of a** [Comprehensive and Consolidated View](http://www.site.uottawa.ca/~oren/MSBOK/MS-big-picture.htm) of M&S |
|  | 1.3.2 | [Different perspectives](http://www.site.uottawa.ca/~oren/MSBOK/MS-big-picture-perceptions.pdf)  |
|  | 1.3.3 | [Domain-independent Application Areas](http://www.site.uottawa.ca/~oren/MSBOK/catSimApps.pdf) |
|  | 1.3.4 | Tuncer Ören’s [publications and activities](http://www.site.uottawa.ca/~oren/pubsList/MSBOK.pdf) |
|  | 1.3.5 | Other publications and activities |
|  | 1.3.6 | Select articles: |
|  |  | 1.3.6.1 | 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. ([Presentation](http://www.site.uottawa.ca/~oren/pubs-pres/2009/pres-07-ISMC-keynote.pdf)) |
|  |  | 1.3.6.2 | 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. |
|  |  | 1.3.6.3 | 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**

2.1 Science / Methodology

2.2 Types of simulation

2.3 Life cycles of M&S

2.4 Technology

2.5 Infrastructure

2.6 Reliability

2.7 Ethics

2.8 History

2.9 Trends, Challenges, and Desirable Features

2.10 Enterprise

2.11 Maturity

|  |
| --- |
| * 1. **Science / Methodology**
 |
|  | **Data** |
|  |  | [Issues](http://www.site.uottawa.ca/~oren/MSBOK/core-sci-data.pdf) |
|  |  |    ([types of data and terms related with data](http://www.site.uottawa.ca/~oren/MSBOK/terms-data.pdf))                                 (over 260 terms) |
|  |  | Variables ([types of variables and terms related with variables](http://www.site.uottawa.ca/~oren/MSBOK/terms-variables.pdf))     (over 160 terms) |
|  |  |     -- Input Variables ([types of inputs and terms related with inputs](http://www.site.uottawa.ca/~oren/MSBOK/terms-inputs.pdf)) (over 110 terms) |
|  |  | Values ([types of values and terms related with values](http://www.site.uottawa.ca/~oren/MSBOK/terms-values.pdf))                 (over 90 terms) |
|  |  |
|  | **Models & Modeling Formalisms** |
|  | **Models** ([types of models and terms related with models](http://www.site.uottawa.ca/~oren/MSBOK/terms-models.pdf))                  (over 1100 terms) |
|  | Issues: Reusability, Interoperability, Composability, Dynamic composability |
|  | Conceptual models and Conceptual modeling |
|  | Taxonomy of simulation models (some [M&S taxonomies](http://www.site.uottawa.ca/~oren/pubsList/taxonomies.pdf)) |
|  | 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](http://www.site.uottawa.ca/~oren/MSBOK/terms-experiment.pdf)) (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](http://www.site.uottawa.ca/~oren/MSBOK/core-sci-behavior.pdf))    ([types of model behavior and terms related with behavior](http://www.site.uottawa.ca/~oren/MSBOK/terms-behavior.pdf))  (over 120 terms) |
|  |  | Types of Model Behavior  |
|  |  | Generation of Model Behavior |
|  |  | Processing of Model Behavior (Analytical, Statistical) |
|  |  | Visualization of Model Behavior (3-D, animation) |
|  |  |  |
| **2.2 Types of Simulations** (types of simulation and terms related with simulation)(over 850 terms) |
|  |  | For over 500 types of simulation, see the appendix of the article at: [link](http://www.site.uottawa.ca/~oren/y/2012/-08-MS-BOK.pdf) |
|  |  |  |

|  |
| --- |
| **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** [**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) |
|  |  |  |
| **2.5** [**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 |
|  |  |  |
| **2.6** [**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](http://www.site.uottawa.ca/~oren/MSBOK/terms-errors.pdf))                            (over 200 terms) |
|  | Validation ([types of validation and terms related with validation](http://www.site.uottawa.ca/~oren/MSBOK/terms-validation.pdf))             (over 50 terms) |
|  | Verification  (types of verification and terms related with verification)  |
|  | Built-in Quality Assurance |
|  | Failure Avoidance |
|  |  |  |
| **2.7 Ethics** |
|  |  | (at [SCS](http://www.scs.org/ethics/)) (at Tuncer Ören's [site](http://www.site.uottawa.ca/~oren/SCS_Ethics/SCS_Ethics.pdf)) |
|  |
| **2.8** [**History**](http://www.site.uottawa.ca/~oren/MSBOK/core-history.pdf) |
|  |  |  |
| **2.9** [**Trends, Challenges, and Desirable Features**](http://www.site.uottawa.ca/~oren/MSBOK/core-trends-challenges.pdf) |
|  |  |  |
| **2.10** [**Enterprise**](http://www.site.uottawa.ca/~oren/MSBOK/core-enterprise.pdf) |
|  |  | Business practice: |
|  |  |  Economics of M&S: [SISO](http://www.sisostds.org/StandardsActivities/StudyGroups/EconomicsofMSSSG.aspx), [Bill Waite](http://www.sim-summit.org/simsummit/0311/0311e.pdf) |
|  |  | Enterprise infrastructure |
|  |  |  |
| **2.11** [**Maturity**](http://www.site.uottawa.ca/~oren/MSBOK/core-maturity.pdf) of |
|  |  | Individuals |
|  |  | Organizations |
|  |  | Educational programs (individual courses, as well as undergraduate and graduate degree  programs and professional development seminars). |

**Part 3. M&S BOK:**

**Supporting Domains (Independent of the Application Areas)**

3.1 Computers and Computation

3.2 Supporting Science Areas

3.3 Supporting Engineering Areas

3.4 Supporting Management Areas

3.5 Education

|  |
| --- |
| **3.1 Computers and Computation** |
|  | Impact of Computers |
|  |  -Digital, hybrid, analog; mobile, cloud |
|  |  -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-based models](http://www.agent-based-models.com/ABM_Lab/Home.html) |
|  |  -Agent simulation (and agent-initiated simulation) |
|  |  -Agent-supported simulation |
|  |  -Agent-monitored simulation |
| **3.2 Supporting Science Areas** |
|  | Systems Science (a historic ref by [Ören & Zeigler](http://sim.sagepub.com/content/88/9/1033.abstract?etoc)) |
|  | Physics |
|  | Mathematics (Differential Equations, Numerical Analysis, Probability, Statistics) |
|  | Queuing Theory |
|  **3.3 Supporting Engineering Areas** |
|  | [Systems Engineering](http://www.incose.org/) |
|  | Visualization |
| **3.4 Supporting Management Areas** |
|  | Enterprise Management |
|  | Project Management |
|  | Product Management |
| **3.5 Education** |
|  | [Education](http://www.site.uottawa.ca/~oren/MSBOK/simEd.htm) |
|  |  |

**Part 4. References**

|  |
| --- |
| M&S [Portals](http://www.site.uottawa.ca/~oren/MSBOK/refs-MS-Portals.pdf)  |
| Social Network |
| M&S [Blogs](https://www.google.ca/search?hl=en&ie=UTF-8&q=simulation&tbm=blg#hl=en&tbm=blg&sclient=psy-ab&q=%22blog+simulation%22&oq=%22blog+simulation%22&gs_l=serp.12...44781.50464.0.53094.7.7.0.0.0.3.1501.3543.0j1j6-1j1j1.4.0.les%3B..0.0...1c.1.Ew--SlPb4Qs&pbx=1&bav) |
| Google [News on Simulation](http://news.google.ca/?hl=en&q=simulation&ie=UTF-8&client=blogsearch) |
|  |
| References [by Authors](http://www.site.uottawa.ca/~oren/MSBOK/refs-byAuthors.pdf) |
| References [by Application Areas](http://www.site.uottawa.ca/~oren/MSBOK/refs-byApps.pdf) |
| References [by Topics](http://www.site.uottawa.ca/~oren/MSBOK/refs-byTopics.pdf) 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 |
|  |  |