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

The **official site** of M&S BOK Index is at: scs.org/MSBOK-Index,
within the website of SCS (The Society for Modeling & Simulation International)

This unofficial site represents the draft and used for 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
(The Society for Modeling & Simulation International)

The developments of the M&SBOK Index agreed by the Tiger Team members will continuously be posted at the official site.

*Please **share** your views with all members of the Tiger Team.*
For any addition/correction, please contact Dr. Tuncer Ören.

updated by Dr. Tuncer Ören: 2017-11-18
ISO 8601: (yyyy-mm-dd)

- The members of the Committee (at SCS website)
- Messages to the members of the Technical Committee
- Part 1 **Status**:
  - ✓ is under scrutiny [2017-04-19 –
  - ✓ Part 2 – only highest level of its structure is under scrutiny [2017-05-25 –

Index

Part 1. Background

1.1 Preliminary

1.2 Terminology

1.2.1 Background: 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. 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. 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
(Currently, the list that I maintain has over 12 500 terms)

1.2.3.2 Terms and Concepts Related with Similarity

1.2.4 M&S Dictionaries

1.2.5 Ontology-Based Dictionaries

1.2.5.1 Ontology-Based Dictionary of V&V (rationale and an example)

1.2.5.2 Ontology-Based Dictionary of Understanding

1.3 Comprehensive View of M&S

1.3.1 **Challenges and Benefits of a** Comprehensive and Consolidated View of M&S

1.3.2 Different perspectives

1.3.3 Domain-independent Application Areas

1.3.4 Tuncer Ören's publications and activities

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, 1-25. (Based on the keynote speech of the 2009 International Simulation Multiconference of SCS and SISO, July 13-16, 2009, Istanbul, Turkey. (Presentation)

1.3.6.2 Ören, T.I. (2009). Modeling and Simulation: A Comprehensive and Integrative View. 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. 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

2.1 Science / Methodology

2.1.1 Data

Issues
(types of data and terms related with data) (over 260 terms)
Variables (types of variables and terms related with variables) (over 160 terms)
-- Input Variables (types of inputs and terms related with inputs) (over 110 terms)
Values (types of values and terms related with values) (over 90 terms)

2.1.2 Models & Modeling Formalisms

2.1.2.1 Models (types of models and terms related with models) (over 1100 terms)
Issues: Reusability, Interoperability, Composability, Dynamic composability
Conceptual models and Conceptual modeling
Taxonomy of simulation models (some M&S taxonomies)
Modeling formalisms (list of modeling formalisms)
Modeling physical systems
(By Prof. Dr. Françoís Cellier (in English, in German, in Spanish)
Modeling qualitative systems

2.1.2.2 Model Building
Modeling
Model composition (and dynamic model composition)

2.1.2.3 Model-base Management
Model search, semantic model search
Model integrity

2.1.2.4 Model Parameters and Parameter-base Management
Parameters, Auxiliary parameters
Deterministic parameters, Stochastic parameters

2.1.2.5 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 (Analytical, Statistical)
Visualization of Model Behavior (3-D, animation)

2.1.2.6 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

2.1.2.7 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)

2.1.2.8 Model Transformation
Types of model transformation (copying, reduction, pruning, simplification, elaboration,
isomorphism, homomorphism, endomorphism)

2.1.3 Experimentation (Main issues related with experimentation)
(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

2.1.4 Experience (Main issues related with experience)
(types of simulation-based experiences and related terms)

Experience **for skill development (training)**

- Motor skills
- Decision making skills
- Operational skill

Experience **for entertainment**

2.2 Types of Simulations (types of simulation and terms related with simulation)(over 850 term

For over 500 types of simulation, see the appendix of the article at: link

2.3 Types of Simulators

2.4 Life Cycles of M&S

for Experimentation

to Gain Experience

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)

2.5 Life Cycles of Simulators

2.4 Technology

M&S languages
M&S tools and environments
Computer-Aided Problem Solving Environments
(for Modeling, Model Processing, Program Generation, Experimentation, and Problem Solving)
Simulators

2.5 Infrastructure

Standards
Code of Best Practice
Lessons Learned
Resource Repositories

2.6 Reliability & 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

- Avoidance of AI errors
- Avoidance of Dysrationalia
- Avoidance of Cognitive biases
-

2.7 Ethics

(at SCS) (at Tuncer Ören's site)

2.8 History

2.9 Trends, Challenges, and Desirable Features

2.10 Enterprise

Business practice:
Economics of M&S: SISO, Bill Waite
Enterprise infrastructure

2.11 Maturity 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

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
- -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)
Physics
Mathematics (Differential Equations, Numerical Analysis, Probability, Statistics)
Queuing Theory

3.3 Supporting Engineering Areas

Systems Engineering
Visualization

3.4 Supporting Management Areas

Enterprise Management
Project Management
Product Management

3.5 Education

Education

Part 4. References

M&S Portals
Social Network
M&S Blogs
Google News on Simulation

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