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**Simulation and Reality:
The Big Picture and Challenges**
(keynote – ISMc'09)

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Some Motivations to see the big picture:

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Some Motivations to see the big picture:

“The smaller a man, the closer his horizon”
(John McLeod, founder of SCS)

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Some Motivations to see the big picture:

“The smaller a man, the closer his horizon”
(John McLeod, founder of SCS)

“The greater a person, the larger his horizon”
(Tuncer Ören)

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For a passenger, it is not sufficient to see only the horizon. He needs to see beyond it.
Mustafa Kemal Atatürk

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Having a large horizon is desirable;
but not sufficient.

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Having a large horizon is desirable;
but not sufficient.

Two important factors: (also figuratively)

- **Where we are:**
- **Our perspective:**

Having a large horizon is desirable;
but not sufficient.

Two important factors: (also figuratively)

- **Where we are:** At the North Pole, all directions point out the South!
- **Our perspective:**

Having a large horizon is desirable;
but not sufficient.

Two important factors: (also figuratively)

- **Where we are:** At the North Pole, all directions point out the South!
- **Our perspective:**
 - "Horizon" is relevant if we are outside of a sphere;
 - When we are within a sphere, our **perspective (point of view)** & our **ability to discern** are relevant.

Why we need to see the Big Picture of the M&S:

Among other activities, we need to develop:

- (1) appropriate M&S **curricula** and **degree programs**
- (2) effective professional **certification exams** for different types of simulationists at different levels of maturity
- (3) **maturity levels** of M&S establishments
- (4) **codes of a classification** system for M&S industry
- (5) enhance **perception** of M&S as a vital discipline (science, technology, market, . . .)

For these activities: A **comprehensive M&S Body of Knowledge (M&S BoK)** is needed.

Ways to See The Big Picture



Another way to see **The Big Picture:**

Periodic Table of Elements

Dmitri Mendeleev
1834-1907

Legend - click to find out more...

H - gas	Li - solid	Br - liquid	Tc - synthetic
Non-Metals	Transition Metals	Rare Earth Metals	Halogens
Alkali Metals	Alkali Earth Metals	Other Metals	Inert Elements

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A reference for a **comprehensive** and **integrative** view of M&S

- Ören, T.I. (2009-In Press). *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.

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Aspects of Reality

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Aspects of Reality: **Representation of . . .**

Tragic Comic Masks
Hadrians
Villa mosaic.
(Near Tivoli gardens,
Rome)

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Aspects of Reality: **Representation of . . .**

- Person** (English): **Personne** (French)
Human being, individual

Etymology

- Per **soma** (for the body)
- Possibly borrowed from Etruscan **phersu**, from Greek *prosōpa*, plural of *prosōpon* face, "mask"

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Aspects of Reality: **Representation of . . .**

Chinese Opera (Beijing Opera) Masks.

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Aspects of Reality: **Model versus reality**



Which one is "model?"

The **model** –for an artist– is what a simulationist would say **real system!**

Apollo and Daphne
Gian Lorenzo Bernini
(1598-1680)
Villa Borgese, Roma, Italy


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Aspects of Reality: **Pretention**

Getting travel information
(in a French travel agency)

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Aspects of Reality: **Illusion**




René Magritte
(1898-1967)
Belgian
Surrealiste

Ceci n'est pas une pipe.

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Aspects of Reality: **Illusion**



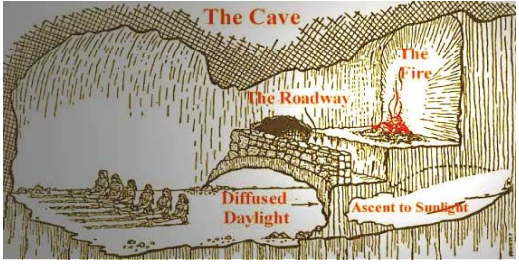
Stafford Beer
British
Cybernetician
1926-2006

From: HubbleSite
Image credit:
ESA & NASA
Acknowledgment:
E. Olszewski
(University of Arizona)

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Aspects of Reality: **Illusion**

Plato's (428/427 BC– 348/347 BC)
allegory (myth) of the cave:



The Cave

The Roadway

The Fire

Diffused Daylight

Ascent to Sunlight

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Aspects of Reality: **Illusion**

Plato's (428/427 BC– 348/347 BC)
allegory (myth) of the cave:

Currently,

- Movies
- Videos,

Applications of:

- Virtual reality
- Augmented reality

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Aspects of Reality: **Illusion**

Jean Baudrillard (1929–2007) (French post modernist)

- in *Simulation and Simulacra* articulates the principle of a fundamental rupture between modern and postmodern societies.
- For **Baudrillard**, *modern societies* are organized around the *production and consumption of commodities*,
- while *postmodern societies* are organized around *simulation* and the play of images and signs, denoting a situation in which codes, models, and signs are the organizing forms of a new social order where simulation rules.

<http://plato.stanford.edu/entries/ baudrillard/>
Stanford Encyclopedia of Philosophy

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According **Jean Baudrillard**,

- **postmodern societies** are organized around “simulation” by which he means the cultural modes of representation that “simulate” reality as in television, computer cyberspace, and virtual reality.

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Aspects of Reality: **Imitation**

- False appearance
- Counterfeit

Examples:

- Simulated leather
- Simulated pearl

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Aspects of Reality: **Perception, Anticipation**

The way we perceive reality affect our emotions, decisions, and our actions.


- Halo effect

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Reality/model dichotomy depends on the purpose:

Artist:	Reality (or a model): a source of inspiration.
Engineer:	A design (or a model): an instrument to engineer a system. A model: a basis to control a system.
Scientist:	A model: a representation to understand a system.
Decision m.:	A model: a substitute of reality to perform experiments.
Education:	A model: a representation to explain/teach.
Training:	A representation of a system: provides experience to enhance 3 types of skills: <i>motor skills</i> (simulators), <i>decision making skills</i> (virtual simulation), <i>operational skills</i> (live simulation).
Entertainment:	A representation of a system: provides experience for entertainment.
Pretence, representation:	We are often exposed to (simulated reality), in postmodern societies (Jean Baudrillard).

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 Concepts related with “similitude”:
(from Ören’s web site of M&S BoK)
<http://www.site.uottawa.ca/~oren/MSBOK/MSBOK-index.htm>

Analog, analogic, analogical, analogous, analogy
Assimilate (v), assimilated, assimilation
Autosimulation, autosimulative
Bisimilar, bisimulate (v), bisimulation
Comparable, comparable, comparative, compare (v), comparison
Congruence, congruent, congruity, congruous
Copy, copy (v)
Cosimulation, cosimulative
Differentiate (v), Differentiated, differentiation
Dissimilar, dissimilarity, dissimulation, dissimilator, dissimilatory, dissimilitude, dissimulate (v), dissimulated, dissimulating, dissimulation, dissimulater
Emulate (v), emulated, emulating, emulation, emulative, emulator
Endomorph, endomorphic, endomorphism

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Concepts related with "similitude":

Homology, homomorph, homomorphie, homomorphism, homomorphous, homothetic, homothetism, homothety
Imitate (v), imitation, imitative
Isomorph, isomorphic, isomorphism
Like, likeness
metasimulation, multisimulation, nonsimulatable
Replica
Resemblance, resemble (v), resembling
Self-similar, self-similarity
Similar, similarity, similitude
Simulacra, simulacra, simulacrum
Simuland
Simulatable, simulate (v), simulated, simulating, simulation, simulationist, simulative, simulator

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Perceptions of M&S from different perspectives*

* To be able to explore M&S from a wider paradigm

• Purpose of use
• Problem to be solved
• Connectivity of operations
• Types of knowledge processing
• Philosophy of science

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Three purposes of use of M&S

Perform experiments for:	<i>Simulation</i>
Decision support	
Understanding	
Education	
Provide experience (under controlled conditions) for:	
Training (for gaining/enhancing competence):	
- motor skills	<i>Virtual simulation</i>
- decision and/or communication skills	<i>Constructive simulation (Serious game)</i>
- operational skills	<i>Live simulation</i>
Entertainment	<i>Gaming simulation</i>
Imitation, pretence	<i>Representation, fake</i>

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Use of simulation for decision support:

<i>Prediction of behavior and/or performance of the system of interest within the constraints inherent in the simulation model (e. g., its granularity) and the experimental conditions</i>
<i>Evaluation of alternative models, parameters, experimental and/or operating conditions on model behavior or performance</i>
<i>Sensitivity analysis of behavior or performance of the system of interest based on granularities of different models, parameters, experimental and/or operating conditions</i>
<i>Evaluation of behavior and/or performance of engineering designs</i>
<i>Virtual prototyping</i>
<i>Testing</i>
<i>Planning</i>
<i>Acquisition (or simulation-based acquisition)</i>
<i>Proof of concept</i>

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Problem to be solved:

M&S is an infrastructure to support real-world activities.

From this perspective, simulation is perceived as not being the "real thing".

This attitude is well documented in STRICOM's (Simulation, Training & Instrumentation Command) motto: "All but war is simulation."

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Connectivity of Operations of simulation and the system of interest :

Not connected
Standalone simulation
Interwoven – Integrated simulation (symbiotic simulation)
<i>To enrich real system's operation</i> (The system of interest and the simulation program operate simultaneously)
• online diagnostics (or simulation-based diagnostics)
• simulation-based augmented/enhanced reality operation (for training to gain/enhance motor skills and related decision making skills) (AI airplane in a dogfight training with real aircrafts)
<i>To support real system operations</i> (The system of interest and the simulation program operate alternately to provide predictive displays)
• parallel experiments while system is running

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Types of knowledge processing :

M&S is:

a computational activity
a systemic activity & system theory-based activity
a model-based activity
a knowledge-generation activity

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Types of knowledge processing :

M&S as a Computational Activity

Definitions (Limitations ?)

USA DoD: “The **execution** over time of **models**.”

NATO MP: “The **execution** over time of **models** representing the attributes of one or more entities or processes.”

Canada-SECO: “A simulation is the **implementation** of a **model** over time.”

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Types of knowledge processing :

M&S as a Systemic Activity & System Theory-Based Activity

System theoretic-**robust** approaches for

- modeling and
- symbolic model processing
 - DEVS
 - GEST (1971) – first system-theory-based declarative language for continuous systems

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Types of knowledge processing :

M&S as a Model-Based Activity: Some advantages

1. Efficiency in Computerization
2. Reliability
3. Reusability and Composability
4. Interoperability

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Types of knowledge processing :

M&S as a Model-Based Activity: Some advantages

1. Efficiency in Computerization

- **Model bases** (or model repositories) may contain model specifications that can easily be converted into programs. Hence, *programming aspect* can and should be *fully automated*.
- This aspect also *eliminates programming errors* and contributes to the reliability of the computerization of models.

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Types of knowledge processing :

M&S as a Model-Based Activity: Some advantages

2. Reliability

- Models can easily be read and **understood** by specialists in the field assuring model reliability.
- Model specifications can be checked by specialized software as well as manually for *consistency*, *completeness*, and *correctness*. This aspect is definitely superior to traditional V&V techniques that work on code only and can be the basis for **built-in reliability** in M&S studies.

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Types of knowledge processing :

M&S as a Model-Based Activity: Some advantages

3. Reusability and Composability

- Model specifications can easily be modified for **model reusability** as well as **model composition**.
- Some of the **model composability** techniques can be **dynamically** applicable for systems that not only have dynamic behavior but also *can and should be modified dynamically as the simulation evolves*.

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Types of knowledge processing:

M&S as a Model-Based Activity: Some advantages

4. Interoperability

- It is highly desirable to check **interoperability of model specifications** rather than the codes of models.
- Executability of code does not necessarily signify its **semantic interoperability**.

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Types of knowledge processing :

M&S as a Model-Based Activity

1. Model building

- modeling
- model composition (and dynamic model composition)

2. Model-base management

- model search, semantic model search
- **model integrity**

3. Parameter base management

4. Model processing

- **model analysis**
 - model characterization (*descriptive* model analysis)
 - model evaluation (*evaluative* model analysis)
- model transformation
- behavior generation

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Types of knowledge processing :

Descriptive Model Analysis (**Model characterization**) for:

model comprehensibility

- model documentation
 - static model documentation
 - dynamic model documentation
- model ventilation (to examine its assumptions, deficiencies, limitations, etc.)

model usability

- model referability
- model-based management
- model integrity
- model composability

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Types of knowledge processing :

Model Evaluation (evaluative model analysis) with respect to:

- modeling formalisms
- another model (model comparison)
- real system
- goal of study

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Types of knowledge processing :

Model Evaluation wrt modeling formalisms

- consistency of model representation
 - **static structure** of
 - component models
 - total system (coupled model, model of system of systems)
 - **dynamic structure**
 - state transitions, output function(s)
 - structural change
 - dynamic coupling
 - model robustness

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Types of knowledge processing :

Model comparison

- **structural** model comparison
 - model *verification* (comparison of a computerized model and corresponding conceptual model)
 - *checking*
 - model homomorphism, model isomorphism
 - model equivalencing for:
 - any two models
 - a simplified and original model
 - an elaborated and original model
- **behavioral** model comparison (comparison of behaviors of several models within a given scenario)

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Types of knowledge processing :

Model Evaluation wrt real system

- model *qualification*
 - model *realism* (model veracity, model verisimilitude)
 - adequacy of model structure
 - static structure (relevant variables, interface of models)
 - dynamic structure
 - adequacy of model constants and parameters
 - model identification, model fitting, model calibration*
 - model *correctness* analysis
 - dimensional analysis
- model *validity*

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Types of knowledge processing :

Types of model validity

Absolute validity	Gradual validity	Predictive model validity
Conceptual validity	Historical validity	Replicative validity
Convergent validity	Historical-data validity	Statistical validity
Cross validity	Hypothesis validity	Strict validity
Cross-model validity	Internal validity	Structural validity
Data validity	Logical validity	Structural model validity
Dynamic validity	Model validity	Submodel validity
Empirical validity	Multistage validity	Technical validity
Event validity	Operational validity	Theoretical validity
Experimental validity	Parameter validity	Time-series validity
External validity	Partial validity	Validity
Face validity	Predictive validity	Variable validity
Full validity		

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Types of knowledge processing :

Model Evaluation wrt goal of the study

- model *relevance*
 - domain of intended application(s) (appropriate use of a model)
 - range of applicability of a model
- acceptability of a model with respect to its technical system specification

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Types of knowledge processing :

M&S as a Model-Based Activity

1. Model building
 - modeling
 - model synthesis
 - model composition (and dynamic model composition)
2. Model-base management
 - model search
 - semantic model search
 - model integrity
3. Model processing
 - model analysis
 - model characterization (descriptive model analysis)
 - model evaluation (evaluative model analysis)
 - **model transformation**
 - **behavior generation** (generation of behavior of model)

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Types of knowledge processing :

M&S as a Model-Based Activity

Types of model transformation

- Model copying
- Model reduction
- Model pruning
- Model simplification
 - Structural model simplification
 - Behavioral model simplification
- Model elaboration
- Model isomorphism
- Model homomorphism
- Model endomorphism

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Types of knowledge processing :

M&S as a Model-Based Activity

3. **Model processing: Types of model behavior**

- *point behavior*
 - computation
 - optimization
 - search
- *trajectory behavior*
 - simulators
 - simulation
 - intermittent simulation
 - optimizing simulation
 - gaming simulation
- *structural behavior*
 - growth systems
 - Lindenmeyer systems (L-systems)
- **mixed trajectory and structural behavior**

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Types of knowledge processing :

M&S as a Model-Based Activity

3. **Model processing:** behavior generation by

- numerical techniques
- non-numerical techniques
 - by symbolic techniques
 - by analogical techniques
- mixed numerical and symbolic techniques

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Types of knowledge processing :

M&S as a Knowledge-Generation Activity

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Types of knowledge processing :

Advanced simulation environments:

- combine modeling, model processing, behavior generation, and other types of knowledge processing:
 - integrated use of M&S with optimization, AI, and software agents.
- combination of simulation systems with *sensors* and *effectors*.
- Combination of several types of knowledge processing: soft computing, cognitive & emotive computing.

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Perception of M&S from different perspectives

Philosophy of science

Simulation supports and enriches modern scientific thinking [Francis Bacon (Novum Organon, 1620)]

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Perception of M&S from different perspectives:

Purpose of use	<ul style="list-style-type: none"> • Perform experiments for: Decision support, Understanding, Education • Provide experience for: Training, Entertainment • Imitation (fake)
Problem to be solved	<ul style="list-style-type: none"> • Black box perception (M&S is an infrastructure to support real-world activities)
Connectivity of operations	<ul style="list-style-type: none"> • Standalone simulation • Integrated simulation (symbiotic simulation)
Types of knowledge processing	<ul style="list-style-type: none"> • Computational activity (execution of models . . .) • Systemic activity • Model-based activity • Knowledge generation activity
Philosophy of science	<ul style="list-style-type: none"> • Simulation supports and enriches modern scientific thinking [Francis Bacon (Novum Organon, 1620)]

Another testimony to the richness of M&S discipline:



1st version:
 Over 4000 terms
 With collaboration of 15 scientists
 Published in 2006
 At Université Paul Cézanne, Marseilles
 Sponsors: CNRS, I³, LSIS

M&S dictionary project:
http://www.site.uottawa.ca/~oren/SCS_MSNet/simDic.htm

Systematic M&S dictionary project:

http://www.site.uottawa.ca/~oren/SCS_MSNet/simDic.htm

2nd version:
 Over 8800 terms
 English-French-Italian-Spanish-Turkish
 With collaboration of 80 scientists
 To be published in 2010

Systematic M&S dictionary project:

An example: over 150 types of "error"

absolute error ethical error programming error
 acceptance error experimental error projection error
 accidental error experimentation error propagated error
 accumulation error extrapolation error proportional error
 acknowledge error fatal error quadratic error
 algorithm error fixed error random error
 algorithmic error fractional error read error
 ambiguity error frequency error reasoning error
 analysis error gain error rejection error
 angular error global error relative error
 approximation error global integration error representation error

From: Ören, T.I. and L. Yilmaz (2009-In Press). Failure Avoidance in Agent-Directed Simulation: Beyond Conventional V&V and QA. In L. Yilmaz and T.I. Ören (eds.), Agent-Directed Simulation and Systems Engineering, Systems Engineering Series, Wiley-Berlin, Germany.

M&S Body of Knowledge:

Modeling and Simulation Body of Knowledge (M&SBOK)

The M&SBOK is being developed under the auspices of The Society for Modeling and Simulation International (SCS)

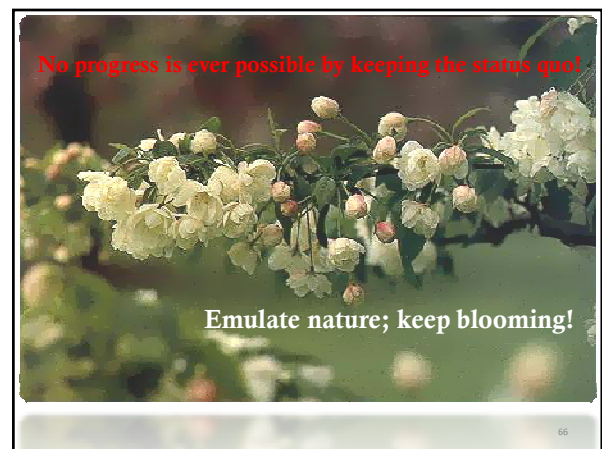
Draft Version 7d
 updated and © by: Dr. **Tuncer Ören** - 2009-07-03 (yyyy-mm-dd)

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

Index

Part 1. **Background:** Preliminary, Introduction, Terminology, Comprehensive View
 Part 2. **M&SBOK:** Core Areas, Supporting Domains, Mutual Contributions
 Part 3. **References:** M&S Portals, References by Authors, References by Topics

<http://www.site.uottawa.ca/~oren/MSBOK/MSBOK-index.htm>



Challenges for the discipline

Technology is based on science; however, science does not need to be bounded by technology (even though its implementation may benefit from appropriate technological maturity).

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Technological advances are easier to achieve.

The most difficult inertia to overcome is the mental inertia (especially of people with bounded vision).

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Publications, Presentations and Other Activities of Dr. Tuncer Ören on Modeling and Simulation: Normative Views for Advancements and Advanced Methodologies
updated: 2010-01-04

Also see:

- Some Citations about the Scientific Work of Tuncer Ören on advancing: [simulation methodology](#), [modelling methodology](#)
- [Agent-Directed Simulation](#)
- [AI and Simulations](#)
- [Cognitive and Emotive Simulations](#): (Personality, Perception, Anticipation, Emotions)
- [Ethics](#) in simulation and
- [Understanding](#) in simulation

	1970s	1980s	1990s	2000s	2010s	total
Publications	14	28	16	51	1	110
Presentations & other activities	8	28	13	13		62
total	22	56	29	63	1	172

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Last two studies to advance M&S

- Dr. Levent Yilmaz et al. – WSC’08:
- Dr. Andreas Tolk et al. – SCSC’09:

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Certification of

- **Individual (professional) simulationists**
 - Currently done by NTSA
 - Could/should be more universal and be a requirement to be hired as a simulationist; as well as employing professional simulationists to get serious M&S contracts.

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Certification of

- **Simulation companies**
 - After development of maturity levels (similar to SEI maturity levels)
 - Also should become a requirement for getting serious M&S contracts.

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Consider the parallel between history and evolution of *simulation, professional engineering, and dentistry*

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History and evolution of *dentistry*

<http://cudental.creighton.edu/htm/history2001.pdf>

- At the onset of the Middle Ages, the **monks** became physicians and **dentists**. **Barbers** had acted as **assistants to the monks**.
- When the pope in **1163** ruled that any operation involving the shedding of blood was incompatible with the priestly office, the **barber took over the practice of Surgery**.
- The barber surgeons were not the only ones doing extractions, another group made up of **Vagabonds** were known as tooth drawers. They plied their trade in public squares.

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History and evolution of *dentistry*

<http://cudental.creighton.edu/htm/history2001.pdf>

- For awhile then, dentistry was carried on by **barber-surgeons** both in France and England.
- However, **in France in 1700** anyone desiring to practice oral surgery and restorative dentistry **had to take a regular prescribed examination**.

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History and evolution of *dentistry*

Two questions:

- Wasn't it good that dentistry became a profession to be carried out only by **professional** dentists?

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History and evolution of *dentistry*

Two questions:

- Wasn't it good that dentistry became a profession to be carried out only by professional dentists?
- Wouldn't it be good that M&S-related projects are carried out by certified M&S professionals?

If you don't think positively, please remember the **revolting luddites*** in England at the beginning of the Industrial revolution.

* - any opponent of technological progress
- one of the 19th century English workmen who destroyed laborsaving machinery that they thought would cause unemployment

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Assure **integrity** and **trustworthiness** of modeling and simulation

- Promote **acceptance** (and **adherence**) of **Code of Ethics**
 - By **Associations / Groups**
 - By **individuals** (all professional simulationists)
 - As a requirement of certification as professional simulationists (NTSA)
 - By **companies**
 - As a requirement of certification as professional simulation organizations (by ?)

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Assure **integrity** and **trustworthiness** of modeling and simulation

- SCS **Ethics** : <http://www.scs.org/ethics/>

The Code has been adopted by (In order of adoption)
[SCS](#) - Society for Modeling and Simulation International ([Resolution](#))
[MISS](#) - Mcleod Institute of Simulation Sciences ([Resolution](#)) ([MISS Centers](#))
[M&SNet](#) - McLeod Modeling and Simulation Network ([Resolution](#)) ([Member Organizations](#))
[SISO](#) - Simulation Interoperability Standards Organization ([Resolution](#))
[SISO Canada](#) ([Resolution](#))
[AMSC](#) - Alabama Modeling and Simulation Council ([Resolution](#))
[Ottawa Student Chapter](#) of the SCS
[NMSG](#) - NATO Modeling and Simulation Group ([Resolution](#))
[DLM](#) - ([Resolution](#)) ([Members](#))
[CMSP](#) - Certification of Modeling and Simulation Professionals.
 By the [M&SPCC](#) (Modeling and Simulation Professional Certification Commission)
[METU Student Chapter](#) of the SCS
[Meteksan](#) - Meteksan Defense Industry Inc. ([Meteksan Savunma Sanayii A.Ş.](#) - in Turkish)
 Riga student Chapter of SCS

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Assure **integrity** and **trustworthiness** of modeling and simulation

Consider* **Failure Avoidance** in M&S especially in ADS (Agent-directed simulation) as a superset of V&V & QA.

Ören, T.I. and I. Yilmaz (2009-In Press). *Failure Avoidance in Agent-Directed Simulation: Beyond Conventional V&V and QA*. In L. Yilmaz and T.I. Ören (eds.). Agent-Directed Simulation and Systems Engineering. Systems Engineering Series, Wiley-Berlin, Germany.

* **Alternative is to stay at the North Pole!**

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