China - September 2011

Beijing: Beihang University, School of Automation and Electrical Eng.

Changsha: National Univ. of Defense Technology, System Simulation Lab.

Future of Modeling and Simulation:

Normative Views, Desirable Growth Areas & Challenges

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The Aims:

- **To develop a framework** to elaborate on –in a *systematic* manner–the desirable growth areas and challenges for the future of modeling and simulation; &
- **to start populating this framework**

Some references (1/3)

Future Modelling and Simulation Challenges.
Papers presented at the RTO NATO Modelling and Simulation Group (NMSG) Conference held in Breda, Netherlands, 12-14 November 2001.

Some references (2/3)

Grand Challenges for Modelling and Simulation

Organizers:

R. Fujimoto, W.H. Lunceford, E. H. Page, A. Uhrmacher

August 25-30, 2002, Seminar 02351

Dagstuhl-Seminar-Report 350

Some references (3/3)

- The **5th** International Conference on Grand Challenges in Modeling and Simulation (GCMS2012), Part of SummerSim2012, Genoa, **Italy**, July 8-11, **2012,**
- *Grand Challenges in Modeling & Simulation.* Part of the **2011** Summer Simulation Multiconference (SummerSim 2011), June 27-30, 2011, The Hague, The Netherlands
- *Grand Challenges in Modeling & Simulation*, Part of the **2010** Summer Simulation Multiconference (SummerSim 2010,) Program
- **2009** Conference on Grand Challenges in Modeling and Simulation (GCMS'09), Part of the 2009 Summer Simulation Multiconference (SummerSim'09)
- Grand Challenges in Modeling & Simulation **2008** (GCMS'08) Part of the 2008 Summer Simulation Multiconference (SummerSim'08), Edinburgh, Scotland.

Publications, Presentations and Other Activities of Dr. Tuncer Ören on

Modeling and Simulation:

Normative Views for Advancement and Advanced Methodologies

updated: 2011-08-25

	1970s	1980s	1990s	2000s	2010s	total
Publications	14	28	16	51	5	114
Presentations & other activities	8	28	13	13	2	64
total	22	56	29	63	7	178

http://www.site.uottawa.ca/~oren/pubsList/MS-advanced.pdf

An article based on this presentation will be submitted to the:

International Journal of Modeling, Simulation, and Scientific Computing (of the Chinese Association for System Simulation - CASS) by the World Scientific Publishing Co. China.

"Until we attempt to simulate a system, we don't realize *how little* we know about it."

Donald Knuth

Anytime a phenomenon is explained,
I remember this quote,
to realize how deep and detailed
the information is; *or is not*.

Simulation requires detailed knowledge; much more than knowledge sufficient to talk about a topic, or an issue.

To be in a position to elaborate on:

Future of Modeling and Simulation:

Normative Views, Desirable **Growth Areas** & **Challenges**

It is imperative that
(1) we have a comprehensive view of M&S &
(2) to develop an appropriate framework for elaboration

For comprehensive view & several aspects of M&S, see:

Ören, T.I. (**2011**). A Basis for a Modeling and Simulation Body of Knowledge Index: Professionalism, Stakeholders, Big Picture, and Other BoKs. SCS M&S Magazine, 2:1 (Jan.).

Ören, T.I. (**2010**). Simulation and Reality: The Big Picture. (Invited paper for the inaugural issue) International Journal of Modeling, Simulation, and Scientific Computing (IJMSSC) (of the Chinese Association for System Simulation - CASS) by the World Scientific Publishing Co. China, Vol. 1, No. 1, 1-25.
DOI: http://dx.doi.org/10.1142/S1793962310000079

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.

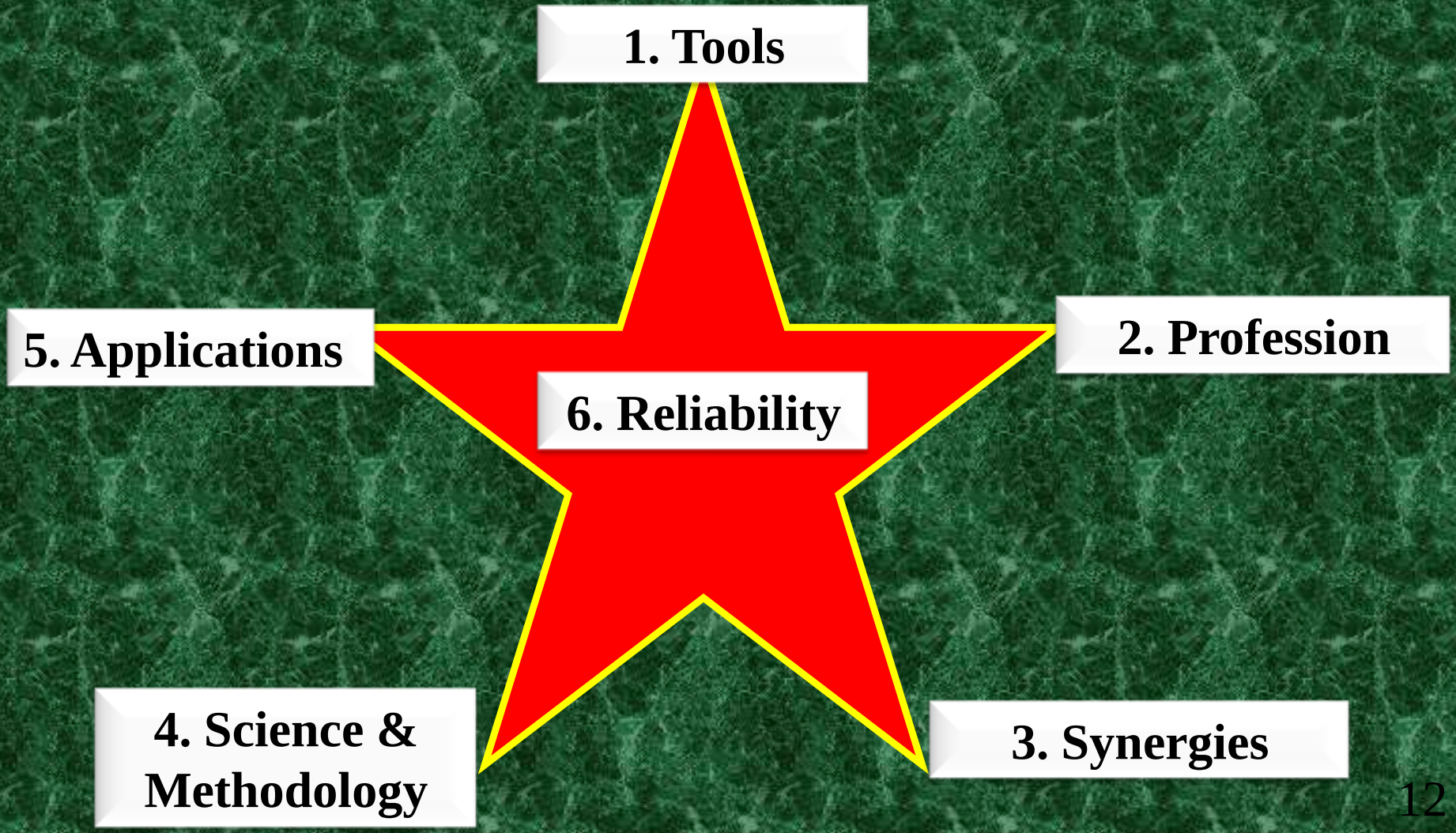
Our arguments can *start* with:
Experiments and **experience**
are the essence of modeling & simulation (M&S)

- Simulation is performing goal-directed **experiments** using a model of a dynamic system.

- Simulation is gaining **experience**,
  by use of a representation of a system,
  - ***to enhance*** any one of three types of **skills**:
    -- *motor skills* (by virtual simulation, or simulators),
    -- *decision making and communication skills*
    (by constructive simulation, gaming simulation),
    -- *operational skills* (by live simulation)
  - *for* ***entertainment*** purposes (simulation games)

A framework for: Future of Modeling and Simulation:
Normative Views, Desirable Growth Areas & ***Challenges***

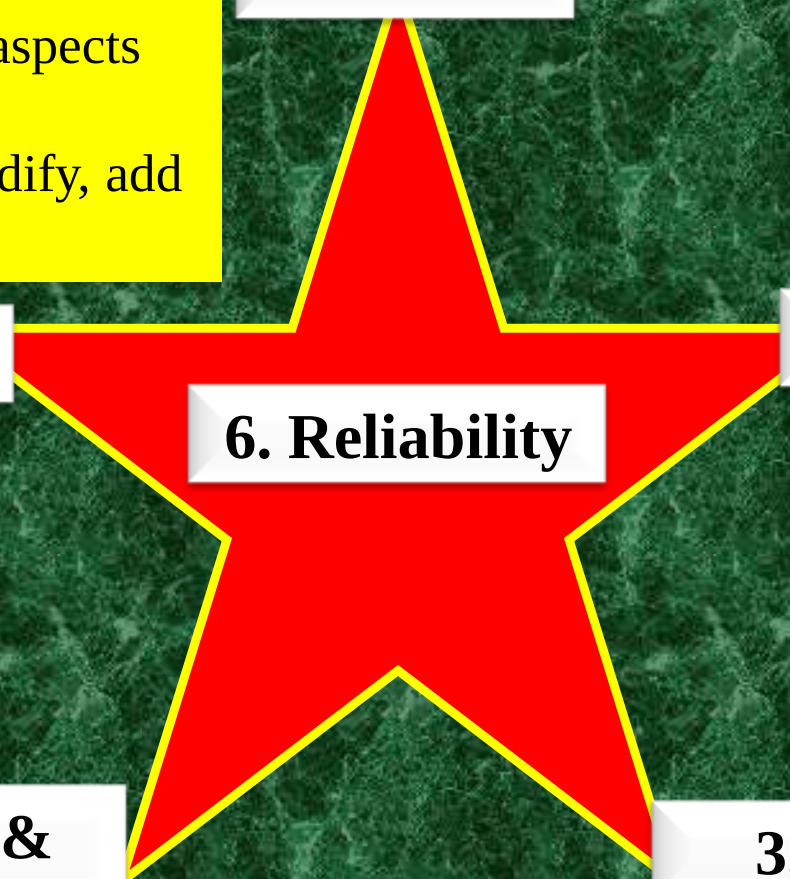
for **six aspects** of **M&S**



A framework for: Future of Modeling and Simulation: *Normative Views, Desirable Growth Areas* & ***Challenges*** for **six aspects** of **M&S**

Advantages of this **systematic approach:**

1. *Elaboration* on the aspects (change, add) &
2. For each aspect, modify, add other *challenges*



1. Tools

2. Profession

3. Synergies

4. Science & Methodology

5. Applications

6. Reliability

Six aspects of M&S

1

- M&S within the spectrum of **tools**
- M&S profession
- Synergies of simulation with some disciplines
- Science & Methodology
- Applications
- Reliability

He that would perfect his work must first sharpen his tools.

Confucius, 551-479 BC

M&S from the **Tool Hierarchy:**

Levels	Types of tools		
	Physical tools	Software tools	M&S tools
Manual tools			
	Additional features		
Power tools			
	Additional features		
Cybernetic tools			

Level	Physical tools	Software tools	M&S tools
Manual tools	• stone tools • metallic tools • …	• hand-coded programs • non-automated documentation (including specification & processing of requirements)	• **hand-coded M&S programs (simulation is an art / craft era)**

Level	Physical tools	Software tools	M&S tools
Manual tools	• stone tools • metallic tools • …	• hand-coded programs • non-automated documentation	• hand-coded M&S programs (simulation is an art / craft era)
Additional features	• ***(Energy)*** **Ability to perform work**	• *Computer-aided* programming • *Computer-support* in software life cycle	• *Computer-aided* M&S programming • *Computer support* in M&S (in areas other than model behavior generation)
Power tools	• simple power tools • machine tools • integrated machines (transfer machines)	• software tools • software tool kits • software environments • integrated computer-aided software engineering tools	• M&S tools (e.g., program generators, symbolic processors of models & other M&S components) • M&S tool kits • M&S environments • integrated environments for M&S • computer-aided design and/or problem solving environments with simulation abilities

Level	Physical tools	Software tools	M&S tools
Manual tools	• stone tools • metallic tools • …	• hand-coded programs • non-automated documentation	• hand-coded M&S programs (simulation is an art / craft era)
Additional features	• (***Energy***) Ability to perform work	• *Computer-aided* programming • *Computer-support* in software life cycle	• *Computer-aided* M&S programming • *Computer support* in M&S (in areas other than model behavior generation)
Power tools	• simple power tools • machine tools • integrated machines (transfer machines)	• software tools • software tool kits • software environments • integrated computer-aided software engineering tools	• M&S tools (e.g., program generators, symbolic processors of models & other M&S components) • M&S tool kits •.M&S environments • integrated environments for M&S • computer-aided design and/or problem solving environments with sim. abilities
Additional features	• ***Knowledge processing***	• ***Advanced*** *knowledge processing* ability - Artificial Intelligence (**AI**), Software **agents**	
Cybernetic tools	**Knowledge processing (kp) machines** • Machines for kp: Computers • Machines with kp abilities (smart machines)	• AI in software • AI in software environments	AI-directed simulation • Simulation of intelligent entities • AI for simulation - AI- supported simulation - AI-based simulation
		• Agents in software • Agents in software environments	Agent-directed simulation • Simulation for agents: - agent simulation • Agents for simulation: - agent- supported simulation - agent- based simulation

AI-directed simulation

- Simulation of intelligent entities
- AI for simulation
  - AI- supported simulation
  - AI-based simulation

Soft computing-directed simulation

Publications, Presentations and Other Activities of Dr. Tuncer Ören on:
Simulation, Artificial Intelligence and Cybernetics

Agent-directed simulation

- Simulation for agents:
  - agent simulation
- Agents for simulation:
  - agent-supported simulation
  - agent-based simulation

Also in synergies of M&S with software agents

Challenge:

- Simulation-based problem solving environments

- Simulation-based Computer-aided design (CAD)
- Simulation-based (several types of) engineering
- Simulation-based science
- Simulation-based education
- Simulation-based social science
- Simulation-based training:
  for conflict management

Six aspects of M&S

2

- M&S within the spectrum of tools
- M&S **profession**
- Synergies of simulation with some disciplines
- Science & Methodology
- Applications
- Reliability

List of Modeling and Simulation (M&S)
Associations/Organizations/Committees (105)
Centers/Groups (34)
Military Organizations (27)

http://www.site.uottawa.ca/~oren/links-MS-AG.htm

List of Modeling and Simulation (M&S) Associations/Organizations/Committees

INDEX

As a testimony of high level recognition of M&S see (In chronological order):

- USA – House Resolution 487 (2007 July 16)
- USA – Enhancing SIMULATION (Safety In Medicine Utilizing Leading Advanced Simulation Technologies to Improve Outcomes Now) Act of 2009 – H.R. 855/S. 616 (2009 February 4)
- USA – A companion bill – S. 616 (2009 March 17

Associations/Organizations/Committees

High Level Recognition of M&S (1)

- US Congressional Modeling and Simulation Caucus (News) (Congressman J. Randy Forbes)

Networking of Professional Organizations (20)

- MSLS - M&S leadership Summit
- SimSummit
- G.A.M.E.S. Synergy Summit (**G**overnment, **A**cademic, **M**ilitary, **E**ntertainment and **S**imulation)

List of Modeling and Simulation (M&S) Associations/Organizations/Committees

Associations - International (26)

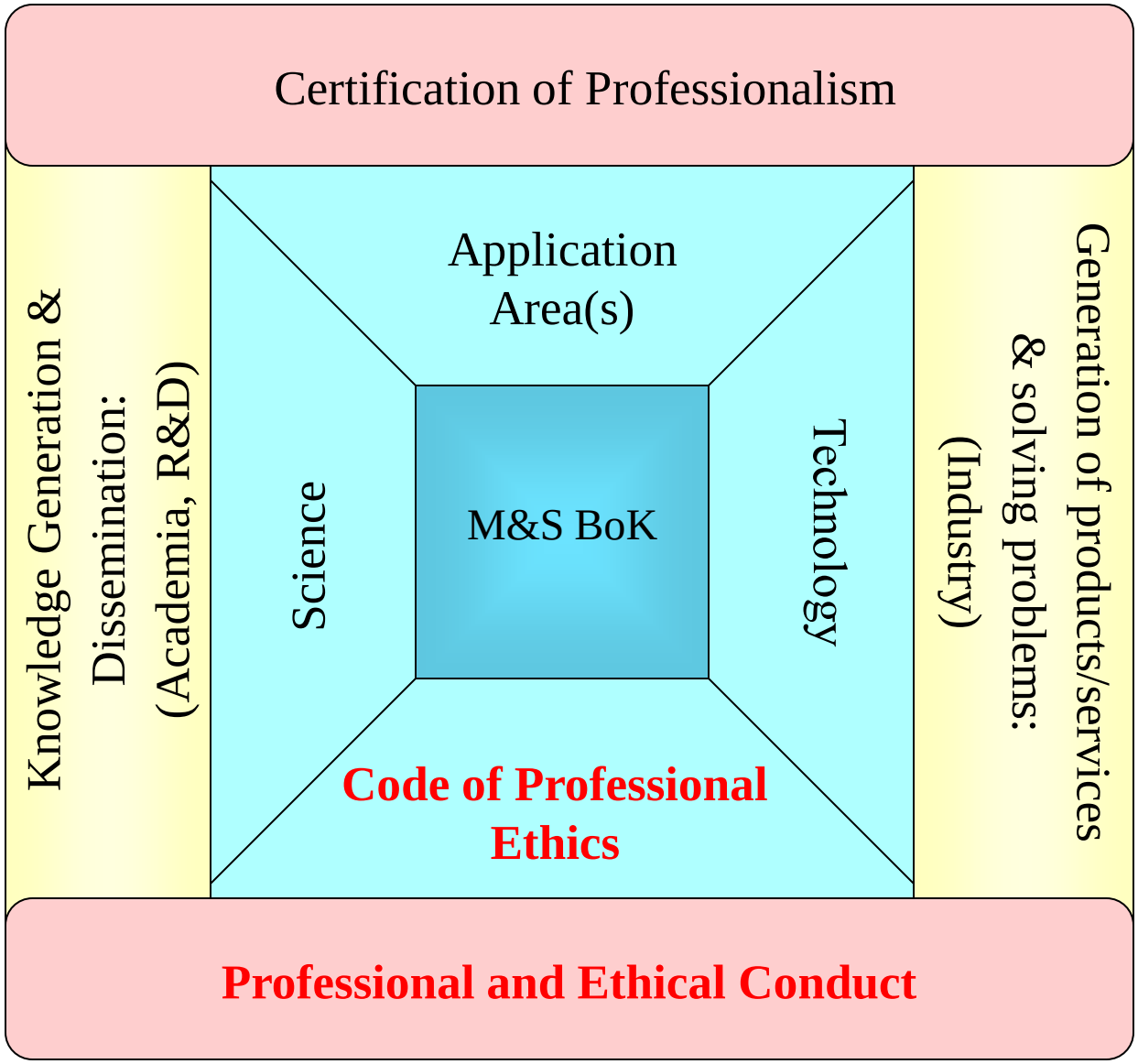
- ABSEL - Association for Business Simulation and Experiential Learning
- ACM SIGSIM - ACM Special Interest Group on Simulation
- AIS SIGMAS - Association for Information Systems Special Interest Group on Modeling and Simulation
- AMSE - Association for the Advancement of Modelling and Simulation Techniques in Enterprises
- ANGILS - Alliance for New Generation Interactive Leisure and Simulation
- DIGRA - Digital Games Research Association
- EBEA - The Economics and Business Education Association
- ESRC SAGE - Simulating Social Policy for an Ageing Society
- IASTED - International Association of Science and Technology for Development
- IBPSA - International Building Performance Simulation Association
- IFIP TC7 WG7.1 - Modelling and Simulation Working Group of the Technical Committee TC 7 (System Modelling and Optimization) of IFIP (International Federation for Information Processing)
- IGDA - International Game Developers Association
- IMA - International Microsimulation Association (a.k.a. microanalytic simulation)
- IMACS - International Association for Mathematics and Computers in Simulation
- INACSL - International Nursing Association for Clinical Simulation and Learning
- INFORMS Simulation Society
- ISAGA - International Simulation and Gaming Association (affiliated regional gaming & simulation associations can be seen at ISAGA)
- M&SPCC - Modeling and Simulation Professional Certification Commission
- Modelica - Modelica Association
- SAE - Human Biomechanics and Simulation Standardization Committee
- SAGSET - The Society for the Advancement of Games and Simulations in Education and Training
- SCS - Society for Modeling & Simulation International (Formerly Society for Computer Simulation) (Ethics, M&SNet, MISS)
- SGI - Serious Games Initiative
- SSAISB - Society for the Study of Artificial Intelligence and the Simulation of Behaviour
- SSH - Society in for Simulation in Healthcare

List of Modeling and Simulation (M&S) Associations/Organizations/Committees

Associations/Groups/Committees - by Country (38)

- Australia: OzSAGA - Australian Simulation and Games Association
- Australia: SIAA - Simulation Industry Association of Australia
- Bulgaria: Bulsim - Bulgarian Modeling and Simulation Association
- China: CASS - Chinese Association of System Simulation
- China: SASS - Shanghai Association for System Simulation (In Chinese)
- Croatia: CROSSIM - Croatian Society for Simulation Modelling
- Denmark: DKSIM - Dansk Simuleringsforening (Danish Simulation Society)
- Finland: FinSim - Finnish Simulation Forum
- France: CNRS-GdR MACS - Groupe de Recherche "Modelisation, Analyse et Conduite des Systemes dynamiques" de CNRS
- France: VerSim - Vers une théorie de la Simulation
- Hungary: HSS - Hungarian Simulation Society
- India: C-MMACS - Indian Society for Mathematical Modeling and Computer Simulation
- Italy: ISCS - Italian Society for Computer Simulation
- Italy: Liophant Simulation
- Italy: MIMOS (Italian Movement for Modeling and Simulation)
- Italy: Simulation Team
- Japan: JASAG - Japan Association of Simulation and Gaming
- Japan: JSST - Japan Society for Simulation Technology
- Korea: KSS - The Korea Society for Simulation (in Korean)
- Latvia: LSS - Latvian Simulation Society
- Norway: NFA - Norsk Forening for Automatisering
- Poland: PSCS - Polish Society for Computer Simulation (in Polish)
- Romania: ROMSIM - Romanian Society for Modelling and Simulation
- Singapore: SSAGSg - Society of Simulation and Gaming of Singapore
- Slovenia: SLOSIM - Slovenian Society for Modelling and Simulation
- Spain: AES - Spanish Simulation Society (Asociación Española de Simulación)
- Spain: CEA SMSG Spanish Modelling and Simulation Group
- Sweden: MoSis - The Society for Modelling and Simulation in Sweden
- UK: NAMS - National Association of Medical Simulators
- UK: UKSIM - United Kingdom Simulation Society
- USA: AIAA (American Institute of Aeronautics and Astronautics) M&S Technical Committee

Aspects of Professionalism in M&S:



1. Knowledge:

To solve problems:

- M&S BoK
- Science
- Technology
- Application Area(s)

How to behave *as a simulationist*

- Code of Professional Ethics

2. Activities:

- Knowledge Generation and Dissemination: (Academia, R&D)
- Generation of products /services & solving problems (Industry)

3. **Monitoring**:

- Professional and Ethical Conduct
- Certification of Professionalism

Knowledge - **Challenges**

- Finalize a universally accepted M&S BoK Index
- Develop practice of maturity levels of individuals and companies similar to the one in software engineering
- Develop universal M&S curricula
- Continue establishment of graduate degrees in M&S with specializations in different application areas
- Job Categorization

Knowledge - **Challenges**

- Develop simulation systems engineering (also for social systems)

- Consider use of simulation (simulators) for pilot training;

& remember that most social systems –even though somehow more resilient– are much more complex.

- Decision skills can be enhanced by simulation-based experiences.

Hence, simulation-based decision in complex social systems can be beneficial in the education.

Six aspects of **M&S**

3

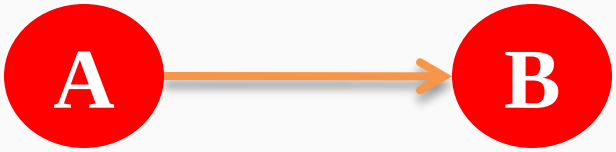
- M&S within the spectrum of tools
- M&S profession
- **Synergies** of simulation with some disciplines
- Science & Methodology
- Applications
- Reliability

Synergies of simulation with some disciplines

Synergies between 2 entities A & B can be:

- **First order synergy:**

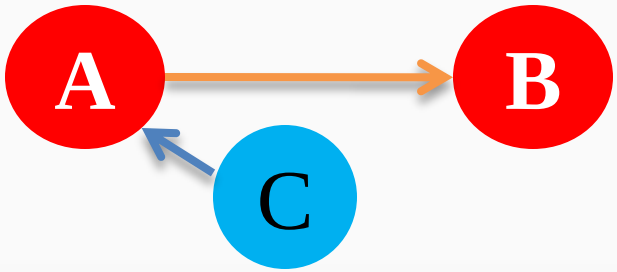
  Direct contributions between them



B is enhanced due to contributions of A to B

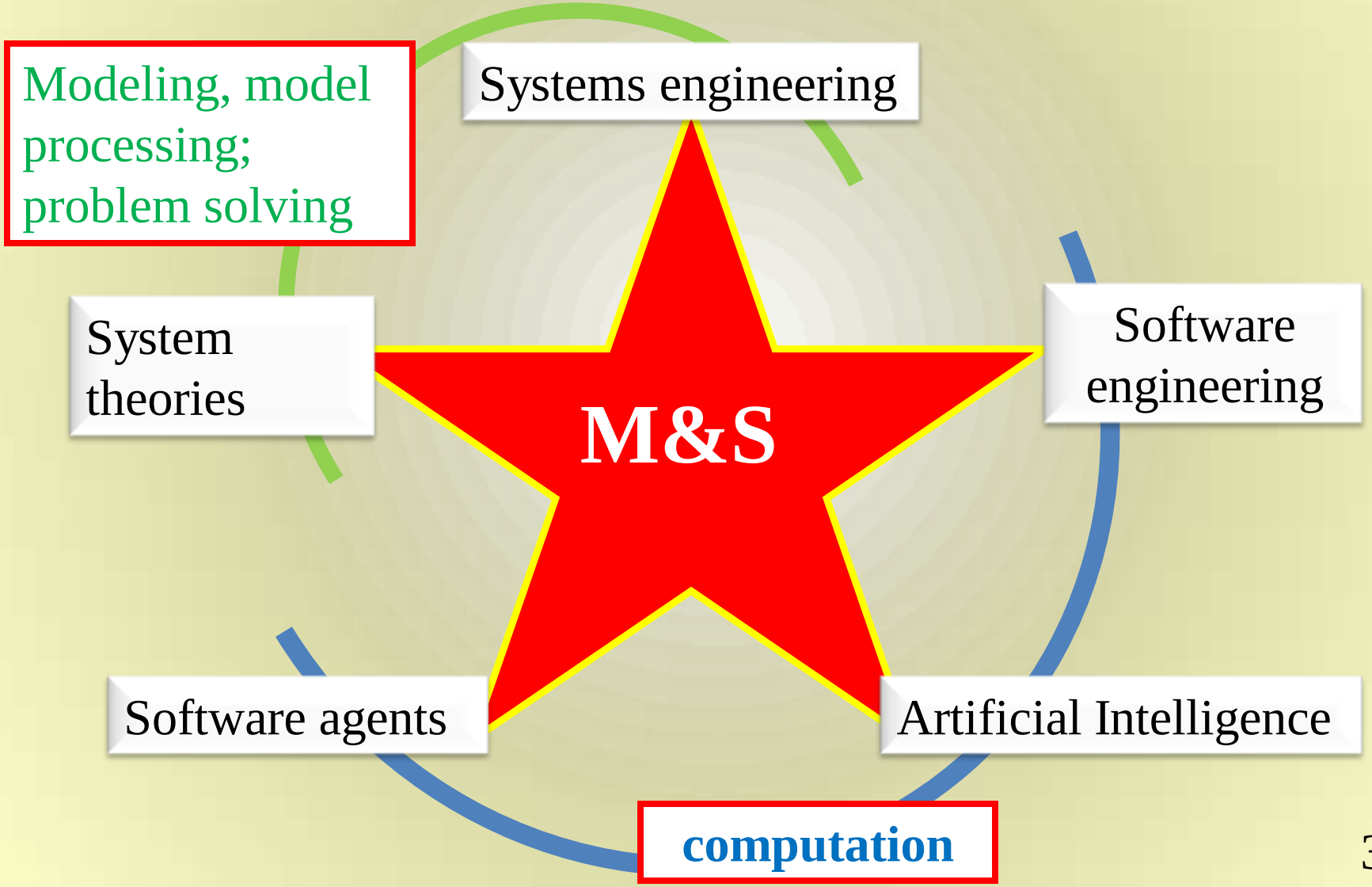
- **Higher order synergy:**

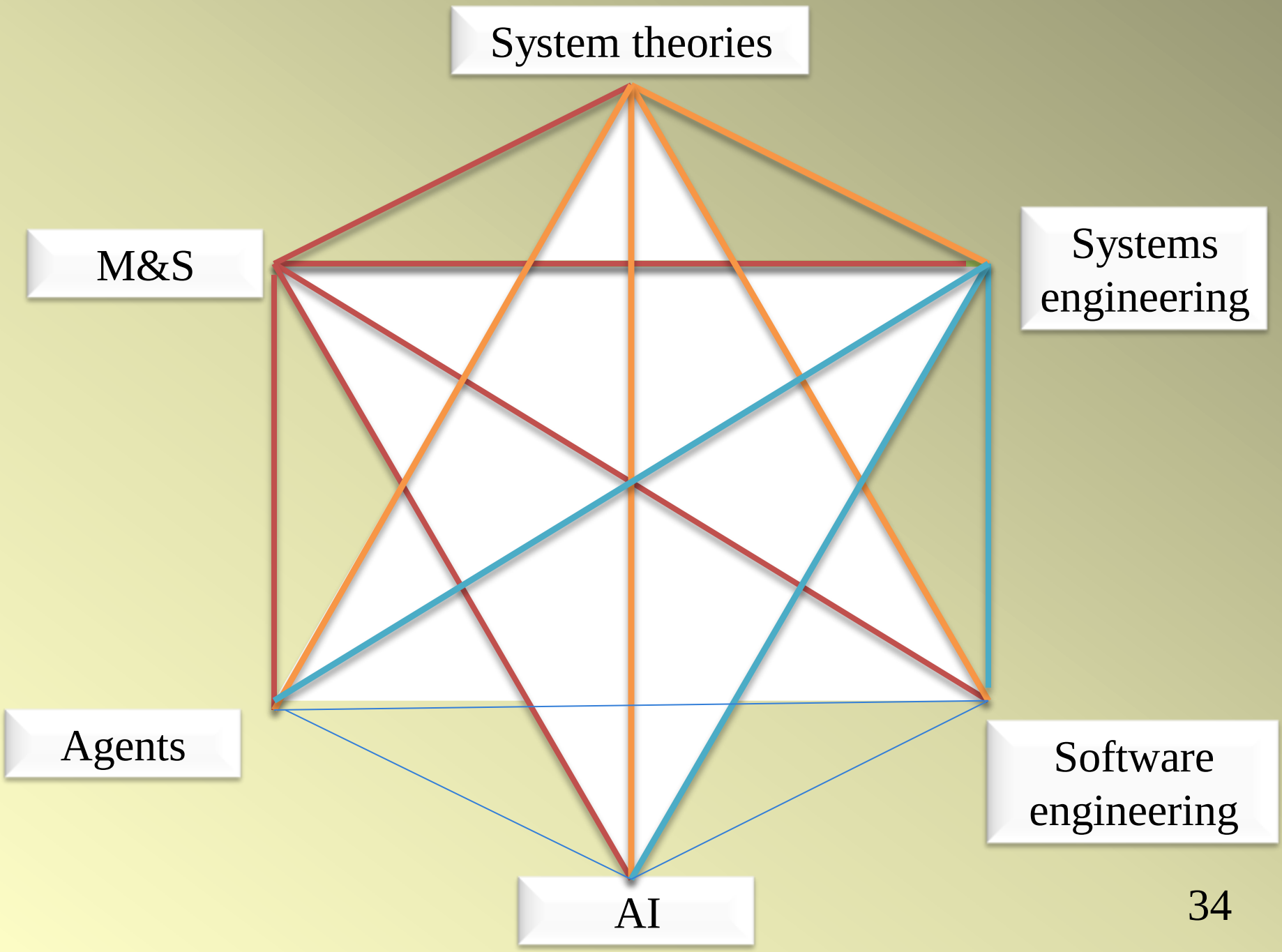
  Indirect contributions between them



B is enhanced due to contributions of enhanced A to B

Synergies of simulation with some disciplines




System theories
M&S
Systems engineering
Agents
Software engineering
AI

contributions

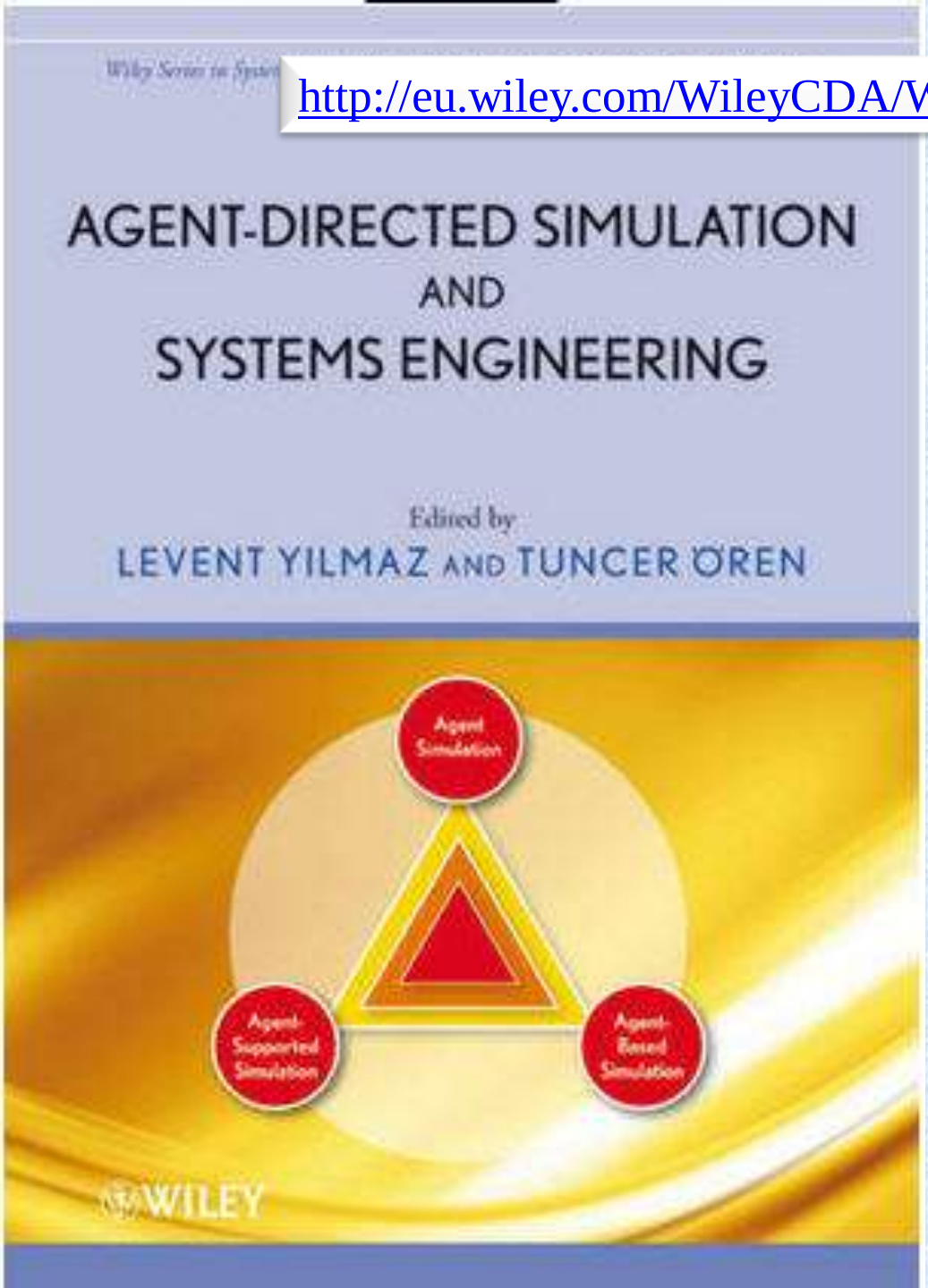
of \ to	M&S	System theories	Systems eng.	Software eng.	Artificial intelligence	Software agents
M&S	–					
System theories		–				
Systems eng.			–			
Software eng.				–		
Artificial intelligence					–	
Software agents						–

Ören, T.I. (**2005** – Keynote Article). *Maturing Phase of the Modeling and Simulation Discipline*. In: Proceedings of: ASC - Asian Simulation Conference 2005 (The Sixth International Conference on System Simulation and Scientific Computing (ICSC'2005), 2005 October 24-27, Beijing, P.R. China, International Academic Publishers - World Publishing Corporation, Beijing, P.R. China, pp. 72-85.

Contribution of	To	Contribution
Modeling & Simulation	System Theories	• Basic tool of inquiry for complex problems
	Software Engineering	• Simulation of software, hardware • Paradigm for module interfacing
	Artificial Intelligence	• Simulation for AI: - Cognitive simulation (i.e., simulation of intelligent entities) • Simulation for agents - Agent simulation (i.e., simulation of entities modeled as agents)
System Theories	Modeling & Simulation	• Bases for system design, analysis • Advanced modeling formalisms • Bases for symbolic model processing
	Software Engineering	• Formalisms to design complex software systems as special cases of methodologies to design complex systems
	Artificial Intelligence	• Bases for modeling cognitive systems such as, learning systems, understanding systems, and goal-directed systems.
Software Engineering	Modeling & Simulation	• Computer-aided modeling • Simulation program generators • Software architectures for modeling and simulation • Modeling smart systems (systems/machines/mechanisms which can

Artificial Intelligence	Modeling & Simulation	• AI for simulation: - AI-supported simulation (for user/system interfaces) - AI-based simulation (for the generation of model behavior, e.g., rule-based simulation, qualitative simulation) • Agents for simulation: - Agent-supported simulation (for user/system interfaces) - Agent-based simulation (for the generation of model behavior) • Modeling intelligent systems (systems/machines/mechanisms which can perform their functions better with the advanced knowledge processing abilities, even though their main functionalities are not knowledge processing.
	System Theories	• Intelligent models (Several types of intelligence)
	Software Engineering	• Intelligent software; • AI in software life cycle

http://eu.wiley.com/WileyCDA/WileyTitle/productCd-3527407812.html



"The only book to present the synergy between modeling and simulation, **systems engineering**, and **agent technologies** expands the notion of agent-based simulation . . ."

550 pages
September **2009**

2010 June 3-5, Kusadasi, Turkey

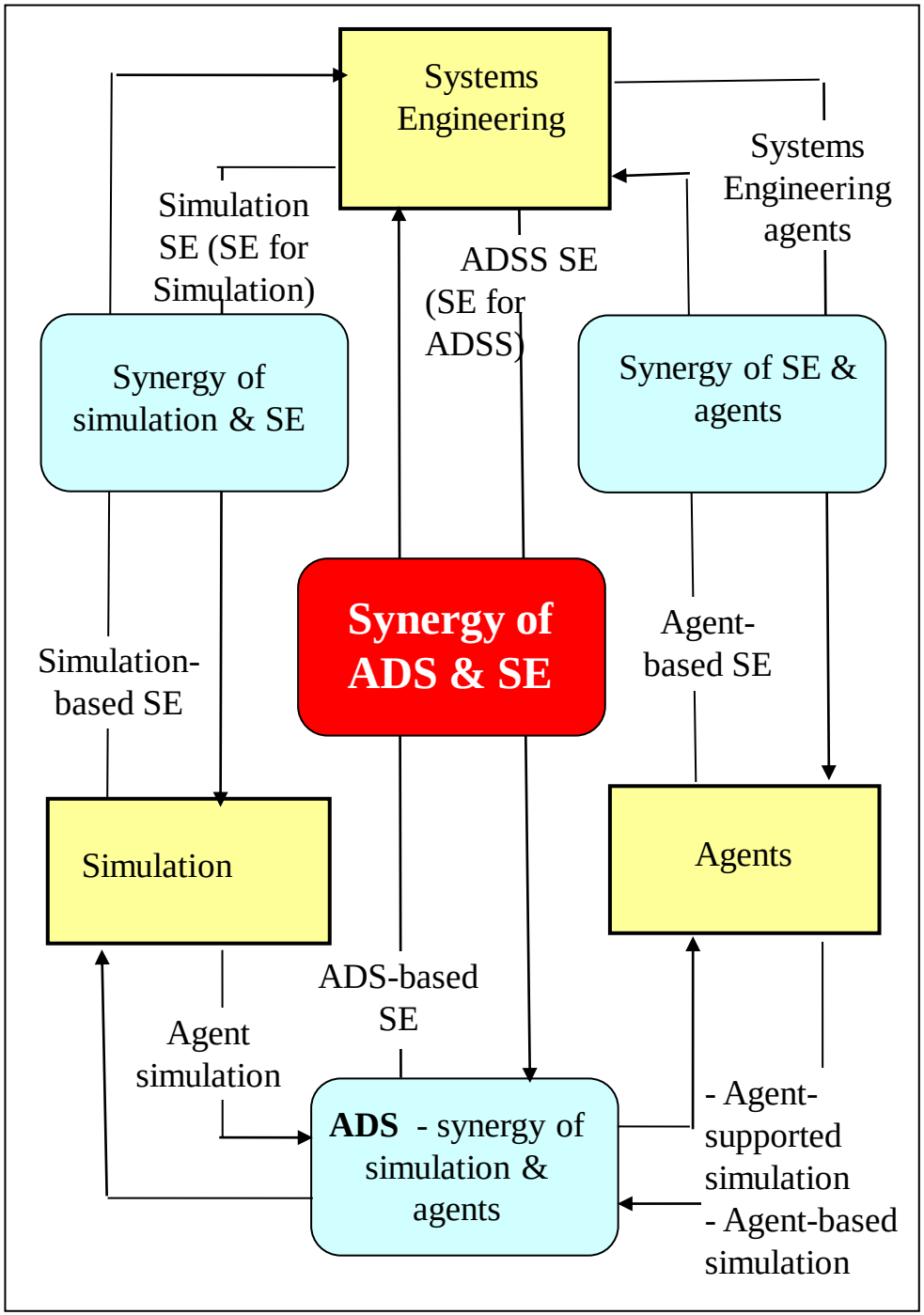
1st International Symposium on Computing in Science and Eng.
Faculty of Engineering, Gediz University, Turkey
- **Invited speaker** at the opening plenary session:
Synergies of Simulation, Agents, and Systems Engineering

Ören, T., & Yilmaz, L. Synergies of simulation, agents, and systems engineering. Expert Systems with Applications (**2011**). doi:10.1016/j.eswa.2011.06.038.

Synergies of M&S with software agents

Agent-directed simulation

- Simulation for agents:
  - agent simulation
- Agents for simulation:
  - agent-supported simulation
  - agent-based simulation



Synergies of simulation, agents, and systems engineering

(abbreviations:
ADS: Agent-directed simulation
ADSS: ADS systems
SE: Systems engineering)

First order synergy

Second order synergy

Synergies of M&S with software agents

Some annual events:

- ADS Symposium at the SpringSim (ADSS)
- ADS track of sessions at the SummerSim
- ADS track of sessions at the EMSS - European Modeling and Simulation Symposium (co-located with the I3M MultiConference)
- ADS track of sessions at MOSIM
- A special issue of an international journal based on selected papers of the ADSS.

Challenge: At Asia Simulation Conferences: ADS track of sessions, instead of merely Agent-based Simulation sessions.

Challenges:

- Cognitive simulation
- Emotive simulation

Possibilities for Enriched (Augmented) Reality:

		Equipment	
		Real	Virtual
Operator	Real	**- Live simulation** (a human operator uses *virtual equipment* (guns))	**Virtual simulation** - Simulator - Virtual simulator
	Virtual	**- Automated vehicles** (auto pilot, aircraft without pilot; vehicle without driver)	e.g., **an AI aircraft** (in dogfight)

Six aspects of M&S

- M&S within the spectrum of tools
- M&S profession
- Synergies of simulation with some disciplines
- **Science & Methodology**
- Applications
- Reliability

4

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

Simulation and Real System:

2 categories of simulation:
(with respect to **connectivity** of operations)

- **Stand-alone simulation**
  (operations of the simulation and the system of interest are **independent**)
- **Integrated simulation** (**symbiotic simulation**)
  (operations of the simulation and the system of interest are **interwoven**)

(Operations of simulation and the system of interest are interwoven.) **Integrated simulation**

Simulation **enriches** real-system operation.
Real-System Enriching Simulation

Simulation **supports** real-system operation.
Real-System Support Simulation

Simulation and Real System:

Integrative simulation (symbiotic simulation)

To (enrich) augment reality

In enriched **(augmented or mixed) reality simulation,** real and virtual entities (that can be people or equipment) and the environment can exist at the same time.

Hence, operations can take place in a richer *augmented reality environment.*

Reality is a special case of simulation!

Simulation **enriches** real-system operation.

Real-System Enriching Simulation (RSES)

The SOI and the simulation program **operate simultaneously** and provide augmented- (enhanced- or mixed-) reality for:

- Decision support (on-line diagnosis)
- Training
- Realistic virtual reality (VR) environments

Simulation supports real-system operation.

Real-System Support Simulation (RS3)

The SOI and the simulation program **operate alternately** and provide predictive displays for:

- Decision support
- On-the-job training

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

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
- a knowledge-processing activity

Considering M&S as a computational activity two categories of advances (**challenges**) are possible:

- Computers
- Type of computation

Considering M&S as a computational activity two categories of advances (**challenges**) are possible:

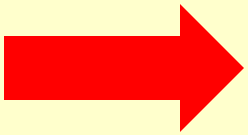
- **Computers** (some examples)
  - Cloud simulation
  - Massively parallel simulation
  - Simulation on portable devices
  - Wearable computer simulation
- Type of computation

Considering M&S as a computational activity two categories of advances (**challenges**) are possible:

- Computers
- **Type of computation** (some examples)
  - Fuzzy simulation
  - Mixed fuzzy & numerical simulation

Types of **knowledge processing :**

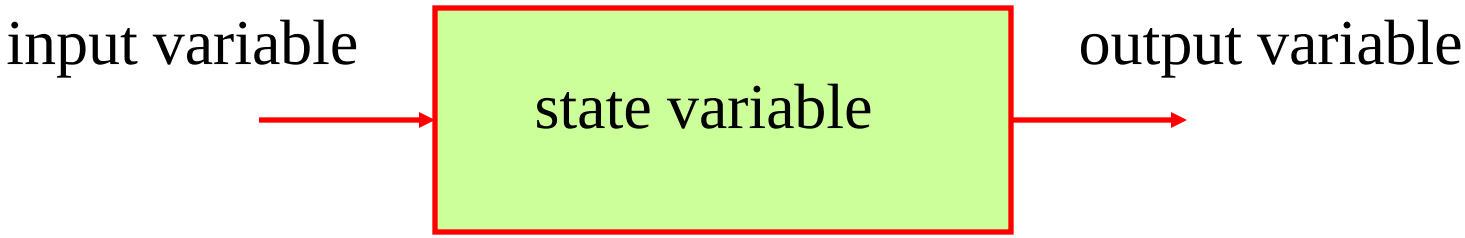
M&S is:



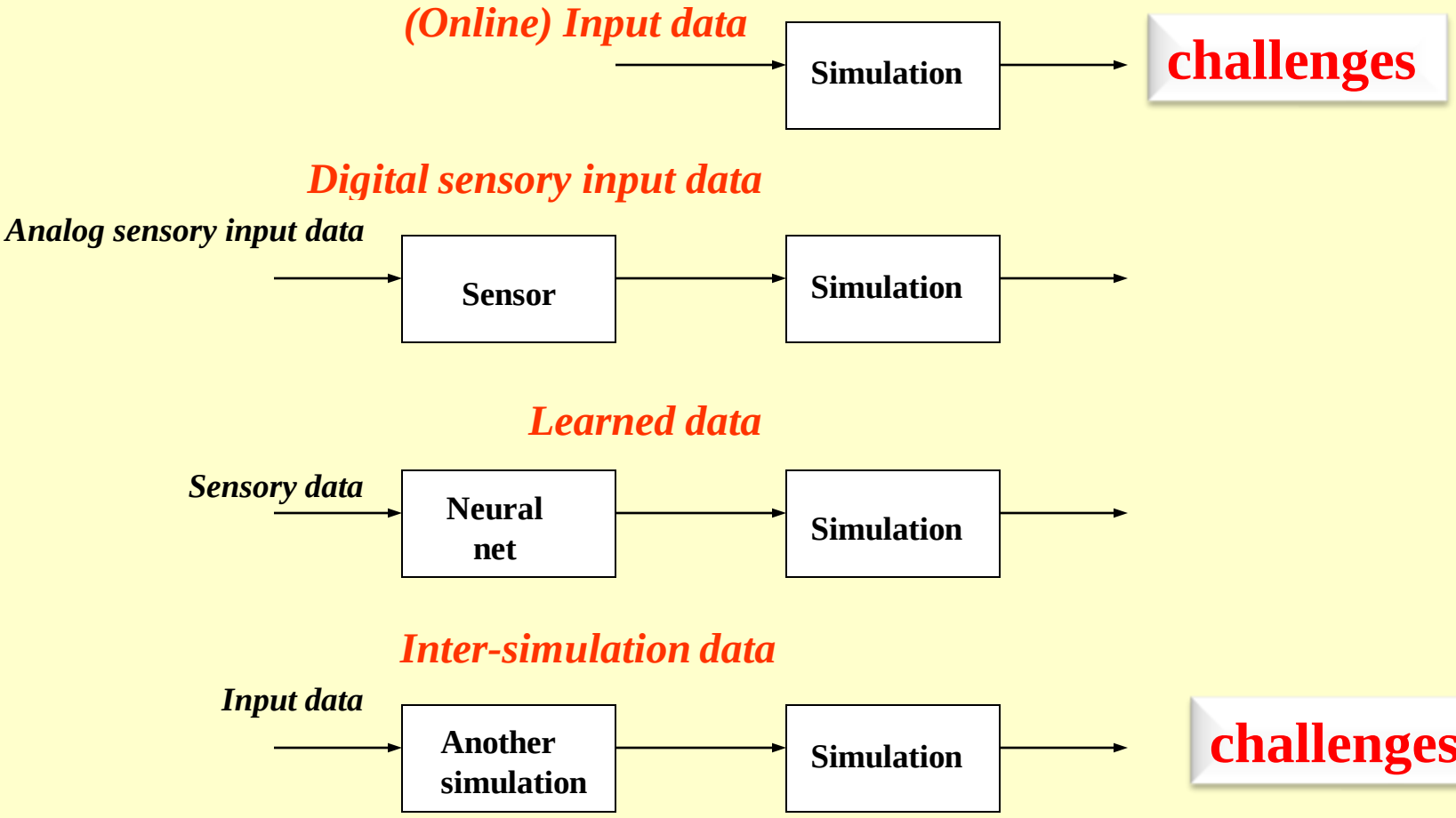
- a computational activity
- a systemic activity & system theory-based activity
- a model-based activity
- a knowledge-generation activity
- a knowledge-processing activity

From a systemic point of view, simulation can be used to find the values of **output**, **input**, or **state variables** of a system; provided that the values of the two other types of variables are known.

(W. Karplus, 1976)



Type of problem:	Given			Find
Analysis	input	state		Output
Design	input		output	State
Control		state	output	Input



Types of Simulation Input Data

Types of Inputs & challenges

Source of input	Mode of input	Type of input
Exogenous input (externally generated input)	**Passive acceptance** of exogenous input (imposed or forced input)	**Type of access to input**: coupling, argument passing, knowledge in a common area, message passing. **Nature of input**: - ***Data*** *(facts)* - *Forced* ***Events*** - ***Sensation*** (converted sensory data: from analog to digital; single or multi sensor: sensor fusion) -***External goals*** *(imposed goals)* - ***Online knowledge***
	Active perception of exogenous input (perceived input)	- ***Perception*** (interpreted, sensory data and detected events) -- includes: decoding, selection (filtering), recognition, regulation - ***Perceived goals*** - ***Evaluated inputs*** -- evaluation of inputs (acceptability) -- evaluation of source of inputs (reliability, credibility)

Types of Inputs

Source of input	Mode of input	Type of input
Endogenous input (internally generated input)	**Active perception** of endogenous input	- ***Introspection*** (perceived internal facts, events; or realization of lack of them)
	Generation of endogenous input	- ***Anticipated facts*** *and/or* ***events*** (anticipatory systems) - ***Internally generated questions*** - ***Internally generated hypotheses*** by: -- Expectation-driven reasoning (Forward reasoning) (Bottom-up reasoning) (Data-driven reasoning) -- Model-driven reasoning - ***Internal goals*** (*internally generated goals)*

Challenge: Use endogenous inputs in simulation

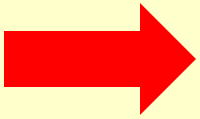
Challenges:

- Use of several system theories (evolutionary systems, goal-directed systems, . . .) as a bases for *modeling* and *symbolic model processing* for advanced simulation .

- Use of simulation to study effects of complexity & emergence in non-linear systems

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
- a knowledge-processing activity

Challenges:

- Use **conceptual models** to be transformed to computational (programmed) models.
- Model bases to store conceptual models.
- Maintenance of conceptual models instead of computational (programmed) models.
- Develop concepts and tools for interoperability of conceptual models

"conceptual modeling“ search on Google (480 000+ hits)

Simulation as a model-based activity

Challenges:

- Symbolic processing of models
  (this is a very rich paradigm)
- Multi-paradigm modeling for simulation
  (several categories of possibilities exist)
- DNA-based modeling
  for dynamic model updates
- . . .

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
- a knowledge-processing activity

Simulation as a knowledge generation activity:

The definition of simulation **can be interpreted** as follows: "**Simulation is** model-based experiential knowledge generation."

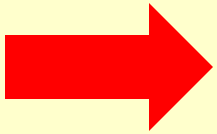
This abstraction facilitates **the synergy** of simulation with other knowledge generation (and processing) techniques:

- optimization
- statistical inferencing
- reasoning (Artificial intelligence)
- hypothesis processing (to be combined with advanced agent-support to generate hypotheses to be tested)

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
- a knowledge-processing activity



Simulation as a knowledge processing activity

Challenge:

• Advanced visualization techniques, e.g., *holographic visualizations.*

Ref: MSIAC M&S Newsletter, July/Aug. 2011 Issue.

Six aspects of M&S

- M&S within the spectrum of tools
- M&S profession
- Synergies of simulation with some disciplines
- Science & Methodology
- **Applications**
- Reliability

5

Challenge: Simulation-based solutions to World's important / vital problems

-

-

-

What would be the areas that you would like to suggest?

Or, cite some important problems that you think simulation cannot be used to find a good solution.

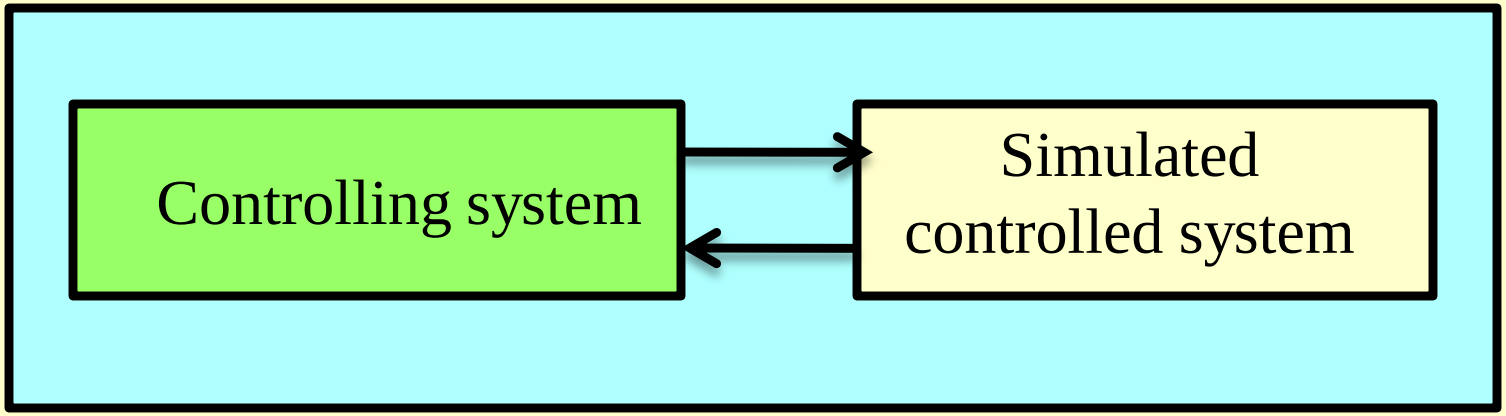
Challenge:

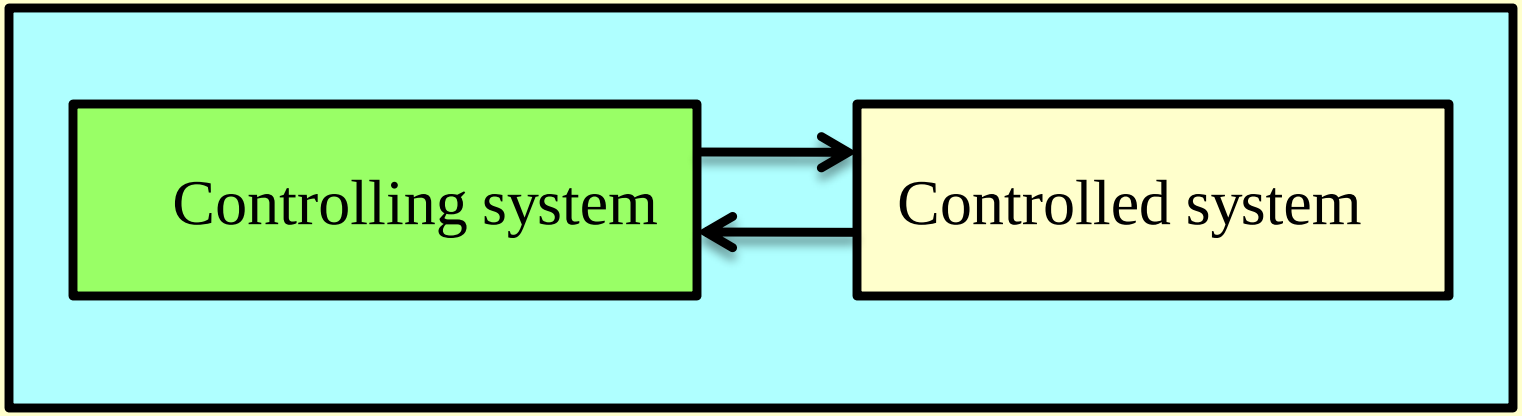
Simulation-based enhancement of **creativity** & **innovation**?

Challenge:

Simulation-based software development

- for control systems, for example





Challenge:

Add virtual gauges (measurement devices)
(with or without threshold controls)
to simulation systems

Abdullah, B., Ören, T., (**1997**). Enhancement of a Simulation Environment with IMAGES (Intelligent Multi-Agent Based Virtual Gauges). In: Proceedings of the 1st World Congress on Systems Simulation, Singapore, Sept. 1-4, 1997, pp. 359-363

Challenge:

Use simulated experiments of material genome knowledge to create new materials.

http://www.materialsgenome.org/

This would be similar to SPICE / PSPICE system used for electronic circuit design.

Six aspects of M&S

- M&S within the spectrum of tools
- M&S profession
- Synergies of simulation with some disciplines
- Science & Methodology
- Applications
- **Reliability**

6

Reliability - **Challenges:**

Contributions of:

- **simulation to reliability**
  (e.g., reliability of systems, buildings, decisions, . . .)
- **reliability to simulation**
  (validation, verification, QA (Quality Assurance), FA (Failure Avoidance) (Ethics in simulation)

Reliability - **Challenges:**

- **Built-in** Quality Assurance
- Failure Avoidance
- Reliability of AI in simulation
  - Reliability of rule-based systems in simulation
- Reliability of agents in simulation

. . .

Challenge:

Have understanding ability and avoid inabilities and filters that can induce misunderstanding in cognitive simulation in agent-directed simulation.

Ref: Agents with understanding abilities and ways to avoid misunderstanding

Invited seminar, Changsha, China, September 2011

Inabilities and filters that can induce misunderstanding

Ability (**inability**) to understand

- meta-model
- perception
- interpretation

Filters for **misunderstanding**

- context
- biases
- fallacies

http://www.site.uottawa.ca/~oren/pubsList/QA.pdf

updated: 2011-01-21

Publications and Presentations of Dr. Tuncer Ören on

Modeling and Simulation:

Reliability, Quality Assurance (QA), and Failure Avoidance (FA)

(Some statistics)

(Meetings include conferences/symposia/tracks of sessions organized/invited/participated)

		0	1	2	3	4	5	6	7	8	9	total
1970s	publications						1					1
	meetings											
1980s	publications	1	4	4	2	3	4	5	5	2	4	34
	meetings & others	1		1	1	1	1		1	2	4	12
1990s	publications	5	6	1	2		2	1	1	1	2	21
	meetings & others	2	3								2	7
2000s	publications			1			2		1		1	5
	meetings	3									1	4
2010s	publications	1	1									2
	meetings											

publications	63
meetings	23
total	86

Some personal views on advancement

“ No progress is ever possible by keeping the state-of-the-art, no matter how advanced it is.”

Tuncer Ören


Emulate nature; keep blooming!
Tuncer Ören

- Competition is the essence of progress and necessitates the ability, willingness and drive to **surpass oneself**.
- **Those –be it an individual, an institution, or a country– unable to surpass themselves cannot exceed others**.
- **Therefore, in achieving progress, what is difficult is to supersede oneself;** then outdoing and even eclipsing others may become possible.

Ören, T.I. (1995). Enhancing Innovation and Competitiveness Through Simulation. Preface of the Proceedings of 1995 Summer Computer Simulation Conf., Ottawa, Ont., July 24-26, SCS, San Diego, CA., pp. vi-vii.

To my current & future colleagues:

Good **luck*** in your careers!

*“**Luck** is what happens when ***preparation*** meets ***opportunity***.”

Seneca – Roman philosopher, mid-1st century AD

Q & A