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Tutorial:

Toward the Body of Knowledge of M&S

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Aim:

To discuss highlights of

Knowledge Needed for M&S Studies:

- **Especially: Core Elements of M&SBOK**
- Core Elements of Supporting Domains
- Knowledge of Application Areas

Scope as well as richness of M&S

- Military and Other Views
- Demand-based **Push** & Advancement-based **Pull**

Need also to cover:

Introduction

Background

Plan

1. M&SBOK: **Introduction**
   - 1.1 What, Why & For Whom (Stakeholders)?
   - 1.2 BOK of Related Disciplines
2. M&SBOK: **Background**
   - 2.1 Early Studies
   - 2.2 Possible Uses
3. **Scope of M&S**
   - 3.1 Military and Other Views
   - 3.2 Demand-based Push & Advancement-based Pull
4. **Knowledge Needed for M&S Studies**:
   - 4.1 Knowledge of Application Areas
   - 4.2 Core Elements of Supporting Domains
   - 4.3 **Core Elements of M&SBOK**

Body of Knowledge is:

- "Structured knowledge that is used by members of a discipline to guide their practice or work." *
- "The prescribed aggregation of knowledge in a particular area an individual is expected to have mastered to be *considered* or *certified as a practitioner*."
- Waite's pragmatic view: "BOK is **a stepping stone *to unifying community***."

* Most of the references are given in the text.

Development of the Body of Knowledge for the modeling and simulation (M&S) profession is an activity for which **time is ripe**:

(1) There is enough science, technology, and craftsmanship accumulated.
(2) The importance of simulation has been well established.
(3) There are over 60 associations for M&S professionals:

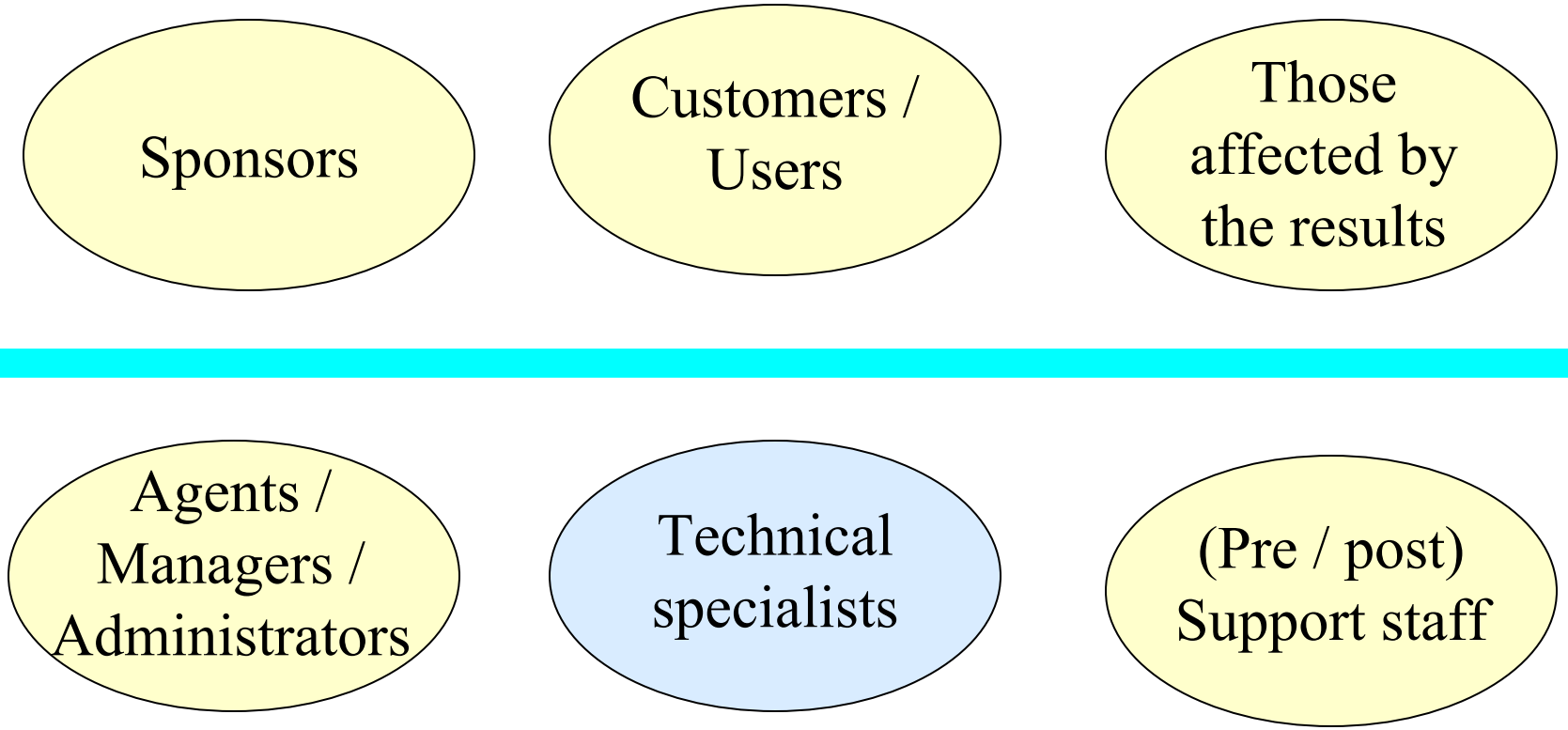
(4) Large number of professionals are active in M&S.

- Some of them are members of the above mentioned professional societies and
- for some, M&S is very much interwoven in their professional lives.

(5) In academia, for each M&S course –undergraduate or graduate– there are several other non-simulation courses with strong M&S content.

(6) Simulation is used in many important application areas.

Stakeholders in M&S:



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For the following disciplines, their respective BOKs are well established or under development:

- Systems engineering
- Information systems engineering
- Software engineering
- Information technology
- Project management
- Body of Quality Knowledge
- New Product Development Body of Knowledge

An interesting aspect of these disciplines is that they are, like M&S, **applicable in wide areas of disciplines and applications**.

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- An early study by the Technical Committee on Simulation of the IEEE Computer Society.

- On-going effort: the establishment of a clearinghouse (Bill Waite, Aegis Docushare).
  However, the clearinghouse is not yet accessible to public.

- Workshops are also organized
  (Waite and Skinner 2003, Waite 2004, …)

- Fairchild (2002)

- Birta (Birta, Birta 2003)
- A critique by Elzas.
- Studies elaborating on an “ideal simulationist” such as reports (Madewell and Swain 2003, Rogers 1997) and their critiques also contain valuable information.

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Possible users of M&SBOK:

- Novice
- Practitioner
- Learner
- Academician
- Industrialist
- Funding agencies (grant officiers)
- Licencing / Certification
  (of individuals / organizations)
- Acquirer / User of M&S Product / Service
- Market

M&SBOK may also help to enlarge our horizon!

"The smaller a man, the closer his horizons."
John McLeod, founder of SCS

Or emphasizing the positive aspect:

"The greater a man, the larger his horizons."

Stakeholder	Possible uses
Novice	Explore the discipline Determine applicability
Practitioner	Expansion of knowledge Specific problem solving Identification and evaluation of techniques
Learner	Expansion of knowledge Verification of derived knowledge Accomplishment of corporate or certificate requirements

Stakeholder	Possible uses
Academician	Referencing Expansion of knowledge Curriculum / course development (including degree programs, academic / professional development courses)
Industrialist	Exploring opportunities / Satisfying needs Offering professional development courses Personal selection

Stakeholder	Possible uses
Funding agencies (grant officiers)	Explore the discipline Determine timeliness and applicability of proposals Evaluation of alternatives
Licencing / Certification (of individuals / organizations)	Determination of professional standards for: individuals commercial organizations academic degree programs

Stakeholder	Possible uses
Acquirer/User of Product Service	Source selection Evaluation of products, services, techniques, vendors/providers
Market	Formation of market, niche markets, and workforce

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M&S from **Different Perspectives:**

"Simulation," derived from Latin "***simulacre***"

has several images:

- **military perception**
- **non-scientific view**
- **scientific view**

Military perception of simulation (from the point of view of training) is summarized as: *"All but war is simulation."*

3 types of military simulation (used in three types of training):

- For **live training: Live simulation** (real people use simulated (imitation) weapons and real/or simulated equipment in real environments)
- For **constructive training: Constructive simulation** (gaming simulation - war gaming)
- For **virtual training: Virtual simulation** (use of virtual equipment –simulators, virtual simulators)

- Military perception: **Live simulation**

In **live simulation**, training (experimentation) is performed with fake (imitated - simulated) ammunition and real and virtual (simulated) equipment acting in real environment.

In *live simulation,* real people and real equipment are augmented with special sensors to act as target designators.

- Military perception: Constructive simulation

Constructive simulation is "war gaming."

Forces, equipment, and environment are represented by models.

At decision points, decision makers inject their decisions to the simulation system.

- Military perception: Virtual simulation

In virtual simulation, *virtual* equipment –namely, a physical model of the system– is used for training purposes.

the terms **simulator** and **virtual simulator** are used to denote nature of models, i.e., *physical model* of the system or *all software model* of the system.

Military **training** applications of
modeling and simulation are very important!
e.g., I/ITSEC has about **16000 participants**!

However, we are not alone.

- There are over 60 M&S Associations

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

that promote use of simulation in many different areas.

- Some of these other types of use of simulation **are also applicable to important military problems**!

A recent reference
for a **comprehensive view** of modeling and simulation:

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

- Non-scientific view of simulation:

"Simulation" means fake, counterfeit, or **imitation** (used since 14th century)

Examples: simulated leather, simulated pearl

- Scientific view of simulation

"Simulation" is goal-directed experimentation with dynamic models.

when the experimentation

cannot or **should not** be done on the real system,

one can perform it –even under extreme conditions–

using a dynamic model; and hence ***use simulation***.

Simulation is used for :

- **Training:**
  Three types of training (live, constructive, virtual)
  - to enhance *decision* and/or *communication skills* (gaming simulations)
  - to enhance *motor skills* (simulators, virtual simulators)
- **Decision support**
- **Understanding**
- **Education and Learning**
- **Entertainment**
  (simulation games, animation of dynamic systems)
- **Enrich real system operations** (augmented reality)

Use of M&S for Decision Support

Prediction of ***behavior*** or ***performance*** of the system of interest within the constraints inherent in the simulation model (e.g., granularity)

Evaluation of alternative models, parameters, experimental and/or ***operating conditions*** on model ***behavior*** or ***performance***

Sensitivity analysis

Engineering design

Prototyping ***(virtual prototyping)***

Planning

Acquisition ***(simulation-based acquisition)***

Proof of concept

Predictive displays *to* ***support real system operations***

On-line diagnosis

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

Donald Knuth

Some Other Perceptions of Simulation:

Simulation can be perceived as:

- a computational activity
- a model-based activity
- a knowledge generation activity

Simulation as a computational activity:

The emphasis is on the generation of model behavior.

Simulation as a model-based activity

In addition to generation of model behavior, the following can be considered:

- **computer-aided modelling** (model composability)
- **model-base management** (for reusability)
- parameter-base management
- **symbolic processing of models**

(each with its own consequences)

Simulation as a knowledge generation activity:

At this abstract level, 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,
- hypothesis processing

Simulation and Real System:

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

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

In Integrated simulation where operations of the simulation and the system of interest are **interwoven**:

Simulation **enriches** real-system operation.

Real-System Enriching Simulation

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

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

- Decision support
- On-the-job training

Stand-alone Simulation for **Training**
(3 groups of possibilities)

Aim: train as you operate

To enhance **decision making** and/or **communication skills**

To provide **real-life-like experience** opportunities (in a controlled environment)

Aim: proficiency of use of equipment(s)

To enhance **motor skills**

Stand-alone Simulation for **Training**

Aim: train as you operate

To enhance **decision making** and/or **communication skills**

Constructive simulation (Gaming simulation)

Zero-sum simulations

- War simulation, battle simulation at different levels

Non-zero-sum simulations

- Peace operations simulation such as (peace keeping, peace support, Non-Article V operations)
- Conflict management simulation
- **Coopetition simulation** (focused cooperation of otherwise competitive groups)

Interoperable war gaming

Applications of distributed simulation (HLA, TENA)

Aim: proficiency of use of equipment(s)

To enhance **motor skills**

Virtual simulation

- **Simulators** (with limited environmental interactions)

To use single **vehicles** such as aircrafts, helicopters, tanks, submarines.

To use single **equipments** as in weapon system simulators (e.g., torpedo simulator)

- **Virtual simulators** (all software) (some to be perceived, for example, by head-mounted displays (HMDs))

Stand-alone Simulation for **Training**

Aim: train as you operate

To provide real-life-like experience opportunities (in a controlled environment)

- To get experience in combat situations (Real operator uses real equipment with real and/or virtual weapon) **Live simulation**
- To get experience at several levels of integrated situations
  - **Integration** of constructive simulation with C4ISR
  - **Integration** of several types of weapon on a platform (such as a submarine)
  - simulation of systems of systems; federations of federations – hyper federations
- **Linkages to live simulation**
  - **Augmented/enhanced reality simulation**
    - -- Virtual UAVs (with auto pilots) in a live simulation
    - -- Linkage of live, virtual, and constructive simulations

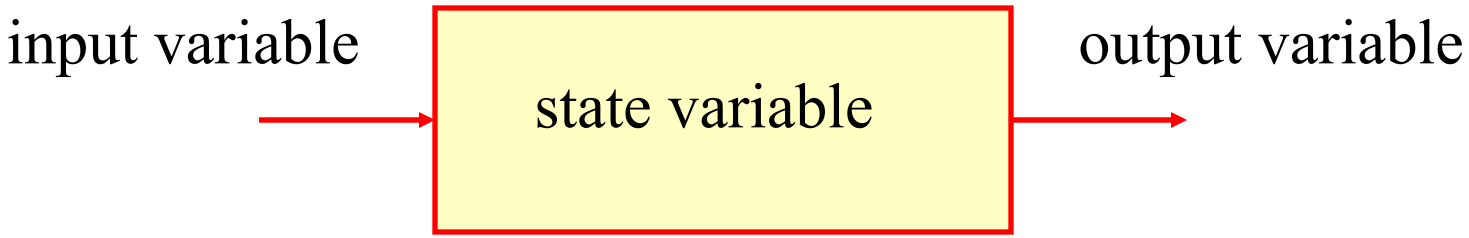
(augmented / enhanced) live simulation

Aim: proficiency of use of equipment(s)

To enhance **motor skills**
Virtual simulation

- **Simulators**
- **Virtual simulators**

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.



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

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Demand-based **Push:**

Higher expectations from the advanced user's community:
- are very desirable for the M&S discipline and
- will definitely influence advancement of the field.

"We raised the bar; now we have to have to leap to new heights" *(Numrich 2004)*.

Demand-based **Push:**

Some other points raised by Numrich are:

- **Complexity** of today's environments
- **Emerging integration environments**, federation of federations similar to system of systems
- Respond to increased demands for **rapid**, **reconfigurable**, **adaptive M&S capability**
- HLA is necessary but not sufficient, **composable frameworks** address needs beyond HLA.

Some other challenges to push the existing capabilities of M&S can be found in the literature (ICGCMS 2002, Goad 2004).

Advancement-based **Pull**

- **Interest areas** in M&S are shifting with the advancements in **enabling technologies** such as types of computers, advances in software engineering, and application of system theoretic bases.
- **System-theory based simulation** has been advocated since early 1970s (Ören 1971; Zeigler 1976, 1984).
- The fact that **DEVS** (Discrete Event System Specification) formalism developed by Zeigler (1984) is well accepted by the simulation community (both researchers and advanced practitioners) is one of the signs of maturity of the field of M&S.

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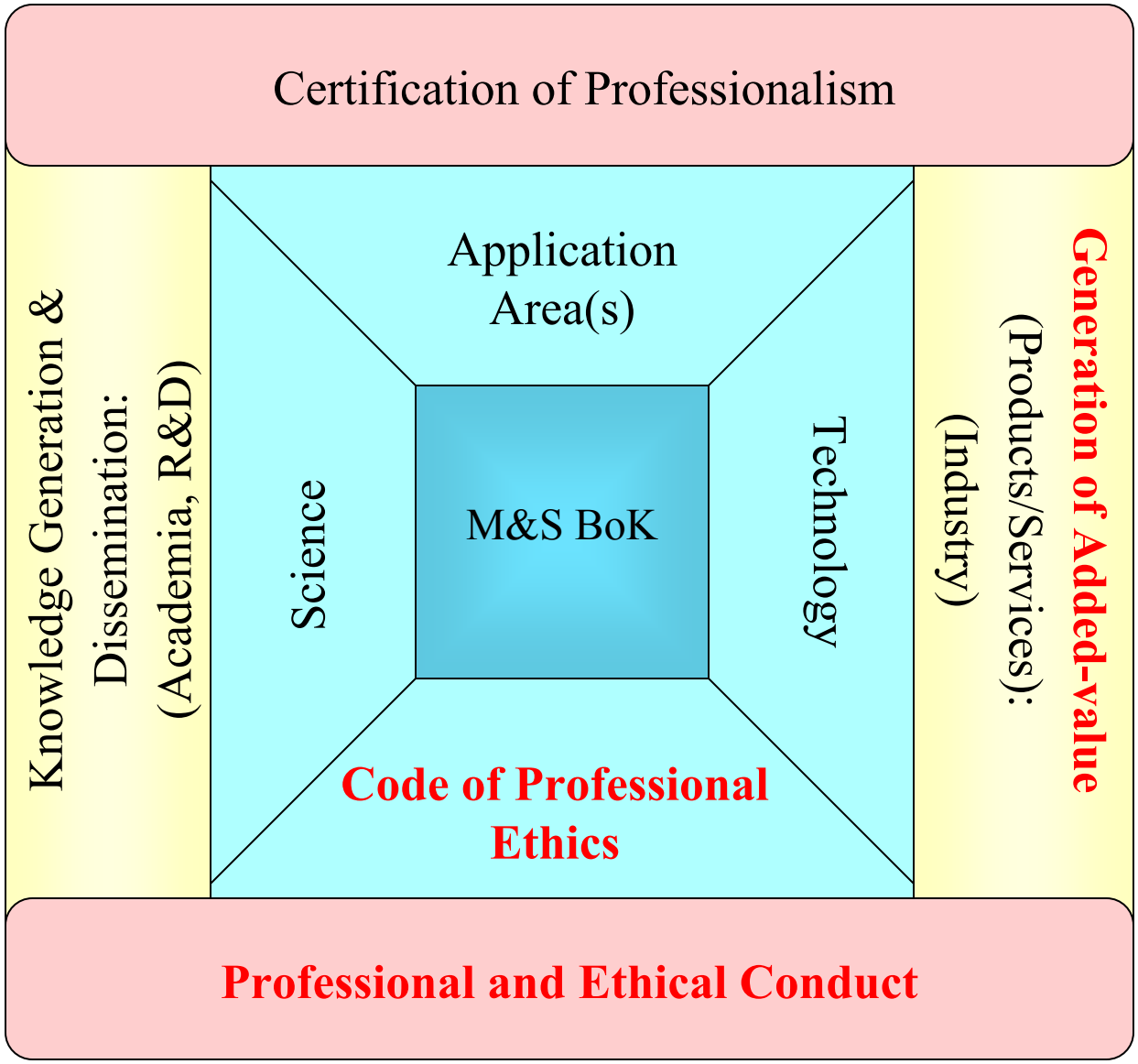
Aspects of Professionalism in M&S:



Knowledge:

To solve problems:

- Application Area(s)
- Supporting Domains: Science, Technology
- M&S BoK

How to solve them (behavior):

- Code of Professional Ethics

Activities:

- Knowledge Generation and Dissemination: (Academia, R&D)
- **Generation of Added-value in Applications** (Products/Services): (Industry)

Monitoring:

- Professional and Ethical Conduct
- Certification of Professionalism

Simuland

- Simulation is used in hundreds of application areas.
- Application domain knowledge is essential!

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Core Elements of Supporting Domains

Area	Competency Requirement
Systems Engineering	For large and complex simulation studies
Mathematics – differential equations	For engineering or scientific applications
Mathematics – numerical analysis	For engineering or scientific applications
Queuing theory	In discrete systems
Probability and Statistics	For discrete systems

Core Elements of Supporting Domains

Area	Competency Requirement
Physics	For engineering or scientific systems
Software engineering	For developers of M&S tools/environments
Artificial intelligence	"Unintelligent computerization is not enough!" *(Olympus)*
Software agents	For many advanced studies (agent simulation, agent-supported simulation, agent-based simulation)
Project management	If will become manager or supervisor, otherwise to appreciate the needs
Interpersonal skills	For team work
Oral and written reporting and documenting	(A person with limited reporting and documenting skill would be similar to a computer having processing ability but with very limited I/O abilities.)

Systems Engineering Paradigm for M&S

State the problem

Assure consensus of the customer on the life cycle of the project, needs, goal, and several **performance metrics**:

- Fitness to purpose, Usefulness, Usability, Cost effectiveness, Timeliness, Efficiency, Maintainability at specification level / code level
- Scope of usability / applicability
- Document at every level: the study, system, assumptions (explicit, implicit), …
  (Documentation standards)

Investigate alternatives

Model the system

Systems Engineering Paradigm for M&S

Integrate

Systems of systems
Federations of federations

Simulate the system

Launch the system

Assess performance

- Consider the success of M&S from satisfying the original goal of the system and not just a limited point of view such as efficiency of M&S study.
- For military applications, for example, as expressed by Darkin (2004): "What impact have we had on how soldiers, sailors, and marines prepare for and execute their missions?"
- Similarly, **use a goal-directed performance assessment**, in all application areas.

Re-evaluate

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Notes:

- A multilingual –English, French, Turkish*– **M&S dictionary**, scheduled to be published this year in France (Ören & the French team: Torres et al.)
  contains –in a systematic way– over 4000 terms and provides **an inventory of terms and concepts** germane to M&S discipline.

  * To be extended to include
    Spanish, Italian, German, and Chinese terms

- Some references on M&S taxonomies:
  http://www.site.uottawa.ca/~oren/pubsList/taxonomies.htm

Core Elements of M&SBOK

- Input **data**
- **Models** and modeling
- Model processing
- **Experimentation**
- Model **behavior**
- Behavior generation
- Behavior processing
- M&S **infrastructure**
- **Computerization**
- User/system **interfaces**
- **Reliability** and ethics
- M&S **history**

Input **data**

Types
Structure
Analysis
Conditions under which:
- Instrumented
- Observed
- Collected

A list of About 100 Types of Variables

Across, Action, Activation, Algebraic, Allocated, **Antithetic**, Arbitrary, Argument, Artificial, Attached, Auxiliary, Behavior, Binary, **Boolean**, Bounded, Class, Constrained, Continuous, **Continuous-change**, Controlled, Coordination, Correlated, Decision, Declared, Declared Random, Dependent, Descriptive, Deterministic, Discrete, **Discrete-change**, Discrete-time, Discriminant, Dual, Dummy, Endogenous, Essential, Exogenous, Experimental, Experimentation, External, **Externally generated**, **Flow**, Formal, Free, **Fuzzy**, Gaussian, Global, Goal, Holistic, Independent, **Initialized**, **Input**, Instance, Instantiated, **Instrumentable**, Instrumental, Instrumented, Internal, Internally generated, Interpolated, Irrelevant, Key, Lag, **Lagged**, Latent, Lead, Level, **Linguistic**, Local, **Logical**, Monitored, **Nonnumerical**, Nonobservable, Numerical, Observable, **Output**, Qualified, **Qualitative**, Quantified, Quantitative, Random, Rate, Relevant, Run control, Simple, Slack, Stabilized, **State**, Statistical, Stochastic, Subscripted, Temporal, Temporary, **Through**, Time, Transition, Typed, Uncontrollable, Uninitialized, Yoked.

Consider types of "inputs" in modeling and simulation:

Input (stimulation or triggering) of a system can be:

- Externally generated (exogenous) or
- Internally generated (endogenous)

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)* – ***goal-determined systems***
	(Active) perception of exogenous input (perceived input)	-**Perception** includes interpretation: decoding, selection (filtering), recognition, regulation -- Sensory data -- Detected events -- Perceived goals - **Evaluated inputs** -- evaluation of inputs (acceptability: relevance, reliability) -- evaluation of source of inputs (acceptability: credibility, reliability)

<table>
<tr><th>Source of input</th><th>Mode of input</th><th>Type of input</th></tr>
<tr><td rowspan="4">Endogenous input

(internally generated input)</td><td>(Active) perception of internally generated input</td><td>(Introspective systems)
-Introspection (perceived internal facts, events; or realization of lack of them)</td></tr>
<tr><td rowspan="3">Generation of internal input</td><td>(Deliberative systems)

- Internally generated questions
- Internally generated hypotheses by:</td></tr>
<tr><td>-- Expectation-driven reasoning
(Forward reasoning)
(Bottom-up reasoning)
(Data-driven reasoning)
-- Model-driven reasoning</td></tr>
<tr><td>-Internally generated goals
(Teleogenetic systems)
-- Internal goals
(Behaviorally anticipatory systems)
-Anticipation of the current image(s) of the future leading to multimodels and/or multisimulation studies</td></tr>
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Models and modeling

Conceptual modeling
Basis for modeling and model processing:
    system theories
modeling formalisms
modeling methodologies
model specification languages and environments

Model **processing**

Includes:

- building and using **model bases** and **model repositories**,
- model analysis, and
- model transformation

Model analysis consists of

- **model characterization** (Descriptive model analysis) and
- **model evaluation** (Evaluative model analysis)

Model characterization (Descriptive model analysis)

Model comprehensibility

- ***Model documentation***
  - Static model documentation
  - Dynamic model documentation
- ***Model ventilation*** (to examine its assumptions, deficiencies, limitations, etc.)

Model usability

- ***Model referability***
  - **Model integrity**
- ***Model modifiability***
  - **Model composability**

Model evaluation (Evaluative model analysis)

with respect to a **Modeling formalism**

Consistency of representation of the

- component model
- coupled model
- federated model

Model robustness

with respect to **Another model (Model comparison)**

Structural model comparison

- model verification (comparison of a computerized model with its specification)
- model homomorphism
- model isomorphism
- model equivalencing
  - for any two models
  - for a simplified and original model
  - for an elaborated and original model

Behavioral model comparison

(Comparison of several models within a given scenario)

with respect to Real system

Model qualification

- ***Model realism*** (veracity, verisimilitude)
  - Adequacy of model structure
  - Adequacy of model constants and parameters
    -- Model identification
    -- Model fitting
    -- Model calibration
- ***Model correctness analysis*** - Dimensional analysis

Model validity

- Structural validity
- Replicative validity
- Predictive validity

Acceptability of a model with respect to **Goal of the study**

Model relevance

(For single models as well as federated models)

- Domain of intended applications
  - Appropriate use of a model
- Range of applicability of a model

Acceptability of a model with respect to its **technical system specification**

Model Transformation

- Simplification
- Elaboration

- Isomorphism
- Homomorphism
- Endomorphism

Experimentation

Simulation run

- Length of the run, Number of runs, Warm-up period
- Steady-state period
- Antithetic run

(Automation of) Statistical design of experiments

Specification of experimental conditions

- Experimental frame
- Applicability of experimental frame to a model
- Scenario specification
- Composable and synthesizable scenarios
- (Composable/ Reconfigurable) Synthetic environments

Analysis of simulation results

- Post simulation analysis and report
- Post live/virtual/constructive simulations reports

Multisimulation
(to experiment with several aspects of reality simultaneously

Model Behavior

Behavior is trajectory - Trajectory simulation
Behavior is structure - Structural simulation

Types of Simulation Based on the Generation Characteristics of Model Behavior

Criteria	Type of simulation
Hardware use Hardware is: - used - not used	-Simulator ((hu)man-in-the-loop simulation) - Simulation - Virtual simulator
Time: Real-time Compressed time Expanded time	- Real-time simulation - Compressed time simulation - Expanded-time simulation

Types of Simulation Based on the Generation Characteristics of Model Behavior: Procedure

Continuous generation of model behavior	**Simulation run** (single-run simulation study)
Intermittent generation of model behavior	
- Multiple runs	- [**Multiple-run**] simulation study - **Antithetic run** - Regenerative simulation - Sensitivity simulation
- Nested simulation	- Optimizing simulation -- sim. within optimization -- optimization within sim.
	- Expert system (ES) & Simulation -- simulation within ES -- ES within simulation

Types of Simulation Based on the Generation Characteristics of Model Behavior: Procedure

Intermittent generation of model behavior	
- Interaction among decision makers	- Gaming simulation (game-theoretic simulation) -- competition (zero-sum games) wargaming, netcentric wargaming business gaming -- cooperation peace game -- coopetition conflict management simulation

Types of Simulation Based on the Generation Characteristics of Model Behavior

Interaction between model behavior generation and the real system	- Stand-alone simulation - Integrated simulation

Additional Topics for Model Behavior Generation and Processing

• Behavior generation techniques - for each modeling formalism
• Behavior generation
• Behavior analysis: - compression (statistical, numerical, qualitative) - confidence intervals - variance reduction
Visualization (display, graphics, virtual environments)

M&S Infrastructure

Standards	Metadata
	Documentation of M&S studies
	Common services
	Interoperability
Repositories	Specifications of (models, physical environments, scenarios, studies)
	Data, constants, parameters, auxiliary parameters
	Simulation components (*not just program components*) (reusable, extensible, composable)
M&S capability	Rapid, reconfigurable, and adaptive capability
	HLA, RTI, and beyond
	Composable frameworks

M&S - Computerization

Software	Packages, languages, tools, environments
	Large-scale simulation environments
	Problem solving environments with (several level of) simulation abilities
Execution	
Desirable features	Reusability of software **with ties to reusability of specifications**
	Interoperability: HLA necessary but not sufficient
	Integrated composable M&S ability
Special computers	Simulation **on high-performance computers**
Platform	**Web-centric** (Web-based, Web-enabled, network-centric) **simulation**
	Grid computing Simulation on GIG (Global Information Grid)

M&SBOK – User/System Interfaces

Front end interfaces
Back-end interfaces

Sound, color, multimedia, motion, vibration, touch, gesture

A recent reference:

Ören, T.I. and L. Yilmaz (2005). Quality Principles for the Ergonomics of Human-Computer Interfaces of Modeling and Simulation Software, Proceedings of SIMCHI'05 - 2005 International Conference on Human-Computer Interface Advances for Modeling and Simulation, January 23 - 25, 2005, New Orleans, Louisiana, pp. 5-11.

Reliability and Ethics

M&S attributes (What? How much?)

- Fidelity
- Resolution
- Scalability

Ethics (for individuals and organizations)

Reliability and Ethics - Types of errors in:

- Instrumentation
- Data collection
- Experimentation
- Scenarios (consistency of joint scenarios in federations and federations of federations)
- Computation
  - Numerical computation
  - Soft computing
- AI: Rule-based (expert) systems
- Software agents
  (trustworthy agents, moral agents)
- Types of fallacies in logic
  - paralogisms,
  - sophisms
- M&S infrastructure

M&SBOK – M&S history

Analog simulation: Differential analyzer

Hybrid simulation
Digital simulation

Simulators: First pilot trainer of Link (1929)

M&S languages: Early languages and their critique
M&S environments: Conventional, AI support

Early applications: Space flight simulations …

Visualization for simulators, synthetic environments:
The beginnings

We Have Seen

1. M&SBOK: **Introduction**
   - 1.1 What, Why & For Whom?
   - 1.2 BOK of Related Disciplines
2. M&SBOK: **Background**
   - 2.1 Early Studies
   - 2.2 Possible Uses
3. **Scope of M&S**
   - 3.1 Military and Other Views
   - 3.2 Demand-based Push & Advancement-based Pull
4. **Knowledge Needed for M&S Studies**:
   - 4.1 Knowledge of Application Areas
   - 4.2 Core Elements of Supporting Domains
   - 4.3 **Core Elements of M&SBOK**

Your views sent to:

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will be very much appreciated.

- Please also indicate whether you would like to be in the list* of colleagues to review the M&SBOK Drafts.

* Currently over 40 colleagues.

Many Thanks