Certified Modeling and Simulation Professional

Professional Development Workshop

01 December 2023

Ivar Oswalt, PhD CMSP
The MIL Corporation

0800

! BOTTOM LINE UP FRONT !

- CMSP is the only comprehensive M&S professional certification in the U.S.
- It provides differentiation, community awareness, specialized networks, and membership benefits
- Its Reinvention started at I/ITSEC 2021 with the launch of CMSP 3.0
- Improvements streamline the application process, provide new levels, include updates to the examination, and the creation a vibrant community of practice
- *All M&S practitioners seeking to enhance their credentials and to add a level of distinction to their qualifications - from Intern, Apprentice, Practitioner, and Master Levels - will find this PDW informative and valuable*

WORKSHOP OUTLINE

- Learning Objectives
- Introductions
  - Acknowledgements
- Role of M&S, Certification, CMSP
- CMSP
  - Certification Levels
  - Education and Experience
  - Exam Philosophy and Overview
  - Exam Specifics
  - Tracks and Topics / Subtopics
  - Tips, Techniques, and Timeline
- Overview of Topics / Subtopics
  - M&S Types, Applications,…
- The Type is Right Game
- Certification Exam
  - Sample Questions
- Review
  - Topics
  - Rapid Fire Game
- CMSP
  - Context
  - Current Events
- Jeopardy Game

- Course Evaluations

LEARNING OBJECTIVES

- After this PDW, Attendees will be able to:
  - Describe CMSP's Motivation / Origin and Development
  - Articulate the Ways CMSP Can Benefit their Career Progression
  - Recount the Process for Becoming a CMSP
  - Define CMSP Levels and Types of Questions to be Asked on the Exam
  - Characterize Key Features and Functions of M&S and Supporting Processes
  - Demonstrate, via Gaming Simulations, Knowledge of Relevant M&S Knowledge

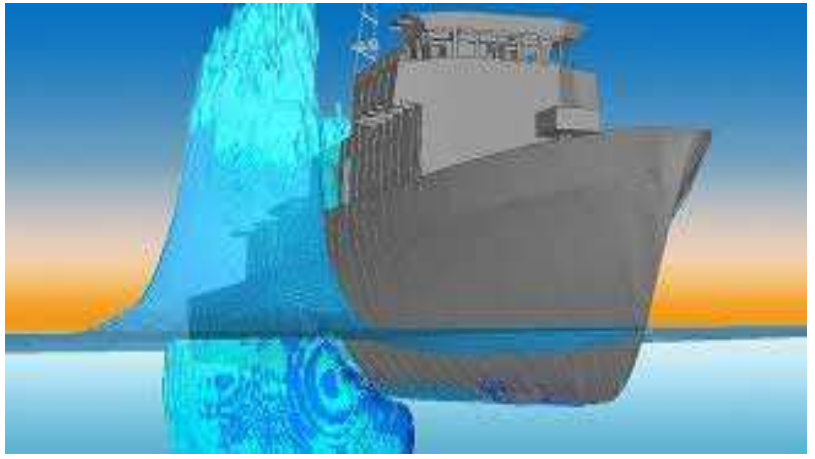
That is, Successfully Apply, Pass the Appropriate Exam, and Become a CMSP of the Type that Matches Your Qualifications and Experience

INTRODUCTIONS

- **Ivar Oswalt**
  - 30+ Years of M&S experience, supporting the Navy's M&S Office, DoD M&S Office, NRL, etc.
  - PhD in 1989, CMSP in 2019, NET+ in 2022
  - *Simulation-Based Trainings Incorporation of ML*, MODSIM Best Paper and I/ITSEC BFATG 2019
  - *Operationalizing AI in Simulation Based Training*, I/ITSEC 2021
  - The Modeling and Simulation Profession, John Wiley & Sons, 2017 - Chapter Contributor, e.g., Observations on ROI
  - *Calculating ROI for U.S. DoD M&S*, Hirsch Prize Recipient, ARJ, 2011
  - Currently: DON M&S and VV&A Management SECNAVINST, NMSO PP&S, NRL VV&A Support
- **Around the Room**

- I'm Motivated To Go From...

- To...



ACKNOWLEDGEMENTS

- Dr. Mikel Petty, University of Alabama in Huntsville
- Dr. Amy Henninger, Branch Chief Advanced Computing, DHS
- Mr. Bill Waite, President, The AEgis Corporation
- Mr. William V. Tucker, Boeing
- Ms. Margaret Callahan, The MIL Corporation
- Mr. Daryl Wynn, NSWC DD DNA

ROLE OF M&S

- Provides assessment without operating or destroying expensive items
- Creates immersive training environments that are otherwise impossible
- Enables the analysis of extremely complex multi-variate problems
- Forecasts the future state of incredibly complex processes
- Allows the controlled examination of items within secure multi-spectral environments
- Increasingly, M&S learns!

"Science used to be composed of two endeavors, theory and experiment. Now it has a third component: computer simulation, which links the other two." [Colwell, 1999] [Colwell, 2000]

Rita R. Colwell, Ph.D.
Director, NSF
1998-2004

ROLE OF CERTIFICATION

- Certification is the formal confirmation of particular characteristics of a person or organization and is normally provided by an external review, education, assessment, or audit
- Examples Include: Certified Public Accountant (CPA), Professional Engineer (PE), Project Management Professional (PMP), and Network+ (NET+) IT Professional
- Professional Rationale: Certification helps to establish the legitimacy of any occupational field and to standardize the quality of its membership
- Organizational Rational: Certification helps to demonstrate the qualifications / discriminators of an entity (Corporation, Research Center, etc.)
- Personal Rational: Certification demonstrates and individual's commitment to superior professionalism, upholding industry standards, and continued learning

ROLE OF CMSP

- Is a sign of distinction and increasingly formally recognized
  - Within the leadership of the M&S community
  - Within draft DoD and Service M&S Procurement Guidelines
- Increasingly delivers a supportive and career enhancing community
  - CMSP Quarterly Newsletter, Mentorship Program, Local and Regional Events
  - CMSP Member Children Scholarship Being Developed
- Communicates an indicator of currency
  - Publications, presentations, CEUs required for renewal

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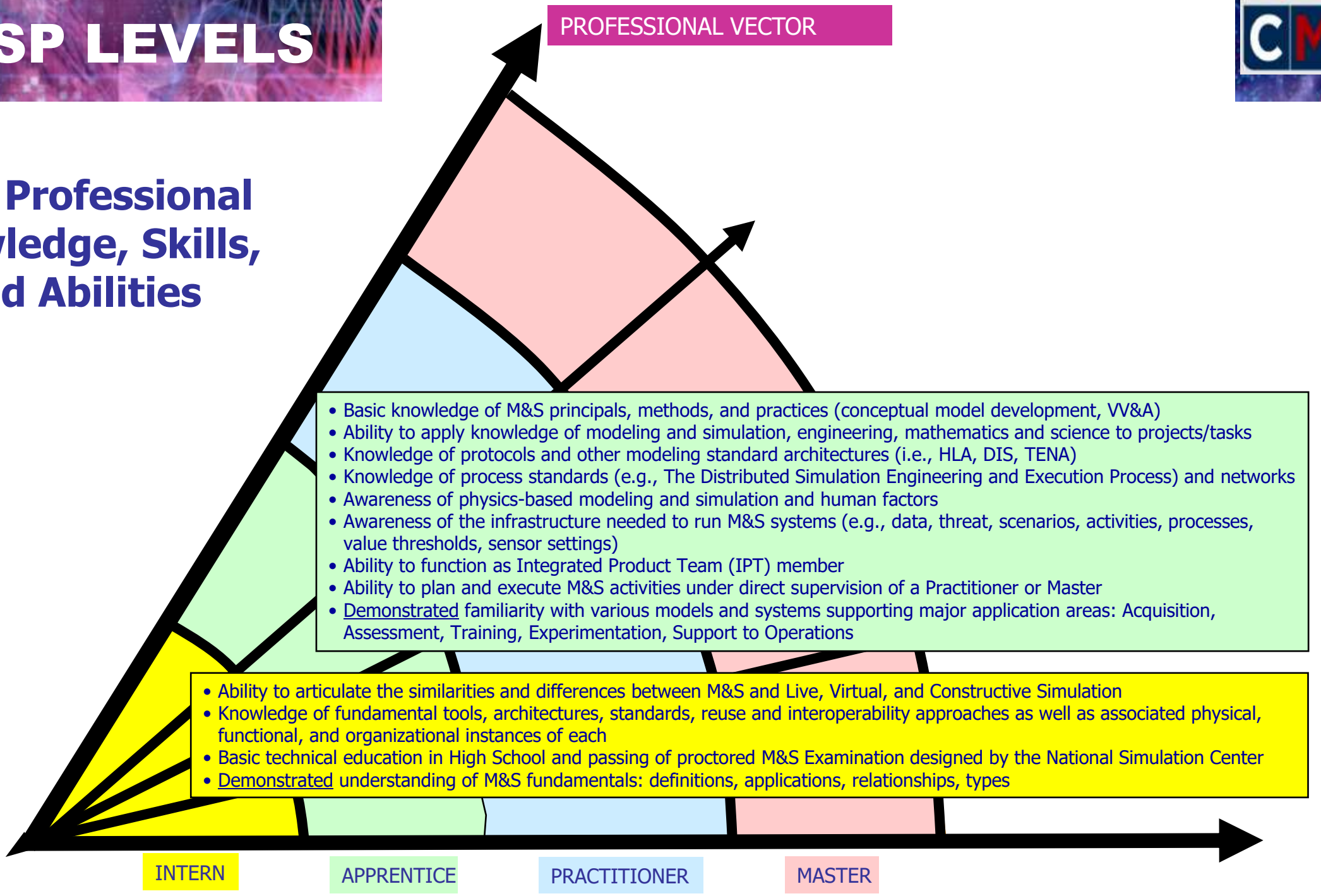
DESCRIPTION & REQUIREMENT AREAS

- The CMSP is a professional certification, governed by NTSA and administered by the M&S Professional Certification Commission
- It designates individuals who have attained knowledge and experience in M&S – ***the extent to which varies by level***
- Requirements for certification are:
  - Evidence of sufficient M&S education and experience
  - Supporting references forwarded from professional colleagues
  - Passing an examination
  - Signing a statement of ethics
  - Paying application fee
- CMSP is good for 4 years, after which recertification is required
  - Continuing education, papers, presentations, etc.
  - Paying a fee

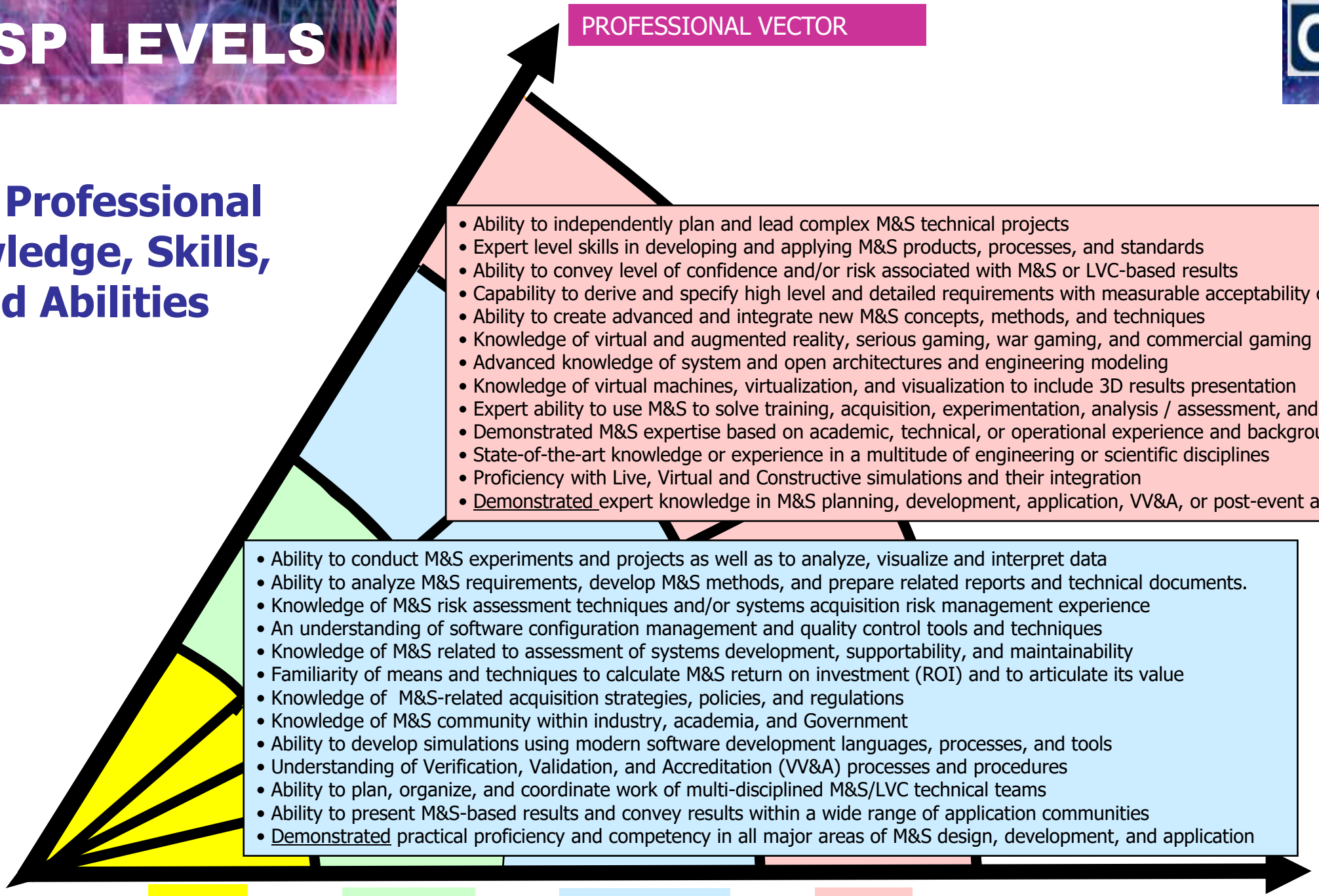
CMSP LEVELS

M&S Professional Knowledge, Skills, and Abilities



CMSP LEVELS

M&S Professional Knowledge, Skills, and Abilities



APPRENTICE LEVEL

- This level is designed for individuals who are new to the M&S field and serves as a foundation for future advancement
- Identifies individuals who have demonstrated an awareness of basic M&S concepts, methods, and applications
- Individuals possess an entry-level understanding of M&S principles and practices and are committed to expanding their knowledge and understanding of the M&S discipline
- E.g., Basic knowledge of M&S principles, methods, practices, and project lifecycles and awareness of general M&S concepts, such as abstraction, model attributes (e.g., validity and resolution), time representation, and environment (e.g., Live, virtual, and Constructive)

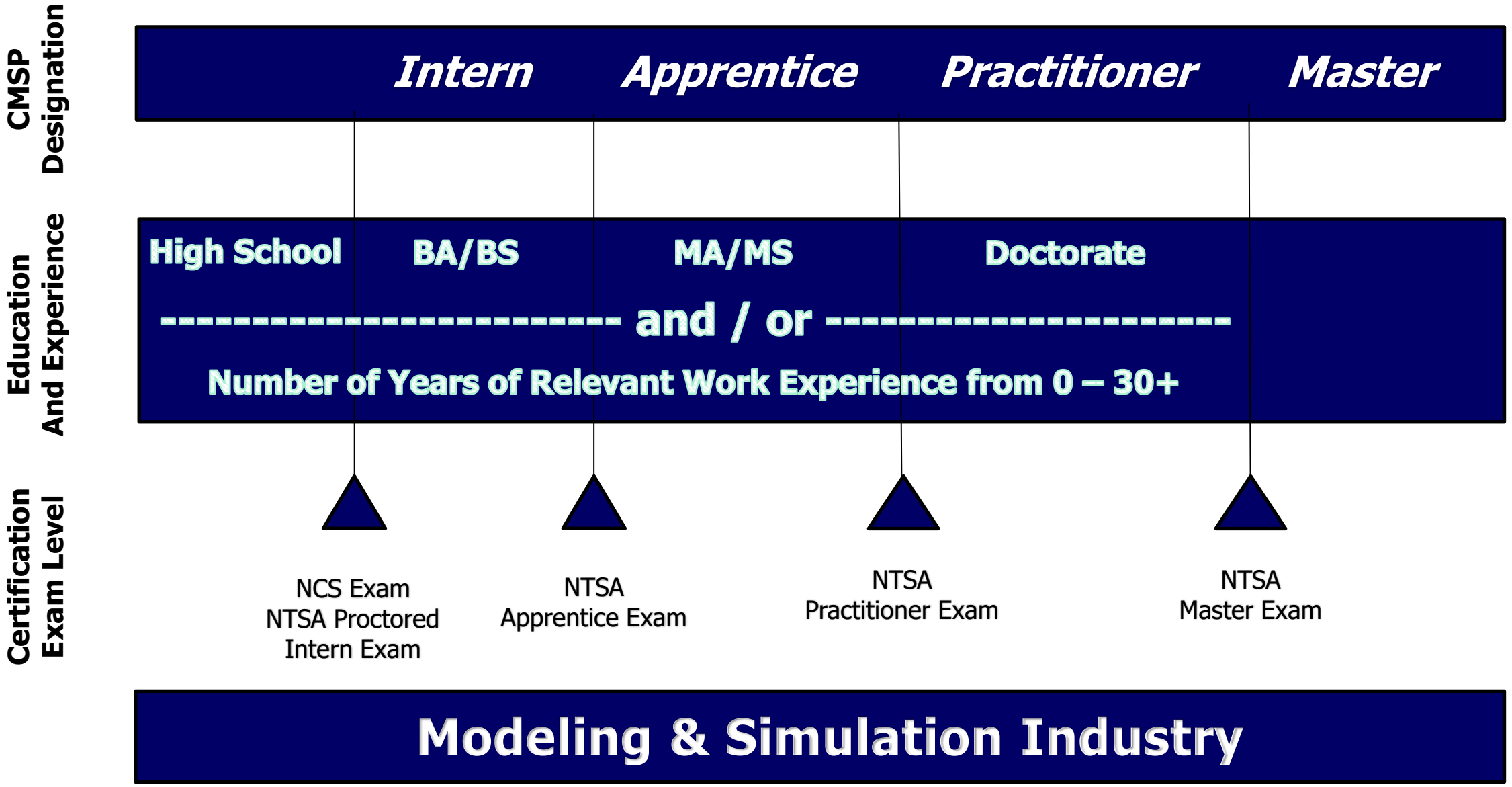
PRACTITIONER LEVEL

- This level designates professionals who possess applied knowledge of M&S principles and practices in a variety of domains
- They understand M&S applications and their role in addressing current and future challenges in specific contexts
- Designed for M&S professionals who have a demonstrated ability to lead technical teams, conduct short-term studies, translate project requirements into model contexts, and coordinate with SMEs and key stakeholders
- Ability to develop basic models and simulations using modern software development languages, processes, and tools, including configuration management, VV&A, and quality control

MASTER LEVEL

- This level designates professionals who have a demonstrated understanding of the M&S BoK its application in a variety of contexts
- Possess the capability to plan and execute short- and long-term M&S projects, design and implement complex and sophisticated models, conduct advanced research, communicate findings, and expand the application of M&S into new domains
- Ability to independently plan and lead complex M&S technical projects, to derive and specify high level and detailed requirements with measurable acceptability criteria, etc.
- Demonstrated ability to present M&S designs, implementation architectures, and results to other M&S professionals and to senior leaders

CMSP LEVELS


CMSP Designation
Intern
Apprentice
Practitioner
Master
Education And Experience
High School
BA/BS
MA/MS
Doctorate
and / or
Number of Years of Relevant Work Experience from 0 – 30+
Certification Exam Level
NCS Exam
NTSA Proctored
Intern Exam
NTSA
Apprentice Exam
NTSA
Practitioner Exam
NTSA
Master Exam
Modeling & Simulation Industry

EXAM PHILOSOPHY

- Ensure that successful candidates have an appropriate and *representative understanding of the full spectrum of M&S*
- Designed to be a challenging trial to garner respect and credibility and to demonstrate professionalism
- Degree of exam difficulty is targeted to level of certification being sought – Intern, Apprentice, Practitioner, or Master – currently in a take-home format
- Study is required to successfully complete the examination
- But part of the intent, especially for Practitioner and Master, is that applicants will research and learn new M&S knowledge

EXAMINATION OVERVIEW

- Scope is defined by a consensus-based M&S Body of Knowledge (BoK)
- Composed of questions drawn from all BoK topics and subtopics
- Every question is traceable to a published, publicly-available, and peer-reviewed source
- Each candidate is provided an automatically generated exam instance consisting of questions selected from the question bank
- The exam's design is customized by level
- An on-line learning management system allows candidates to take the exam conveniently
- Each exam type requires a 70% score to pass (skipped questions are scored as incorrect)

EXAM SPECIFICS

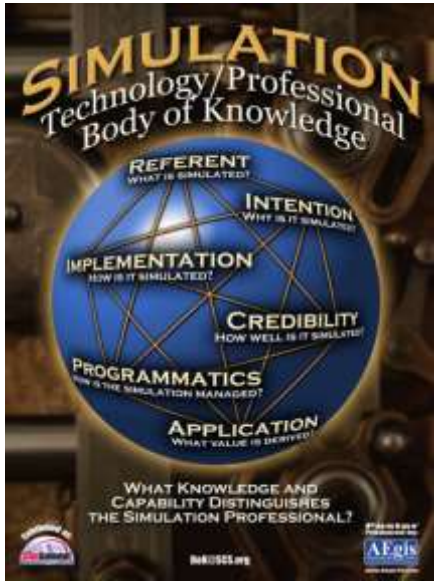
- Intern
  - Proctored exam of ~20 questions in 1 hour
  - Cross Certification with the National Simulation Center's Certification
- Apprentice
  - Exam consists of 40 questions in 4 hours
  - Cost is $150.00
- Practitioner
  - Exam consists of 2 sets of 40 questions. 4 hours for the 1st set. 6 hours for the 2nd set.
  - Both sets have to be completed within 7 days.
  - Cost is $275.00
- Master
  - Exam consists of 3 sets of 40 questions. 4 hours for the 1st set. 6 hours for the 2nd set.
  - 8 hours for the 3rd set. All have to be completed within 14 days.
  - Cost is $400.00

EXAM RESOURCES

- We recommend that you review the resources listed below as a study tool for the exam. In addition, you can review the slides from this CMSP PDW
  - Modeling and Simulation Fundamentals: Theoretical Underpinnings and Practical Domains
  - Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice
  - The Profession of Modeling and Simulation: Discipline, Ethics, Education, Vocation, Societies, and Economics
  - Principles of Modeling and Simulation: A Multidisciplinary Approach
- These monograms can be borrowed from NTSA to help review for the exam
  - You may borrow the books requested for 1 month and will have to only pay for shipping.
- The exam platform also includes practice quizzes that you can take to get a good sense of each exam part.

EXAM TOPICS AND SUBTOPICS

- Intent
  - Include topics spanning the M&S Body of Knowledge (BoK)
- Structure
  - 8 topics, 54 subtopics
- Content:
  - Initially based on SimSummit M&S Body of Knowledge Index
  - Revised per expert recommendations
  - Revised per source availability and topic testability



CERTIFICATION TOPICS AND SUBTOPICS

1. **Concepts and context**
1.1 Fundamental terms and concepts
1.2 Categories and paradigms
1.3 History of M&S

2. ***Applications***
2.1 Training
2.2 Analysis
2.3 Experimentation
2.4 Acquisition
2.5 Engineering
2.6 Test and evaluation

3. ***Domains / Question Context***
3.1 Combat and military
3.2 Aerospace
3.3 Medicine and health care
3.4 Manufacturing and material handling
3.5 Logistics and supply chain
3.6 Transportation
3.7 Computer and communications systems
3.8 Environment and ecology
3.9 Business
3.10 Social science
3.11 Energy
3.12 Other domains of use

4. ***Modeling Methods***
4.1 Stochastic modeling
4.2 Physics-based modeling
4.3 Structural modeling
4.4 Finite element modeling and CFDs
4.5 Monte Carlo simulation
4.6 Discrete event simulation
4.7 Continuous simulation
4.8 Human behavior modeling
4.9 Multi-resolution simulation
4.10 Other modeling methods

5. ***Implementation***
5.1 Modeling and simulation life-cycle
5.2 Modeling and simulation standards
5.3 Development processes
5.4 Conceptual modeling
5.5 Specialized modeling and simulation languages
5.6 Verification, validation, and accreditation
5.7 Distributed simulation and interoperability
5.8 Virtual environments and virtual reality
5.9 Human-computer interaction
5.10 Semi-automated forces/computer generated forces
5.11 Stimulation

6. **Supporting tools, techniques, and resources**
6.1 Major simulation infrastructures
6.2 M&S resource repositories
6.3 M&S organizations

7. **Business and management of M&S**
7.1 Ethics and principles for M&S practitioners
7.2 Management of M&S projects and processes
7.3 M&S workforce development
7.4 M&S business practice and economics
7.5 M&S industrial development

8. **Related communities of practice and disciplines**
8.1 Statistics and probability
8.2 Mathematics
8.3 Software engineering and development
8.4 Systems science and engineering

EXAM TIPS / TECHNIQUES / TIMELINE

- Complete pre-requisites: Application, References, Etc.
- Pick Level ← *Consider your strengths and limitations…*
- Pick Start Time ← *Consider your time commitments, etc.!*
- Gather Up Source Material
- Start

My Suggestions…

- Skim
- Segregate
  - Easy, Medium
  - Hard, Super Hard
- Answer
  - Normal Question Strategies Apply
- Submit

- Finish

- Read the entire question
- Answer questions you know first
- Eliminate wrong answers
- Look for words from the question in the answers
- Select the best answer
- Read every answer option
- Make an educated guess

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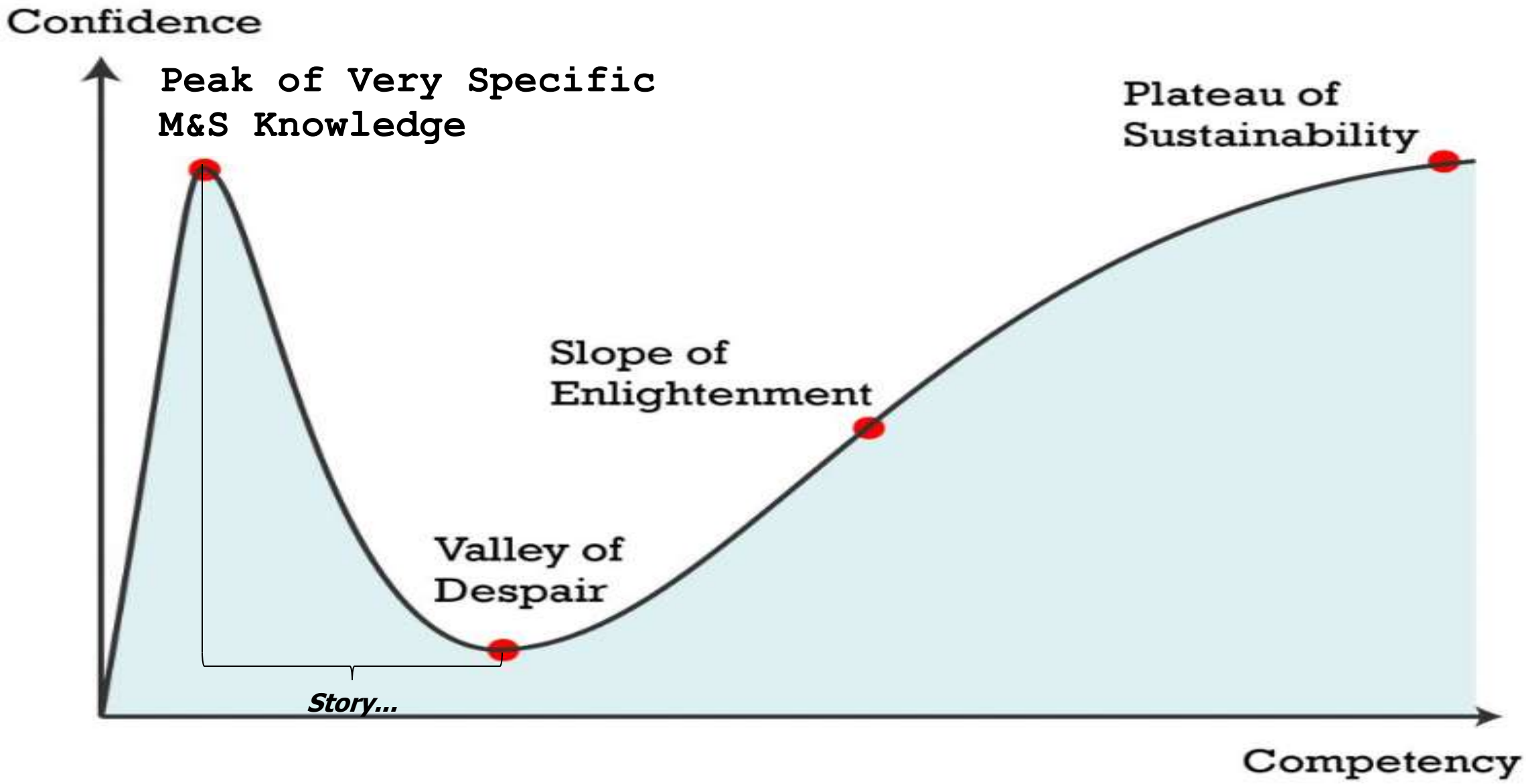
JEOPARDY BOARD				FINAL JEOPARDY
Definitions	Methods	Uses	VV&A	Acronyms
$100	$100	$100	$100	$100
$200	$200	$200	$200	$200
$300	$300	$300	$300	$300
$400	$400	$400	$400	$400
$500	$500	$500	$500	$500

- Course Evaluations

FROM M&S SPECIFIC KNOWLEDGE TO M&S ENLIGHTENMENT

ADAPTED FROM THE DUNNING-KRUGER EFFECT



https://www.dreamendstate.com/2021/01/11/dunning-kruger-effect-are-you-at-a-peak-or-plateau/

FIRST - WHY DO WE NEED M&S ?

- Typically, M&S is performed to generate data to support a decision maker or an activity

- M&S can be used to provide data to support studies to:
  - **Describe** how systems could, would, or do operate
  - **Predict** how much a system will cost, or how many units will be required, or the effects of a change
  - **Predict** the effect of changes to the system
  - **Prescribe** best approach to a problem or condition

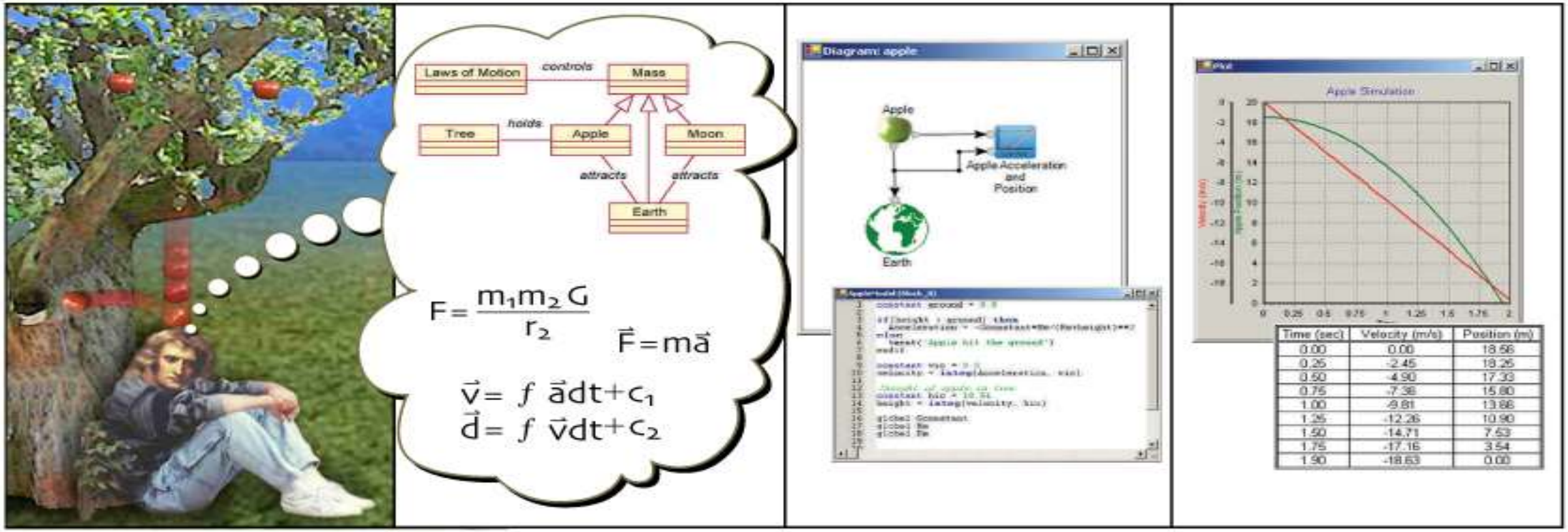
- Why not use the real system?
  - Not yet available
  - Too dangerous or expensive to use
  - ***Live tests can be destructive***
  - Need to simulate system under unusual or undesirable environmental conditions
  - Need to analyze randomness in a system
  - Impossible to observe internal processes

TOPIC 1: CONCEPTS AND CONTEXT

- Essential terminology, foundational concepts, community consensus categorizations, and overarching modeling paradigms; history of the development and use of M&S.

1. Concepts and context
   - 1.1 Fundamental concepts and terms
   - 1.2 Categories and paradigms
   - 1.3 History of M&S

FOUNDATIONAL CONCEPT - ABSTRACTION



Real World | **Conceptual Model** | **Simulation** | **Analytical Results**

- *How would you define each step?*

FOUNDATIONAL CONCEPT - TERMS

- **Model**: A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process
- **Conceptual Model**: An implementation neutral (simplified) representation of a system that provides a bridge between the developer and the user
- **Simulation**: A method for implementing a model over time / an imitation of a situation or process
- **Game**: A competition between human adversaries, based on rules, for entertainment or learning
- **M&S Includes**: Emulators, prototypes, simulators, stimulators, appended trainers, etc.
- **Monte-Carlo Simulations**: Uses (pseudo) random samples of parameters or inputs to explore complex behavior
- **Distributed or Federated Simulations**: Geographically remote simulations acting against each other in an LVC environment
- **Live Simulation**: Real people employing real systems in a non-operational role or location (e.g., on a training range)
- **Virtual Simulation**: Real people operating simulated systems in a synthetic environment
- **Constructive Simulation**: Simulated people operating simulated systems in a simulated environment
- **Parametric**: System-level represented by a set of generic algorithms and data structures
- **Engineering**: Captures component functionality rather than the details of signal processing
- **Emulative**: Sub-component / signal processing level of detail sufficient to support detailed analysis





FOUNDATIONAL CONCEPT - MORE TERMS

- **Simuland**: The object, process, system, or phenomenon that is to be simulated. For instance, in mannequin-based patient simulators, the simuland is a human patient
- **Calibrate:** To calibrate a model is to determine reasonable values for critical model parameters
- **Referent**: A codified body of knowledge about a thing being simulated
- E.g., Validation Referent: Is the best or most appropriate codified body of information available that describes characteristics and behavior of the reality represented in the simulation
- **Constraint Model**: Constraint-based modeling is a mathematical approach, in which the outcome of each decision is constrained by a minimum and maximum range of limits
- **Conceptual Model**: Conceptual modeling is the abstraction of a simulation model from the real-world system that is being modeled and describing it in an implementation neutral manner
- **Functional Model**: Is a (graphical) representation of a system. Each building block represents a discrete function. The inputs and outputs flow in and out of the system and between functions.
- **Declarative Model**: Uses symbolic expressions to represent models to formalize high-level mathematical models. They rely on preconfigured capabilities in the language to accomplish a task without explicit case-by-case instructions on what steps to take. Declarative programming focuses on the end result.
- **Agent Based Model**: Agent models are generally top-down, with the model focusing on the overall collective behavior of the set of agents

FOUNDATIONAL CONCEPTS - CATEGORIES

Where do M&S Systems that you know fit?

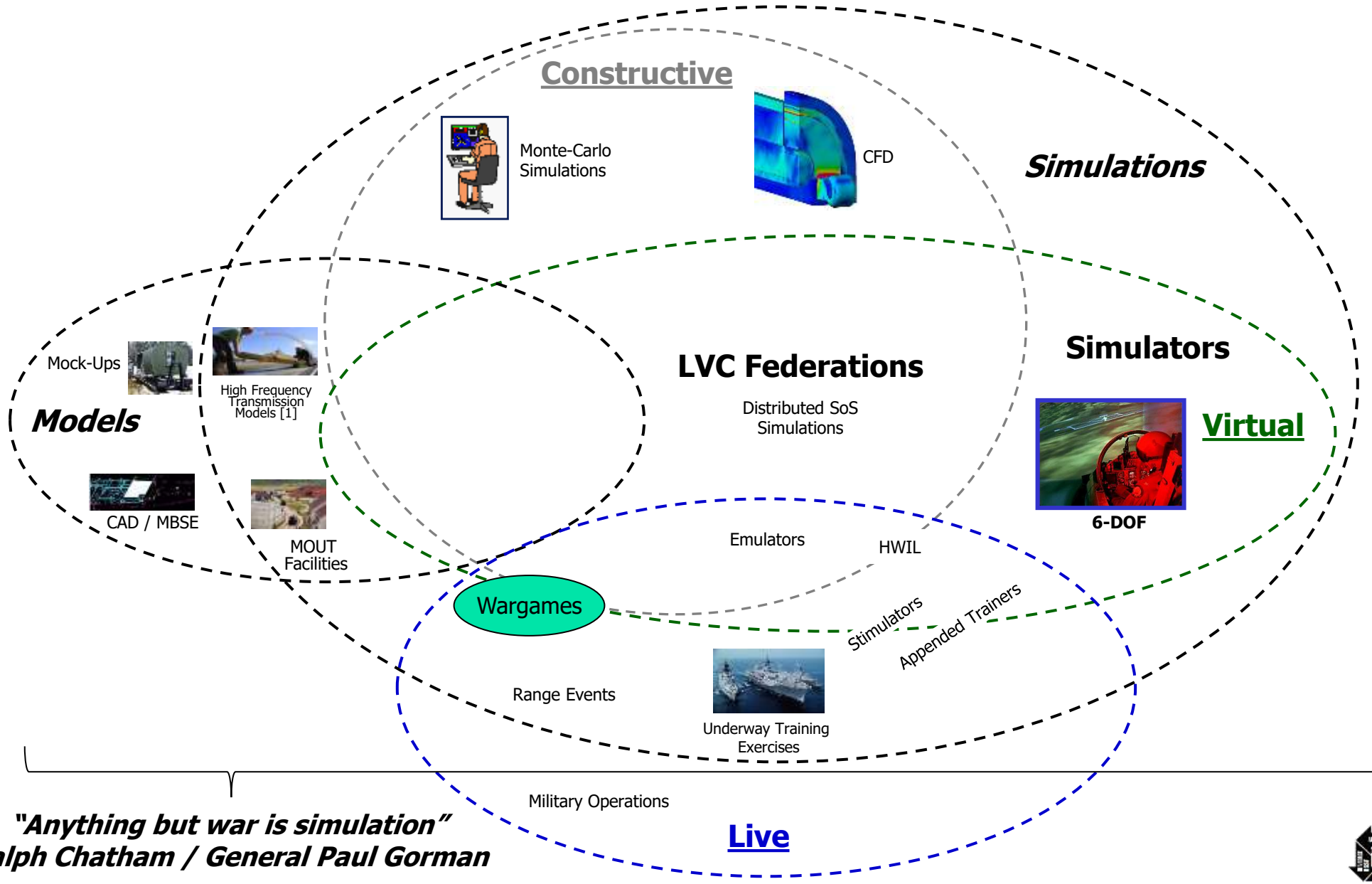
STORM

JSE Used for F-35 OT&E

Others…

Where do Wargames fit?

- Events with Real People
- Gaming Simulations
- Can use M&S for Adjudication



[1] - S. R. Best, "On the use of scale brass models in HF shipboard communication antenna design," in *IEEE Antennas and Propagation Magazine*, vol. 44, no. 2, pp. 12-23, April 2002.

CAD - Computer Aided Design
CFD - Computational Fluid Dynamics
DOF - Degrees of Freedom,
HWIL - Hardware in the Loop
JSE – Joint Simulation Environment
MOUT - Military Operations on Urban Terrain,
SoS - System of Systems

"Anything but war is simulation"
Ralph Chatham / General Paul Gorman

M&S HISTORY

The1942 model C-3 Link Trainer was manufactured by Link, an organ and player piano maker. It was used by the allies during World War II to train pilots to fly using only instruments. During World War II, 6271 Link trainers were delivered to the Army and 1045 to the Navy. The Link trainers were also used by 35 foreign countries. Movement of the trainer is accomplished by vacuum operated bellows, controlled by valves connected to the control wheel (or stick) and rudder pedals. An instructor sat at the desk and transmitted radio messages which the student in the Link heard through his earphones.

So:

- What has changed?
- What has NOT?

Puppets

Simple 6DOF

Simple PC

Multiple PCs+

PC Cockpit and Visuals

PC Cockpit and 3 Visuals

Emulated Cockpit and Visuals

6DOF and Visuals

Multiple 6DOFs and Visuals+

6DOF, Visuals+, Associates

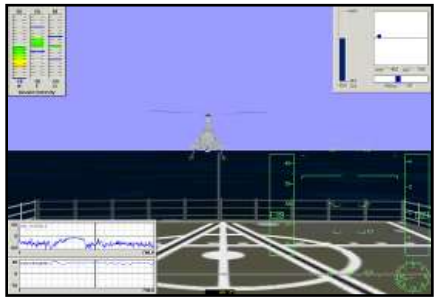
A/C Plus Other Warfare Areas

Plus Multi-Echelon C2

TOPIC 2: APPLICATIONS OF M&S

- Important and cross-cutting M&S application types; modeling methods and organizing principles for each.

2. Applications of M&S
   - 2.1 Training
   - 2.2 Analysis
   - 2.3 Experimentation
   - 2.4 Acquisition
   - 2.5 Engineering
   - 2.6 Test and Evaluation



Digital Modeling

Hardware In-The-Loop

Systems Test and Measurement Facilities

Flight Testing Open Air Training

TRAINING

M&S used to produce learning results for a user or participant

Proficiency…

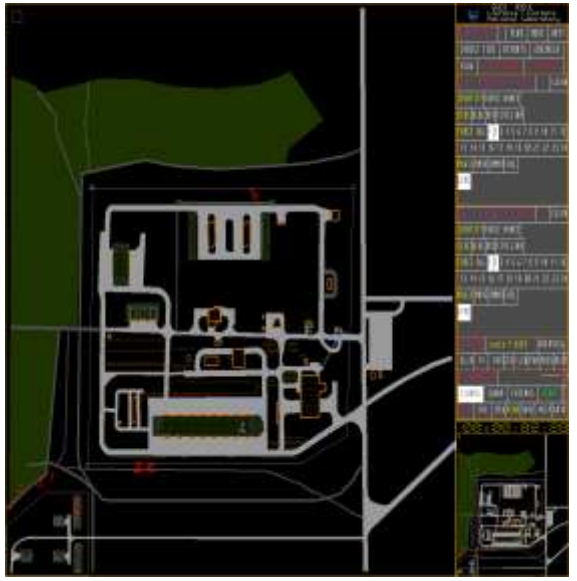
- Realistic enough to produce useful skills or knowledge
- ***Much safer***, more forgiving of mistakes
- Especially valuable in teaching skills relative to unusual and/or dangerous situations

MUCH SAFER, BUT…

- In October 1992, during a NATO Simulation / Exercise…
- The TCG Muavenet, a Turkish Navy Destroyer was crippled by two Sea Sparrow missiles
- These missiles were launched from the USS Saratoga
- Senior officers on watch on the Saratoga decided to take advantage of the NATO exercise to rehearse the procedures for responding to a simulated attack, according to the Navy investigation
- The American sailors, awakened late at night, mistook a drill for an actual attack
- The result was the killing 5 Turkish sailors and the wounding of 15

ANALYSIS

- M&S used to define / understand, predict, or assess a real or notional system or idea
- To answer questions
  - That vary from Factory Output, to Transportation Bottlenecks, to Force Structure, …
- Repeatability often desirable
  - To avoid confounding variability
- Requires careful experimental design
  - Trials are pre-planned to cover the spanning cases
  - Multiple trials for statistical significance

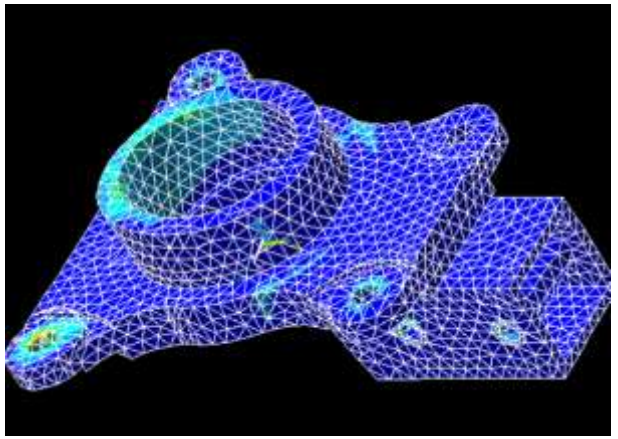


JCATS, Wurtsmith AFB

ENGINEERING

- M&S used to develop, analyze, or test an engineering design

- Model artificial systems and components
- Models are physics-based, no “behavior”
- No virtual environment or simulators
- User not expected to benefit from experience of execution
- Primary goal: Generate useful information



FEM of a bracket

5 Min

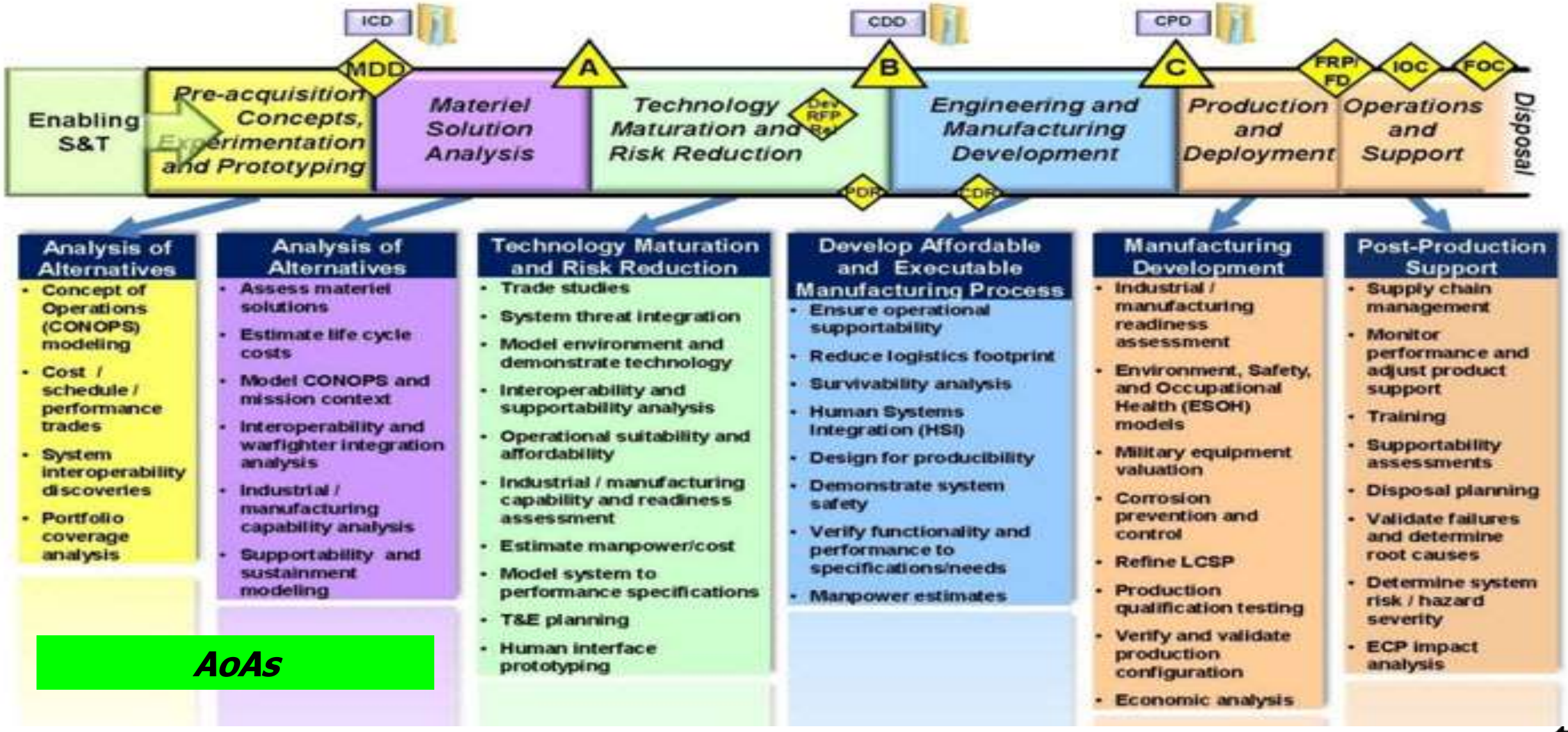
https://www.facebook.com/NUWCNewport/videos/the-matrix-the-weapons-analysis-facility/10151096373222083/

TEST AND EVALUATION

- M&S can be a source of additional test “data” when actual testing is:
  - Too expensive or impractical to conduct
  - Too dangerous to conduct
  - Prohibited by treaties, laws, or policies
- Result in savings in cost, schedule, and/or number of test articles
- Can provide higher confidence levels due to having more data

- But…
  - Accuracy - M&S cannot fully replicate live T&E
  - Real world outcomes dependent on interactions which are complex and difficult to fully understand, quantify and model
  - M&S can be very expensive to develop, especially for first user
  - M&S is not a replacement for testing - By law, OE & OS cannot be evaluated solely via M&S
  - VV&A can be very expensive and time consuming

M&S ACROSS DoD's ACQUISITION LIFE CYCLE



TOPIC 3: DOMAINS OF USE OF M&S

- Domains in which M&S has found wide use; key modeling methods and applications for each.

3. Domains of use of M&S
   - 3.1 Combat and Military
   - 3.2 Aerospace
   - 3.3 Medicine and Health Care
   - 3.4 Manufacturing and Material Handling
   - 3.5 Logistics and Supply Chain
   - 3.6 Transportation
   - 3.7 Computer and Comms Systems
   - 3.8 Environment and Ecology
   - 3.9 Business
   - 3.10 Social Science
   - 3.11 Energy
   - 3.12 Other Domains of Use

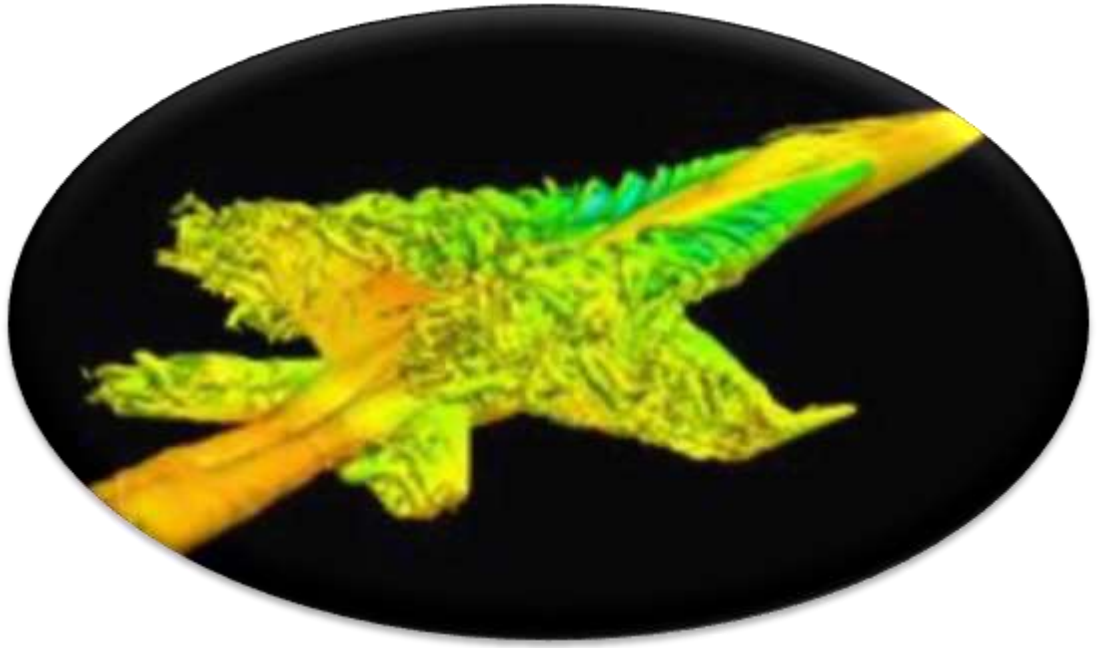
What are some other domains of use?

Cybersecurity
Networking
Chemistry
Biology / Bio-Sciences
City Planning
Construction
Highway Design

TOPIC 4: MODELING METHODS

- Technical aspects of widely used modeling methods; characteristics and suitable applications for each.

- Modeling Methods
  - Deterministic
  - Stochastic Modeling
  - Physics-based Modeling
  - Finite Element Modeling and CFD
  - Monte Carlo Simulation
  - Discrete Event Simulation
  - Continuous Simulation
  - Human Behavior Modeling
  - Multi-resolution Simulation
  - Real-time Simulation
  - Other Modeling Methods



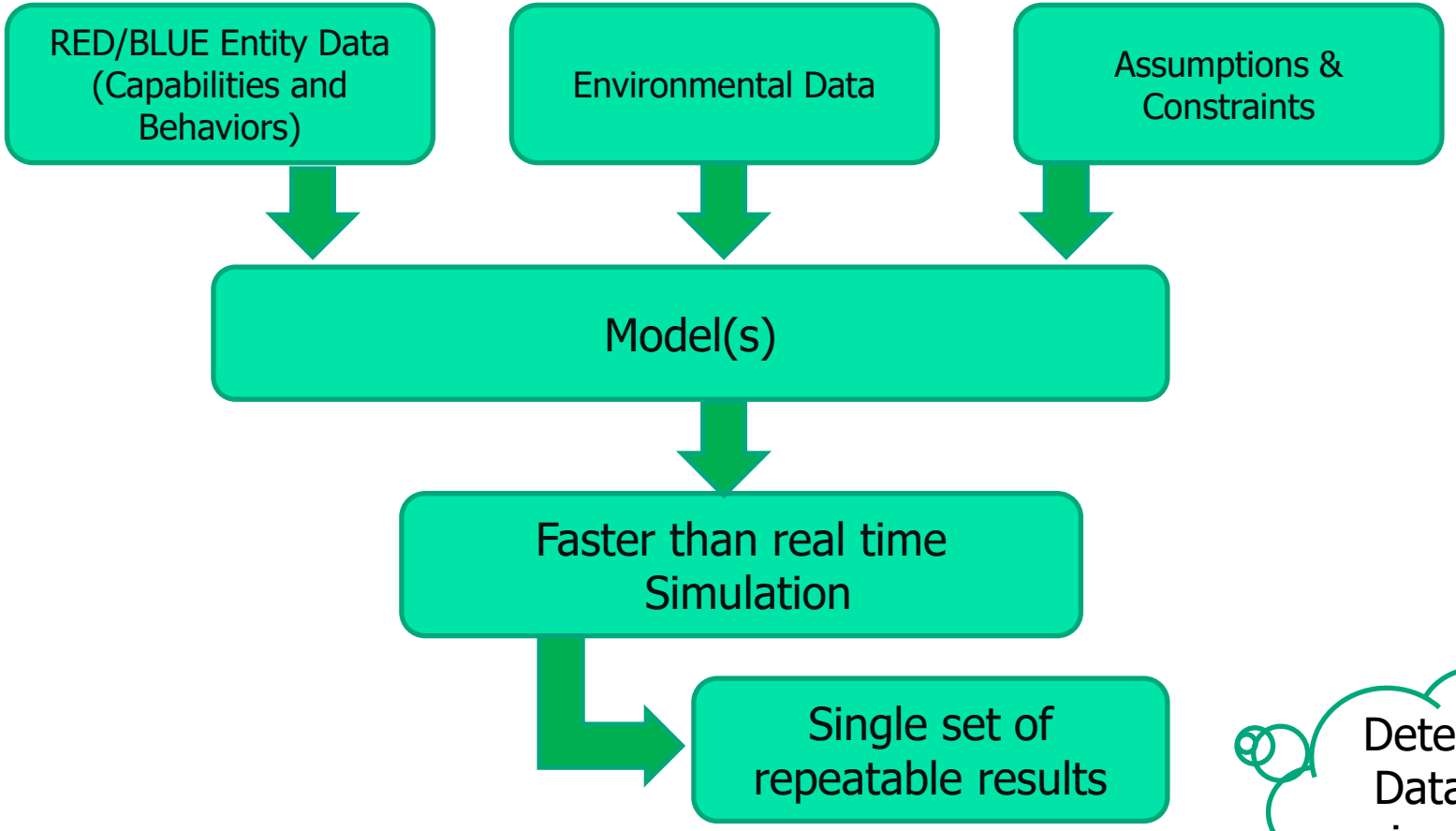
DETERMINISTIC

- Model where a given set of inputs will produce a determined, unique set of outputs

- Example: *Chess*
  - No dice rolls or random elements
  - Same decisions → same results

- Example: Engineering simulation
  - FEM simulation of engine part
  - Physics-based models deterministic
  - Output determined by input

DETERMINISTIC CONSTRUCTIVE SIMULATION



Deterministic Data results in discrete results

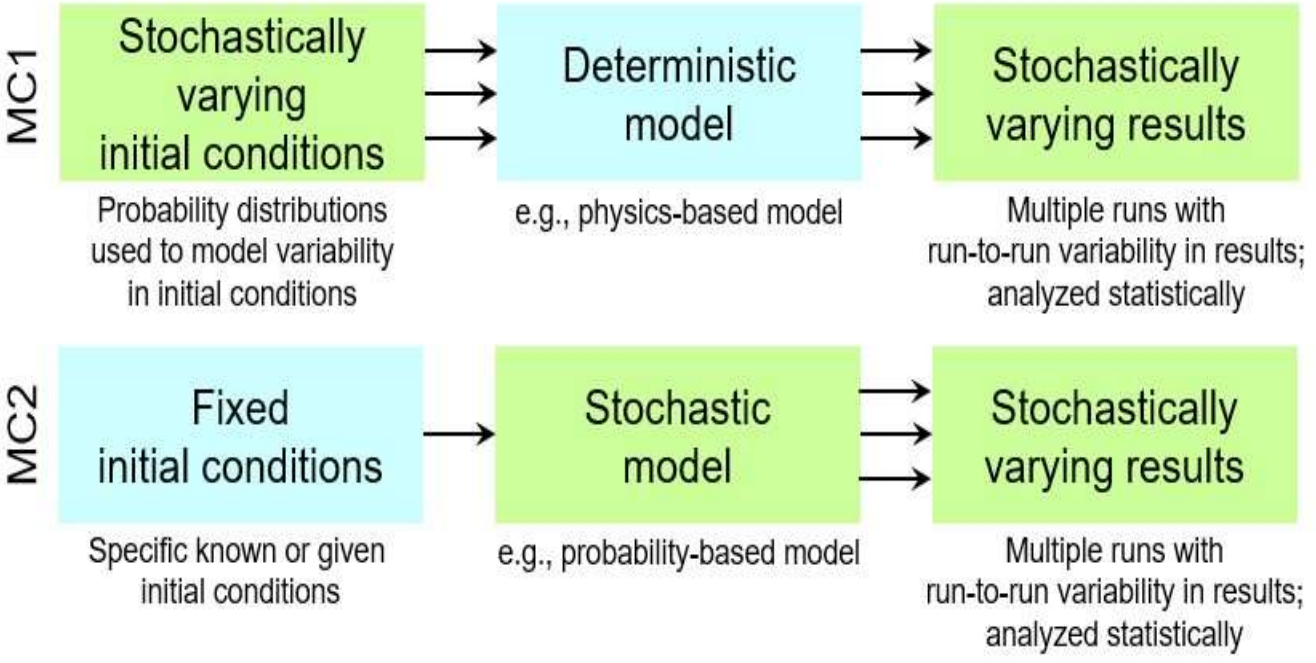
Two Types

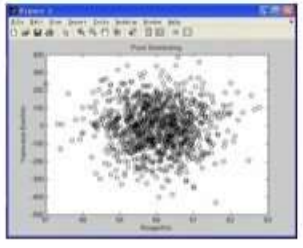
Stochastic initial conditions input to deterministic model

- Randomly generated initial conditions provided as input, model calculates results deterministically

Deterministic initial conditions input to stochastic model

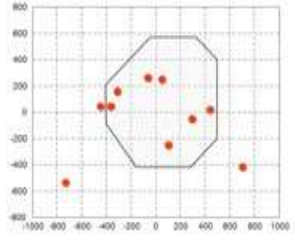
- Given input, model calculates results stochastically to generate physics or process outcomes





MC1
Missile impacts
[Zhang, 2008]

MC2
Bombing accuracy
[BanksJ, 2010]



STOCHASTIC CONSTRUCTIVE SIMULATION

RED/BLUE Entity Data (Capabilities and Behaviors)

Environmental Data

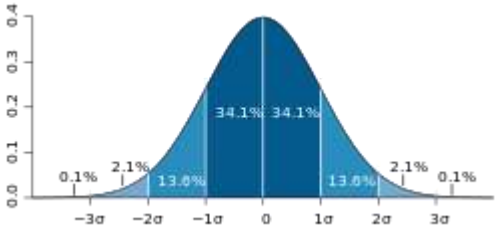
Assumptions & Constraints

Model(s) w/ probability distributions

Faster than Real Time "Monte Carlo" Simulation (100+ replications)

100+ sets of randomly distributed results

Mean, Std Dev, 95% confidence Interval



Stochastic Data results in Probabilistic insights

IMPLICATIONS

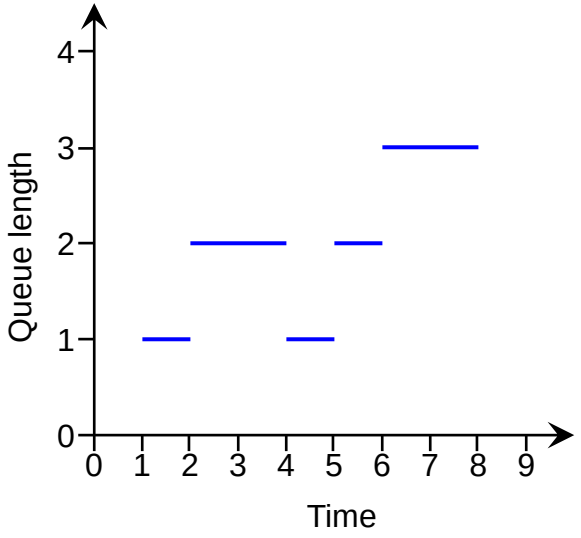
- **Deterministic simulations** are especially useful in training where repeatable scenarios are required to provide consistent synthetic training venues

- **Stochastic simulations** are valuable when there are many sources of uncertainty that interact in unforeseeable ways, e.g., warfare analysis. They:
  - Can be computationally quite complex and normally require more in-depth statistical and computational abilities
  - Can be used for sensitivity and Design of Experiments analysis
  - Represent ~~the~~ real-world variability of inputs and parameters

- **Stochastic simulations** provide analysts and decision makers with “likelihood” information (example: 80% chance of mission success) and enable decision making flexibility

DESCRETE EVENT SIMULATION

- Model state variables change only at a discrete set of points in time (“events”)
- Simulation using discrete models and event handling / event-driven
- E.g., Aircraft launch → Arrives on station → Starts close-air-support

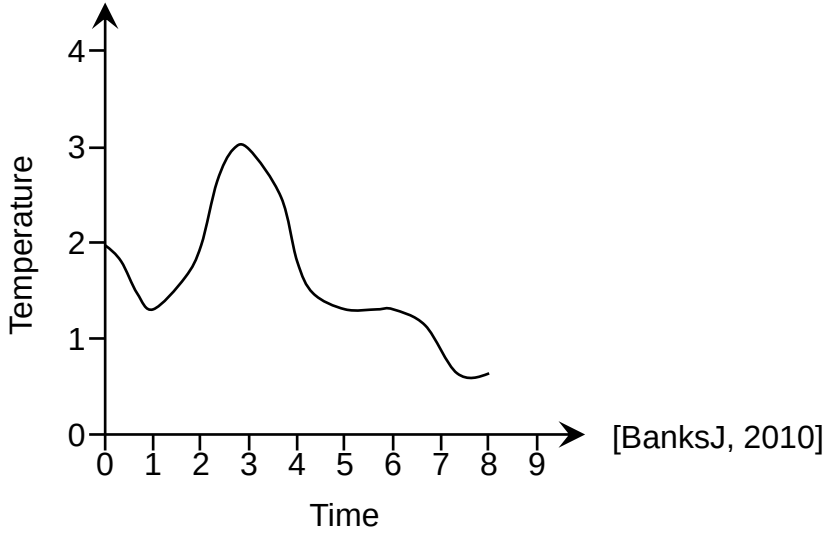


[BanksJ, 2010]

```
t = 0
while t < end_time
    t = time of next event e
    process event e
    possibly schedule future events
endwhile
```

CONTINUOUS

- Model where state variables change (pseudo-) continuously over time. Typically, time advances in small fixed time steps
- AKA “time-stepped” [Banks J, 2010]
- Continuous simulation uses continuous models



[BanksJ, 2010]

```
t = start_time
while t < end_time
    t = t + Δt
    calculate simulation state at t
endwhile
```

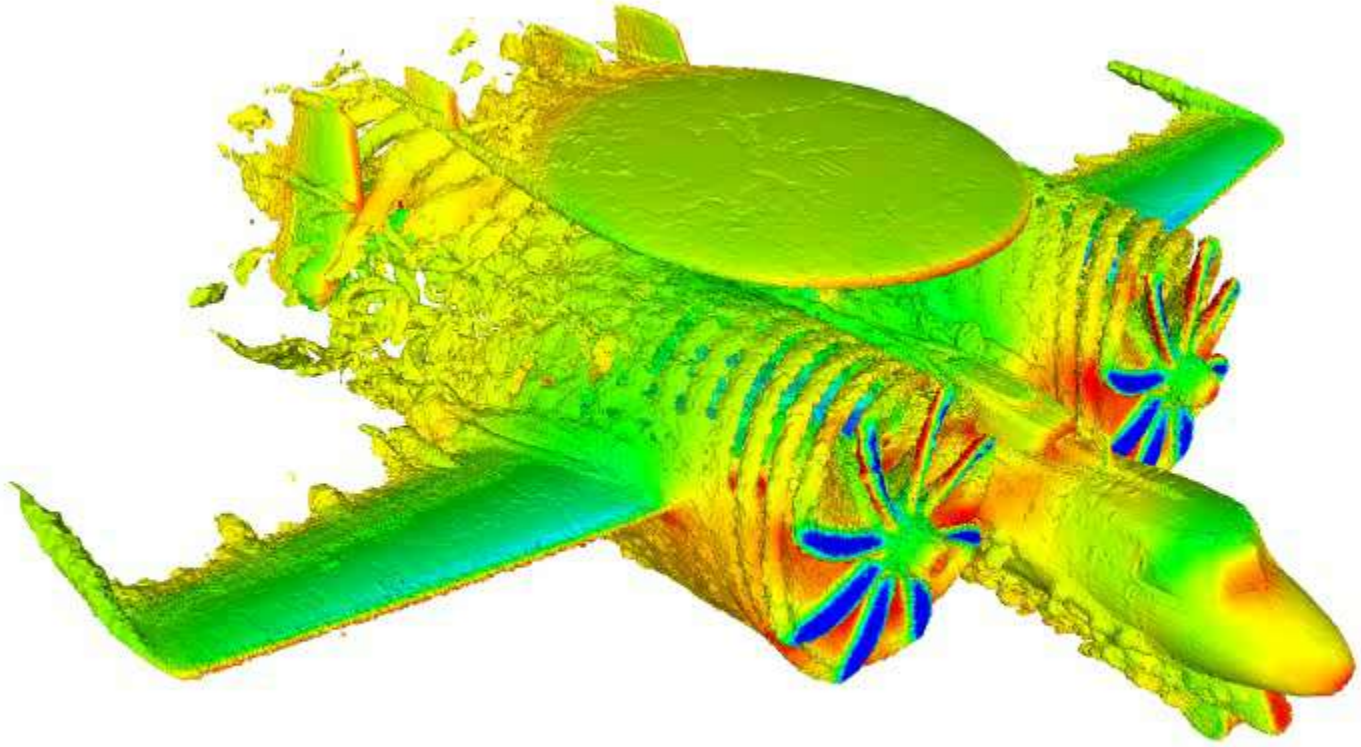
REAL-TIME SIMULATION

- Real-time simulations often include interaction with live components (possibly humans) and interact with real-world systems
  - Yet, the clock might still jump ahead, back, or advance at a faster or slower rate – but the clock is shared among the simulation and the real world

- Example – A flight simulator or a Hardware in the Loop (HWIL) Test Bed

COMPUTATIONAL FLUID DYNAMICS

- CFD is the process of mathematically modeling a physical phenomenon involving fluid flow and solving it numerically using high performance computer resources
- The propeller geometry investigated is representative of a modern eight-bladed design for high-speed turboprop transport aircraft



VIRTUAL ENVIRONMENTS & VIRTUAL REALITY

- Virtual Scene Realism
- Natural Interaction
- User Controls Environment
- Displays
  - CAVE
  - HMD
  - LCD/CRT/Plasma
  - Stereoscopic
  - Multi-Modal
- Immersion!

AUGMENTED REALITY

- Integrating computer displays into real-world environments
- This technology will be fueled by improvements in position and orientation technologies as well as dynamic real-time database updates

WHAT IS MISSING?

- Analog

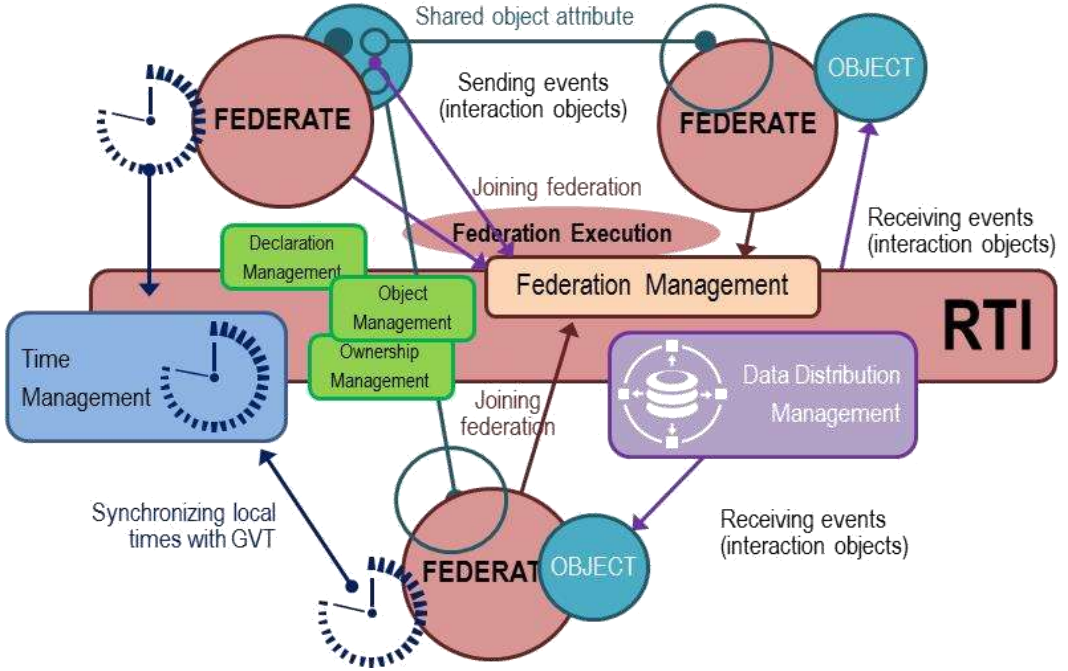
- Virtualized Hybrid Simulation Systems (LVC++)
- Quantum Simulation
- Others...

The Matrix's "digital rain" is one of the most recognizable images from the film. ANIMAL LOGIC/WARNER BROS

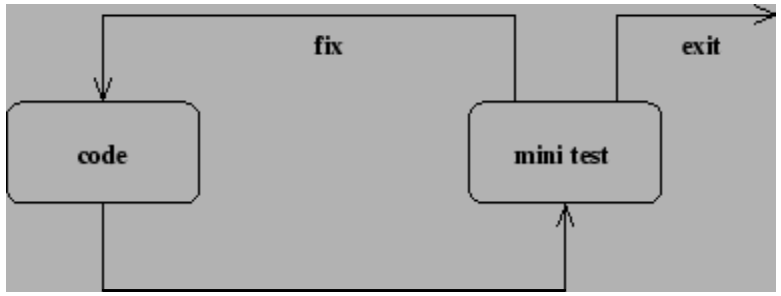
TOPIC 5: SIMULATION IMPLEMENTATION

- Engineering principles and practices for developing and validating M&S systems; M&S standards; special models.

5. Simulation implementation
   - 5.1 Modeling and simulation life-cycle
   - 5.2 Modeling and simulation standards
   - 5.3 Development processes
   - 5.4 Conceptual modeling
   - 5.5 Specialized languages
   - 5.6 Verification, validation, and accreditation
   - 5.7 Distributed simulation and interoperability
   - 5.8 Virtual environments and virtual reality
   - 5.9 Human-computer interaction
   - 5.10 Semi-automated forces
   - 5.11 Stimulation

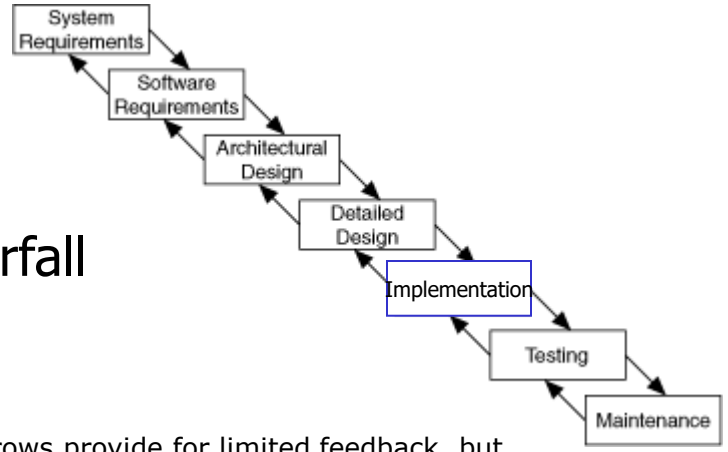


SOFTWARE (M&S) LIFE-CYCLE MODELS 1 of 2



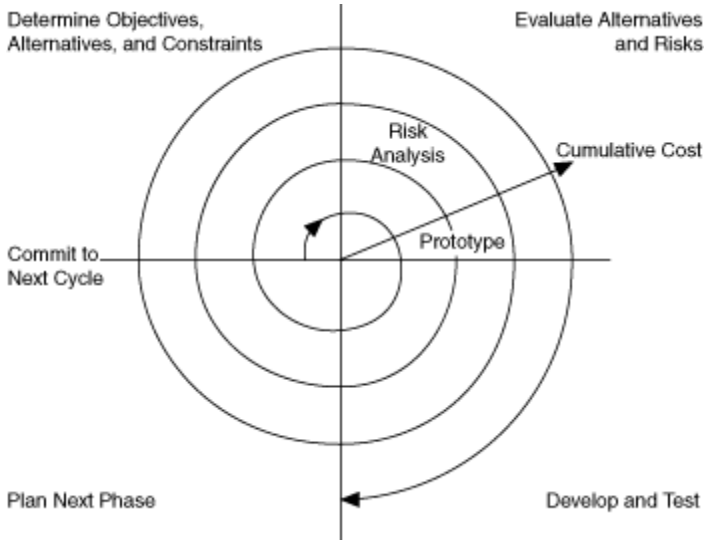
Code & Fix

Problems: No Requirements, No Design



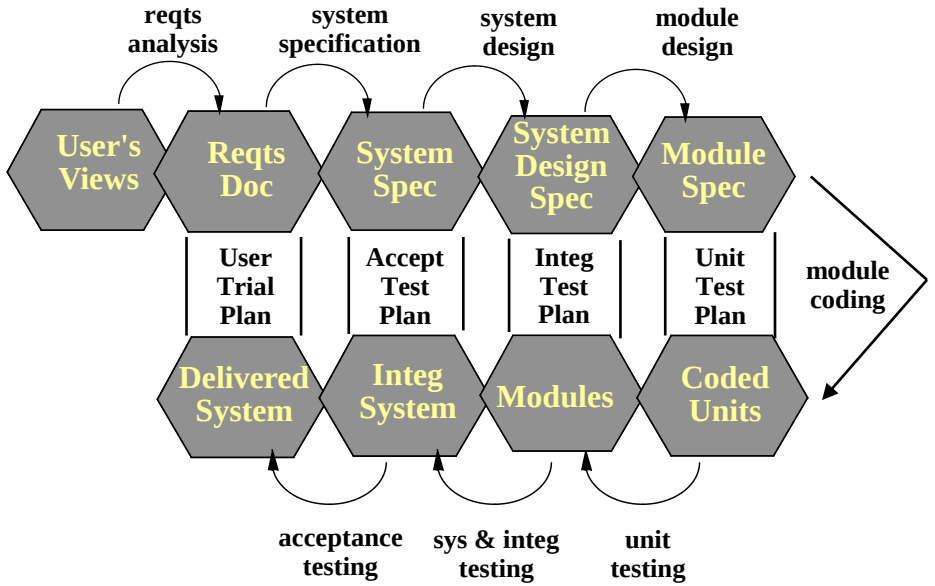
Waterfall

Problem: Arrows provide for limited feedback, but no iterations, and no mechanism for prototyping.



Spiral Model

Notes: Spiral model added iterations and rapid prototyping



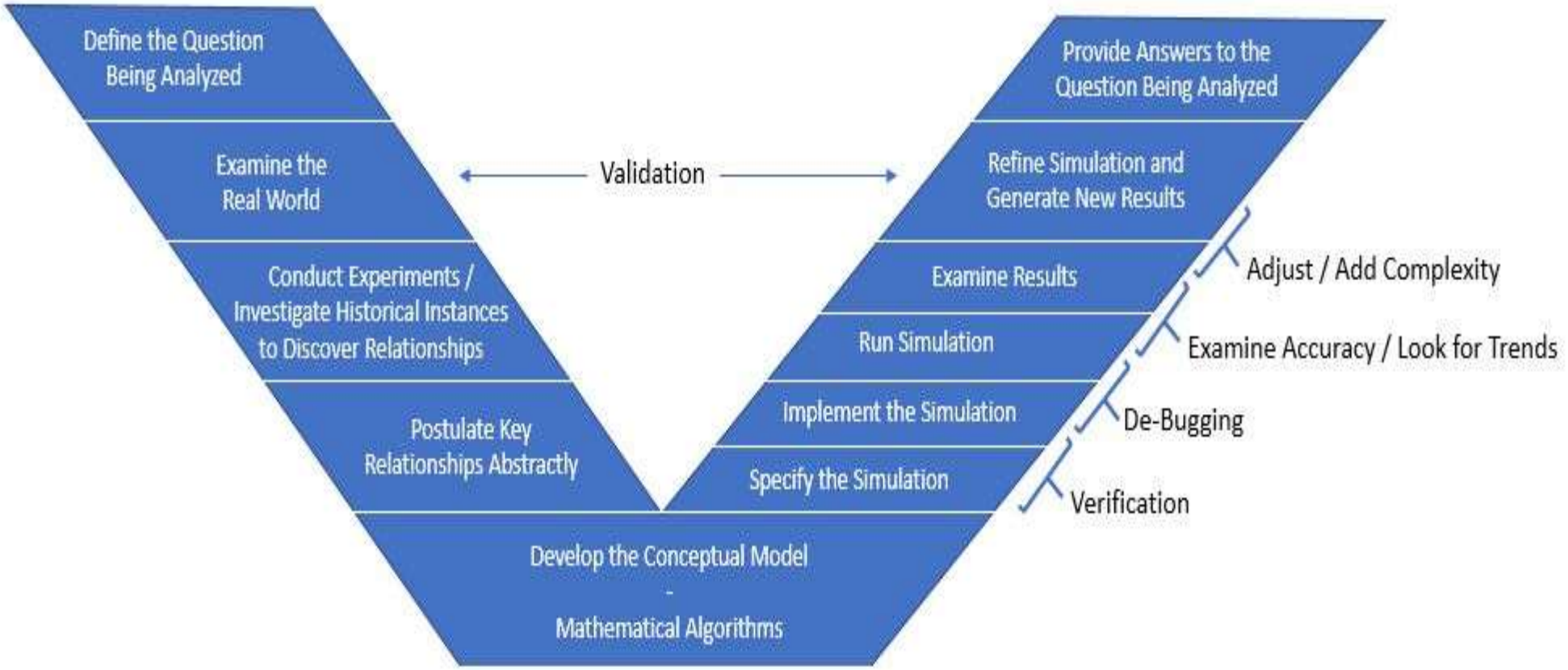
Ould & Unwin

Ould, M. A. and Unwin, C. (1986). *Testing in Software Development*. Cambridge University Press, Great Britain.

SOFTWARE (M&S) LIFE-CYCLE MODELS 2 of 2

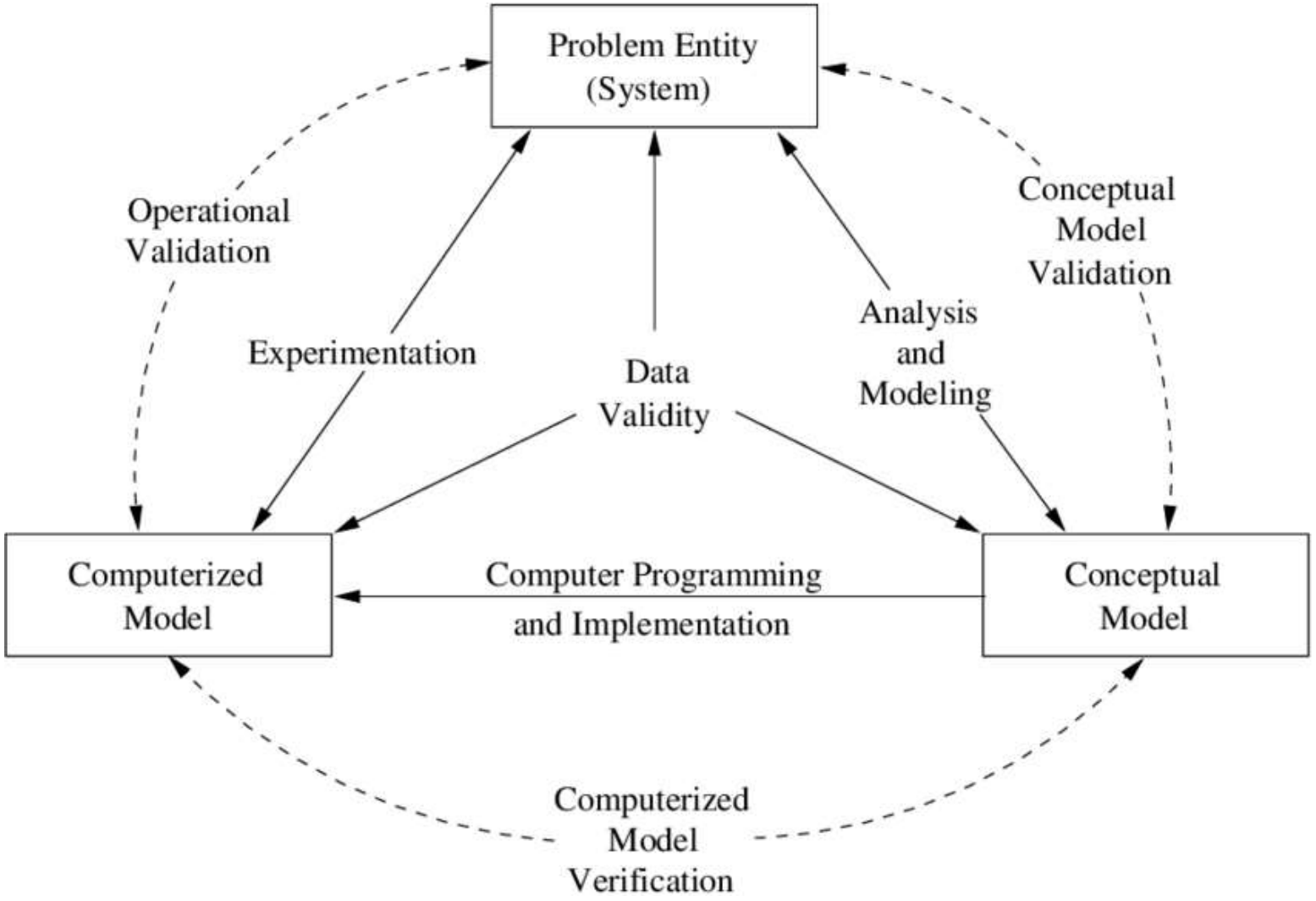
- Agile evolved to constantly define and execute small development activities (2-week sprints!)
  - Define requirements, select what seems achievable in short sprint, try to build that piece and test it internally…after many sprints, requirements have been met, deliver
- DevOps evolved from agile to integrate constant testing and delivery of capability to customers/users
- DevSecOps is just the next evolution to include security considerations into the process

M&S DEVELOPMENT PROCESS - 1 of 3



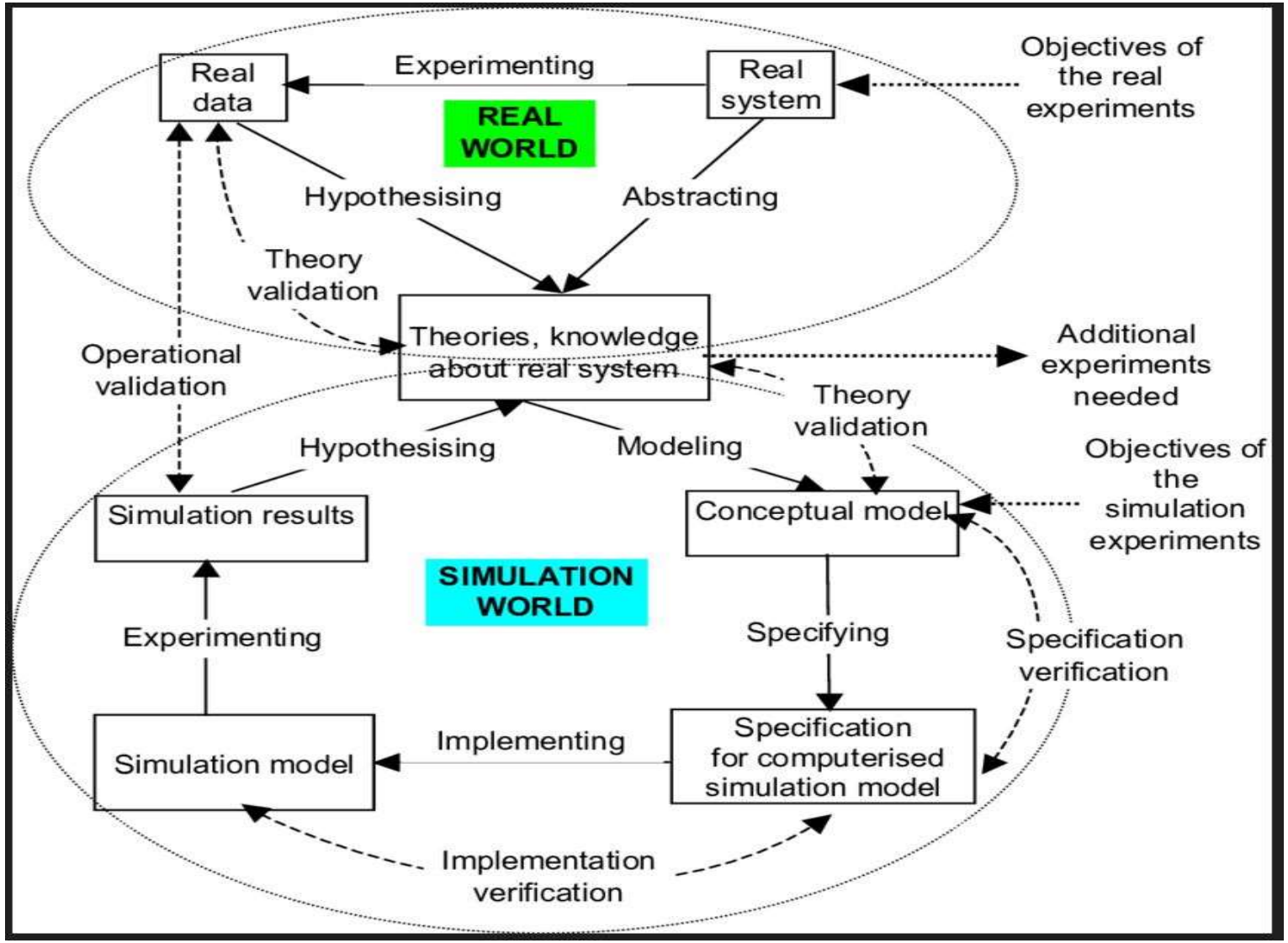
See **EXPLORING SIMULATION** (https://acsg2.com)

M&S DEVELOPMENT PROCESS - 2 of 3



Verification and Validation of Simulation Models, Robert G. Sargent, Simulation Research Group, Department of Electrical Engineering and Computer Science, College of Engineering and Computer Science, Syracuse University, 1998

M&S DEVELOPMENT PROCESS - 3 of 3

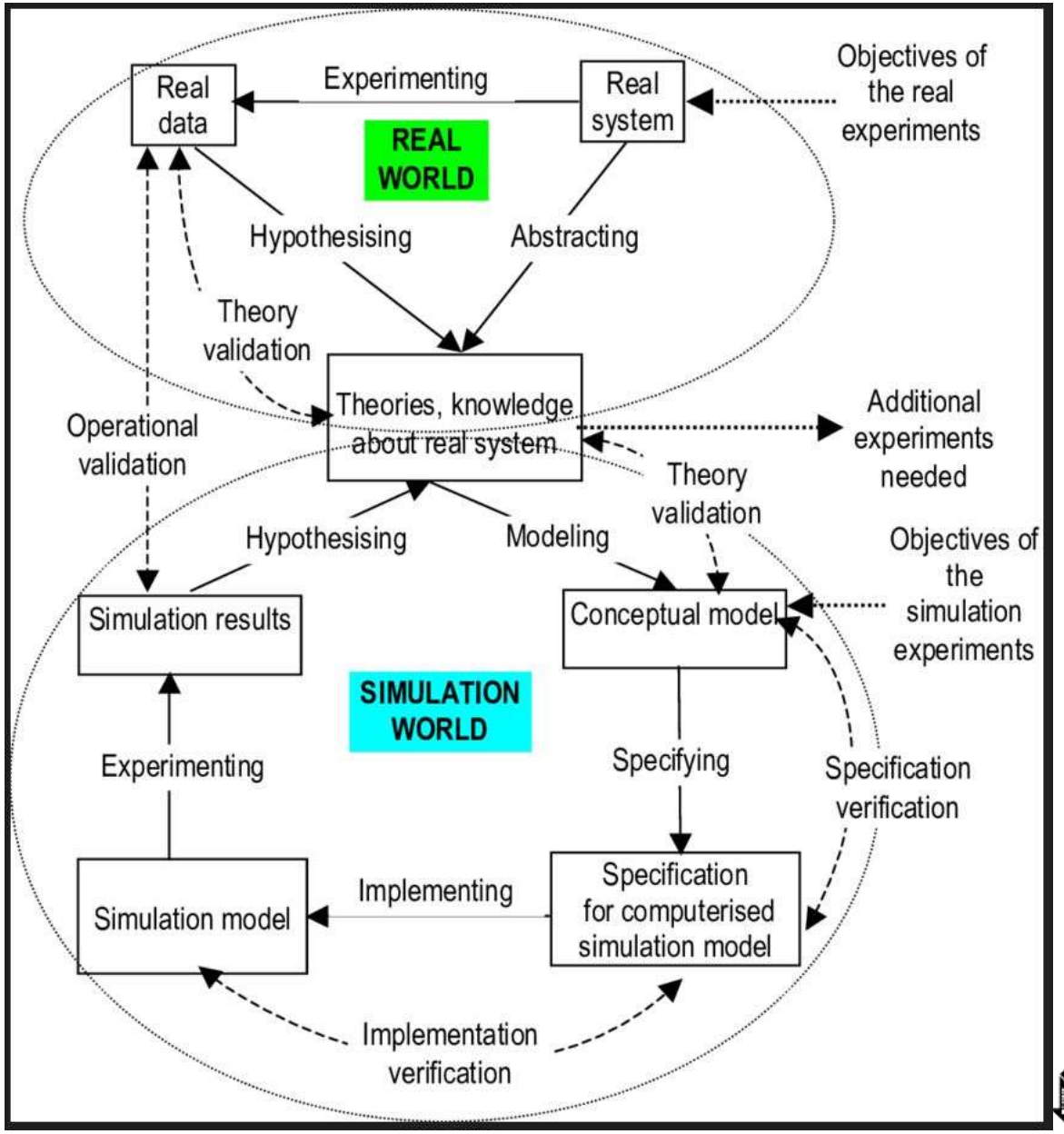


https://www.researchgate.net/figure/SIMULATION-MODEL-DEVELOPMENT-PROCESS-Source-Sargent-2008_fig1_24008600

Verification and Validation of Simulation Models, Robert G. Sargent, Simulation Research Group, Department of Electrical Engineering and Computer Science, College of Engineering and Computer Science, Syracuse University, 1998

M&S DEV PROCESS – COMBAT MODELING - 3a

- Start with the real world
  - Columns of forces engaging in lines (Started early in the 17th Century - To Maximize Firepower*)
  - (Describe Linear Combat)
- Abstract / Hypothesize
  - Understand combat lethality / causality rates based on force numbers in linear arrangement
- Develop a Conceptual Model!
  - Each side starts with a defined number of forces
  - Forces can be specified regarding their ability to inflict damage (1:3)
  - Forces are constrained in their ability to move (flanking maneuvers are not allowed)
- Specify the Simulation Capability to be Developed
  - Deterministic / Non-Probabilistic
- Develop (Implement) the Simulation System
  - Difference Equations
- Run / Execute the Simulation
  - Generate Output
- Analyze the Results / Outputs
  - Look for Correlations, Trends, Causality, etc.
- Operational Validation of the Simulation
  - See, for instance, "Exploring the Validation of Lanchester Equations for the Battle Of Kursk," John A. Dinges, NPS, June 2001



M&S DEV PROCESS - COMBAT CONCEPTUAL MODEL - 3b

English →

The size of Red at time (t) Equals ***The size of Red at the previous time slice (t-1)*** Reduced by ***The combat effectiveness of Blue and its size at the previous time slice (t-1)***

Math →

$$R(t) = R(t\text{-}1) - \beta \times B(t-1)\delta t$$

Algorithm →

The size of Red at time (t) — Force Strength = Force Size

Equals

The size of Red at the previous time slice (t-1)

Reduced by

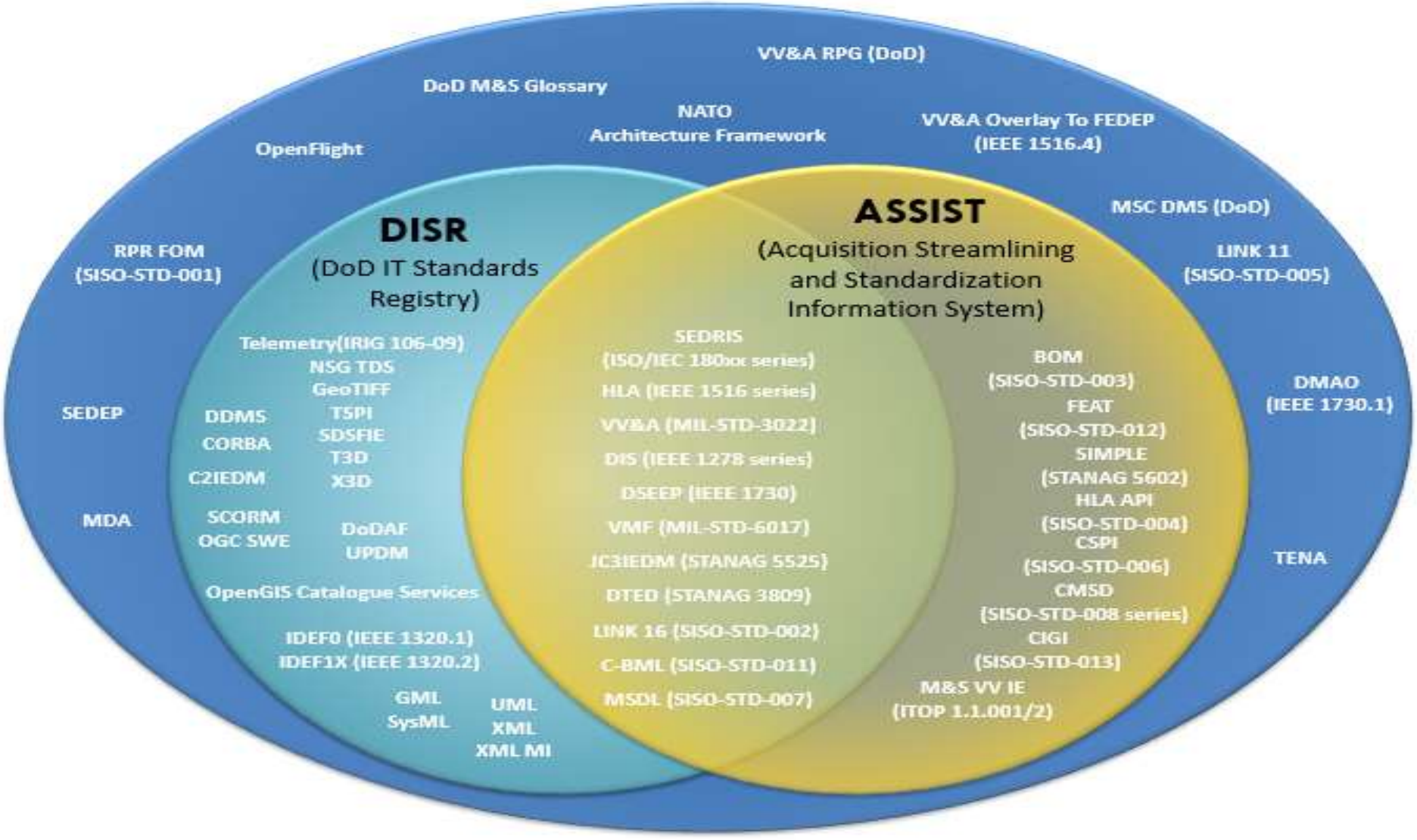
The combat effectiveness of Blue (β) — Efficiency Factor = Combat Effectiveness = Constant of Proportionality

The Size of Blue at time (t-1)

As it Changes

Over Time

M&S STANDARDS



VV&A

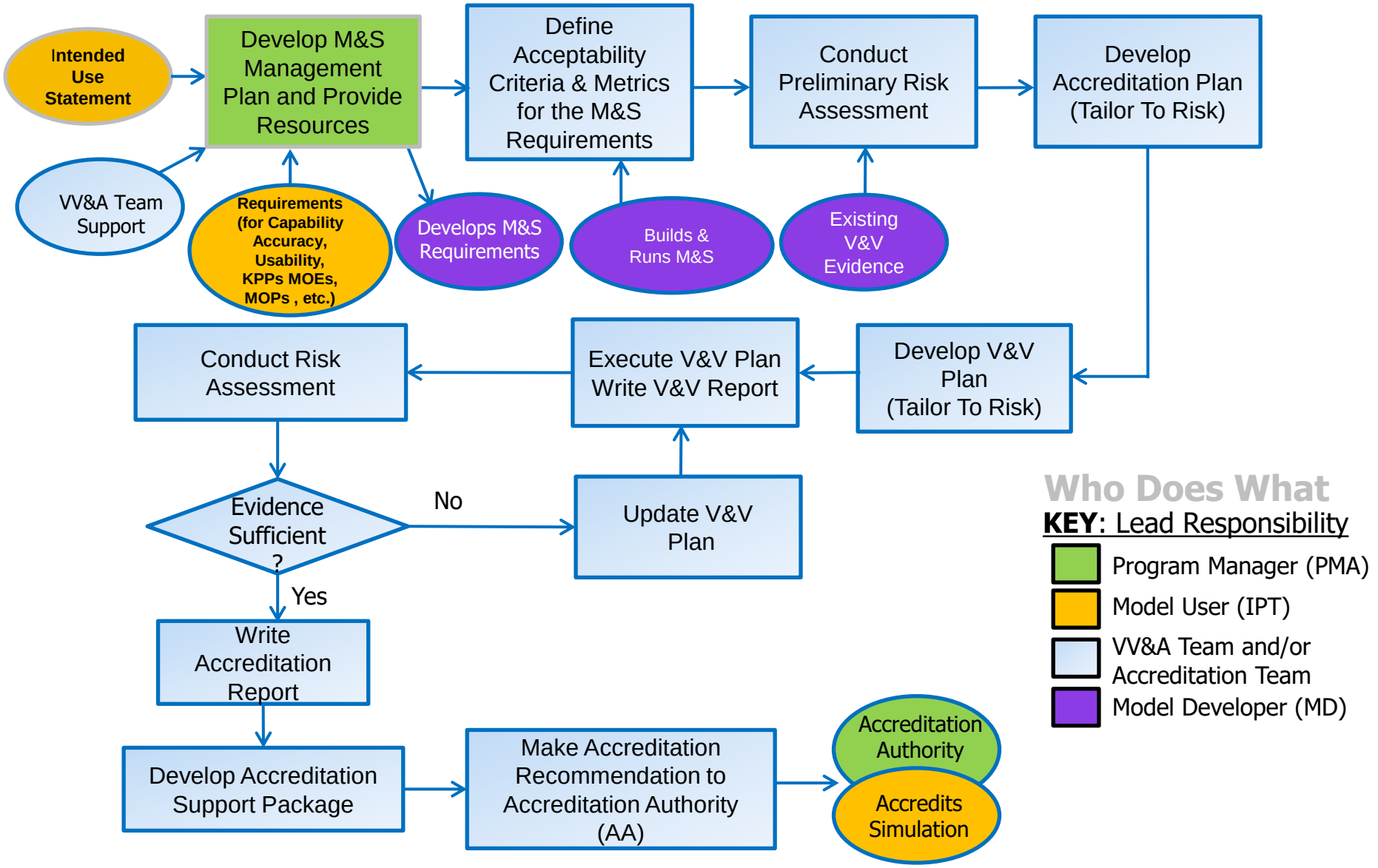
- **Verification** is the process of determining that a model implementation accurately represents the developer's conceptual description and specifications.
  - It answers the question, "Did we build it correctly?"

- **Validation** is the process of determining the manner and degree to which a model is an accurate representation of the real-world from the perspective of the intended uses of the model, and of establishing the level of confidence that should be placed on the results of its use.
  - It answers the question, "Did we build the right thing?"

- **Accreditation** is the formal endorsement ~~certification~~ that a model or simulation is acceptable to be used for a specific purpose.[1] A recognized subject matter expert in the field can accomplish accreditation.
  - Accreditation answers the question, "Does it meet my needs?"

1 - DoDI 5000.61, December 9, 2009

OVERALL VV&A PROCESS



DETERMINING VV&A REQUIREMENTS

CMSP

Determined/Categorized Requirements According To The Three Pillars of M&S/Tool Credibility

Intended Use Requirements

What the M&S shall do…

- Requirement #1
- Requirement #2
- …
- …
- Requirement #(n-1)
- Requirement #n

Requirement

ACCEPTABILITY CRITERIA

CAPABILITY REQUIREMENTS

What can the M&S do (the functions) and to what level of detail (fidelity)?

Detailed Functional Decomposition

Clearly Stated Assumptions & Limitations

ACCURACY REQUIREMENTS

How well does the M&S do what it is designed to do and is it relatively error-free?

- *Software Accuracy*
- *Data Accuracy*
- *Output Accuracy*
- *Configuration Management*

USABILITY REQUIREMENTS

What do users need to operate the M&S correctly and without introducing errors?

What are the implications of the Assumptions & Limitations?

RISK ASSESSMENT: *How fit is the M&S system to satisfy the intended use with respect to the specified Capability and Accuracy and Usability?*

Capability

ACCEPTABILITY CRITERIA

But "How Fit for Purpose?"

Intended Use Components or Aspects?

Likely Employment Environment?

Degree of Trust or Confidence?

DECISION

VALIDATION

- The validity of the system refers to the relation between the model, simulation, and real world
  - Often thought of as the degree to which a model faithfully represents its system counterpart

- Types of validity:
  - Replicative validity requires that the model and system agree at the I/O level
  - Predictive validity requires the ability to predict new / emergent unseen behavior
  - Structural validity requires that the M&S mimics step-by-step, component-by-component fashion the way in which the system does its transitions.

- Validation is the process of testing the M&S for validity
  - Face Validation - Subject Matter Expert (SME) expectations
  - Benchmarking - Another simulation with established credibility
  - Results Validation - Test Data, Operational Data, Historical Data

AKA - Registration

- Validation techniques have well-known limitations:
  - Disagreements among SMEs
  - Uncertain benchmark simulation credibility or inadequate fidelity
  - Test data availability, limitations, and cost

FOR MORE ON VV&A, SEE…

Modeling and Simulation (M&S)
Verification, Validation, and Accreditation (VV&A)
Implementation Handbook

01 September 2023

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ASN(RD&A) Chief Engineer
Department of the Navy M&S Executive

Prepared by:
Navy Modeling and Simulation Office
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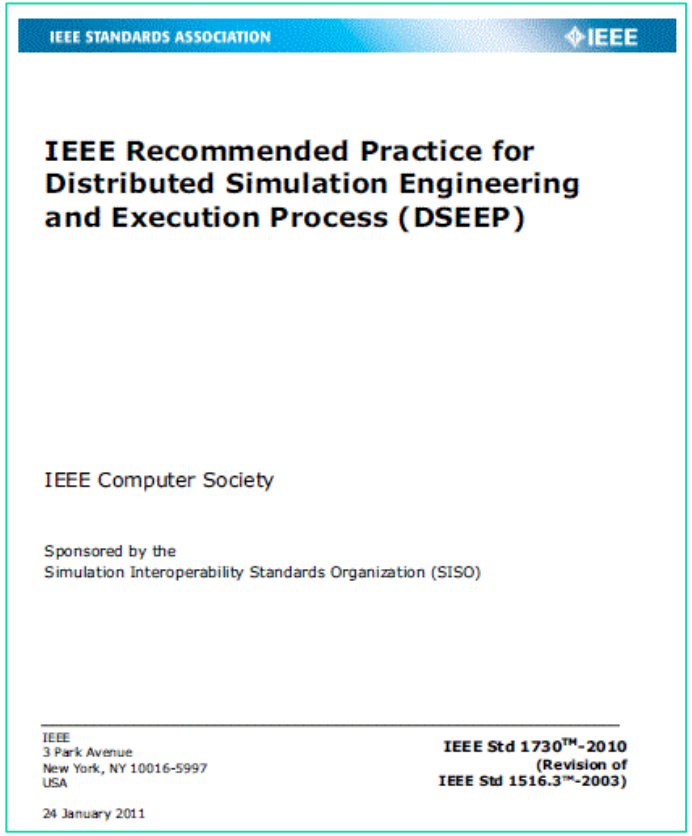
Table of Contents

Distributed Simulation Engineering and Execution Process (DSEEP)

- An architecture-neutral, high-level process framework into which the lower-level systems engineering practices native to any distributed simulation user can be easily integrated
- Applies to federation engineering in a single-architecture environment


IEEE STANDARDS ASSOCIATION

IEEE

IEEE Recommended Practice for Distributed Simulation Engineering and Execution Process (DSEEP)

IEEE Computer Society

Sponsored by the
Simulation Interoperability Standards Organization (SISO)

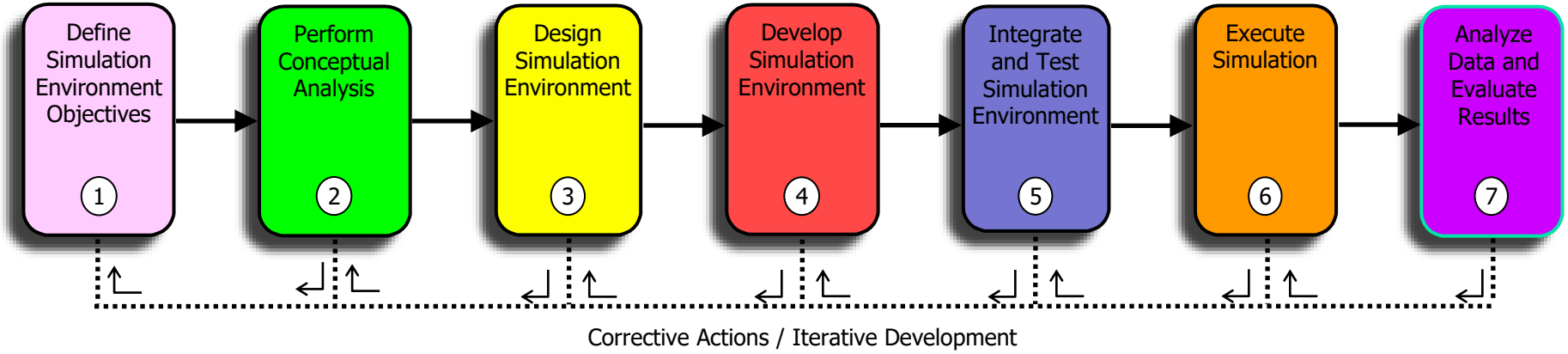
IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 1730™-2010
(Revision of
IEEE Std 1516.3™-2003)

24 January 2011

DSEEP TOP LEVEL VIEW

- The DSEEP was developed based on several, widely-adopted, authoritative systems engineering processes
- These processes were adapted and extended to address engineering requirements unique to distributed simulations



DSEEP ACTIVITIES

Step	(1) Define Simulation Environment Objectives	(2) Perform Conceptual Analysis	(3) Design Simulation Environment	(4) Develop Simulation Environment	(5) Integrate and Test Simulation Environment	(6) Execute Simulation	(7) Analyze Data and Evaluate Results
Activities	Identify User/Sponsor Needs Develop Objectives Conduct Initial Planning	Develop Scenario Develop Conceptual Model Develop Simulation Environment Requirements	Select Member Applications Design Simulation Environment Prepare Detailed Plan Design Member Applications	Develop Simulation Data Exchange Model Establish Simulation Environment Agreements Implement Member Application Designs Implement Simulation Environment Infrastructure	Plan Execution Integrate Simulation Environment Test Simulation Environment	Execute Simulation Prepare Simulation Environment Outputs	Analyze Data Evaluate and Feedback Results

Each major step of the DSEEP consists of multiple activities, each of which has multiple inputs, tasks, and outcomes that must be evaluated during federation engineering.

TOPIC 6: SUPPORTING TOOLS, TECHNIQUES, RESOURCES

- Technical infrastructures, M&S resources, and organizations supporting the development and use of M&S.

6. Supporting tools, techniques, and resources
   - 6.1 Major simulation infrastructures
   - 6.2 M&S resource repositories
   - 6.3 M&S organizations

https://nmsg.sto.nato.int/themes/msaas

MAJOR SIMULATION INFRASTRUCTURES

- AWS SimSpace Weaver is a managed service that lets you create expansive simulation worlds at increased levels of complexity and scale.
  - https://aws.amazon.com/simspaceweaver/

- Intel® Integrated Simulation Infrastructure with Modeling Supports functional, performance, power, and thermal simulations in a single environment with this versatile framework.
  - https://www.intel.com/content/www/us/en/developer/tools/integrated-simulation-infrastructure.html

- OneSim™ is Elbit Systems' platform-agnostic simulation software infrastructure that provides land, air and marine users a complete solution for training systems, from a stand-alone simulator and up to multi-platform Mission Training Centers.
  - https://elbitsystems.com/pr-new/elbit-systems-simulation-infrastructure-becomes-cloud-native/

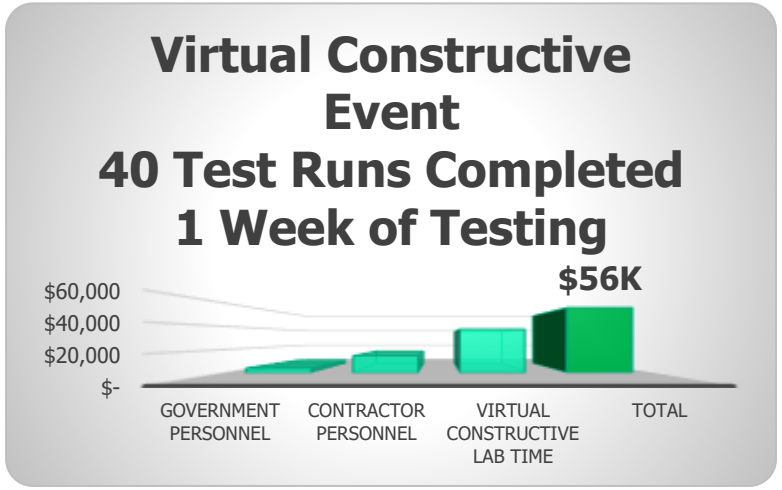
DoD DEPARTMENT and SERVICE M&S ORGANIZATIONS

- Promote interoperability and use of M&S capabilities; reuse of M&S capabilities; R&D to respond to emerging challenges
- Develop and provide updates to supporting manuals, guidebooks, and best practice guides
- Oversee core Service M&S projects, and support the development and use of enabling publications, collaborative environments, and portfolio management activities
- Support development of common M&S and VV&A tools, interfaces, services, and capabilities
- Review and provide recommendations on M&S and VV&A issues including those pertaining to data standards, metadata/repository guidelines, contracting, and cybersecurity
- Support and expand M&S workforce education and strengthen M&S training and education content and capabilities
- Conduct and participate in M&S technical exchanges and workshops to promote collaboration, coordination, and efficient implementation of models, simulations, and data
- Maintain their Service's part of DON M&S capabilities management tools; provide inputs to DoD M&S Enterprise discovery and access capabilities

TOPIC 7: M&S BUSINESS & MANAGEMENT

- Business of M&S and M&S as a business; professional conduct for M&S practitioners; M&S workforce.

7. Business and management of M&S
   - 7.1 Ethics and Principles for M&S practitioners
   - 7.2 Management of M&S Projects and Processes
   - 7.3 M&S Workforce Development
   - 7.4 M&S Business Practice and Economics



ETHICS AND PRINCIPLES FOR M&S PRACTITIONERS

1. PERSONAL DEVELOPMENT & PROFESSION

As a simulationist, I will:

1.1 Acquire and maintain professional competence and attitude.

1.2 Treat fairly employees, clients, users, colleagues, and employers.

1.3 Encourage and support new entrants to the profession.

1.4 Support fellow practitioners and members of other professions who are engaged in modeling and simulation.

1.5 Assist colleagues to achieve reliable results.

1.6 Promote the reliable and credible use of modeling and simulation.

1.7 Promote the modeling and simulation profession; e.g., advance public knowledge and appreciation of modeling and simulation as well as clarify and counter false or misleading statements.

2. PROFESSIONAL COMPETENCE

As a simulationist, I will:

2.1 Assure product and/or service quality by the use of proper methodologies and technologies.

2.2 Seek, utilize, and provide critical professional review.

2.3 Recommend and stipulate proper and achievable goals for any project.

2.4 Document simulation studies and/or systems comprehensibly and accurately to authorized parties.

2.5 Provide full disclosure of system design assumptions and known limitations and problems to authorized parties.

2.6 Be explicit and unequivocal about the conditions of applicability of specific models and associated simulation results.

2.7 Caution against acceptance of modeling and simulation results when there is insufficient evidence of thorough validation and verification.

2.8 Assure thorough and unbiased interpretations and evaluations of the results of modeling and simulation studies.

3. TRUSTWORTHINESS

As a simulationist, I will:

3.1 Be honest about any circumstances that might lead to conflict of interest.

3.2 Honor contracts, agreements, and assigned responsibilities and accountabilities.

3.3 Help develop an organizational environment that is supportive of ethical behavior.

3.4 Support studies that will not harm either humans (current and future generations) or the environment.

4. PROPERTY RIGHTS & DUE CREDIT

As a simulationist, I will:

4.1 Give full acknowledgment to the contributions of others.

4.2 Give proper credit for intellectual property.

4.3 Honor property rights, including copyrights and patents.

4.4 Honor privacy rights of individuals and organizations as well as confidentiality of the relevant data and knowledge.

5. COMPLIANCE WITH THE CODE

As a simulationist, I will:

5.1 Adhere to this code and encourage other simulationists to adhere to it.

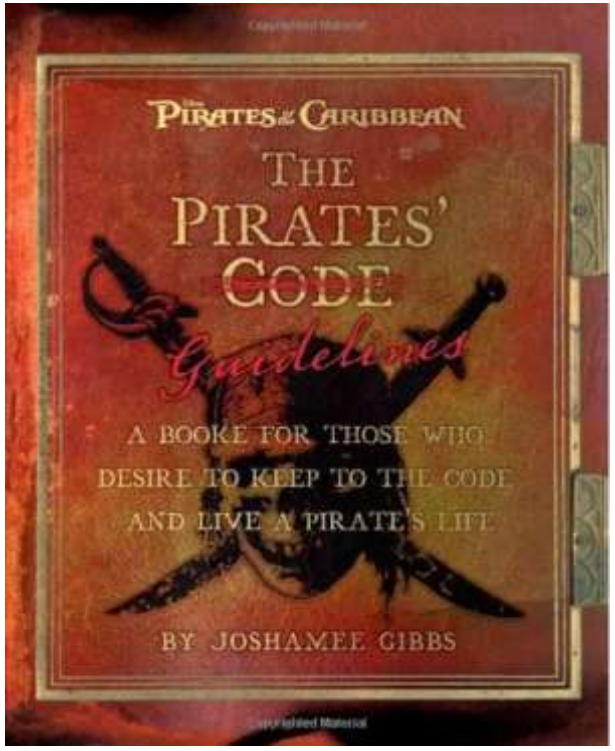
5.2 Treat violations of this code as inconsistent with being a simulationist.

5.3 Seek advice from professional colleagues when faced with an ethical dilemma in modeling and simulation activities.

5.4 Advise any professional society that supports this code on desirable updates.

Signature

Date



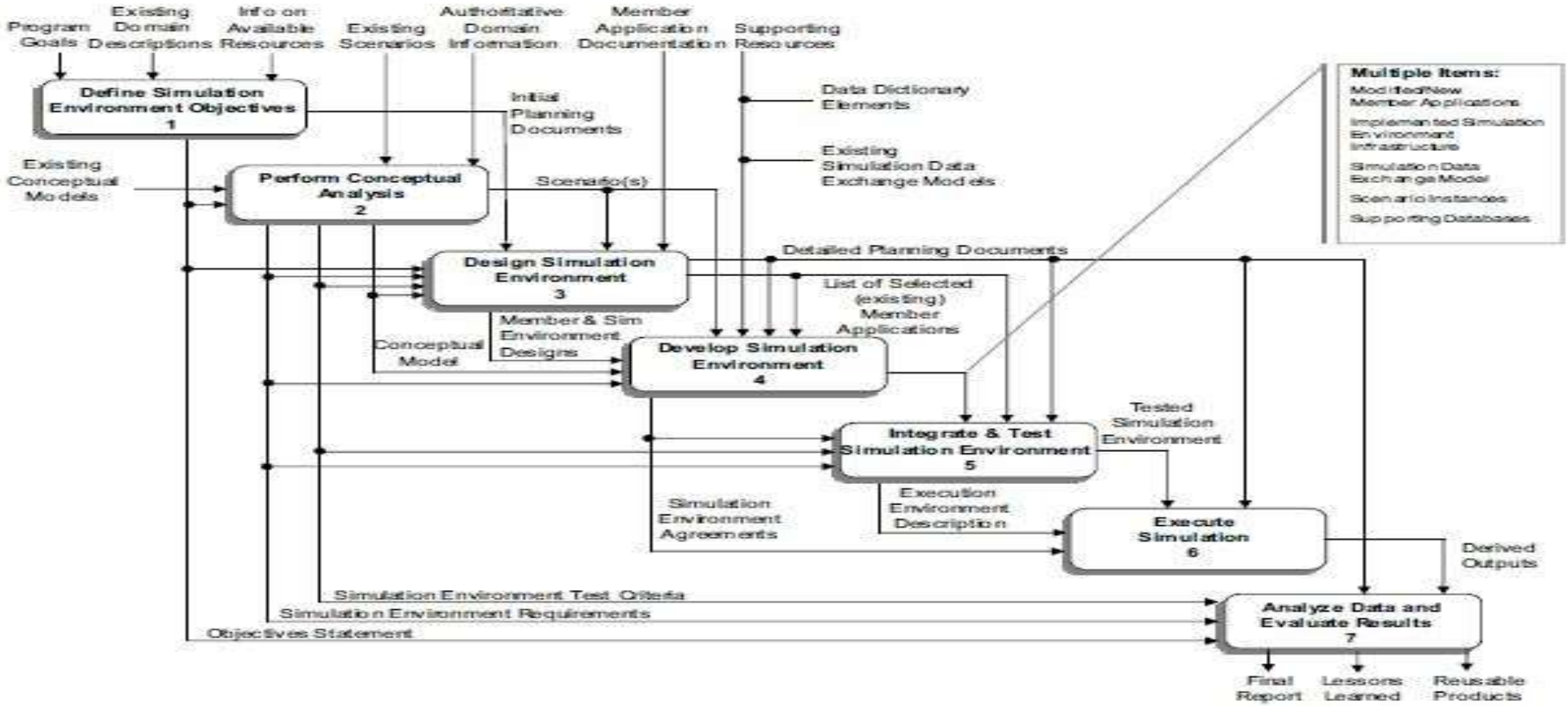
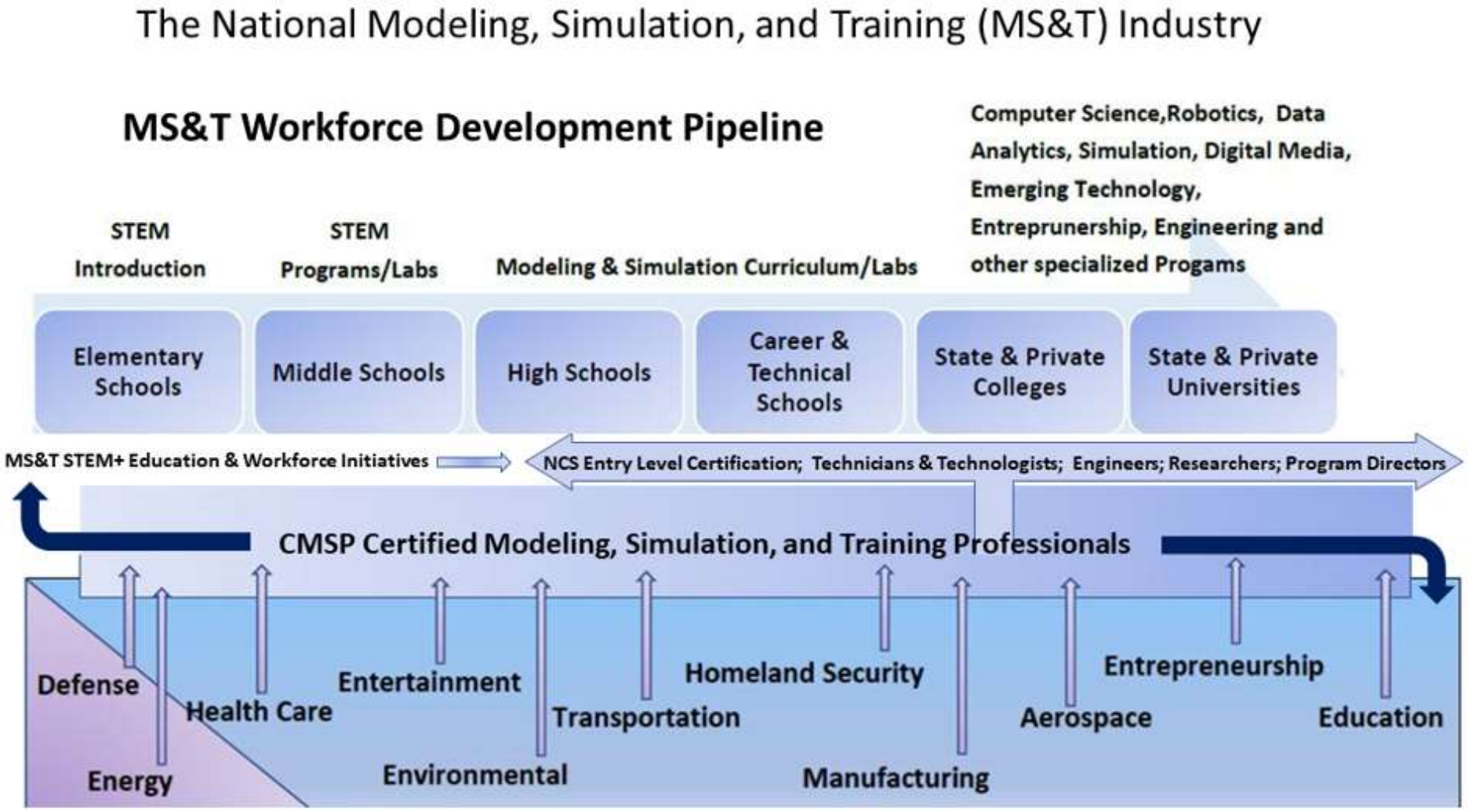


Figure 2—Distributed Simulation Engineering and Execution Process (DSEEP), detailed product flow view

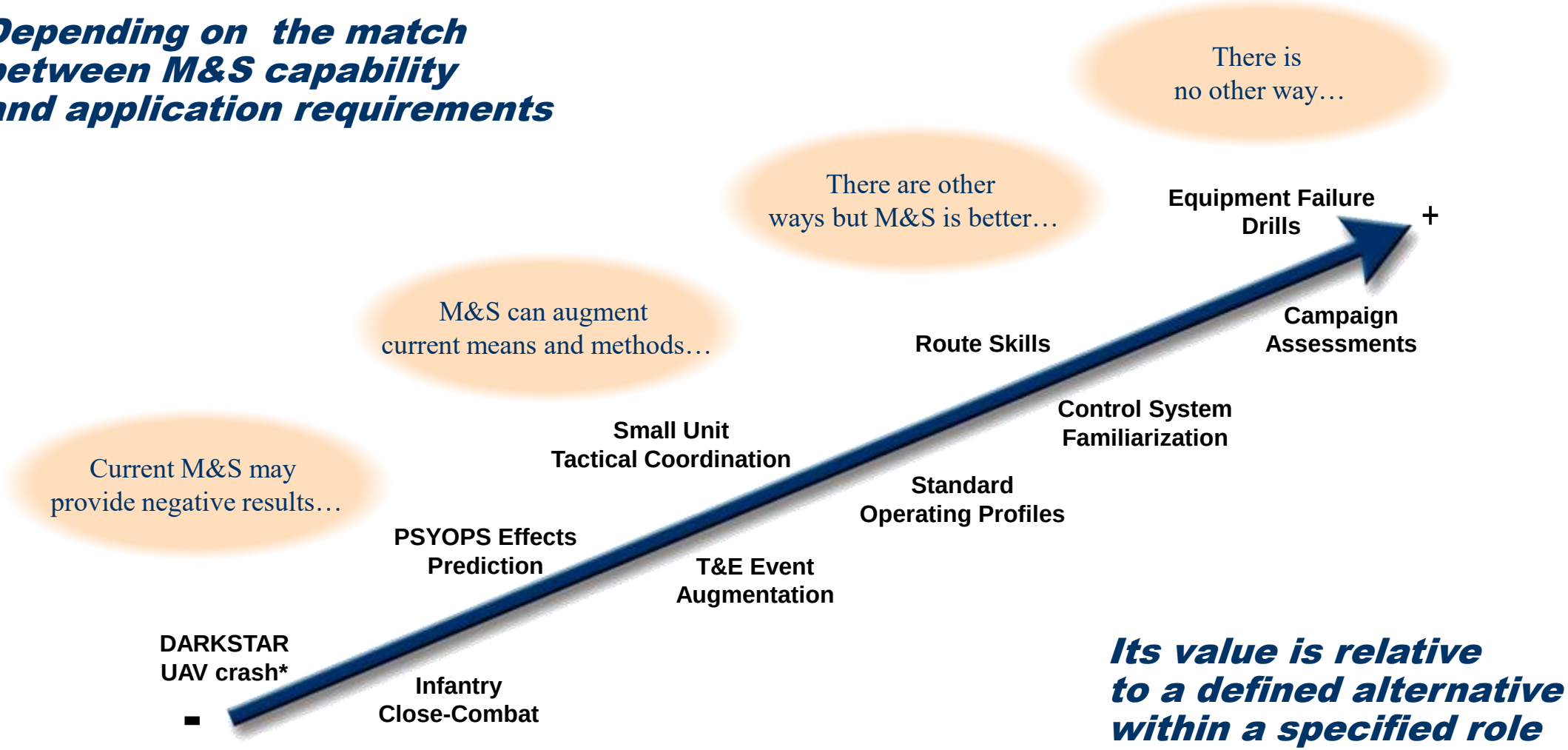
The MS&T Workforce Development Pipeline



Slide from: Lindsey Spalding, Director, STEM Programs, The National Center of Simulation

- M&S Value Varies...

Depending on the match between M&S capability and application requirements

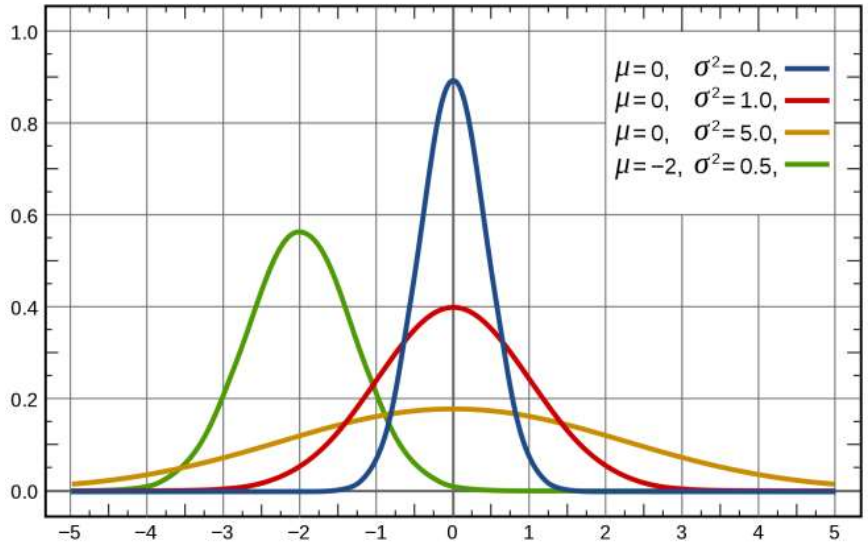


Its value is relative to a defined alternative within a specified role

TOPIC 8: RELATED COMMUNITIES OF PRACTICE AND DISCIPLINES

- Non-M&S topics with which M&S professionals should have some familiarity.

8. Related Communities of Practice and Disciplines
   - 8.1 Statistics and Probability
   - 8.2 Mathematics
   - 8.3 Software Engineering and Development
   - 8.4 Systems Science and Engineering



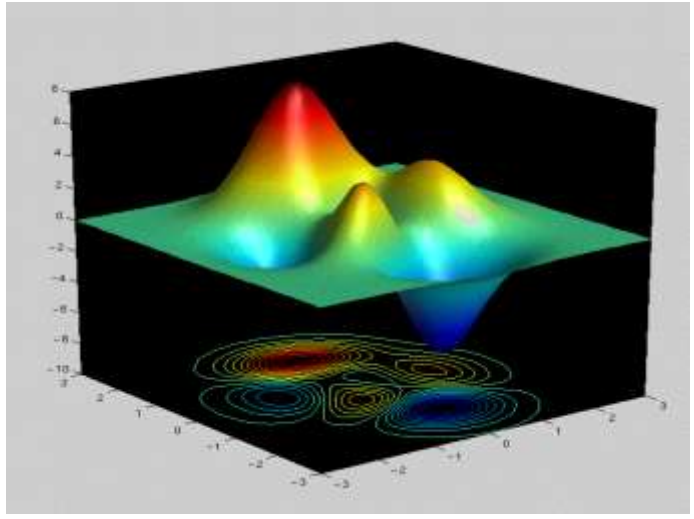
- Especially in Validation of Simulations, Statistics is an Essential Tool

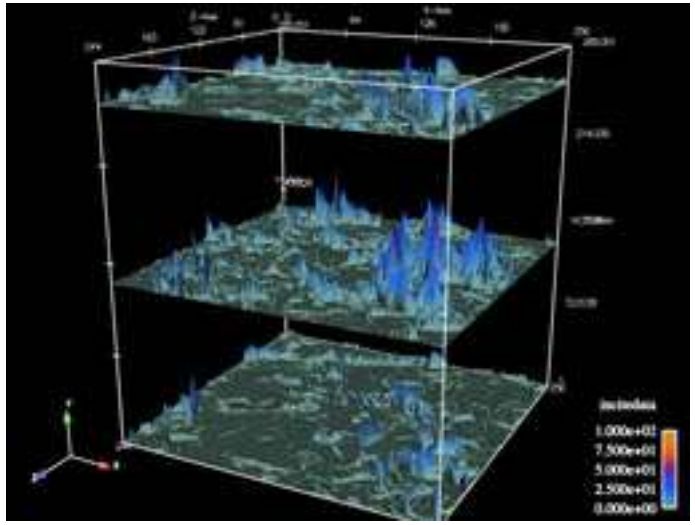
Table 1. Correlating Statistical Concepts to the VV&A Process

VV&A Information	Process Step	Statistical Concepts
M&S Requirements and Intended Use	1 – 4	Response variables Factor space Stochastic vs. deterministic models
Data Requirements	5	Design for Computer Experiments (Chapter 3) Classical Design of Experiments (Chapter 3)
Iterate Model-Test-Model	6	Design for Computer Experiments (Chapter 4) Classical Design of Experiments (Chapter 4) Variation Analysis & Statistical Emulation (Chapter 3) Comparison to M&S runs (Chapter 3) Calibration (Chapter 4)
Verification Analysis	7	Parametric Analysis (Chapter 3)
Validation Analysis	8	Parametric Analysis (Chapter 3) Comparison of live and M&S data (Chapter 3)
Quantify Uncertainty	8 – 9	Hypothesis Testing and Interval Estimation (Chapter 3)

VISUALIZING THE RESULTS

- Simulations generate incredible amounts of data; interpreting this data is often aided by using information visualization, sometimes called scientific visualization





WORKSHOP OUTLINE

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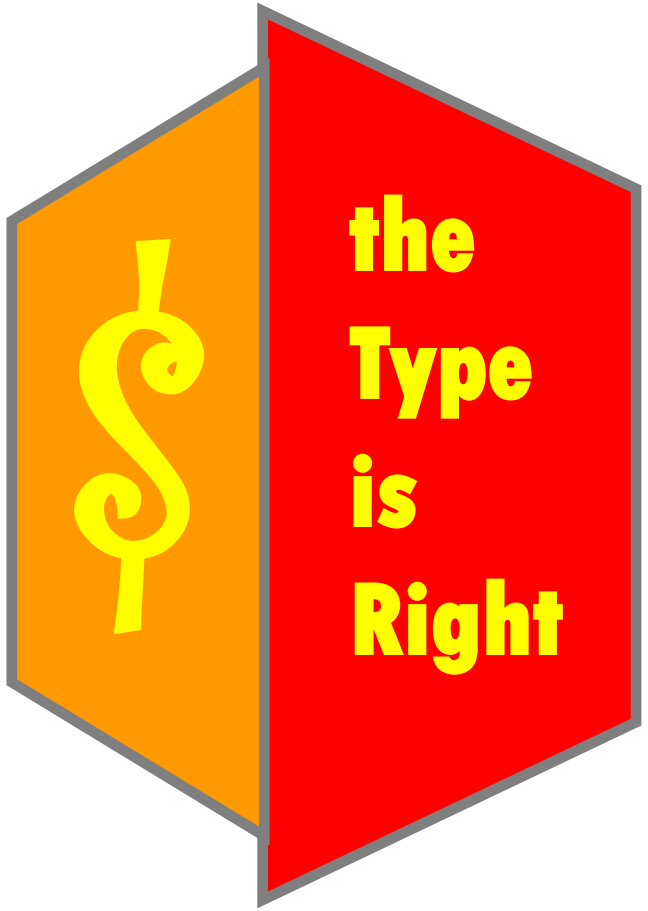
  - Context
  - Current Events
- Jeopardy Game

JEOPARDY BOARD				FINAL JEOPARDY
Definitions	Methods	Uses	VV&A	Acronyms
$100	$100	$100	$100	$100
$200	$200	$200	$200	$200
$300	$300	$300	$300	$300
$400	$400	$400	$400	$400
$500	$500	$500	$500	$500

- Course Evaluations

"THE TYPE IS RIGHT"

- An M&S Image will be flashed on the screen and then disappear
- You need to decide what Type of M&S system it is!
- Is it a simulation, emulation, simulator, appended trainer, game, etc.
- Win a CMSP Reference Book!
- Load Game File.....
- ***GO!***



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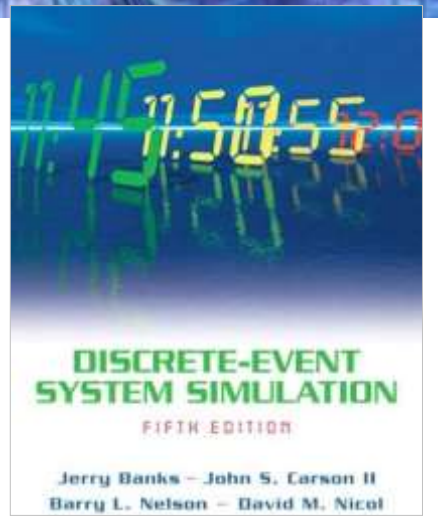
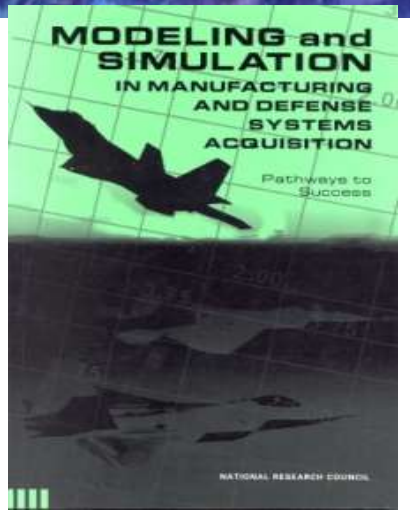
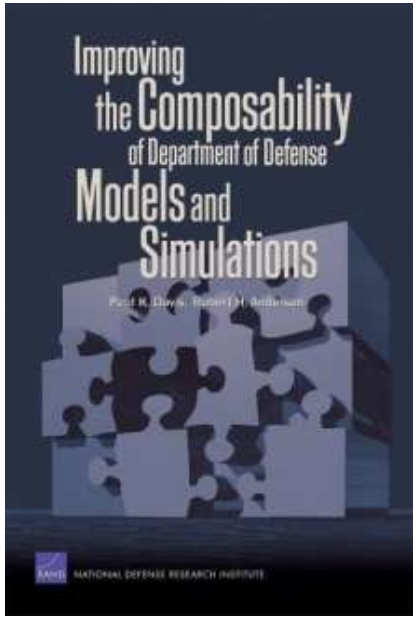
- Course Evaluations

OVERVIEW OF QUESTIONS

- Number
  - Total: 1,000+ questions
  - Selection: Varies by CMSP Level
- Sources
  - Each question based on specific source
  - Sources: published, peer-reviewed, publicly available







SAMPLE QUESTION #1

Intern

What type of simulation involves real people operating simulated systems in a synthetic environment?

A. Emulative Simulation

B. Virtual Simulation

C. Virtualized System

D. Constructive Simulation

Live Simulation: Real people employing real systems in a non-operational role or location (e.g., on a training range)

Virtual Simulation: Real people operating simulated systems in a synthetic environment

Constructive Simulation: Simulated people operating simulated systems in a simulated environment

SAMPLE QUESTION #2

Apprentice

What type of simulation is often based on differential equations?

A. Discrete event simulation
B. Continuous simulation
C. Monte Carlo simulation
D. Cellular automata simulation

A differential equation is any equation which contains derivatives (which calculates the rate of change at a given point)

There is one differential equation that everybody probably knows, that is Newton's Second Law of Motion. If an object of mass M is moving with acceleration A and being acted on with force F then Newton's Second Law tells us that F = MA

SAMPLE QUESTION #3

Practitioner

Which of the following phenomena is generally considered to be a suitable application of ensemble modeling?

A. Weather forecasting

B. Ballistics calculation

C. Queue optimization

D. Image generation

Ensemble modeling is a process where multiple diverse models are created to predict an outcome, often by using many different modeling algorithms

An ensemble weather forecast is a set of forecasts that present the range of future weather possibilities. Multiple simulations are run, each with a slight variation of its initial conditions and with slightly perturbed weather models.

SAMPLE QUESTION #4

Master

Which of the following terms is best defined as "uncertainty associated with a phenomenon or event modeled as random because there is no better way to characterize it as known"?

A. Epistemic uncertainty
B. Exponential uncertainty
C. Ontologic uncertainty
D. Aleatory uncertainty

- **Epistemic uncertainty.** The potential inaccuracy in any phase or activity of the M&S process that is due to a lack of knowledge or to intentional approximations applied by the simulationist. It is reducible by model improvements or through the use of better measuring techniques to assess model parameters.
- **Exponential uncertainty**. Uncertainty Calculation in exponential function, y = 10^x
- **Ontological uncertainty**. Different parties in the same interactions having different conceptualizations about what kinds of entities inhabit their world.
- **Aleatory uncertainty.** The inherent variation associated with a physical system or the environment under consideration, e.g., the variation of geometric and or material properties within a manufacturing process. It is stochastic and irreducible below a certain threshold.
- P. F. Reynolds, "The Role of Modeling and Simulation?", in J. A. Sokolowski and C. M Banks, (Editors), Principles of Modeling and Simulation: A Multidisciplinary Approach, John Wiley and Sons, Hoboken NJ, 2009, pp. 25−43."

LVC SIMULATION – NAVY TRAINING CAPABILITY

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$500	$500	$500	$500	$500

- Course Evaluations

SUMMARY AND REVIEW

Had Enough?

KEY TERMS AND TYPES - MODEL

- A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process
- To an observer *B*, an object *A** is a model of an object *A* to the extent that *B* can use *A** to answer questions that are of interest about *A*
- Representation of something else, normally a “real-world” system
- Some aspects of the modeled system are represented in the model, others not

Simuland
P-51D Mustang

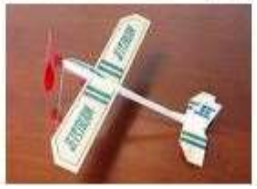
Models

Physical model
Represents:
Appearance
Abstracts:
Size

Physical model
Represents:
Aerodynamics
Omits:
Ailerons

[Bollay, 1951]

Physical model
Represents:
Flight
Omits:
Appearance



Models

Visual model
Represents:
Appearance
Omits:
Flight

[Han, 2012]

$$\iiint_{\Omega} \mathbf{P}\frac{\partial \mathbf{W}}{\partial t}\,d\mathbf{V} + \iint_{\partial\Omega} \overline{\overline{\mathbf{H}}} \cdot \mathbf{n}\,dS = \iint_{\partial\Omega} \overline{\overline{\mathbf{H}}}_{v} \cdot \mathbf{n}\,dS$$

Functional model
Represents:
Aerodynamics
Omits:
Appearance

Aggregate model
Represents:
Combat
Abstracts:
Pilot skill

SIMULATION

- The imitation of the operation of a real-world process or system over time
- A technique for testing, analysis, or training in which real world systems are used, or where a model reproduces real world and conceptual systems

Simulation Environment	Acronym	Description
Digital Simulation	DSIM	A full digital representation of the system and intended operational environment
Hardware in-the-Loop	HITL	A simulation environment that includes actual system hardware
Software in-the-Loop	SITL	A simulation environment incorporating actual system software and logic
Operator in-the-Loop	OITL	A simulation environment designed to include inputs and decisions from at least one operator
Land-Based Test Facility	LBTF	A simulation environment, constructed on an open range, which incorporates various aspects of DSIM, HITL, SITL, OITL, and/or live-test assets
Laboratory/Chamber	LAB	A facility allowing for the stimulation via DSIM, HITL, SITL, and/or OITL, of various aspects of an operational system in a closed secure environment
Threat Representation	TR	Any engineering representation (physical or digital) of a threat system which will be used
C4I System Integration Environments and Facilities	C4IEF	A Command, Control, Communications, Computers, and Intelligence (C4I) environment, that operates external to the System Under Test (SUT)/System of Systems (SoS), and provides the capability to test system function and interoperability.
Reliability Simulation	RSIM	A simulation that provides reliability predictions for the SUT in live/captive carry/chamber or DSIM to represent the SUT

M&S TECHNOLOGY GOALS

- Since the 90s, there have been a set of technical goals pursued by empowered organizations - of many types!
- Progress has been made in all (e.g., ships in one sim no longer hover above waves provided by another), yet there is still much to do in:
  - **Composability**: The degree to which an M&S user can effectively develop, from a pallet of components, an executable simulation to address a question of interest.
  - **Interoperability**: The ability of an M&S system to provide services to and accept services from others, and to use these services to operate effectively together.
  - **Reuse**: Using again, in whole or part, existing M&S tools, data, or services.
  - **Scalability**: The ability of a simulation to maintain time and spatial consistency as the number of entities and accompanying interactions increase.

M&S - KEY FACETS

- **Facets = T**echnologies, processes, and infrastructure components that make M&S possible and practical but also innovative and adaptive. They include:

- **Algorithms**: A set of rules to be followed in performing calculations or problem-solving operations, especially by a computer. Includes Artificial Intelligence and Machine Learning to enable M&S to adapt and improve its capabilities.
- **Data**: Facts, descriptors, statistics, etc. with the level of accuracy and pedigree required for M&S systems to generate results with a given level of confidence.
- **Distributed/Federated**: Use of geographically dispersed assets and standardized protocols (e.g., DIS, HLA) to execute M&S / LVC events and exercises.
- **Networks**: Host M&S / LVC including: JMETC, NETTN, DREN, and SDREN.
- **Security / Cybersecurity**: Federated, distributed, and networked M&S systems and LVC simulations implement RMF via ATOs, IATTs, etc. issued by ISSMs, FAOs, and the NAO.
- **Standards and Guidelines**: Exist for architectures (e.g., HLA, AMIE), processes (e.g., DSEEP), LVC Network Security, Contracting, etc.

RAPID FIRE GAME

- A set of 5 questions on M&S will be presented
- You have 8 seconds to answer
- Only those getting the previous question right will advance to the next round
- The prize is an M&S Monograph going to the last remaining contestant
- Load Game File.....
- ***GO!***

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CMSP 3.0 in Context

- Other M&S Certifications and Initiatives

CHSE: Certified Healthcare Simulation Educator, CHSOS: Certified Healthcare Simulation Operations Specialist, A: Advanced

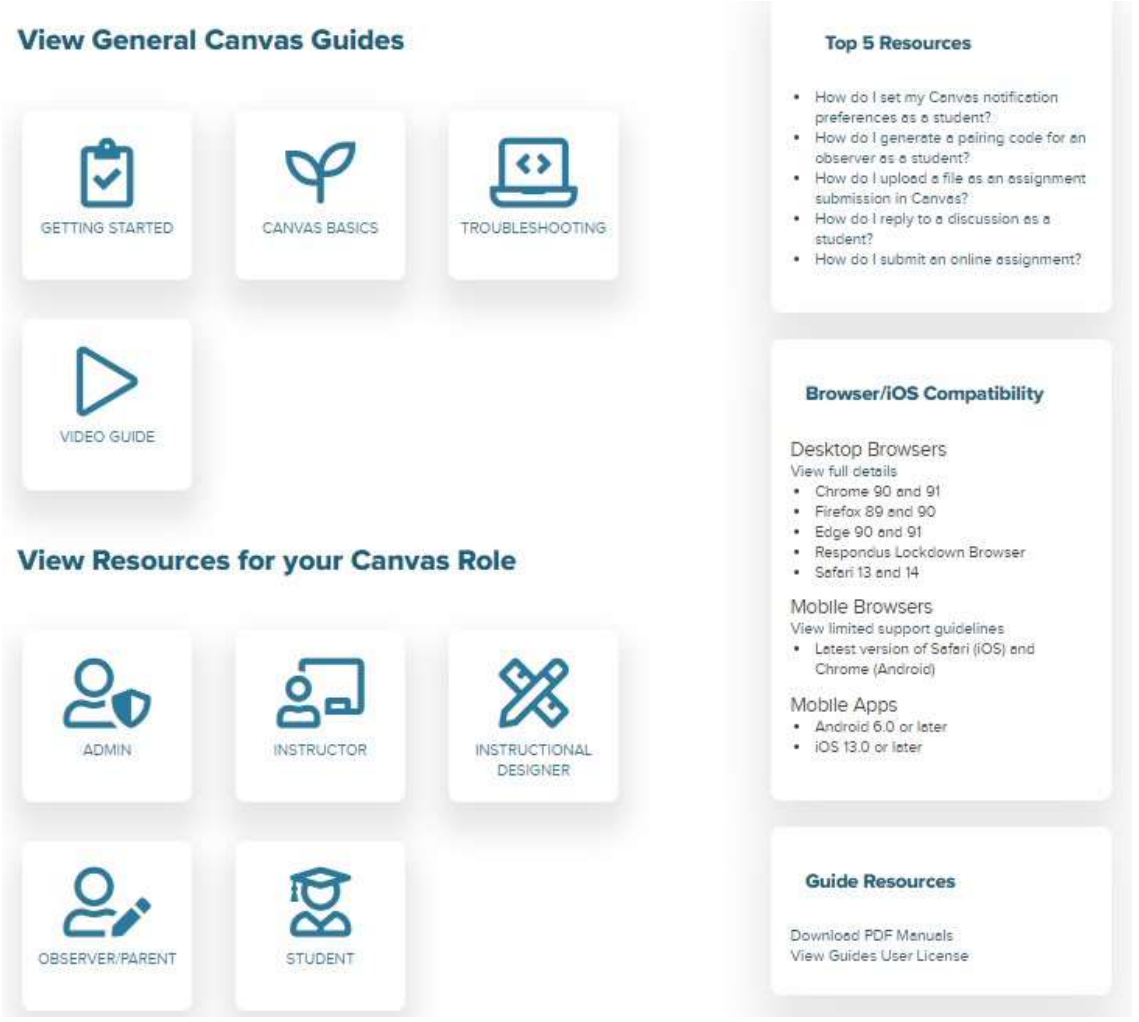
NEW FEATURES OF CMSP 3.0

- CMSP Evolution: Version 1.0 in 2001, 2.0 in 2010, 3.0 Released

- CMSP 3.0
  - Now Includes Four Integrated Levels – Intern, Apprentice, Practitioner, and Master
  - Streamlines the Processes and Employs a Learning Management System
  - Updates the Examination
  - Creating a Vibrant Community of Practice
    - Quarterly Newsletter
    - Local Meetings – TSIS!
    - Conference Presence - I/ITSEC Over the Last Week
      - Special Event
      - STEM and Career Fair Participation
      - State of the Nation and then Reception
      - Professional Development Workshop

LEARNING MANAGEMENT SYSTEM

- The platform we are using is called Canvas
- It's a learning management system used by UCF and many others
- CMPS 3.0 is built like a course on the platform
- Here is a link to a short "Student tour" video
  - https://community.canvaslms.com/t5/Video-Guide/Canvas-Overview-Students/ta-p/383771



LEARNING MANAGEMENT SYSTEM

CMSP 3.0 CURRENT EVENTS

- Increase demand by Government/Industry/Academia, etc.
- Improve awareness in Academia/Industry/Government/Professional Societies, etc.
- Use Restructured the CMSP certification process and artifacts
- Collaborate/Cooperate/Compete with Other Certifications
- Increase Certificate Holder Engagement (Both New Certifications and Renewals)
- Consider New Certifications (e.g., MBSE, LVCP)
- Explore CMSP Sub-Certifications (e.g., Engineering, Logistics,)
- Employ Revised and Updated the CMSP Exam

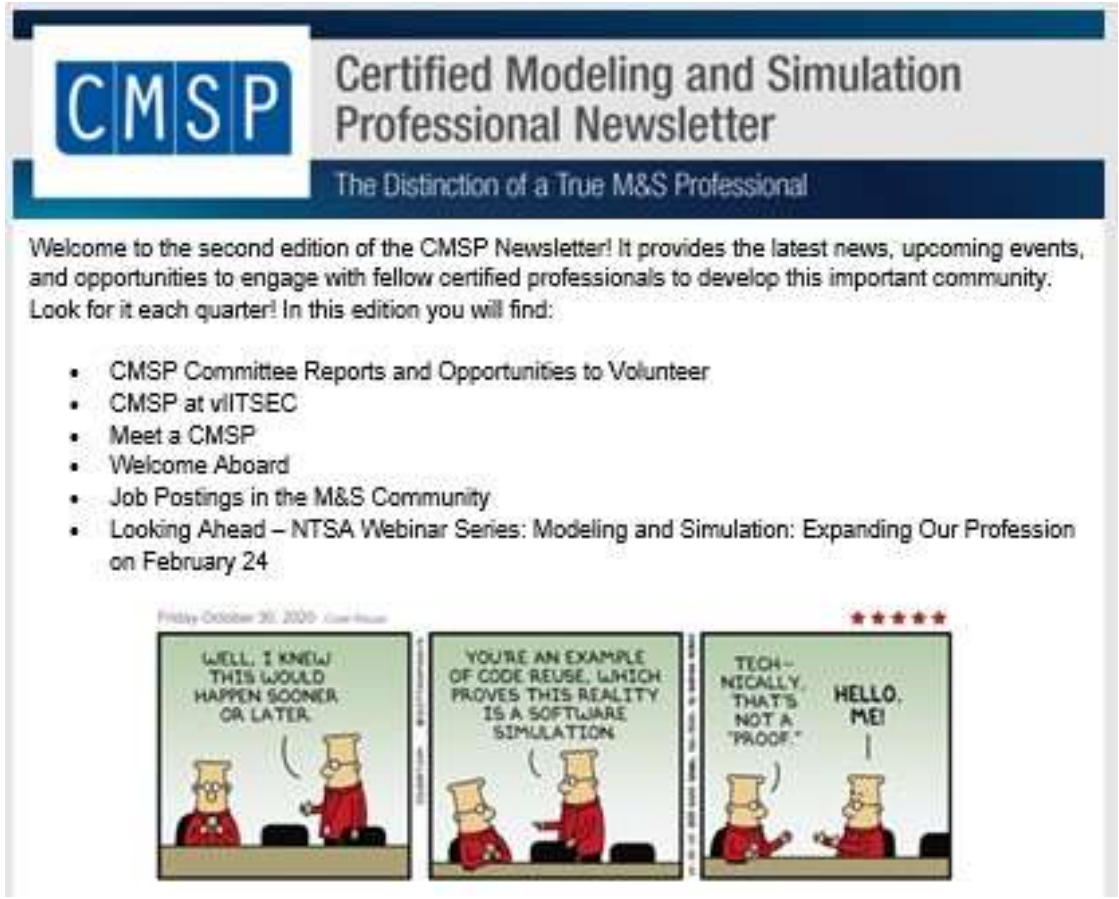
Participants and Contributors Welcome!

CMSP - ENGAGEMENT PROPOSALS

- Engage Current and Past CMSP Recipients
  - Re meetings, newsletter (with list of alumni), and certificate renewal
- Schedule CMSP Meeting (State of the Nation at I/ITSEC)
  - Aggressively follow-up on recommendations and engage attendees
- Create and Initiate a CMSP Mentorship Program
  - Each current CMSP Recipient mentor 1 prospect per year
- Establish “CMSP Guild”
  - Meetings on Topics of Interest, Newsletter, Special Events, Nominations and Awards
- Create a Renewal Support System
  - Reminders, resources, etc.
- Submit articles on CMSP to M&S publications (SISO, SCS, Etc.)
- Activities are Ongoing re Other Committee initiatives

CMSP NEWSLETTER

- Education, Certification, Institutionalization
  - 3.0 is aggressively working to support the Expansion of Our Profession
- CMSP Newsletter now being distributed regularly
- Volunteers are being sought for
  - Mentors
  - Committee Members
  - Exam Question Generators
- CMSP 3.0 looks forward to assisting with the Institutionalization of M&S



CMSP

Certified Modeling and Simulation Professional Newsletter

The Distinction of a True M&S Professional

Welcome to the second edition of the CMSP Newsletter! It provides the latest news, upcoming events, and opportunities to engage with fellow certified professionals to develop this important community. Look for it each quarter! In this edition you will find:

- CMSP Committee Reports and Opportunities to Volunteer
- CMSP at I/ITSEC
- Meet a CMSP
- Welcome Aboard
- Job Postings in the M&S Community
- Looking Ahead – NTSA Webinar Series: Modeling and Simulation: Expanding Our Profession on February 24

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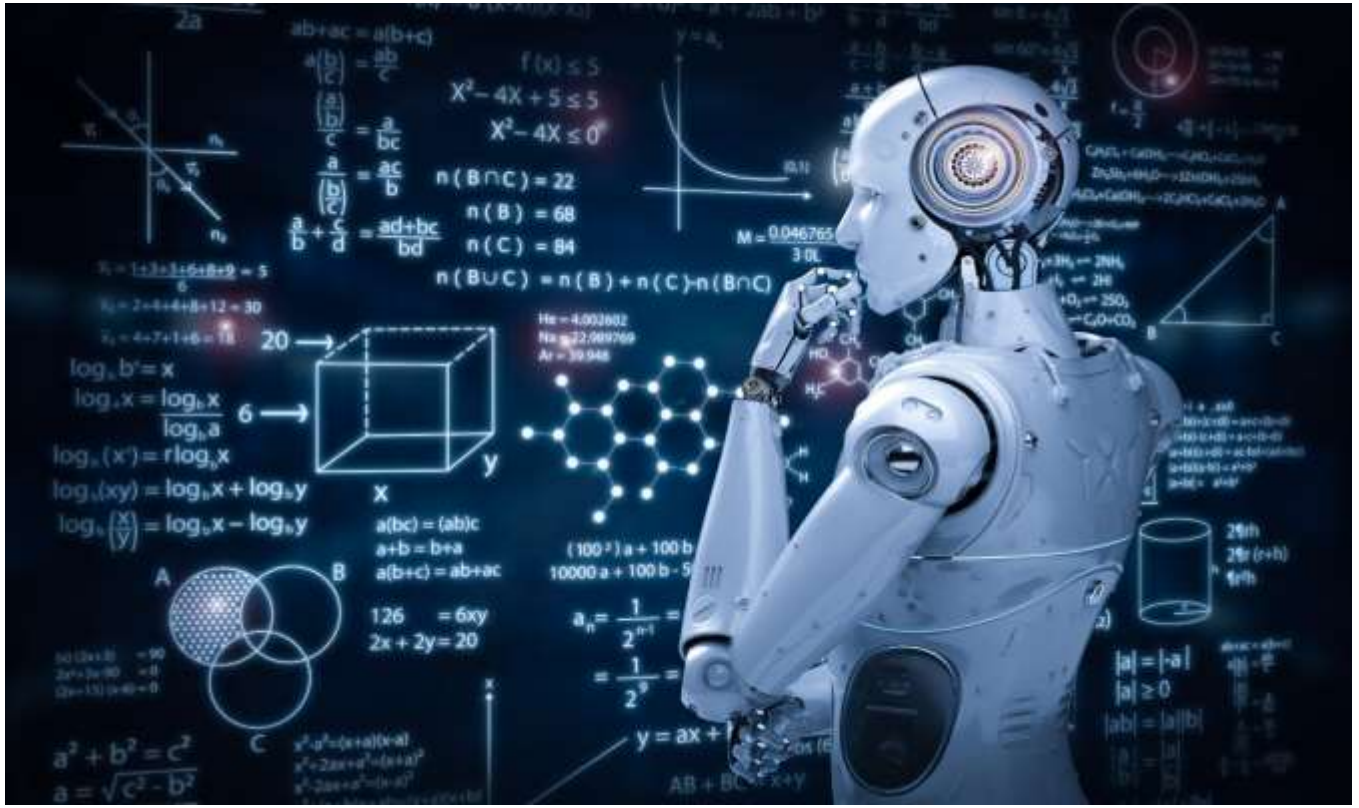
JEOPARDY GAME

- Round One
  - Select Answers from Game Board
  - Respond with a Question
  - Proceed Through Categories
- Go to Final Jeopardy
  - Answer
- All Participants Get Candy Coins / Wrapped Candy
- The prize is an M&S Monograph going to the Winner
- Load Game File.....
- ***GO!***

CMSP PDW CONCLUSIONS

Keep striving, we need to stay smarter than the machines!

- Feedback
- Q&A



- For more information email Carol Dwyer at cdwyer@ndia.org