National Defense Industrial Association Systems Engineering Division Modeling and Simulation Committee

Summary of Results of the
Digital System Model Workshop
of 17-18 August 2015

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What is the Digital System Model?

From the Defense Acquisition University Glossary:

- **The Digital System Model is a digital representation of a defense system, generated by all stakeholders, that integrates the authoritative technical data and associated artifacts which define all aspects of the system for the specific activities throughout the system lifecycle.**

System Architecture & The Digital System Model Concept
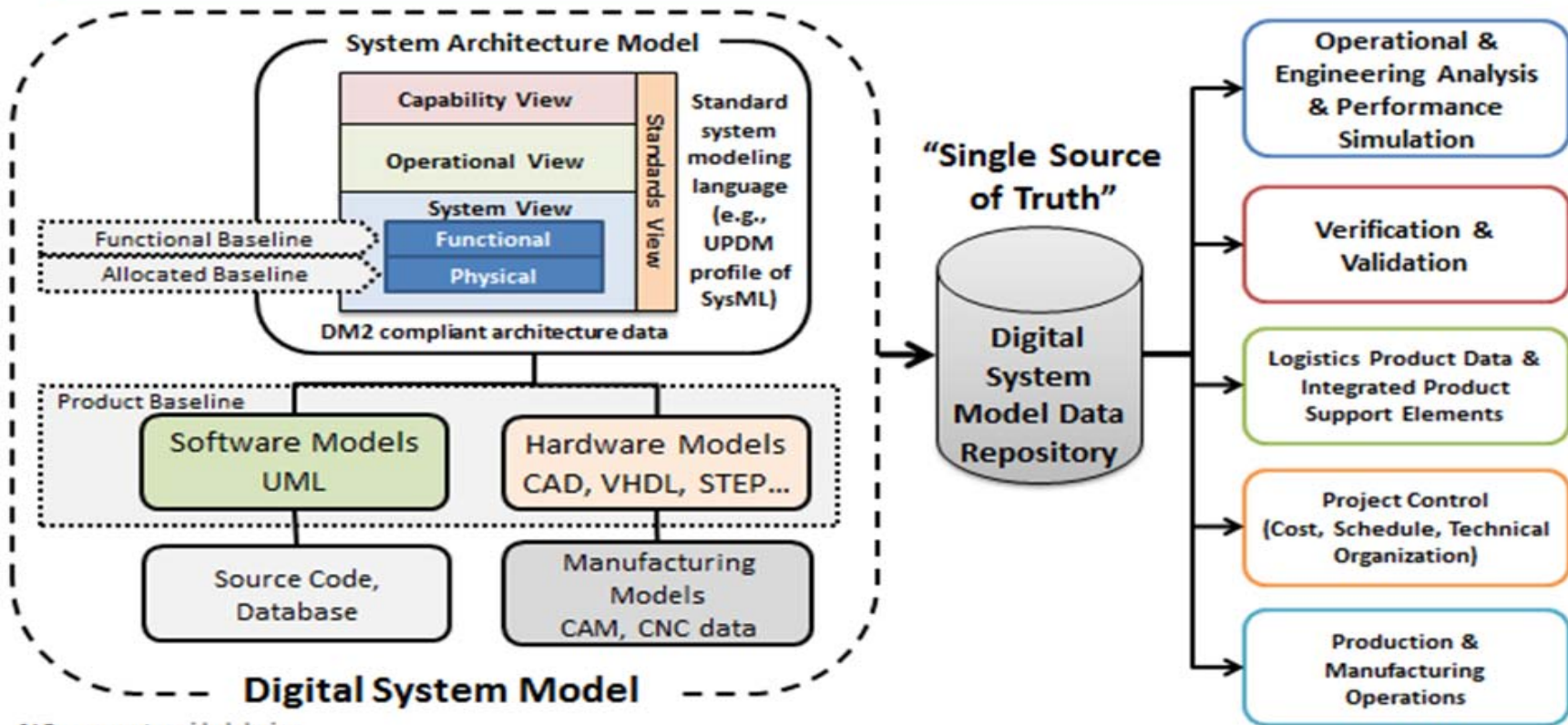
CAD = computer aided design
VHDL = very high speed integrated circuit hardware description language
STEP = standard for technical exchange of product data
CAM = computer aided manufacturing
CNC = computer numerical control

ENG-301 Leadership in Engineering Defense Systems

3

Digital System Model Workshop – Objectives

- **To define/refine the principal uses of the Digital System Model in the acquisition of systems – from concept to disposal – to aid in ensuring its usefulness and completeness**

- **To obtain Systems Engineering community input (particularly from Industry) on the critical contents of the Digital System Model**

- **To obtain community input on the issues associated with the implementation of the Digital System Model across the acquisition lifecycle and between the Government and Industry**

- **To assess the degree to which the Digital System Model is consistent with the larger goal of Model-Based (Systems) Engineering, to aid in determining if there are gaps in the Digital System Model concept.**

Digital System Model Workshop – Agenda, Day 1

13:00	**Introduction**	Jim Coolahan (Coolahan Assoc.)
13:10	**Advancing Digital Model-Centric Engineering: Digital System Model/Digital Thread**	Plil Zimmerman (ODASD(SE))
13:40	**Digital System Model - A Raytheon Perspective**	Louisa Guise (Raytheon)
14:10	**Digital Tapestry: Digital System Modeling at Lockheed Martin**	Chris Schreiber (Lockheed Martin)
14:40	**MBSE Implementation Across Diverse Domains at The Boeing Company**	David Allsop (Boeing) Curtis Potterveld (Boeing)
15:10	**A Look at the State-of-the-Art of the Digital System Model: the Status Beyond the Hype**	Hubertus Tummescheit (Modelon) James Roche (CIMData)
15:40	**Essential Elements of the Digital System Model: Sharing and Evolving Data Across the Acquisition Life Cycle**	Jeff Bergenthal (JHU/APL)
16:05	**Potential Taxonomy for Digital System Model Data**	Jim Coolahan
16:30	Adjourn for the day	

Digital System Model Workshop – Agenda, Day 2

8:30	**Summary of Day 1 Activities and Charge to Breakout Groups**	Jim Coolahan (Coolahan Assoc.)
9:00	**Breakout Sessions** (mid-morning break, as needed)**:**	Facilitators:
	System Characteristics (e.g., form and fit) Data	Louisa Guise (Raytheon)
	System Performance/Effectiveness (e.g., function) Data	Jeff Bergenthal (JHU/APL)
	System Financial (e.g., cost) Data	Beth Wilson (Raytheon)
	Policy and Legal Considerations	Jim Coolahan
12:00	Lunch break (on your own)	
13:00	**Breakout Sessions Continue and Prepare Out-briefs**	Breakout session faciltators
15:00	Break	
15:15	**Plenary Session: Breakout Session Out-briefs**	Breakout session faciltators
16:30	Adjourn workshop	

Selected Results from Breakout Sessions

- **A few selected slides from each of the breakout groups follow.**

System Characteristics Data Breakout Session – Participants

Facilitator: Louisa Guise (Raytheon)

Participants:
- Sandy Friedenthal
- David Hench – Eagle Ray R&D
- Howard Owens - NAVAIR
- Curtis Potterveld – Boeing
- Frank Salvatore – Engility

Questions for System Characteristics Data Breakout Session

1. What critical System Characteristics data elements that should be included in the Digital System Model (DSM) are missing from the list generated by the current NDIA study?

2. What other aspects of the system information need to be considered (for example, linkages and relationships among the data)?

3. What concerns might system stakeholders have regarding sharing of System Characteristics data?

4. Are there existing data taxonomies or standards that could be used to help specify how System Characteristics data elements should be specified in the DSM, and to what degree are they applicable to only certain types of systems?

5. What are appropriate constructs (e.g., databases, repositories, registries) for storing, accessing, and distributing System Characteristics data in the DSM?

6. To what degree does the DSM, as currently defined, support a Model-Based (Systems) Engineering approach, and what gaps might exist in the DSM?

DSM Intended Use

- Virtual CONOPS
- Develop and understand requirements
- Provide evolvability (re-use) – design evolution
- Perform analysis of alternatives
- Drive need for or capture results R&D
- Model based-specification – improve quality of specification
- Virtual assembly, test, training
- Testing / verification / validation / Quality assessment
- Supplier part integration
- Virtual prototype to evaluate solution space
- Model-based contracting
- Validation of solution against consistently described and consumable CONOPS
- Traceability is preserved – past history / decisions / rationale are captured - Knowledge is captured – technical data is preserved through time
- Impact analysis
- Diagnostics
- Automate key calculations
- Additively manufacture in the field? – need model to drive printers

Are there existing data taxonomies or standards that could be used to help specify how System Characteristics data elements should be specified in the DSM, and to what degree are they applicable to only certain types of systems?

- MIL-STDs, DIDs
- ASME Y14.100, 14.41, 14.46, MIL-STD-31000A
- IDF - Electrical/Mechanical Design Integration
- STEP
- OMG (metamodels) - e.g., threat metamodel
- Metrology / Units of measure (IS0 80000)
- Wikipedia – list of material properties
- FMI, HLA, DIS, TENA, Modelica
- Building Information Model

Standards are really important here!

Facilitator: Jeff Bergenthal (JHU/APL)

Participants:
- Michael Bisconti (ManTech)
- Greg Haun (AGI)
- Dave Kaslow (self)
- Joseph Keren (ManTech)
- Jane Orsulak (Raytheon)
- Kati Schmidt (Lockheed Martin)
- Rob Schoenberger (ManTech)
- Chris Schreiber (Lockheed Martin)
- Charles Turnitsa (GTRI)
- Simone Youngblood (JHU/APL)

Questions for System Performance / Effectiveness Data Breakout Session

1. What critical System Performance/Effectiveness data elements that should be included in the Digital System Model (DSM) are missing from the list generated by the current NDIA study?

2. Which of the critical System Performance/Effectiveness data elements can be more fully specified through a model as opposed to a traditional data element? What type(s) of model(s) could be used to specify those data elements?

3. What concerns might system stakeholders have regarding sharing of System Performance/Effectiveness data?

4. Are there existing data taxonomies or standards that could be used to help specify how System Performance/Effectiveness data elements should be specified in the DSM, and to what degree are they applicable to only certain types of systems?

5. What are appropriate constructs (e.g., databases, repositories, registries) for storing, accessing, and distributing System Performance/Effectiveness data in the DSM?

6. To what degree does the DSM, as currently defined, support a Model-Based (Systems) Engineering approach, and what gaps might exist in the DSM?

Which of the critical System Performance/Effectiveness data elements can be more fully specified through a model as opposed to a traditional data element? What type(s) of model(s) could be used to specify those data elements?

- May be drawbacks of eliminating documentation
  - Assumptions, pedigree, etc.
- Desirable to have models for operational environment (CONOPS, threat, environment, …)
- If the data element represents a range of values to which the performance is related, then a model provides additional robustness
  - Both inputs and outputs
- Decomposition and allocation of performance to subsystems / components
- Must include information on the modeling tool (e.g., version)

What are appropriate constructs (e.g., databases, repositories, registries) for storing, accessing, and distributing System Performance/Effectiveness data in the DSM?

- Approach requires strong governance and configuration management
  - Established processes and rule sets for exchange of data
  - Data exchange standards
  - Handover of the data
- Require discovery mechanisms / data mining & filtering
  - Must support discovery across programs
- Persistent archival methods
- Desire access to view any data element/view without use of a specific tool (e.g., HTML)
- Authoritative program-specific DSM owned by the USG
  - Potentially multiple working instances of subsets of the DSM across other stakeholders (e.g., the contractor team during EMD)

System Financial Data Breakout Session – Participants

Facilitator: Beth Wilson (Raytheon)

Participants:

- David Allsop, Boeing

- Denise Duncan, LMI

- Bob Erickson, Raytheon

- Joe Kochocki, Draper Lab

- Hubertus Tummescheit, Modelon

- Kevin Winton, Engility

Questions for System Financial Data Breakout Session

1. What critical System Financial/Cost data elements that should be included in the Digital System Model (DSM) are missing from the list generated by the current NDIA study?

2. Is there anything that needs to be added to what has already been discussed to include all elements of cost in the DSM for the lifecycle (e.g., including sustainment)?

3. What concerns might system stakeholders have regarding sharing of System Financial/Cost data?

4. Are there existing data taxonomies or standards that could be used to help specify how System Financial/Cost data elements should be specified in the DSM, and to what degree are they applicable to only certain types of systems?

5. What are appropriate constructs (e.g., databases, repositories, registries) for storing, accessing, and distributing Financial/Cost data in the DSM?

6. To what degree does the DSM, as currently defined, support a Model-Based (Systems) Engineering approach, and what gaps might exist in the DSM?

Essential System Financial Data from Ongoing NDIA Study

- Affordability Analysis Results
- Annual System Support Costs
- Component Cost Estimate
- Component Cost Position   **Trees**
- Cost Risks
- Rates
- Resource Costs
- Budget
- Manufacturing Setup Cost
- Historical Cost Basis
- Lifecycle Cost Estimate (Initial, Refined, Current)   **Forest**
- Time vs. Cost Curve
- Training Cost (Including Individual and Team Training Devices)
- Support Costs Due to Supply Chain (Including Personnel)
- Disposal Cost Estimate (Including Hazardous and Recyclable Materials)

To what degree does the DSM, as currently defined, support a Model-Based (Systems) Engineering approach, and what gaps might exist in the DSM?

- MBSE enables DSM to expose cost impact in a Semantic Cost Model
  - Automatically processed by a computer system (more than Excel)
  - Data plus the interpretation of the data

- Need to expand MBSE beyond delivered system
  - Need to add temporal representation
  - Non-recurring, recurring, and operations/sustainment
  - Evolving throughout acquisition lifecycle
  - Need guidance on fidelity: cost and confidence

TECHNICAL BASELINES

As Conceived
As Developed
As Proposed
As Designed
As Built/Released
As Delivered
As Maintained

Policy and Legal Considerations Breakout Session – Participants

Facilitator: Jim Coolahan (Coolahan Assoc.)

Participants:

- Tyesia Alexander (Engility)
- Tracee Gilbert (System Innovation)
- Michael Heaphy (DMSCO/BAH)
- Mike Lamarche (NMSO)
- Frank Mullen (SimVentions)
- Hart Rutherford (SimVentions)
- Chuck Sanders (Alion)

Questions for Policy and Legal Considerations Breakout Session

1. What contractual language is needed to assure that system contractors and the government populate the DSM with all critical system data?

2. What policies are needed to ensure that data in the DSM is authoritative?

3. What policies are needed to govern access to data in the DSM by various system stakeholders?

4. What policies are needed to govern access to data in a system's DSM to enable sharing for a system of systems?

5. What are the obstacles to adopting a model-based RFP / proposal / evaluation process for contracting for system acquisition?

6. What policies are needed to address DSM long-term retention issues in an electronic environment?

What policies are needed to ensure that data in the DSM is authoritative?

- Pedigree (including assumptions, constraints, date of creation) and appropriate validation (intended use, last verification/validation date) are key elements of authoritativeness.
- Policy should require, for each DSM, that an organization (or set of organizations) be identified as the authority for each element / aggregation of data.
- Each time data is used, the pedigree should be identified.
- Metadata should be required that identifies the authority (pedigree and validation) for each data element.

What are the obstacles/solutions to adopting a model-based RFP / proposal / evaluation process for contracting for system acquisition?

- The implementation of a model-based RFP / proposal process must ensure a level playing field among potential industry participants.
  - E.g., significant investment in IT resources may be needed to read / reply with models
  - Web-based solutions may help in some instances.
- Although there are current legal conventions on construing written documents, interpreting and evaluating machine-readable digital products, in a legal sense, is not mature.
  - Some technology exists, but not standard processes/practices for translating all forms of models to a legally interpretable format.
  - This affects protests, contract compliance, etc.
  - Significant training / cross-training will likely be required between the legal and engineering professions.

Workshop Summary
Some Common Themes

- Although using different terms, the three defense industry presentations displayed a significant degree of commonality in emphasizing the use of models in systems engineering.

- Attention will need to be paid to protection of intellectual property and proprietary data in the population of DSMs.

- Having standards for the organization and representation of various types of DSM elements will be important in constructing DSMs.

- Metadata for identifying the pedigree and validity of data must be associated with all DSM elements.

- In general, the DSM concept is consistent with, and supportive of, the goals of Model Based (Systems) Engineering.

Workshop Summary
Some Unresolved Questions

- There is not general agreement on a detailed taxonomy for DSM data – more work is needed.

- Although the current concept for the DSM is focused on including data describing the system, there is some sentiment that it should also include models, including assumptions.

- There is not complete agreement on the "boundaries" of the DSM – e.g., should the environment in which the system must operate be represented in the DSM, or externally as part of a larger collaborative modeling/simulation environment?

- There is not general agreement on the level of aggregation at which the contents of the DSM should be specified – e.g., a highly aggregated Lifecycle Cost Estimate? Specific technical performance measures?

Workshop Summary Observations

- There appeared to be general agreement at the end of the workshop that the workshop was a productive exercise in better defining the DSM and illuminating potential issues.

- The size of the breakout groups appeared to strike a good balance between having diversity of opinions and being able to reach a consensus on key points during the allotted time.

- Developing more detailed specifications on the boundaries and the content of the DSM will require more concerted sustained effort than can be done in a workshop setting.