Final Report on the Digital System Model Workshop of 17-18 August 2015

NDIA Systems Engineering Division
M&S Committee

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Executive Summary

Background

During the 2012-14 time frame, the Office of the Deputy Assistant Secretary of Defense (Systems Engineering / Systems Analysis) [ODASD(SE/SA)], working in conjunction with the Acquisition Modeling and Simulation Working Group (AMSWG), developed a concept for a "System Model" that would evolve over the system lifecycle. The term eventually was modified to be the "Digital System Model" (DSM), which now has a definition in the Defense Acquisition University (DAU) glossary, as follows:

> "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."

In December 2014, during discussions at the National Defense Industrial Association (NDIA) Systems Engineering Division's Strategic Planning Meeting, the Modeling and Simulation (M&S) Committee agreed to hold a DSM Workshop during 2015 to obtain broader inputs on the DSM concept. The workshop was subsequently scheduled for 1.5 days on 17-18 August 2015.

Workshop Objectives

Prior to the workshop, the leadership of the M&S Committee, in consultation with Ms. Philomena Zimmerman of ODASD(SE)'s Engineering Enterprise (EE; formed during an SE re-organization, including elements of the former SA), developed the following four objectives for the workshop:

- 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.

Workshop Agenda

The afternoon of 17 August consisted of 3.5 hours of presentations to provide the workshop participants with background information on the DSM and industry viewpoints on DSM constructs. Ms. Philomena Zimmerman of ODASD(SE/EE) provided the government overview of the DSM and a related construct known as the Digital Thread. This was followed by four industry presentations giving perspectives on the DSM construct, three of which were given by representatives of major defense contractors, and one by non-defense commercial industry. The M&S Committee leadership then presented information on recent work from the ongoing NDIA study on Essential Elements of the DSM and a perspective on a potential data taxonomy that was used to structure some of the subsequent breakout sessions.

The second day of the workshop was devoted entirely to tasking the breakout groups, conducting the breakout sessions, and providing outbriefs from the breakout groups in a plenary session at the end of the day. The M&S Committee leadership determined the topic areas for the four breakout groups. Three of the breakout groups were focused on specific categories of data expected to be represented in the DSM – system characteristics data, system performance/effectiveness data, and system financial data. The fourth breakout group was focused on policy and legal considerations that would apply to the DSM as a whole.

Breakout Session Topics

Prior to the workshop, the M&S Committee leadership consulted with the volunteer facilitators to construct a list of five or six questions for each breakout group. The questions posed for the three data-focused breakout groups were intentionally rather similar, and each of these groups was provided with a summary listing of essential elements of the DSM in that category based on the in-progress work of the NDIA study. Each breakout group was also permitted to develop an additional question to be addressed, if desired. The five common questions posed to the three data-focused groups were:

- What critical <breakout session focus> data elements that should be included in the Digital System Model (DSM) are missing from the list generated by the current NDIA study?
- What concerns might system stakeholders have regarding sharing of <breakout session focus> data?
- Are there existing data taxonomies or standards that could be used to help specify how <breakout session focus> data elements should be specified in the DSM, and to what degree are they applicable to only certain types of systems?
- What are appropriate constructs (e.g., databases, repositories, registries) for storing, accessing, and distributing <breakout session focus> data in the DSM?

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

The body of this report contains the results of each of the breakout sessions. There is at least one page devoted to each question addressed by each breakout group, consisting of a slide-like summary, followed by accompanying text. In some cases, breakout groups provided additional slides for context and explanatory comments. Slides generated by each breakout group during its session were left unchanged, except for some minor editing, and the accompanying text was generated after the workshop by the session's facilitator.

Summary of Results

The following are some common themes in the results of the workshop:

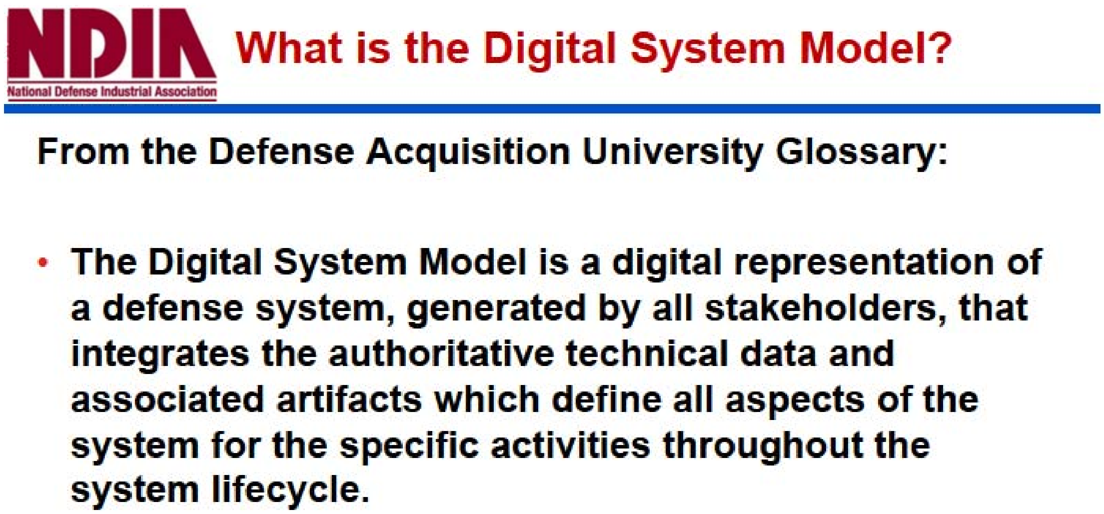
- Although using different terms, the three defense industry presentations displayed a significant degree of commonality in emphasizing the use of models in systems engineering.
- Attention will need to be paid to protection of intellectual property and proprietary data in the population of DSMs.
- Having 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.

Despite the above commonality, the following appear to be some unresolved questions that need further work, discussion, and consensus-building:

- 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?

With respect to the content, format and scope of the workshop, the following observations are offered:

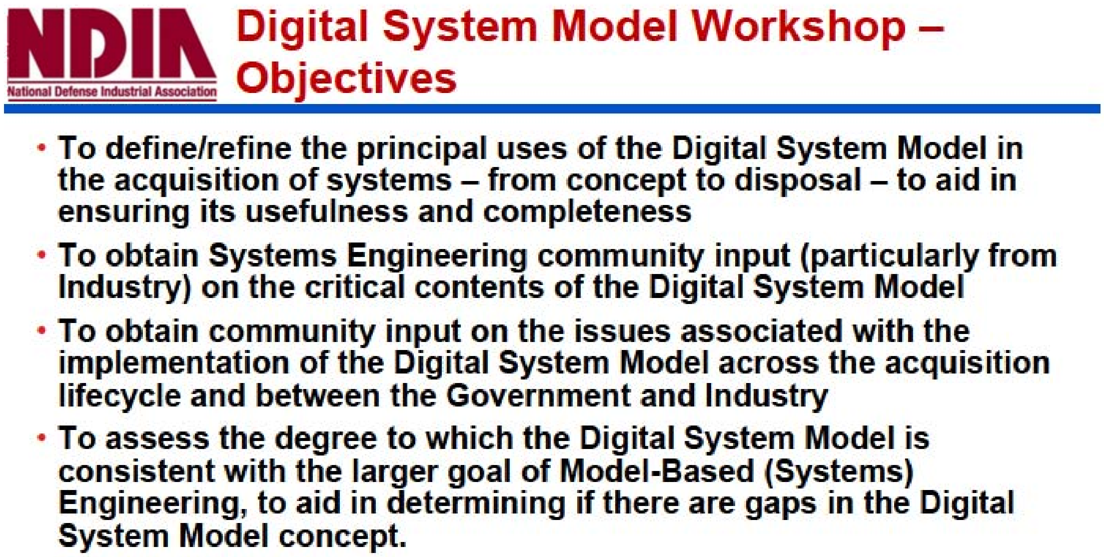
- There appeared to be general agreement at the end of the workshop that the workshop was a productive exercise in better defining the DSM and illuminating potential issues.
- The size of the breakout groups appeared to strike a good balance between having diversity of opinions and being able to reach 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.



Definition of the Digital System Model

During the 2012-14 time frame, the Office of the Deputy Assistant Secretary of Defense (Systems Engineering / Systems Analysis) [ODASD(SE/SA)], working in conjunction with the Acquisition Modeling and Simulation Working Group (AMSWG), developed a concept for a "System Model" that would evolve over the system lifecycle. The term eventually was modified to be the "Digital System Model" (DSM), which now has a definition in the Defense Acquisition University (DAU) glossary, as stated above.

In 2013, the Modeling and Simulation (M&S) Committee of the Systems Enginerring Division of the National Defense Industrial Association (NDIA) accepted the task of trying to identify the "essential elements" of the DSM, and formed a subcommittee to perform a study in this regard, which is completing in early 2016. As an adjunct to that study, in December 2014, the M&S Committee agreed to hold a DSM Workshop during 2015 to obtain additional inputs on the DSM.



Workshop Objectives and Agenda

Objectives

Prior to the workshop, the M&S Committee leadership consulted with the Deputy Director, Engineering Tools & Environments (successor organization to Systems Analysis) in ODASD(SE) concerning the desired outcome of the workshop. Based on these discussions, the M&S Committee leadership defined the four workshop objectives listed above. Particular emphasis was placed on trying to get industry input on the contents of the DSM.

It was decided that the DSM Workshop would consist of a half day of technical presentations to “set the stage” followed by a full day of breakout group discussions with a summary outbrief session. The workshop was conducted on the afternoon of Monday, 17 August 2015, and all day on Tuesday, 18 August 2015, at the offices of Engility Corporation in the Clarendon area of Arlington, VA.

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**	Phil 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	

Day 1 Agenda

The afternoon of 17 August consisted of 3.5 hours of presentations to provide the workshop participants with background information on the DSM and industry viewpoints on DSM constructs.

Ms. Philomena Zimmerman of ODASD(SE/EE) provided the government overview of the DSM and a related construct known as the Digital Thread. This was followed by four industry presentations giving perspectives on the DSM construct, three of which were given by representatives of major defense contractors, and one by non-defense commercial industry. The M&S Committee leadership then presented information on recent work from the ongoing NDIA study and a perspective on a potential data taxonomy that was used to structure some of the subsequent breakout sessions.

Copies of the presentations are posted on the M&S Committee's web site.

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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	

Day 2 Agenda

The second day of the workshop was devoted entirely to tasking the breakout groups, [5] conducting the breakout sessions, and providing outbriefs from the breakout groups in a plenary session at the end of the day.

The M&S Committee leadership determined the topic areas for the four breakout groups. Three of the breakout groups were focused on spefic categories of data expected to be represented in the DSM – system characteristics data, system performance/effectiveness data, and system financial data. The fourth breakout group was focused on policy and legal considerations that would apply to the DSM as a whole. Prior to the workshop, the M&S Committee leadership consulted with the volunteer facilitators to construct a list of five or six questions for each breakout group. The questions posed for the three data-focused breakout groups were intentionally rather similar, and each of these groups was provided with a summary listing of essential elements of the DSM in that category based on the in-progress work of the NDIA study. Each breakout group was also permitted to develop an additional question to be addressed, if desired.

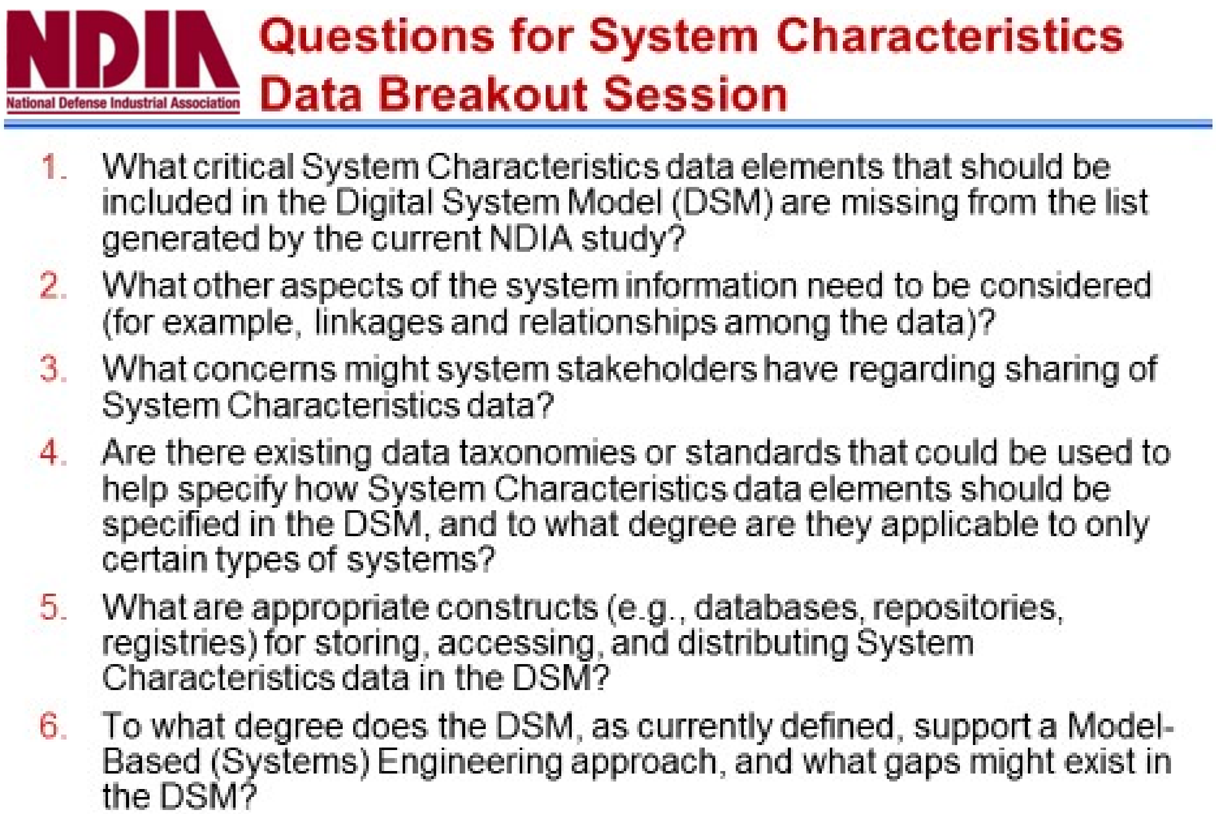
The remainder of this report is devoted to outbriefs of each of the four breakout groups, with explanatory words added by the faciliators after the workshop, as needed.

System Characteristics Data Breakout Session Results

The participants in the System Characteristics Data breakout session were:

- Louisa Guise – Raytheon (Facilitator)
- Sandy Friedenthal – self
- David Hench – Eagle Ray R&D
- Howard Owens – NAVAIR
- Curtis Potterveld – Boeing
- Frank Salvatore – Engility

The purpose of the breakout session was to address the system characteristics that need to be captured in a DSM. The NDIA study on Essential Elements of the DSM had proposed a set of data and this breakout session was charged with reviewing and updating that list.



Questions for the Breakout Session

The breakout group was asked to address six questions, which are listed above. The breakout group did not add any additional questions.

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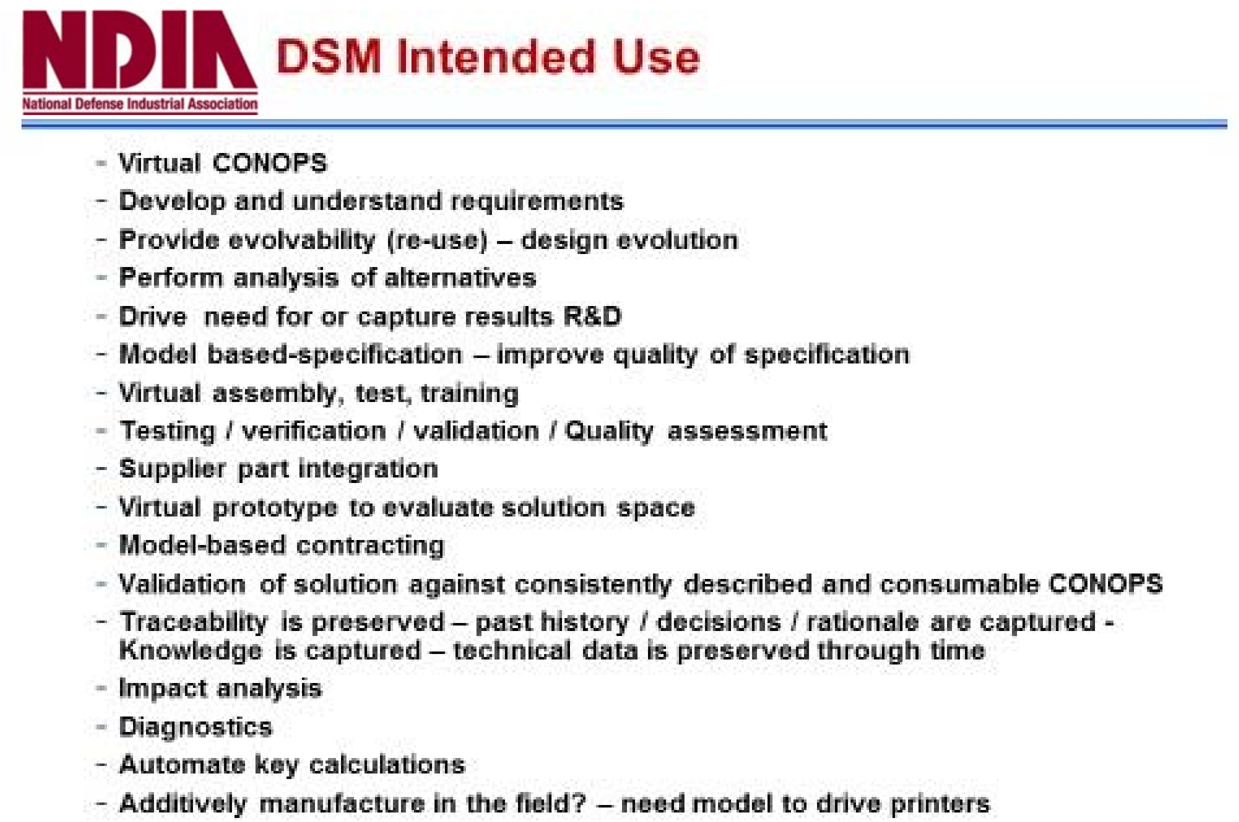
Underlying Assumptions

- The DSM is collaboratively developed between DoD acquisition community and industry.
- It may be started by the DoD acquisition community in the early phases of system development (6.1) in order to support the acquisition process.
- Elements of the DSM may be provided to industry to support proposals and system development in the form of a model-based specification.
- During system development, industry tends to develop the DSM with the acquisition community in an oversight role and with collaboration in the DSM development.
- The DSM is used by the acquisition to verify the industry solution and for verification and validation of the solution.
- The DSM is then used by the Operations and Support community to maintain and operate the system and ultimately dispose of it.
- The DSM is then used to support the creation of new solutions to new problems.

Assumptions Made by the Breakout Group

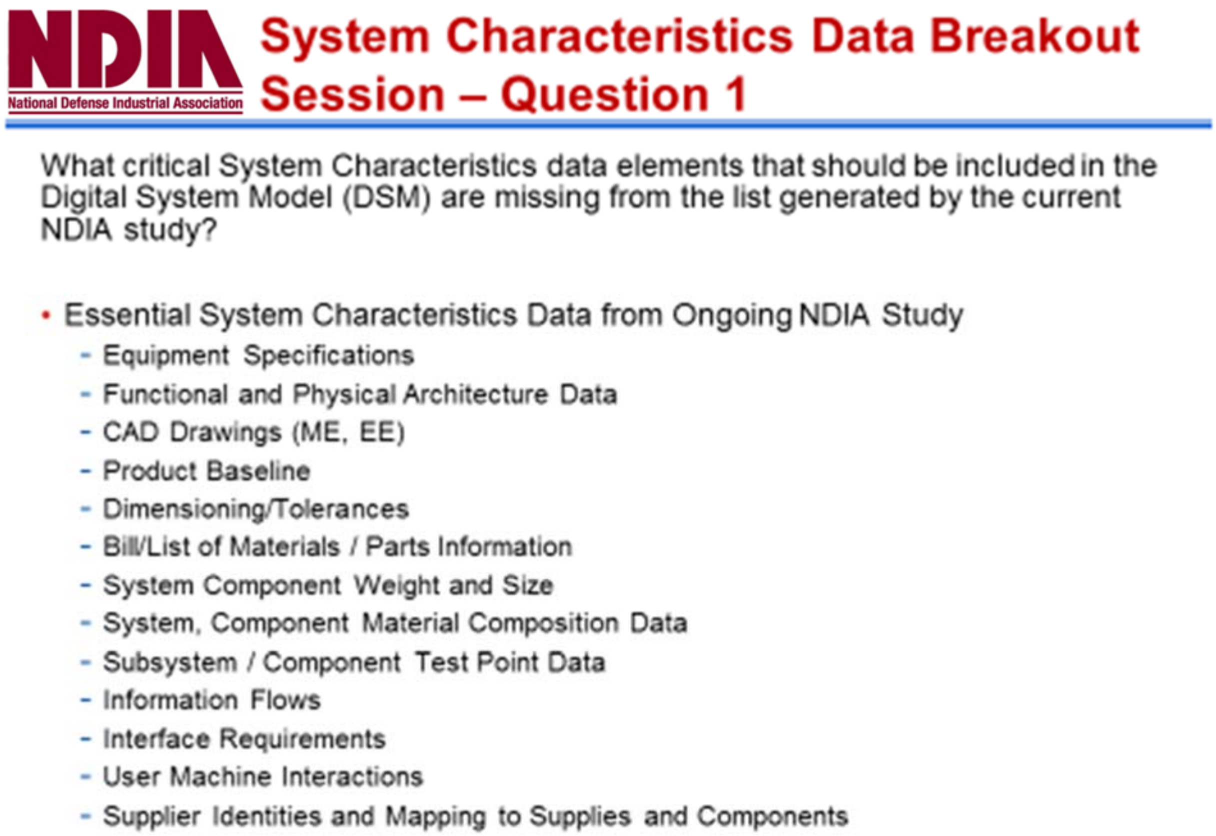
The breakout group started by discussing its charge. Since there was some indication that not all the participants came with the same set of assumptions and definitions, the group decided that explicitly identifying these assumptions would be a useful exercise. The results of that discussion were the assumptions listed above.

With respect to the second bullet in the above list, alternatively, the DSM can be initiated by the stakeholders (warfighters, military commands, and funding agencies) during the requirements phase from operational, scenario, terrain, engineering, and testing models.



Potential Uses of the DSM

The breakout group also felt that it would be a useful exercise to identify some of the potential uses of the DSM in order to be able to scope what the contents should be. Some of the use cases for the DSM are shown in the above list. The list was not meant to be all-inclusive. It was just intended to provide some context for the DSM.



Essential System Characteristics Data from the Ongoing NDIA Study

The breakout group's first approach to developing the list of characteristics was to compare the original NDIA committee's list to various Military Standards (MIL STDs) and Data Item Descriptions (DIDs). As a result, the team concluded that the list identified by the committee was limited and did not represent a complete representation of a system.

After reviewing the System Requirements DID, the breakout group decided that the MIL STDs and DIDs represent a good source of information relative to the identification of the necessary contents of the DSM. The breakout group further recognized that the identification of all the contents for the DSM would be too large a task to undertake in a single day's breakout session, but could form the basis of a general recommendation of the organization and type of data to be captured in the DSM.

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A Potential Organization for System Characteristics Data (1 of 2)

- R&D data
- For each element (HW, SW, people, facility, etc.) at each level of the hierarchy
  - Specifications / requirements
    - Function, Physical, Information Assurance, Interface, etc.
    - Appropriately classified scenario and terrain data that allows verification of progress vs. requirements
  - Architecture (functional, logical, physical)
  - Design (e.g., Geometry, material characteristics, behavior, performance, physical, -ilities, quality characteristics, …)
    - Set of characteristics of the characteristics – for example, design margin, etc
    - ECAD / MCAD / software models / system design models
    - Dimensioning/Tolerances
    - Bill/List of Materials / Parts Information
    - System Component Weight and Size
    - System, Component Material Composition Data
    - Subsystem / Component Test Point Data
    - Information Flows
    - Interface Requirements
    - User Machine Interactions
    - Supplier Identities and Mapping to Supplies and Components

A Potential Organization for System Characteristics Data

After reviewing the System Requirements DID, the breakout group recommended that the data in the DSM be organized in a “fractal type” hierarchy associated with the system product breakdown structure. The breakout group also recommended that the data be organized by a system development lifecycle. An example of the type of information that needs to be in the DSM includes the information shown above and on the next page.

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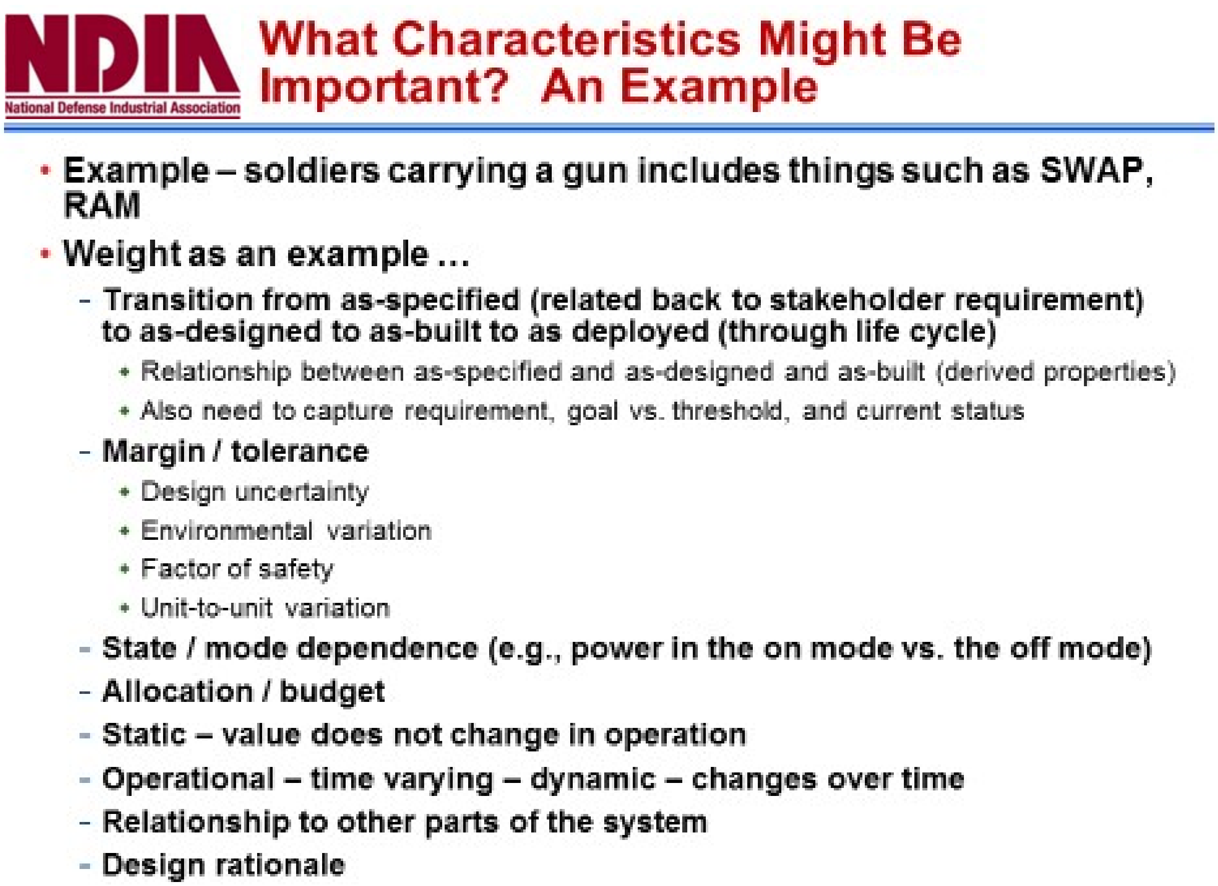
A Potential Organization for System Characteristics Data (2 of 2)

- Integration
  - Integration plans and results
- Test
  - Test results
- Verification
  - Verification results
- Manufacturing / Implementation
  - Manufacturing processes, manufacturing models, etc.
- Support
  - Maintenance Manuals
  - Diagnostics
- Disposal

- Supporting Data (full lifecycle)
  - Analysis – supports all the above
    - Performance
    - Thermal analysis
    - Structural analysis
  - Rationale – supports all the above
  - Relationships of the information
    - Satisfies, cost impact, verifies, traceability / impact, etc.
- Metadata (e.g., model management, configuration management)

A Potential Organization for System Characteristics Data (continued)

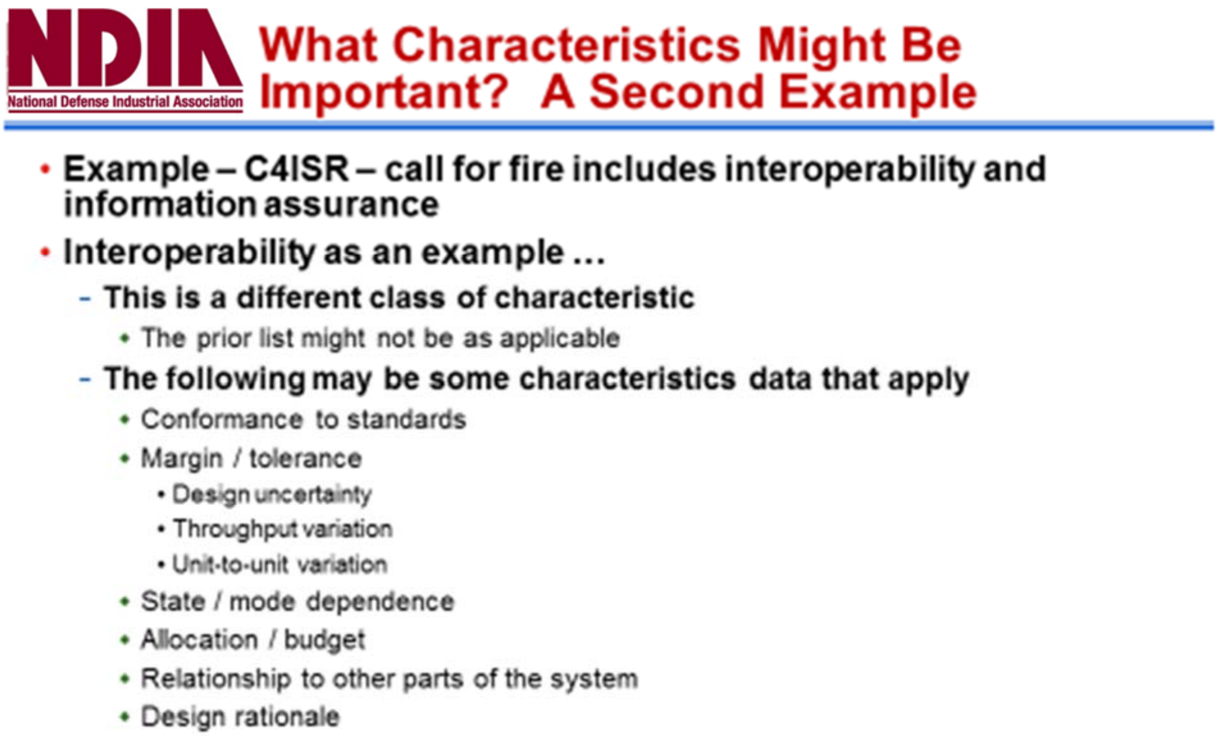
The last two major bullets (supporting data and metadata) resulted from a discussion that more than just the system data needs to be stored. Supporting data such as analyses and rationales need to be captured to put the data into context. Also, it is very important that the relationship of the data elements of the DSM needs to be captured (for example, the weight of a system is relative to the weights of the individual pieces of the system or the cost of the system is relative to the various elements that have the most impact on cost). This information is vital in order to be able to perform impact analyses for system upgrades (e.g., if we change this element, these other parts of the system are affected).



What Characteristics Might Be Important?

The breakout group decided to validate the types of data that would be needed for the DSM by looking at two specific parameters that might be captured: the weight of a soldier-carried system and the interoperability of a Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) system.

The team identified potential characteristics for the soldier-carried system. These included SWAP (size, weight, and power) and RAM (reliability, availability and maintainability). Specifically, for weight, the characteristics data listed above were felt to be important.



What Characteristics Might Be Important? (continued)

For the example of an interoperable C4ISR system, some of the key data includes the items listed above. As noted, the breakout group realized that not all parameters to be identified in one case would be used in the second case, and vice versa.

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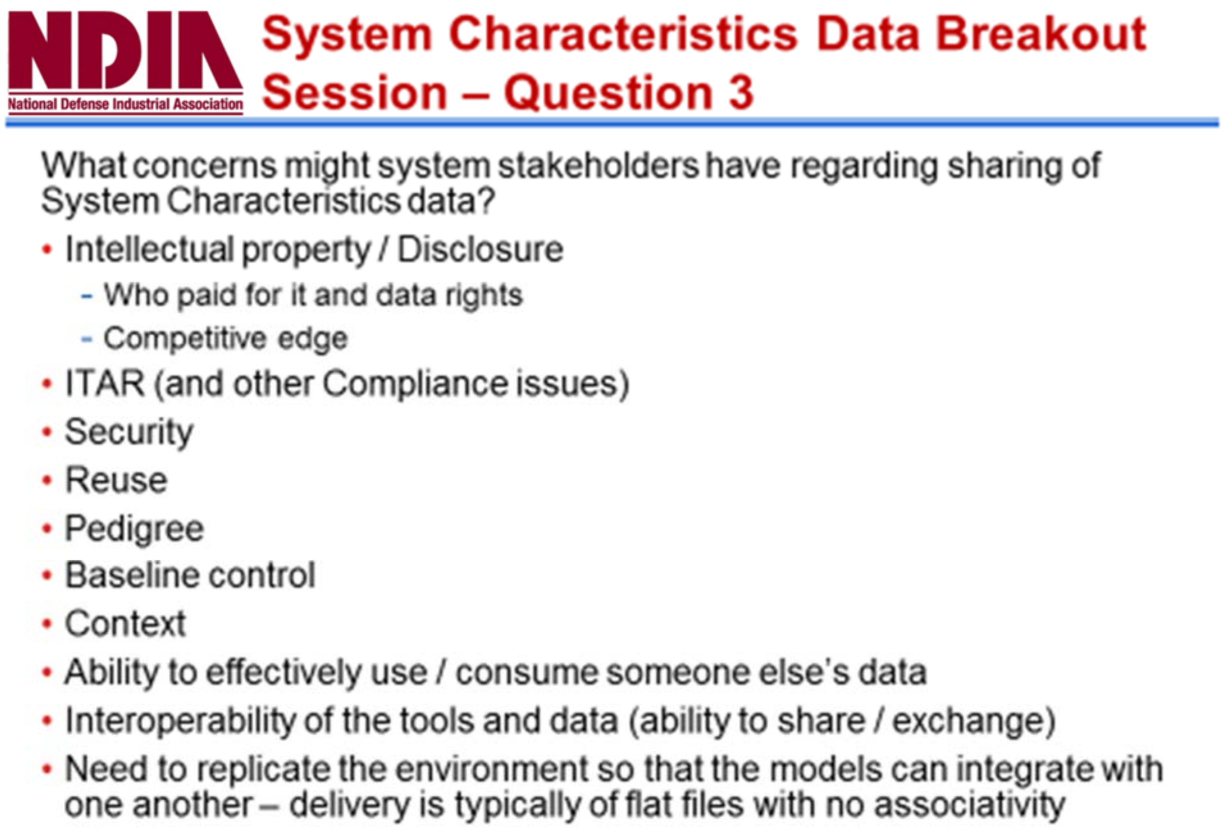
System Characteristics Data Breakout Session – Question 2

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

- Traceability
- Design Rationale
- Metadata
- Relationships to other elements / systems (internal and external)
- Environment / Ecosystem / Context
- Another type of set of properties / hierarchy
  - SWAP-C
  - RAM
  - Interoperability
  - Information assurance
  - … others

What Other Aspects of the System Information Need to Be Considered?

In addition to the system data, it is important that the information about the ecosystem for the system be included. In this case, the ecosystem includes not only the environment in which the system operates, but also the environment in which the system was developed. Some of the data in this regard is shown in the above list.

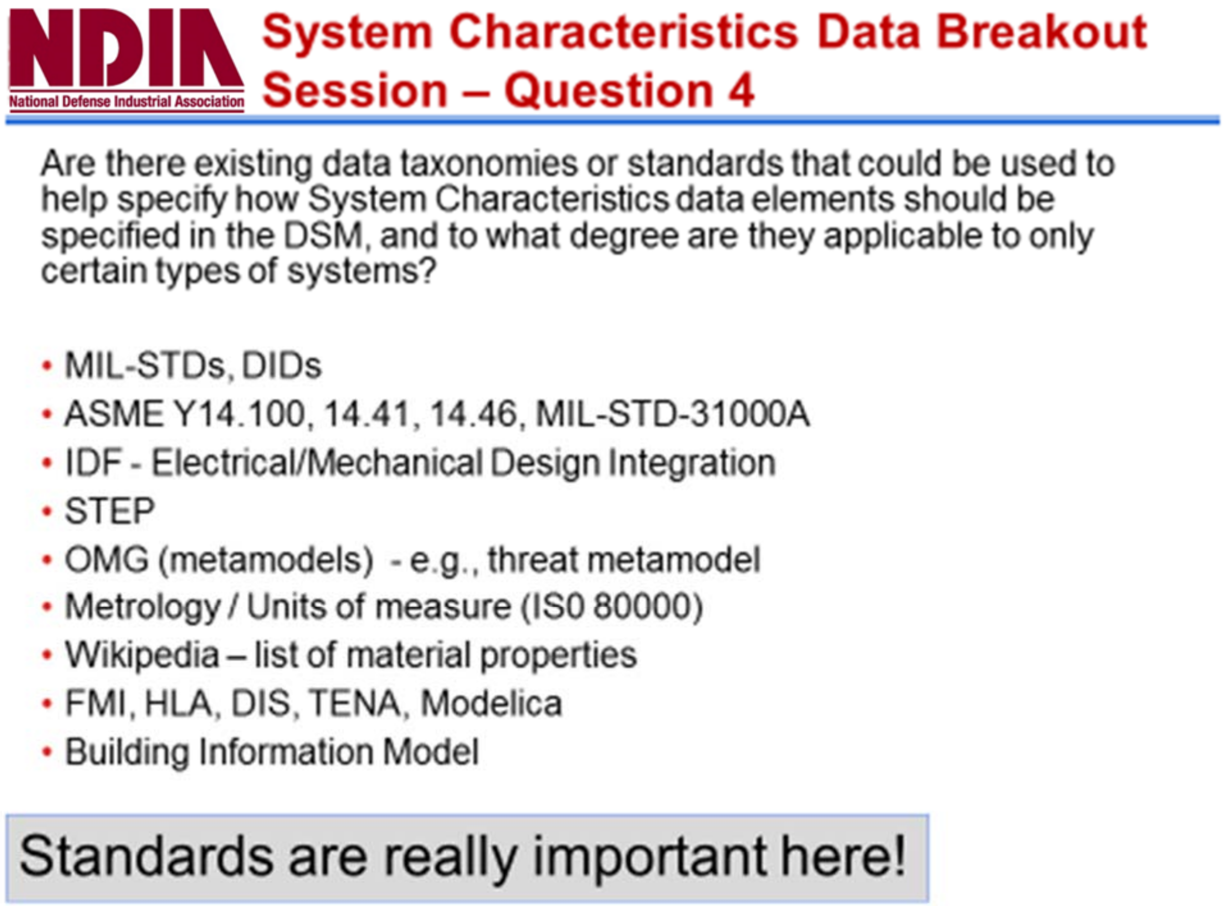


What Might Be Stakeholder Concerns in Sharing System Characteristics Data?

Concerns that stakeholders may have are shown in the above list. In this case, "disclosure" means how much can be disclosed to other partners in the development activity. There needs to be a mechanism for protecting intellectual property of each of the parties involved.

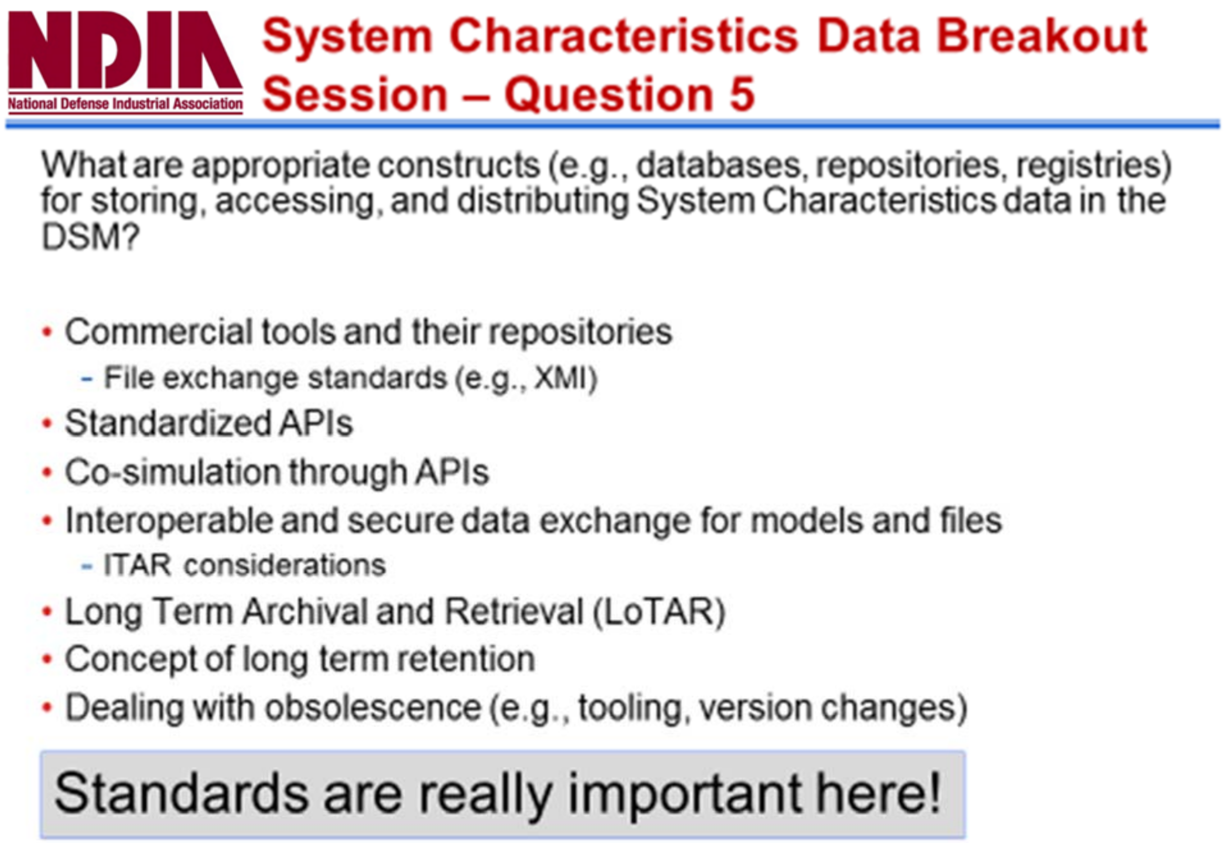
The reuse element needs to address how the system elements are developed. There needs to be some approach to encourage reusable development. While this may cost more for an originating program, in the long run, the advantages to the DoD are numerous.

The context of the solution and associated design artifacts needs to be well characterized and understood in order to be consumed by other parties. Currently, for example, when geometry models are delivered, they are delivered as flat files without association of the data so when, for example, NAVAIR gets them, they have to manually recreate the integrated system. They also get models from multiple different suppliers, with multiple different tools. This example highlights the need for such elements as metadata (to understand the tools and assumptions under which the artifacts are developed) and a well characterized set of assumptions.



What Taxonomies/Standards Might Be Used for System Characteristics Data?

As referenced earlier, the Military Standards and the DIDs are good sources of information for existing data taxonomies. Some of the other recommended resources are listed above.



What Storage/Access/Distribution Constructs Are Appropriate?

A number of example constructs for storage, access, and distribution are shown above, most of which are self-explanatory. Dealing with Long Term Archival and Retrieval encompasses the need to be able to consume artifacts that may have been developed with tools and/or data structures that are obsolete or have been superseded by more recent versions and technologies.

Note that in this area, as well as in the previous area of data taxonomies, the breakout group felt that standards are very important.

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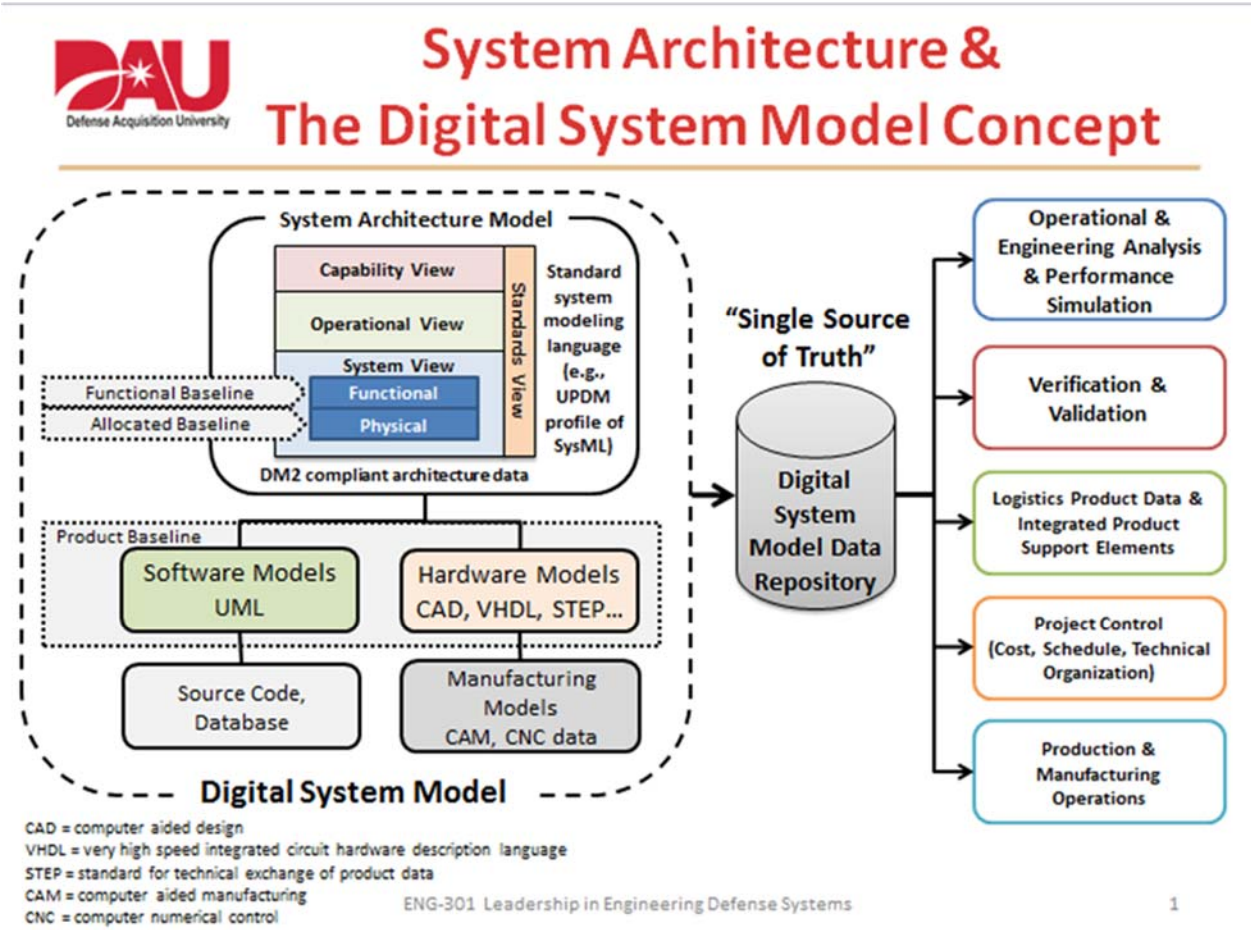
System Characteristics Data Breakout Session – Question 6

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 is an artifact of MBE (MBSE is a subset of MBE)
- Doesn't deal with the management piece of engineering
  - Integration of program management (e.g., risk, cost, etc.) – but it is reasonable to leave it out for this activity
- Should be clarified that software specifications and associated data are part of the Technical Data Package
- Should clarify whether the analysis, rationale, traceability is part of the DSM
- Clarify the relationship between the TDP and the DSM
  - And therefore we need to know what the TDP and DSM consist of and what their relationships are
- Clarify that the DSM needs to include instance model of individual fielded systems and products
- Clarify that the DSM is used to generate the next generation of the product
- The model is truly a living artifact that evolves with the product

To What Degree Does the DSM Support a MBE/MBSE Approach?

During this discussion, the breakout group reviewed a graphic from the Defense Acquisition University that depicts the DSM and its relationship with MBE. The breakout group felt that this was a reasonable depiction. In the figure (shown on the next page), the breakout group felt that MBE is the content on the left side of the graphic, whereas the DSM encompasses the whole, including the data repository and the use of the data for the digital threads on the right.



Summary of the System Characteristics Data Breakout Session

In general, the recommendations from the breakout group are that the system characteristics be identified using the existing set of MIL STDs and DIDs that were in use prior to acquisition reform. These captured many years of experience in the development of defense systems. It is further recommended that the DSM consist of not just system characteristics data, but also the related metadata and relationships among the data.

System Performance/Effectiveness Data Breakout Session Results

The participants in the System Performance/Effectiveness Data breakout session were:
- Jeff Bergenthal – JHU/APL (Facilitator)
- 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

The participants in the System Performance/Effectiveness Data breakout session are shown above. The participants brought experience and perspectives including:
- Large aerospace and defense contractors
- Firms providing systems engineering and technical assistance to the US Government
- Independent systems engineers
- Modeling & simulation tool vendors
- Department of Defense University Affiliated Research Centers

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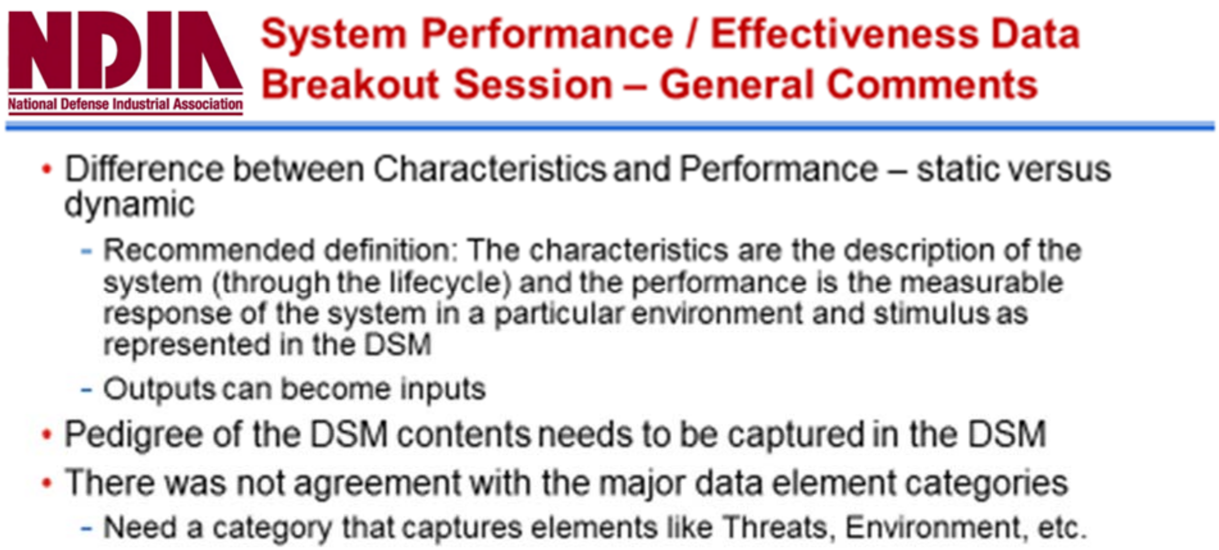
Questions for System Performance / Effectiveness Data Breakout Session

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?

Questions for the Breakout Session

The breakout group was asked to address six questions, which are listed above. The breakout group did not add any additional questions.



General Comments by the Breakout Group

The breakout group started by establishing the difference between System Characteristics Data and System Performance/Effectiveness Data. The following definitions were developed:

- System Characteristics data and models describe the composition and inherent behaviors and characteristics of a system. A system characteristic model is a static representation of the system, and does not include the dynamic incorporation of time in the model. Examples of system characteristic models include: CAD drawings, SysML diagrams, functional decomposition models, etc.
- System Performance data and models address how well the system achieves the desired behavior and provide a measurable response of the system in a particular environment and stimulus. A system performance model implies that there is a "goodness" value to the result of the measurement, whether explicitly a requirement or not. These models typically execute over time and result in measurable responses. Examples of system performance models include: aircraft flight performance models, heat dissipation models, wind tunnel models, and stochastic simulations of SysML activity models.

The breakout group participants also noted that the pedigree of each element of the Digital System Model (DSM) needs to be captured within the DSM.

System Performance / Effectiveness Data Breakout Session – Question 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?

- Stakeholder needs & objectives
- Constraints
- Threats
- Environment
- Sustainability concept
- Definition of the user / human interaction / usability
- Cybersecurity / physical security
- Interoperability / interfaces (system-level outward)
- Disposability
- Trade studies
- System scope (system boundaries)
- Operations performance data

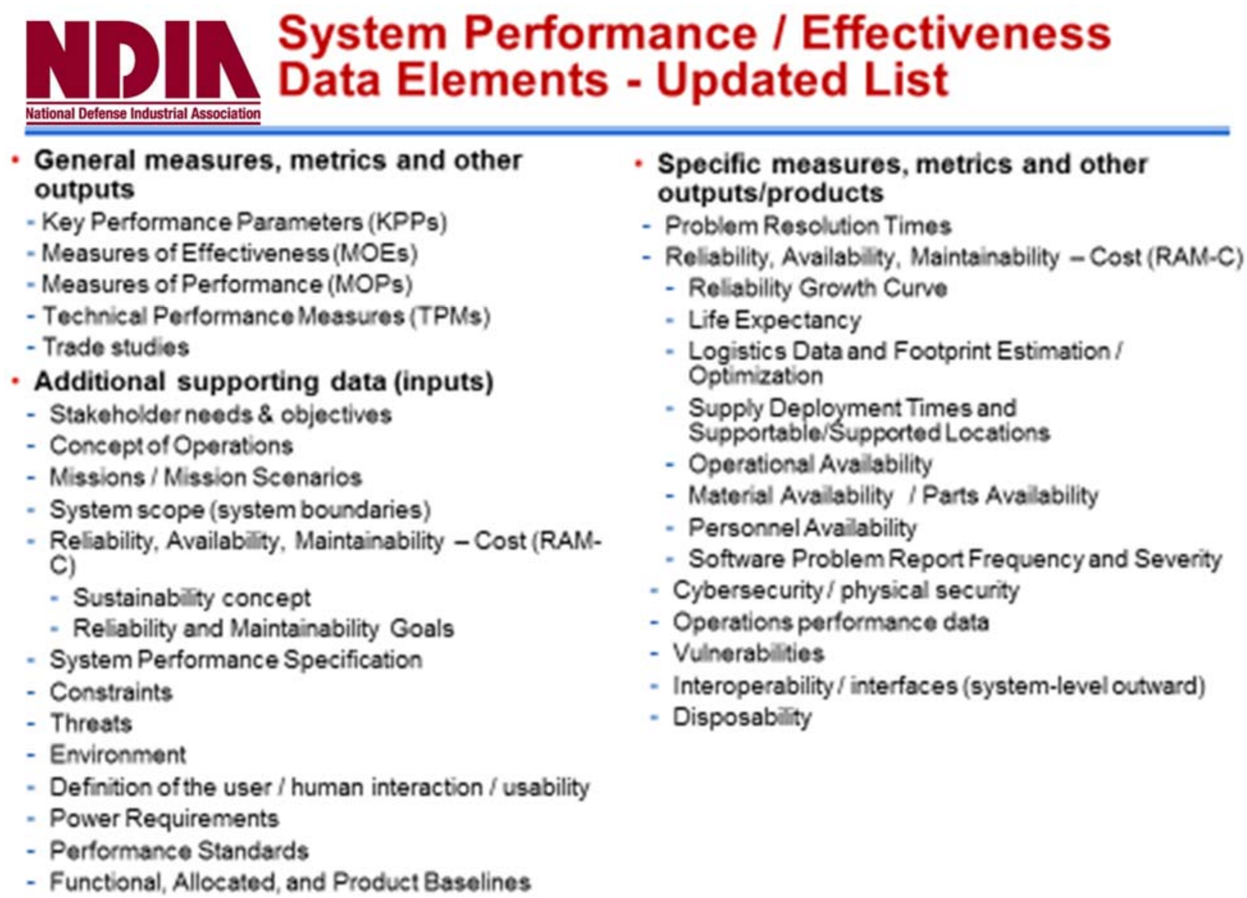
What Critical System Performance/Effectiveness Data Elements Are Missing in the NDIA Study?

The list of System Performance/Effectiveness data elements generated from the current NDIA Essential Elements of the Digital System Model study are:

- Key Performance Parameters (KPPs)
- Measures of Effectiveness (MOEs)
- Measures of Performance (MOPs)
- Technical Performance Measures (TPMs)
- Performance Standards
- System Performance Specification
- Concept of Operations
- Missions / Mission Scenarios
- Functional, Allocated, and Product Baselines
- Vulnerabilities
- Power Requirements
- Life Expectancy
- Logistics Data and Footprint Estimation / Optimization
- Operational Availability (Planned, Actual, Current Best Estimate)
- Reliability and Maintainability Goals
- Reliability Growth Curve
- Material Availability
- Parts Availability
- Problem Resolution Times

- Software Problem Report Frequency and Severity
- Supply Deployment Times and Supportable/Supported Locations

A number of missing data elements were identified by the breakout group, and are shown above in the captured slide.



An Updated List of Performance/Effectiveness Data Elements

There was not consensus among the breakout group participants with the existing categorization of the data elements, and an alternative categorization (shown above) was developed after the workshop.

- There will be planned, actual, current best estimate, etc. values, for many, if not most, of the elements.
- Some items can belong in both specific measures and metrics (outputs) as well as inputs, especially as data goes from concept to planning to modeling, simulation, and analysis. For example, Logistics Data and Footprint Estimation / Optimization can start as something imposed externally (input), then as time goes on, the logistics footprint becomes an output, e.g., how many spares are needed to maintain a certain level of Operational Availability.

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System Performance / Effectiveness Data Breakout Session – Question 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?

- 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)

Which Critical System Performance/Effectiveness Data Elements Are Better Specified by a Model?

The ODASD(SE) current thinking is that the DSM will only contain data, and not models. While many System Performance/Effectiveness elements can be adequately specified as data, it was determined that a number of the elements could be more fully specified through a model. Some specific System Performance/Effectiveness elements that would be more fully specified through a model are listed above. Many of these deal with “how” and “under what conditions” a system will provide its capabilities, both of which are required to fully understanding a system’s performance/effectiveness.

All too often, in-line model documentation will lack critical information that is necessary to use the model appropriately. If models are to be included in the DSM, it will be necessary to include the supporting information for the model, such as underlying assumptions, pedigree, etc., as well as information on the tool/environment in which the model was developed and executes.

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System Performance / Effectiveness Data Breakout Session – Question 3

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

- All data elements must be tagged with appropriate ownership and data rights to prevent exposure of company proprietary information
- All data elements must be tagged with appropriate security classification and/or sensitivity, and managed accordingly
- All competition sensitive data elements must be tagged and managed accordingly
- All data elements must be tagged with when generated (phase and activity) and with the maturity → requires a consistent set of maturity definitions
- All models must include VV&A information to understand the limits of use and limits of performance, fidelity
- Consistent information framework for evaluating competing contractor models – standards, completeness, context, assumptions, intended use, pedigree, etc.
- Policies and practices to handle source selection protests
- Policies and practices must ensure test data is acquired to validate models

What Might Be Stakeholder Concerns in Sharing System Performance / Effectiveness Data?

The breakout group identified a number of concerns with the sharing of System Performance/Effectiveness data. These concerns deal with protecting the following types of information:

- Company proprietary information
- Classified and controlled (e.g., For Official Use Only Only) information
- Competition-sensitive information

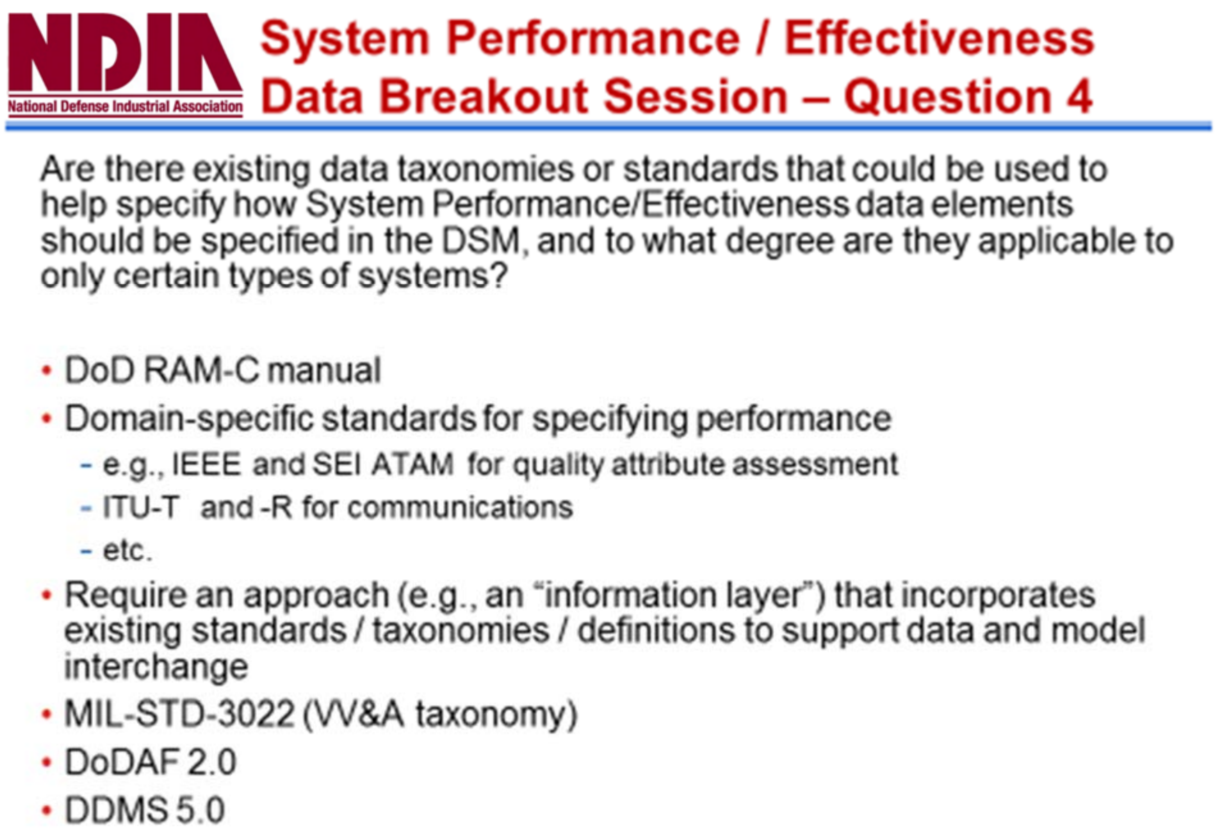
These concerns can be dealt with by:

- Tagging the data elements with the appropriate metadata covering ownership and data rights, security classification, and sensitivity (controlled information, competition-sensitive, etc.)
- Managing the access and release of the tagged data (see the governance discussion in Question 5)

Other concerns identified during the breakout session dealt with providing sufficient information with each data element (or model) to ensure that those accessing the DSM will use the data element (or model) appropriately. Specific information that should be included are:

- When the data element was generated (acquisition lifecycle phase and activity)
- The maturity of the data element; this will require the use of a consistent set of maturity definitions that are quantitatively based.
- Verification, validation, and accreditation (VV&A) information

Model-based approaches to system acquisition and development may enable the acquisition community to evaluate competitive offers via models, rather than, or in conjunction with, paper-based proposals. Ensuring thorough and fair evaluations of competing contractor models will require what the breakout group termed a consistent information framework, supported by standards and with the proper pedigree. Policies and practices to adjudicate protests arising from source selection based on evaluating contractors' models will be needed.

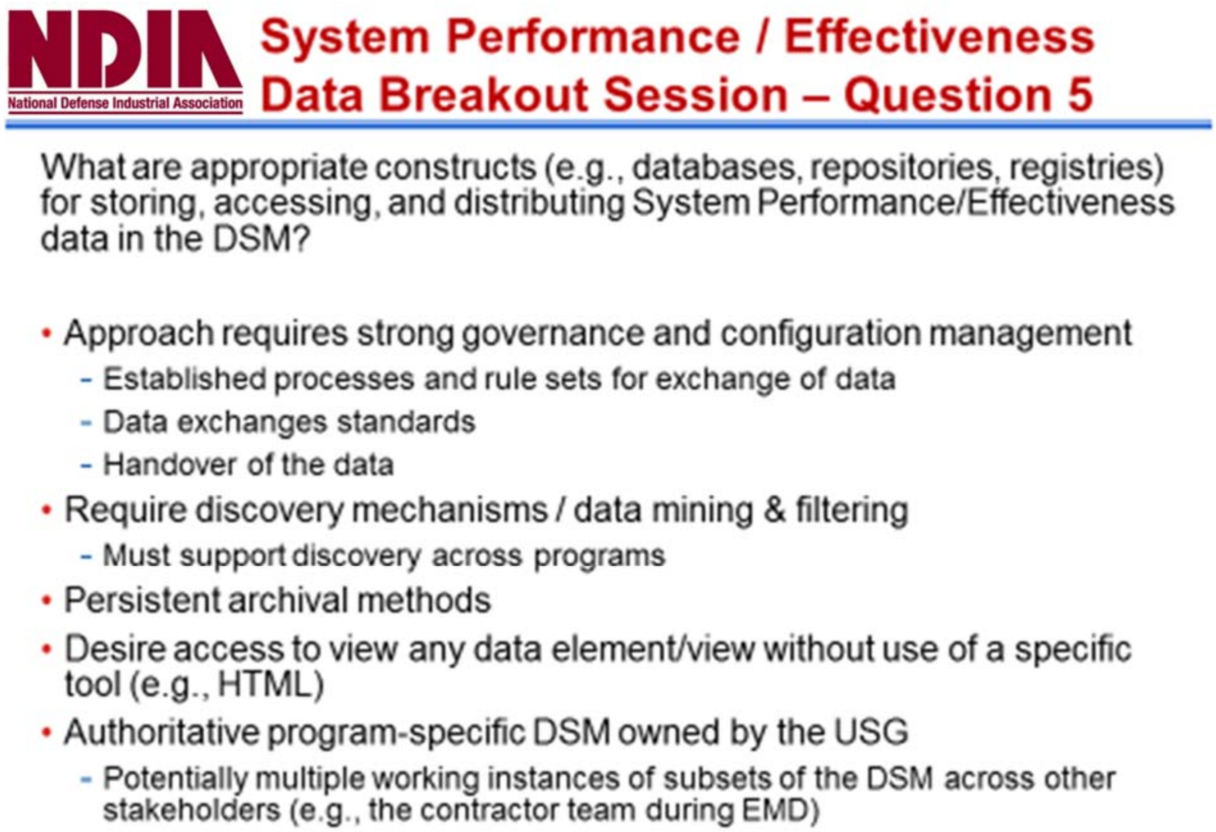


What Taxonomies/Standards Might Be Used for System Performance / Effectiveness Data?

The breakout group identified a number of standards or taxonomies that will apply to how System Performance/Effectiveness data elements should be specified in the DSM, regardless of what the system is. These standards and taxonomies include:

- The Department of Defense Reliability, Availability, Maintainability and Cost Manual
- MIL-STD-3022, which provides the VV&A taxonomy
- Department of Defense Discovery Metadata Standard 5.0
- Department of Defense Architecture Framework 2.0

Many System Performance/Effectiveness data elements will be specific to a type of system, for example, radar performance and ballistic performance. Domain-specific standards and taxonomies should be specified by the government Program Office for the system's DSM. Given the large number of standards and taxonomies that will be associated with the DSM, the breakout group discussed approaches that could enable data and model interchange. An "information layer" or "data abstraction layer" were mentioned as possible approaches.



What Storage/Access/Distribution Constructs Are Appropriate?

The contents of the DSM for a single system will be generated and used by a multitude of organizations across the entire acquisition lifecycle, including multiple DoD organizations, the prime contractor, subcontractors, etc. As discussed in question 3, the data must be tagged and managed to protect against exposure and to aid in proper use of the data. All of these factors require the existence of strong DSM governance practices and structures to manage the availability, usability, integrity, and security of the DSM data throughout the acquisition lifecycle. The governance practices should include, but not be limited to, processes and rule sets for the exchange of data between organizations, the standards for data exchange, and processes for the formal handover/delivery of data.

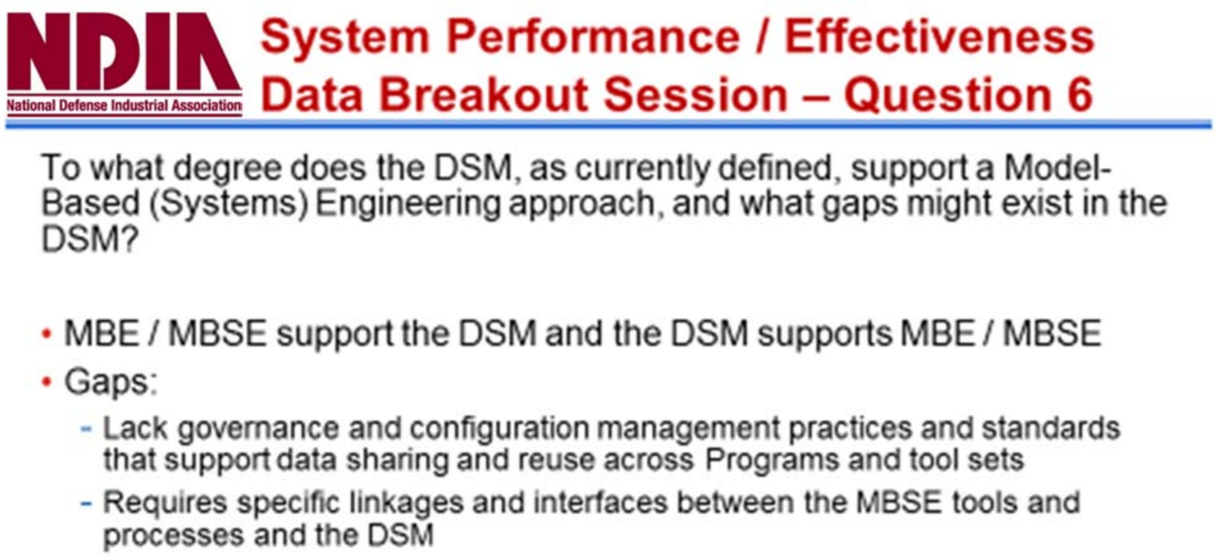
The DSM for a single system (including characteristics, performance/effectiveness, financial, and other supporting data) will be large and consist of data represented in a multitude of formats. Mechanisms to support the discovery, mining, and filtering of data within a DSM will be necessary to enable users to discover and obtain the data they need from the DSM rapidly. These discovery, mining, and filter mechanisms must also work across the DSMs from multiple systems to support both the reuse of data and design, development, evolution and support of Systems-of-Systems.

Individual defense systems may have very long lifecycles. The initial contract for the development of the B-52 bomber was awarded in 1946, and the B-52 remains in-service almost

70 years later. The potential for a very long system lifecycle will require persistent archival methods that support low-cost preservation of the DSM.

Because data captured in the DSM will be from a variety of engineering and non-engineering disciplines, and may as well be from a variety of modeling tools, it is desired that DSM data be consumable in a neutral format allowing use by all interested and appropriate parties. Although some disciplines may already have tools that provide DSM-like data via neutral formats like HTML CAD viewers, not all disciplines are in the same condition. Many of the tools used to create model data require licensed proprietary viewers, if a viewer is available at all. The absence of a "liquid" format for any stakeholder to see and use DSM data will make the sharing of information much less effective and work against the goals and vision of the DSM.

The DSM is a collection of model data from all sourcing parties to the system. The DSM will also not contain all of the model data produced and maintained by contractors. Because of this, the model data required in the DSM will need to be specified and agreed to by customer and vendor. The customer should have ownership of the DSM and stewardship of that data, while contractors and vendors will have potentially larger data sets that relate to (and may, in fact, be included in) the DSM, but will not be the authoritative dataset. There should be only one authoritative data set allowing for the baseline of DSM data to be controlled and managed in one place.



To What Degree Does the DSM Support a MBE/MBSE Approach?

Model Based Systems Engineering (MBSE), as defined by INCOSE, is, "The formalized application of modeling to support requirements, design, analysis, validation, and verification." Model Based Engineering (MBE), as defined by NDIA, is, "An approach to engineering that uses models as an integral part of the technical baseline that includes the requirements, analysis, design, implementation, and verification of a capability, system, and/or product throughout the acquisition life cycle."

MBSE can be implemented by having a systems engineering language, a systems engineering methodology, a suite of system modeling tools, and interfaces with other modeling and simulation tools. A further implementation is to use the System Modeling Language (SysML), a graphical modeling language for modeling complex systems including hardware, software, information, personnel, procedures, and facilities. All this provides for a unifying model of the system that is an authoritative, integrated repository of architecture and design information from concept development through operations.

Using the INCOSE definition of MBSE and the NDIA definition of MBE, conceptualizing, architecting, designing, developing, and sustaining a system will include the generation and use of the System Characteristics and System Performance/Effectiveness data elements of the DSM. As such, MBE and MBSE support the DSM, and the DSM supports MBE / MBSE. As discussed in Question 2, the current ODASD(SE) view is that the DSM only contains data, and not models. This view may well limit the ability of the DSM to capture "how" the system provides its capabilities. That does not fulfill the intent of MBSE and MBE. As stated in Question 2, the breakout group believed that models must be part of the DSM.

The breakout group identified two specific gaps in the DSM, as currently defined:

- Lack of governance and configuration management structures, practices, and standards to:
    - Manage the availability, usability, integrity, and security of the DSM data
    - Support data sharing and reuse across Programs and tool sets
- Need for specific linkages and interfaces between MBSE tools and processes and the DSM. The tools and processes used by the engineering teams must be able to provide data (and models) into the DSM in accordance with the DSM standards.

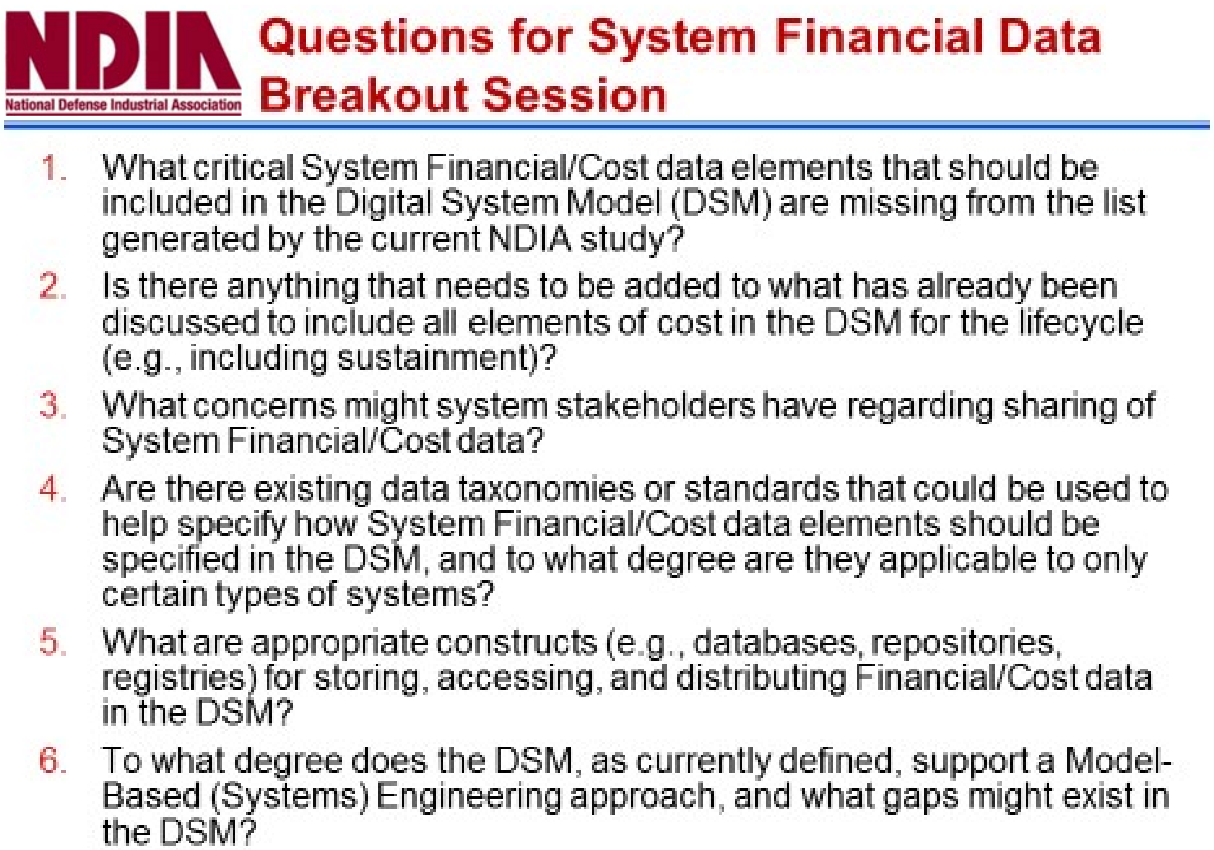
System Financial Data Breakout Session Results

The participants in the System Financial Data breakout session were:

- Beth Wilson – Raytheon (Facilitator)
- David Allsop – Boeing
- Denise Duncan – LMI
- Bob Erickson – Raytheon
- Joe Kochocki –Draper Lab
- Hubertus Tummescheit – Modelon
- Kevin Winton– Engility

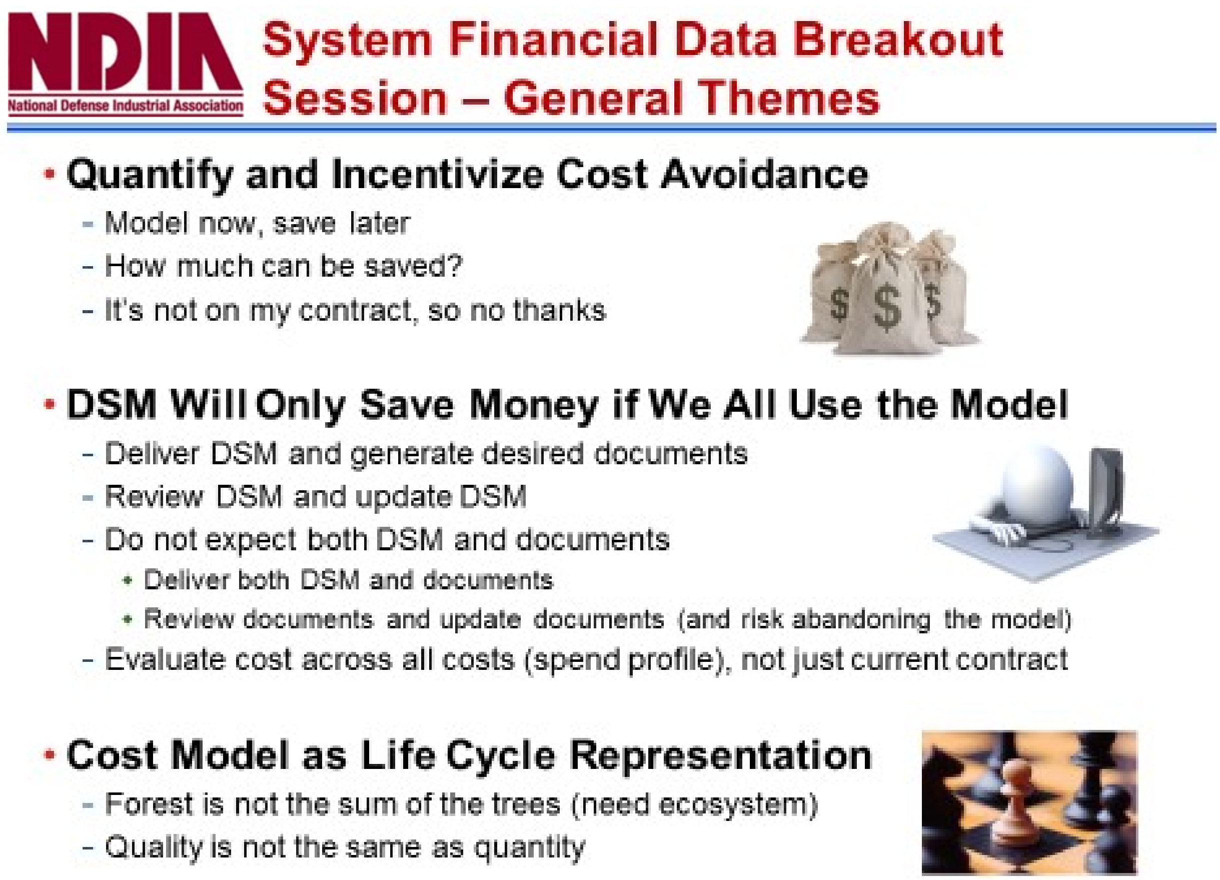
The participants in this breakout session are listed above. Collectively, they brought expertise that spans the lifecycle of a program, including:

- Cost model definition and maturation
- Mapping performance to cost models
- Proposal development using cost data
- Trade studies based on cost
- Implementing cost savings initiatives



Questions for the Breakout Session

The breakout group was asked to address six questions, which are listed above. The breakout group did not add any additional questions.



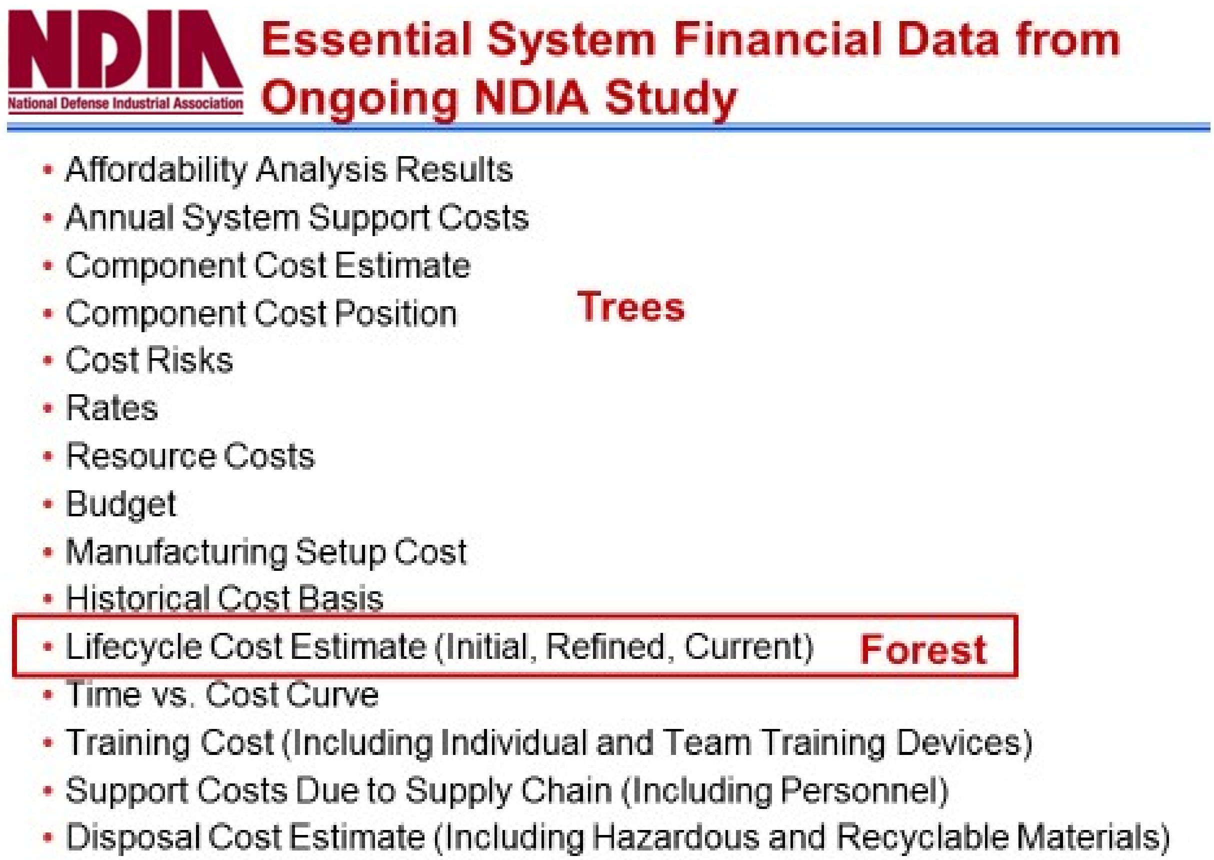
General Themes of the Breakout Group

There were three key themes that emerged throughout the discussion.

First of all, DSM concepts will avoid costs. Adoption of DSM requires that cost avoidance be quantified and incentivized. The analogy presented is that everyone swims three quarters of the way across the river, only to have someone announce it is too far and demand that everyone swim back. While the models are being created, it is likely that more money will be spent than in traditional brute force approaches. If system models are being built to save money in testing and sustainment, the investment is lost if the teams are directed to stop modeling and generate the specifications as previously done. Even when one can quantify the lifecycle cost reduction during sustainment, a program manager is not currently incentivized to spend money on this current contract to save money on a future contract.

Secondly, DSM concepts will only save money if all of the stakeholders use the model. Tools are needed that will generate the desired documents from the model. Stakeholders need to be able to review and update the model and then regenerate the documents. If one updates the documents and abandons the model, then the benefits of DSM are not realized. If one updates the models and updates the documents, the work load of the design team is doubled. If the model is the single authoritative source of truth, then it must be maintained as the technical baseline. Returning to the theme of incentivizing cost avoidance, it is important to adjust the expectations for the spend profile to invest early in a DSM that will reduce the lifecycle cost of the program on future contracts.

Thirdly, DSM concepts will only show the true financial impact if the cost data associated with the model is a lifecycle representation. Inertia will drive teams to collect as much cost data as is available with the belief that more data is better. Quantity is not the same as quality and the sum of all the detailed cost elements is not necessarily the best approach. When looking at cost data, the forest is not necessarily the sum of the trees. A DSM without effective cost data can lead teams to embrace decisions based on poor trades. When the DSM cost data is information, then it can lead the way to effective designs with cost-effective deployment and sustainment.



Essential System Financial Data from the Ongoing NDIA Study

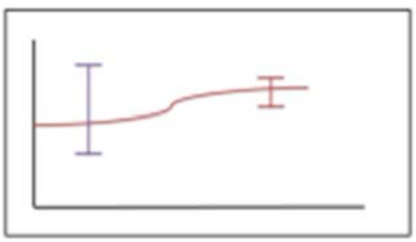
In viewing the system financial data elements proposed by the current NDIA Essential Elements of the DSM study, the lifecycle cost estimate represented as an evolving representation based on the maturity of the design was identified as the key element of information. If the lifecycle cost estimate is viewed as the forest, then the other cost data elements proposed can be viewed as trees in that forest.

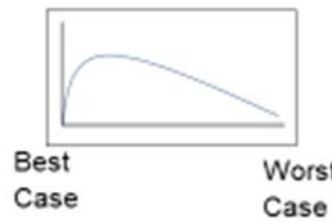
Continuing with the ecosystem analogy, the contributors to the lifecycle cost estimate are the trees in the financial forest. The trees become the data that is needed to support the DSM over the lifecycle. There are other aspects of the ecosystem that are needed to keep the forest healthy. We need to understand the cost with error bars to represent the confidence. We need to understand the best and the worst case. We need to be able to have a sensitivity analysis to understand the impact to the lifecycle costs when there are obsolete parts, extended system life, political supply chain instability, and other issues that impact the health of the trees within the forest.

System Financial Data Breakout Session – Question 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?

- Too many already, we can't see forest through the trees (previous slide)
- Model needs temporal fidelity – the cost model confidence will improve over lifecycle milestones
  - Factor confidence interval / error bars over time
  - Subsystem (and system) costs have variation which are not captured
  - The error bars should correlate to Technology Readiness Level (TRL) / Manufacturing Readiness Level (MRL)
  - Limitations in cost models for sustainment (O&S)





What Critical System Financial Data Elements Are Missing in the NDIA Study?

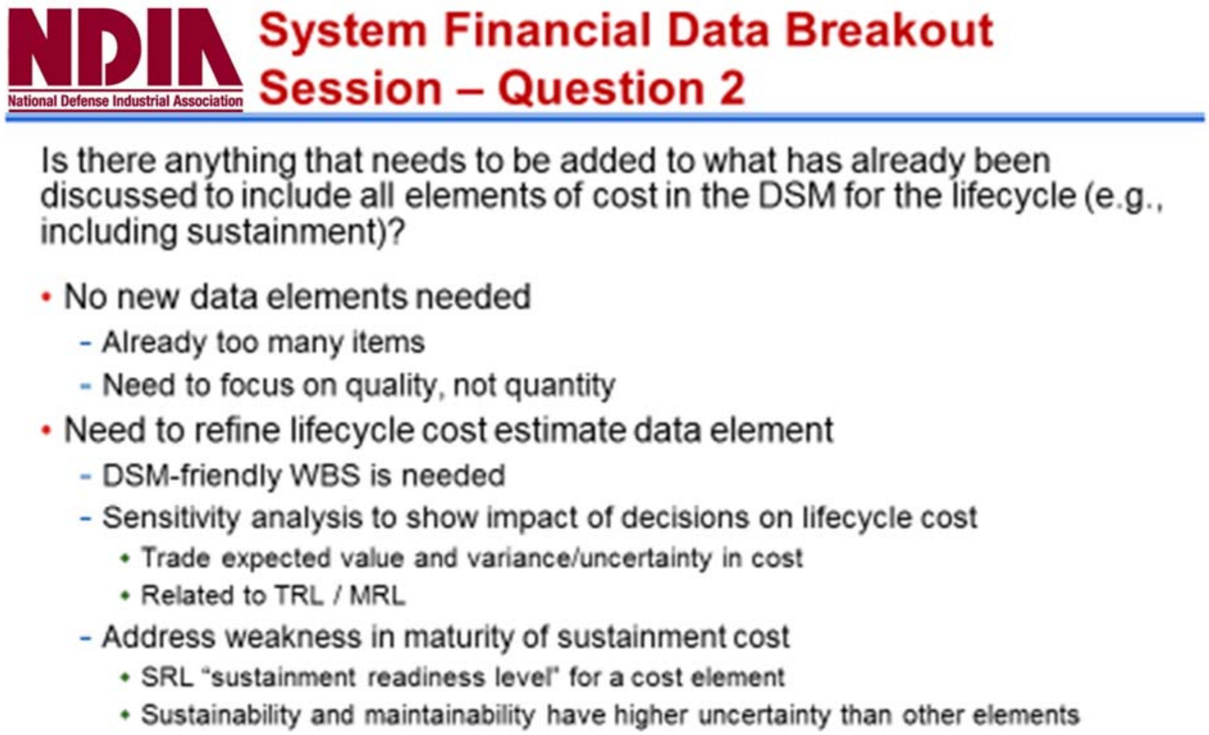
As previously noted, rolling up cost data from every possible entity is not an effective way to represent financial information in the DSM. Following the analogy, this makes it so that the decision makers can't see the forest through the trees. It leads to sub-optimization in trade analysis focused on minimizing cost in one area that may cause lifecycle costs to rise. The lifecycle cost estimate is the most important financial data element to associate with the DSM.

For the lifecycle cost estimate data element, it is important to represent the evolving estimate and its temporal fidelity. As the system matures, the confidence in the cost model improves. This can be represented by error bars that grow smaller as the system design and the sustainment impact of design decisions are better known. Currently, cost models contain precise data and guesses, both with two digits after the decimal point implying overall precision.

The error bar graphic above on the left was constructed to show that while the projected lifecycle cost earlier in the program is lower, the worst case potential is higher. Even though the lifecycle cost estimate is higher later in the program, the error bars are shorter making the cost impact more predictable and the worst case cost is actually lower.

The graphic on the right shows a desired representation of the lifecycle cost estimate elements. There is a best case and worst case that have low probability and a most likely case somewhere in between. If cost is associated with the DSM using a distribution, then Monte Carlo simulations can help to predict the range of variation associated with the less mature cost estimates. As the system design matures, the range between best case and worst case narrows and the resulting error bars on the total lifecycle cost will also narrow. If cost is correlated to a Technology Readiness Level (TRL) and Manufacturing Readiness Level (MRL), then the error bars can be evaluated at review points in the program where these levels are assessed.

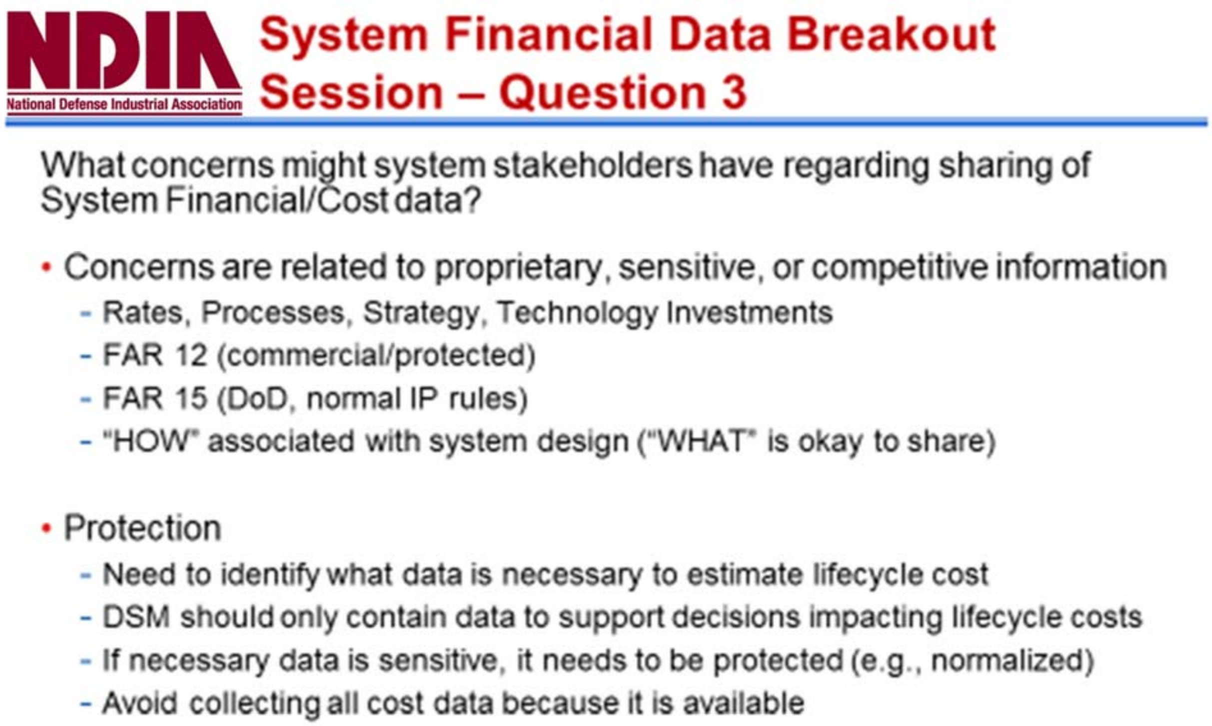
Another element of temporal fidelity is the estimate for operations and sustainment once a system is fielded. The original estimates are based on reliability measures, manning requirements, maintenance schedules, and service life plans. The lifecycle cost model estimate must continue to evolve to emphasize the impact of design decisions on maintenance and sustainment.



Is There Anything That Needs To Be Added to Include All Elements of Cost?

The breakout group did not recommend any additional measures, but rather additional fidelity and sensitivity analysis in the lifecycle cost estimate. There are already too many cost elements identified that promote a focus on quantity over quality.

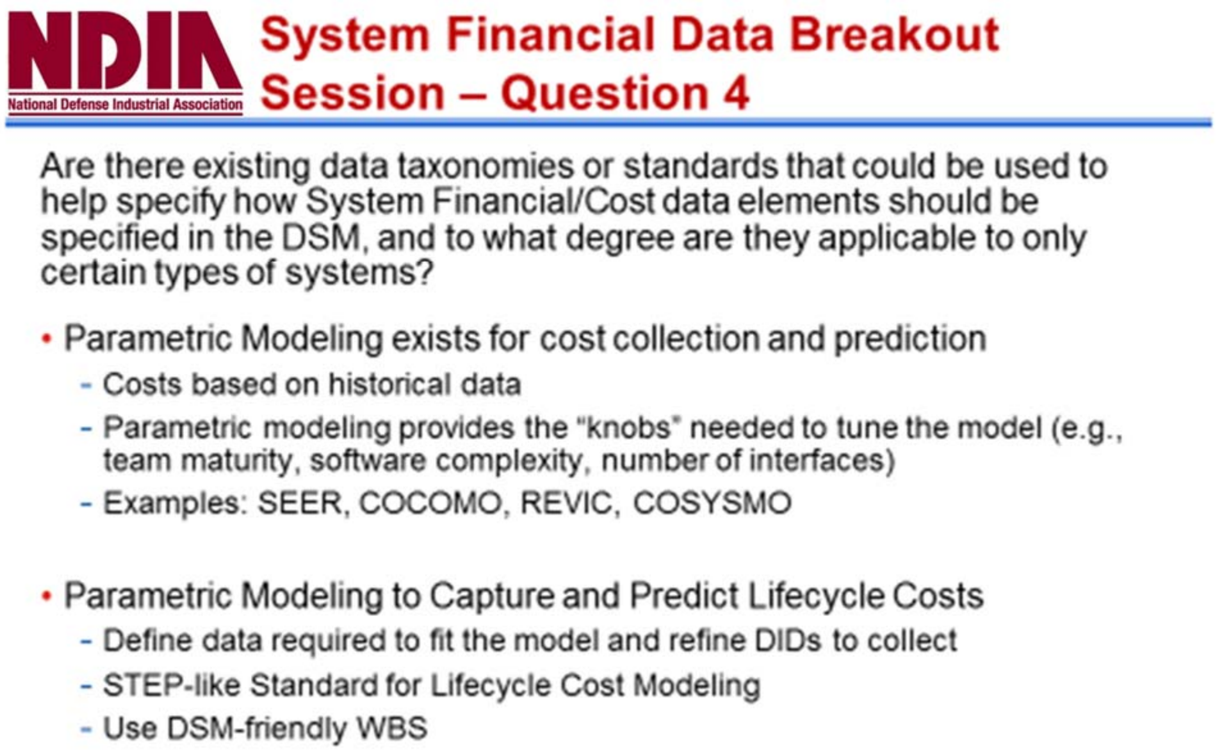
In refining the lifecycle cost estimate to be an evolving measure, it is important to relate costs collected on a program to costs represented in the DSM. A DSM-friendly Work Breakdown Structure (WBS) is needed. Currently the WBS focuses on the Integrated Master Plan and Integrated Master Schedule and aligns design and build costs associated with a single contract. A DSM-friendly WBS would capture financial data impact across the lifecycle.



What Might Be Stakeholder Concerns in Sharing System Financial/Cost Data?

While there are concerns related to disseminating proprietary, sensitive, or competitive cost information, this does not mean that no cost data should be associated with the DSM. The "what" associated with the system solution can be captured in a way that depicts a lifecycle cost estimate and supports trades to understand the impact of program decisions on the lifecycle cost. The "how" associated with the design and delivery of a system (e.g., rates, proprietary processes, company strategy, technology investments) needs to be protected and often is not necessary to the support lifecycle cost trades.

If there is data that is sensitive (such as rates), it may be possible to normalize that data element to protect the information in the cost data. The key point is to avoid the temptation to collect all cost data because it is available at a particular level or because using sensitive cost data makes lifecycle calculation easer at a local or subsystem level.



What Taxonomies/Standards Might Be Used for System Financial / Cost Data?

Parametric cost models exist to estimate program costs and can be applied to DSM elements. Examples include COCOMO, SEER, or REVIC for software and COSYSMO for system modeling. These parametric models are based on collected data with parameters tuned to fit the historical data. These parameters provide "knobs" to select inputs to the model (e.g., team maturity, software complexity, number of external interfaces) to provide estimates of future costs based on the historical data.

A parametric cost model can be developed that would capture and predict lifecycle costs based on DSM elements. Using the DSM-friendly WBS previously mentioned and modifying contract Data Item Descriptions (DIDs) to collect only the necessary information aligned with the parametric lifecycle cost model, this data could be used to capture and predict lifecycle costs. The financial industry has a Society of Trust and Estate Practitioners (STEP) standard. A STEP-like standard for lifecycle cost modeling could organize the data collection in a standard way.

NDIA System Financial Data Breakout Session – Question 5

National Defense Industrial Association

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

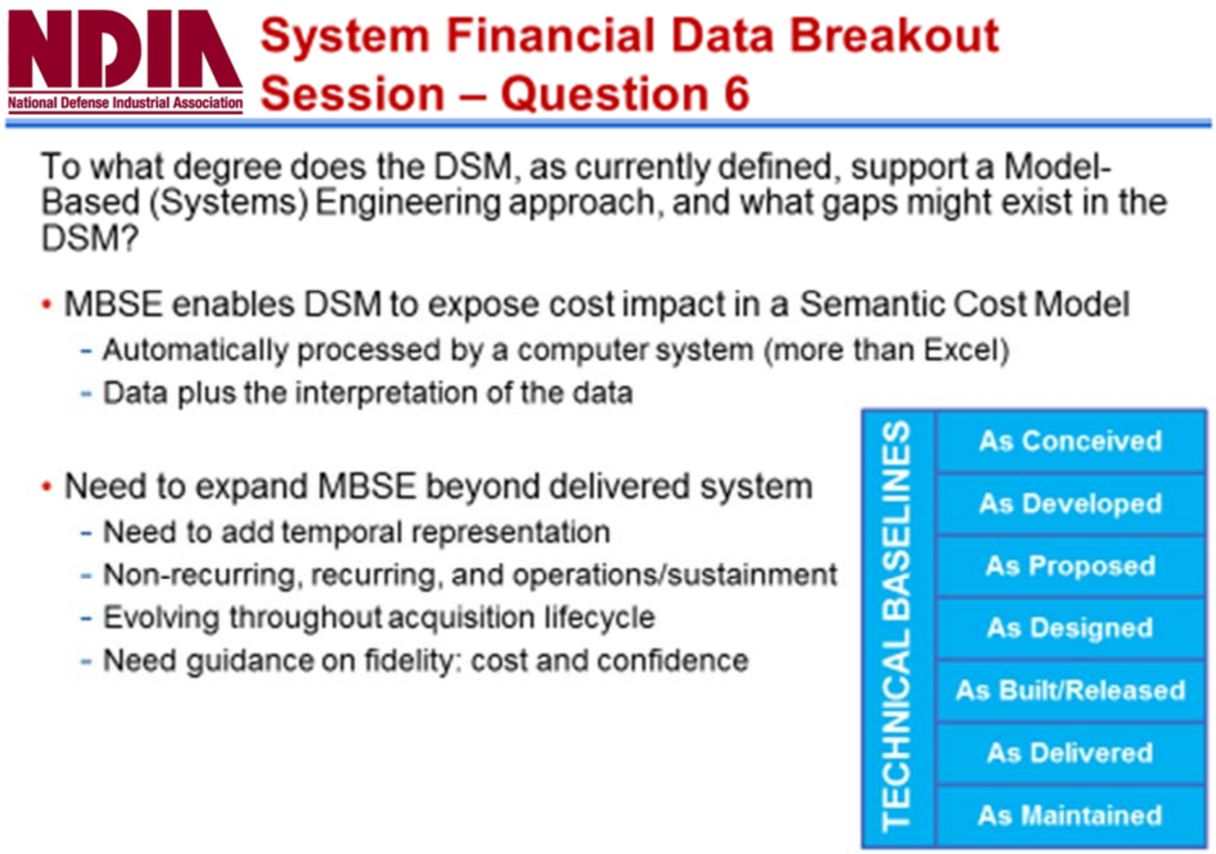
- Determine What Exists Now
  - Non-recurring costs collected during design
  - Build costs collected in Bill of Materials
  - DoD CAIG data and evaluations
  - What is collected now and how it is used?
- Develop a Semantic Model for Cost data
  - Link decisions to lifecycle cost impacts
  - Achieve and reward good behavior (cost avoidance) vs. bad (EAC overrun)
  - TurboTax-like visualization of cost impact
- Repository that enables both discovery and reuse

What Storage/Access/Distribution Constructs Are Appropriate?

The first step is to understand what exists now and how it is used. Non-recurring costs are collected during design and recurring costs are collected during build. Materials are priced in a bill of materials. The Cost Analysis Improvement Group (CAIG) collects and analyzes cost data across programs. The CAIG would be a good place to start to understand what data that is currently collected is used for evaluation and what necessary data is synthesized or estimated because it is not collected.

A semantic cost model construct is needed that links decisions to impacts. DSM elements need to be related to costs to denote the cost of a requirement. For example, what is the relationship between subsystem reliability and sustainment costs? What is the cost impact of performance? If one thinks about the way TurboTax works, one can envision a way to see the impact of DSM element costs on the lifecycle cost element. When one changes the design in a subsystem to use a cheaper material, the production cost may go down at the expense of reliability, showing that the maintenance and sustainment costs go up.

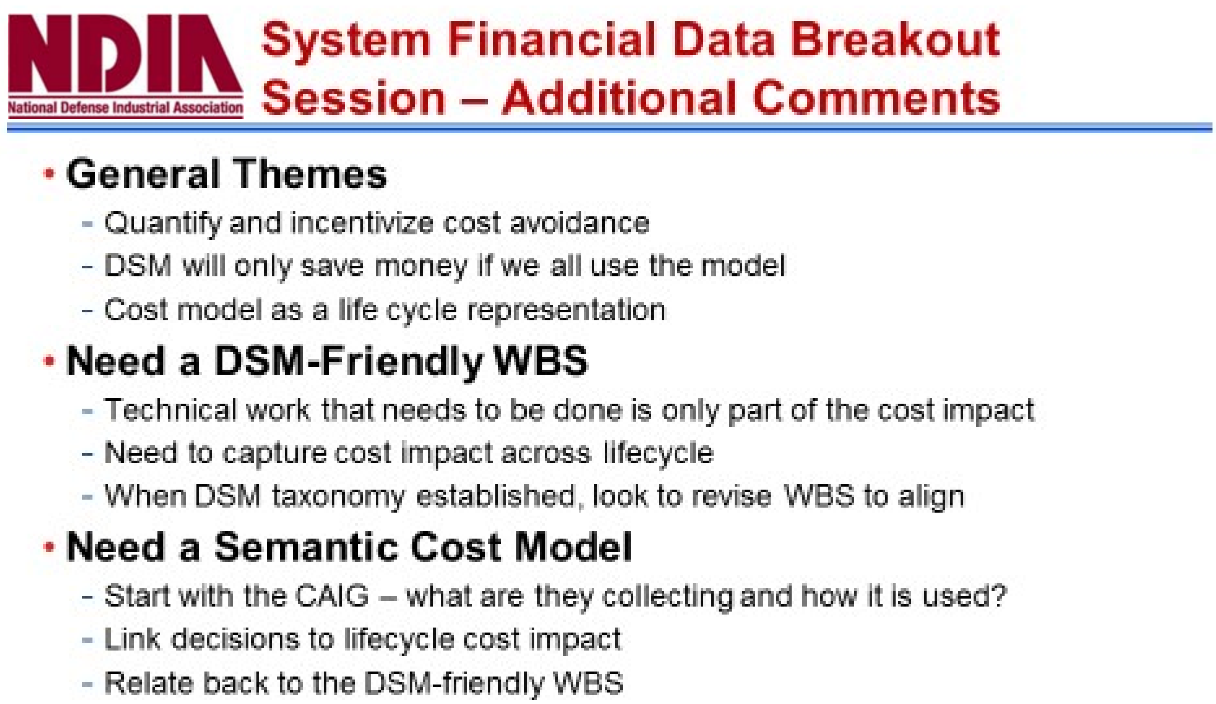
The repository for lifecycle cost associated with the DSM needs to enable discovery and reuse. If a new system is composed from previously designed systems, the repository should support the lifecycle cost model of the new system based on the data collected for the previous system.



To What Degree Does the DSM Support a MBE/MBSE Approach?

The DSM supports MBSE methodologies, and MBSE enables the linking of cost impact to design decisions. If constructed as a semantic cost model, the interaction of the cost to the design decision can be automatically processed instead of statically referenced in Excel spreadsheets. Representing a worst-case to best-case with most likely cost associated with design elements can be simulated to show the range of potential cost elements as the design matures. A semantic cost model means that one has data plus the information to interpret the data.

Snapshots of the digital thread are needed as the Digital System Model evolves from a concept to its digital twins. The cost model needs to represent the as-conceived, as-built, and as-maintained system. Currently, many system models depict a completed system. The DSM lifecycle cost estimate includes the costs to design, build, test, transport, maintain, operate, and dispose of the system. MBSE has the capability to present evolving technical baselines and the MBSE practices to embrace this approach are needed



Additional Comments by the Breakout Group

By way of summary, the general themes identified by the breakout group include the need to focus on the lifecycle impact of design decisions, and to deploy the DSM as an authoritative source of truth that can be used to make these decisions.

There were two recommendations identified in addition to these themes. One is to define a DSM-friendly WBS once the DSM taxonomy is established to make sure the necessary data (and only that data) is collected and associated with the lifecycle cost estimates. The second is to define a semantic cost model that links decisions to lifecycle cost impact and relates back to the DSM-friendly WBS.

Policy and Legal Considerations Breakout Session Results

The participants in the Policy and Legal Considerations breakout session were:

- Jim Coolahan – Coolahan Associates (Facilitator)
- Tyesia Alexander – Engility
- Tracee Gilbert – System Innovation
- Michael Heaphy – Defense M&S Coordination Office / Booz Allen Hamilton
- Mike Lamarche – Navy M&S Office
- Frank Mullen (SimVentions)
- Hart Rutherford (SimVentions)
- Chuck Sanders (Alion)

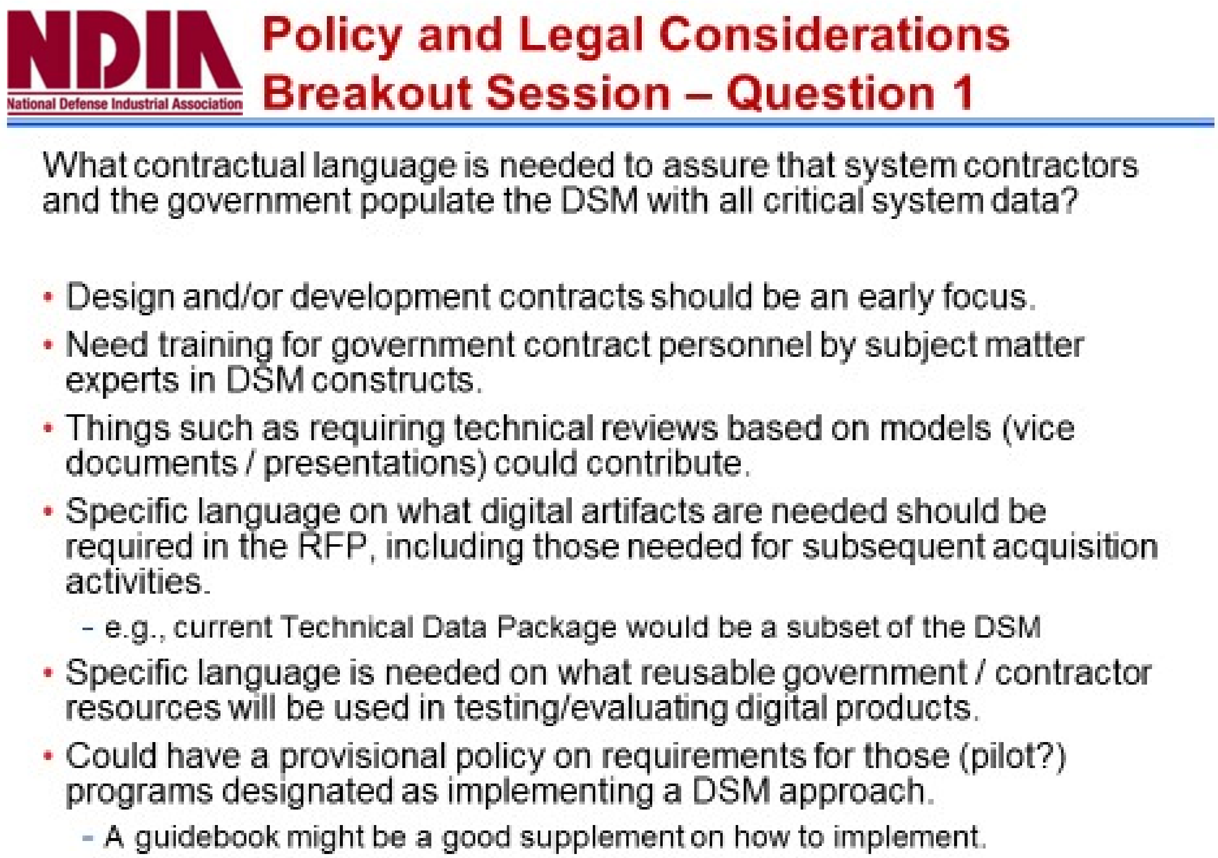
The participants in this breakout session are listed above. The participants included current and former members / support contractors for defense M&S and systems engineering offices and other defense support contractors.

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?

Questions for the Breakout Session

The breakout group was asked to address five questions, which are listed above as numbers 1 through 5. After discussions during the breakout session, the breakout group added a sixth question on DSM long-term retention issues.



What Contract Language Is Needed to Assure DSM Is Properly Populated?

In order to fulfill its objectives, the DSM for a system will need to be populated with all critical system data. To ensure that both government and contractor personnel enter such data in the DSM, there will need to be policy and guidance on what data needs to be entered.

The breakout group felt that contractual language for design/development contracts should be an early focus for this activity. Government contract personnel will initially not be familiar with the DSM construct, so subject matter experts on the DSM will need to provide training and advice to contract personnel on what should be included. Motivation to populate the DSM could be provided by requiring technical reviews of a system to be based on models, rather than just documents/presentations. An M&S Support Plan for the program could be a foundational element for the contract.

With respect to DSM content, the breakout group felt that the currently specified Technical Data Package (TDP) would be a subset of the DSM. Additional system-specific data artifacts would also need to be specified, including those that will be needed for subsequent acquisition activities. Not only the data, but also the format of the data, are important. To assist in the identification of the data elements and their form, specification of what M&S resources/applications will be used in evaluating the digital products will be important.

In early adoption activities of the DSM construct, the breakout group felt that such “pilot” programs implementing a DSM-compatible approach would benefit from having a provisional policy on requirements for the DSM. In addition, a guidebook, perhaps supplemented by Defense Acquisition University (DAU) training, was felt to be a good supplement to the provisional policy for these early DSM efforts.

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Policy and Legal Considerations Breakout Session – Question 2

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

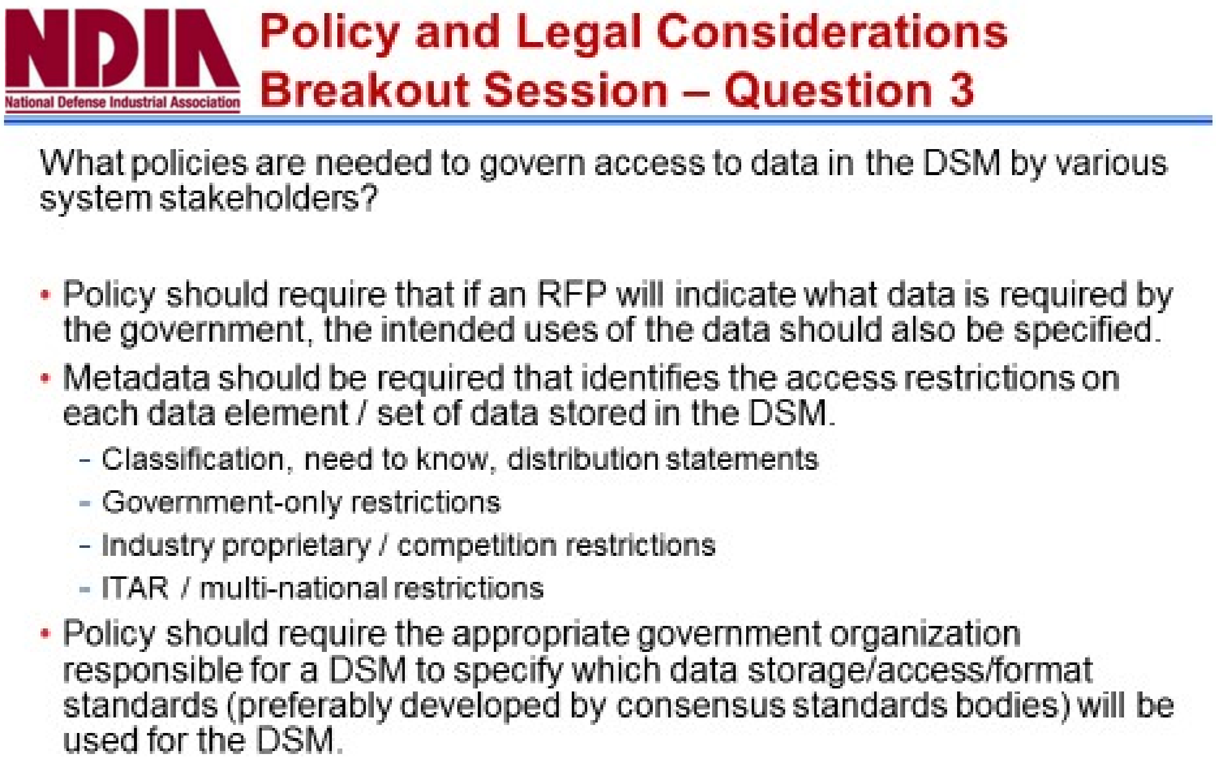
- Pedigree (including assumptions, constraints, date of creation) and appropriate validation (intended use, last verification/validation date) are key elements of authoritativeness.
- Policy should require, for each DSM, that an organization (or set of organizations) be identified as the authority for 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 Policies Are Needed to Ensure DSM Data Is Authoritative?

Authoritativeness of data/information can be seen as having two aspects – technical authority and organizational authority. In the area of technical authority, the breakout group felt that pedigree and validation were two important characteristics. Pedigree would include such things as assumptions made in calculating data values, constraints, and dates of creation and update of data values. Verification and validation information would include such things as intended use of the data, constraints on its use, and the date of its most recent verification/validation.

Different data/information elements in the DSM will have different organizations that are considered the authoritative source for those elements. For example, threats to be encountered by a system, the environment in which it must operate, and its missions will generally have a government agency as the authoritative source. The industry contractor will, at least during development, be the authoritative source for system characteristics and performance data. The breakout group felt that there needs to be a policy that each data/information element/aggregation in the DSM have an organization that is specified as the authoritative source for it.

The breakout group also felt that before each use, at least the pedigree, but more broadly, the authoritativeness of the data, needs to be determined. To do so requires that each data/information element in the DSM have metadata associated with it that defines the important pedigree and validation data/information associated with it. There will likely be a need for standardization of at least a minimum set of metadata for all data/information elements.



What Policies Are Needed to Govern Access to DSM Data?

Although one of the principal purposes of the DSM is to ensure that critical system data is made available, there will certainly need to be restrictions on which stakeholders can access which information. The breakout group felt that, as a starting point for determining data access, if a system's Request for Proposal (RFP) indicates data that is required by the government, it should specify the intended use of that data. Some DSM data will be classified at various levels, and governed by need-to-know restrictions. Other data may be unclassified but sensitive, governed by distribution statements, or requiring government-only access restrictions. Still other DSM data could have industry-imposed proprietary data restrictions. Some data/information will be governed by International Traffic in Arms Regulations (ITAR) or specific multi-national restrictions.

As was the case for data authoritativeness, the breakout group felt that each data/information element/aggregation in the DSM should have metadata associated with it that defines the restrictions on access associated with it. Again, there will likely be a need for standardization of at least a minimum set of access restriction metadata for all data/information elements.

Allowing for access to data/information in the DSM involves not just granting permission, but also ensuring that there are minimal "barriers to entry" for appropriate stakeholders to access the data. If data in the DSM uses conflicting nomenclature or is stored in inconsistent formats, there will be additional expense for stakeholders to access the data electronically and use it effectively. The breakout group felt that the government organization responsible for the DSM as a whole should specify the data storage/access/format standards that will be used for the system's DSM.

Policy and Legal Considerations Breakout Session – Question 4

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

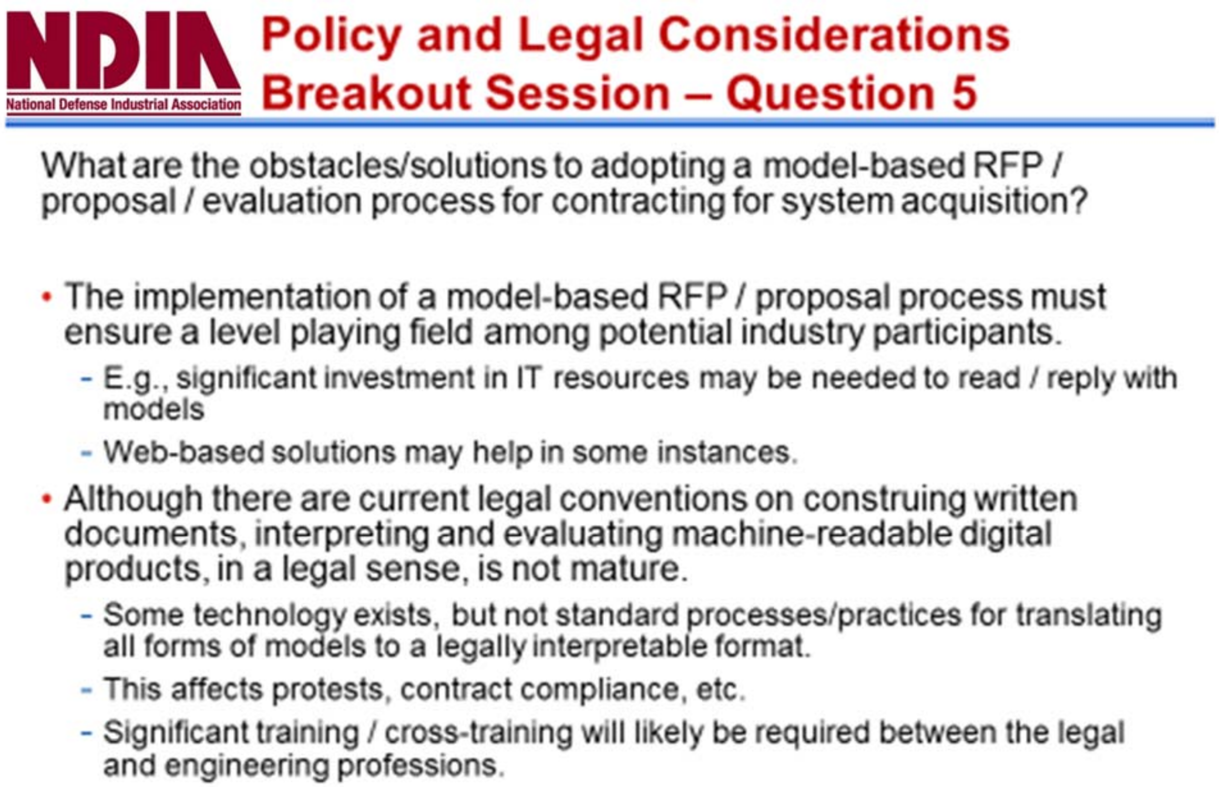
- Policy should require that if an RFP will indicate what data is required by the government, the intended uses of the data beyond the system of origin should also be specified.
- Mission area applications need to be considered as a tool in governing access to individual DSMs.
- Policy is needed to help adjudicate the use of different standards by different DSMs, and to facilitate reuse of mission data across multiple programs.
- Incentives are needed to encourage employment of sharing of data to aid in lowering lifecycle costs, and to benefit related systems.

What Policies Are Needed to Enable DSM Data Sharing in a System of Systems?

The need for sharing of DSM data across systems in a system of systems is an extension of the need for sharing of single-DSM data to additional stakeholders. The breakout group felt, just as for a standalone system DSM, as a starting point for determining data access, if a system's RFP indicates data that is required by the government, it should specify the intended use of that data beyond the system of origin. System use in one or more mission areas needs to be considered in governing access to the system's DSM by other stakeholders in the mission area.

Although the breakout group recommended in responding to the prior question that the government organization responsible for a specific system's DSM as a whole should specify the data storage/access/format standards that will be used for the system's DSM, use in a mission area or system of systems will require policy to help adjudicate the use of different standards by different DSMs. Although, for example, use of a common mission-level performance simulation in a specific mission area could help minimize data translation requirements, there is likely still going to be a need for data translation tools.

Despite it not being a policy/legal issue per se, the breakout group felt that there need to be some type of incentives to encourage data sharing across phases of a program, and across related programs.

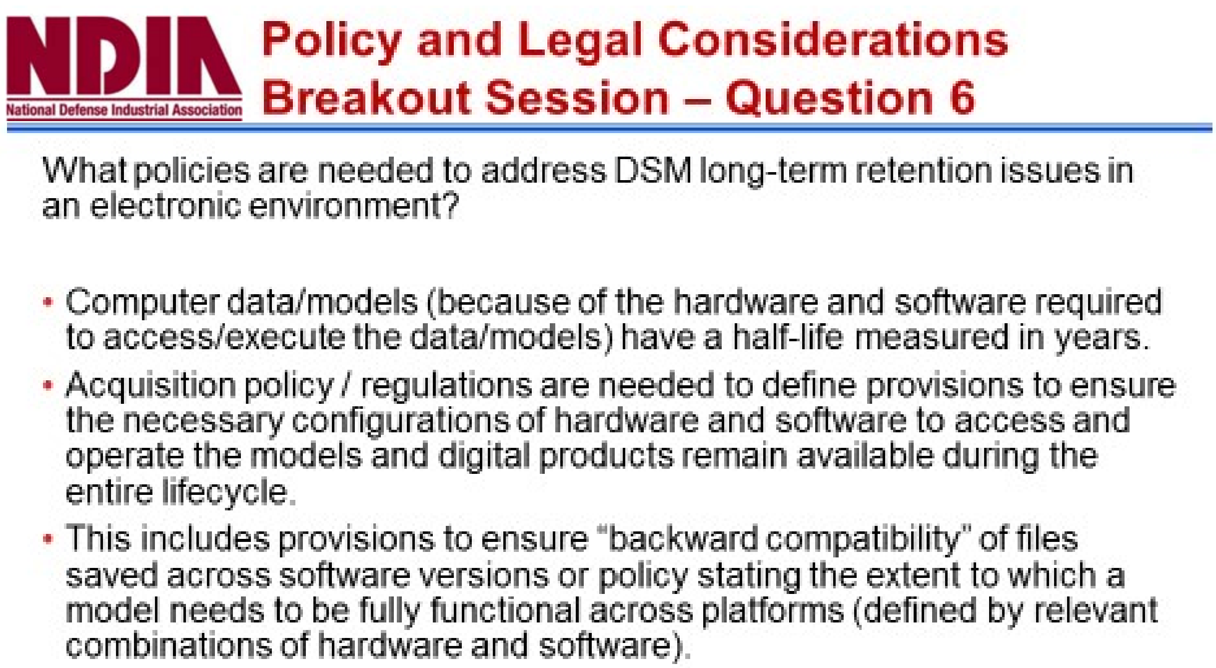


What Are Obstacles/Solutions for Model-Based Request/Proposal/Evaluation?

As the concept of Model Based Engineering (MBE) has advanced in defense circles, a key idea has emerged that RFPs, contractor proposals, and government evaluations for system acquisition should be conducted using models rather than documents. Such a significant change will certainly face some obstacles that will require innovative solutions.

A key concern expressed by the breakout group was that a model-based process must ensure a level playing field among potential bidders. Today, proposals are typically text documents augmented by figures, generally requiring standard office software (although certainly more technical software is used behind the scenes). If expensive modeling tools are required to read the RFP or deliver a proposal, this could create a barrier to entry for some potential bidders. Some web-based technology may help to some degree.

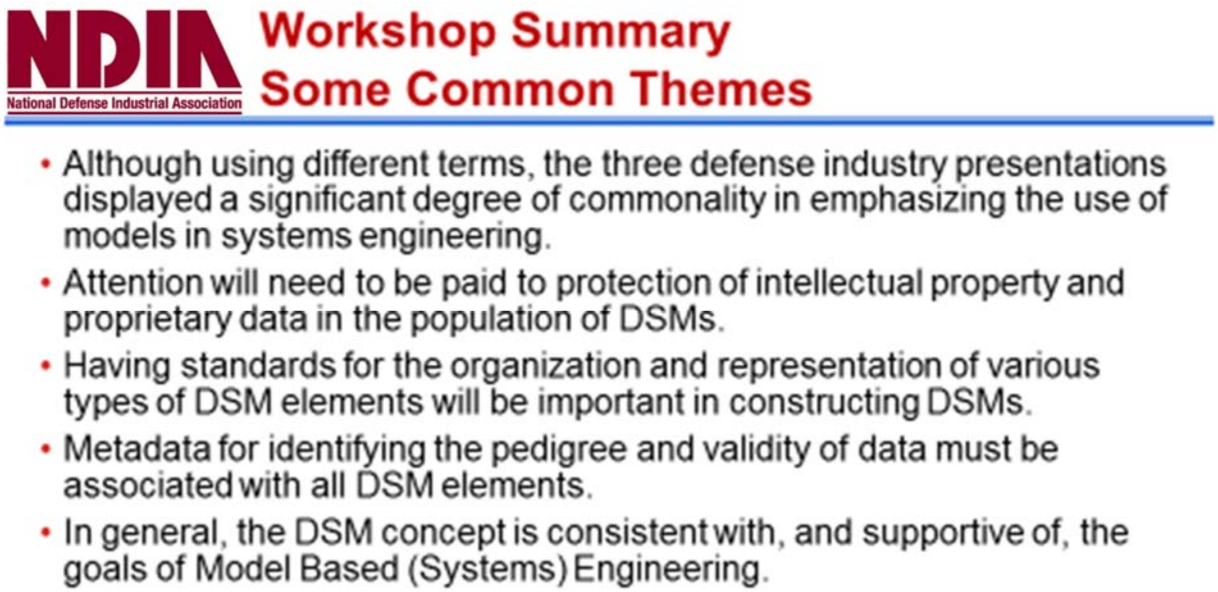
As noted in the NDIA SE M&S Committee's 2011 report on MBE, although there are current legal conventions on construing written contracts, the task of determining compliance with something that is only machine-readable adds a new dimension for disagreement, and methods to do so are not mature. There will need to be significant discussions and cross-training between the legal and engineering professionals involved in system acquisition.



What Are Obstacles/Solutions for Model-Based Request/Proposal/Evaluation?

In addition to the five questions posed before the Workshop, the breakout group felt that another issue needed to be addressed in the area of long-term retention of electronic records. As noted in the NDIA SE M&S Committee's 2011 report on MBE, there are several documents outlining requirements for records retention, including one in the Federal Acquisition Regulations requiring contractors to retain records for three years after contract closeout. Whereas paper records can be preserved for millennia, hardware/software required to access models currently have a half-life measured in years.

The breakout group noted that policies for retention of electronic records will need to address not just the media on which the records are stored, but also the hardware/software required to access and operate the models for the duration of the retention period. This will need to address the need for backward- and/or cross-compatibility, and may have significant cost implications if obsolete / unsupported versions of hardware/software must be maintained for the duration of the retention period.



Workshop Summary

Some Common Themes

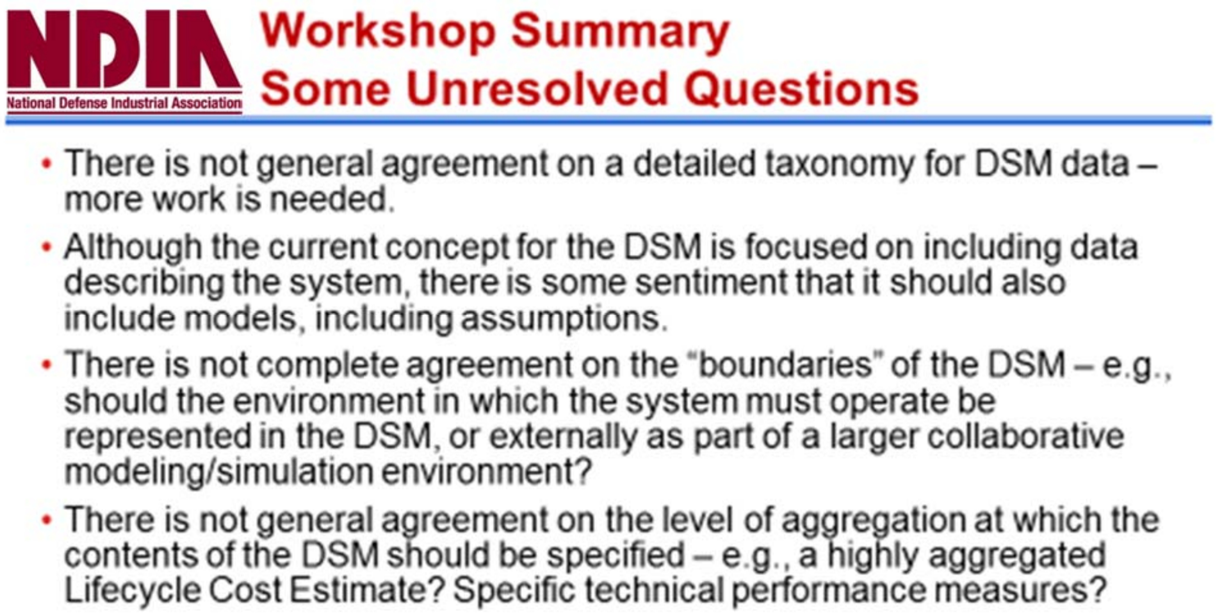
Although the DSM term has only recently emerged, similar concepts have been discussed for over 15 years. As digital technology has evolved, systems engineering professionals in a number of organizations have begun to apply that technology to the modeling of systems in a more unified and coherent fashion. Although they used different terms, the three defense industry presenters on the first day of the workshop displayed a significant degree of commonality in emphasizing the use of models in systems engineering in their respective organizations.

Several similar questions were posed to three of the four breakout groups. This provided an opportunity for some diversity in responses, and also allowed for the discovery of common themes. One consistent theme is that attention will need to be paid to protection of intellectual property and proprietary data in the population of DSMs. In a competitive environment, industry participants will need to feel confident that their intellectual property will not be inadvertently exposed to their competitors in a computing environment owned/managed by the government.

A second theme that emerged from multiple breakout groups was the importance for having standards for the organization and representation of various types of DSM elements will be important when DSMs are constructed. Having agreed-upon data formats and semantics will increase the efficiency and decrease the cost associated with using DSMs, as multiple applications produce and consume the DSM data.

A third theme that emerged from multiple breakout groups was that metadata must be associated with each DSM element in order to identify the pedigree and the validity of the data. Knowing that DSM elements are authoritative, in both a technical and organizational sense, will be important to users of DSM data.

Although it was not unexpected, the breakout groups generally agreed that the DSM concept is consistent with, and supportive of, the goals of MBSE/MBE. As the DSM concept moves toward implementation, and MBSE/MBE evolves, MBSE/MBE tools will need to be able to efficiently access the DSM as DSM elements are produced and consumed by those tools.



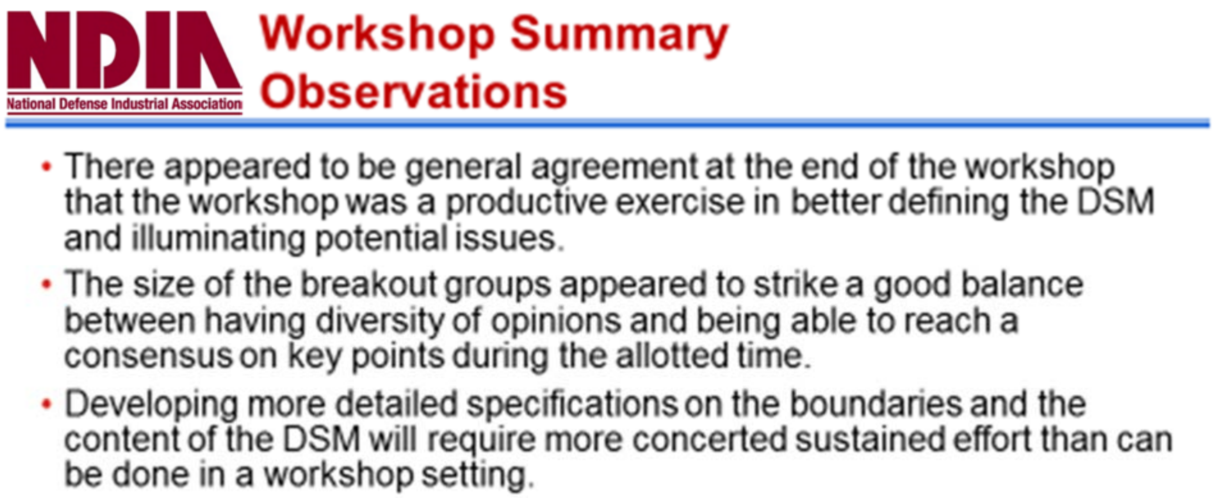
Some Unresolved Questions

In order for there to be consistent communication of required/expected DSM contents, there needs to be terminology that DSM stakeholders will understand in an unambiguous fashion. Although the current definition of a Technical Data Package offers a breakdown at the highest level, there is not general agreement on a detailed taxonomy for DSM data that would apply to all types of systems. Much more work is needed to develop such a detailed taxonomy in a consensus-based fashion.

Although the term Digital System Model implies that the DSM is a model, the current DSM concept is focused on data that describes the system. Some sentiment was expressed that it should also include models, including assumptions. For example, in the cost area, should the DSM contain just data, or should it also be able to contain a spreadsheet that expresses relationships/calculations involving the data? Similarly, in the characteristics area, should the DSM include just data that could be placed into a CAD drawing package to form a 3D model of the system, or should the resulting 3D model of the system be included in the DSM?

Based on the workshop, there also does not to be complete agreement on the "boundaries" of the DSM. For example, in order to model the performance of a system, one has to know the environments in which the system will be used. So, the question is whether data/models of the environment should be included in the DSM itself, or should be maintained separately, perhaps for consistent use for other systems, as part of a larger collaborative modeling/simulation environment.

Somewhat related to the taxonomy issue outlined above, based on the workshop, there does not appear to be general agreement on the level of aggregation at which the contents of the DSM should be specified. For example, it was suggested that for system cost, the highly aggregated Lifecycle Cost Model should be the focus, rather than the detailed cost numbers. The question is whether that is sufficient to express all of the cost data elements that are needed and the authoritative provider of those data elements. On the other hand, different types of systems will have different technical performance measures, some of which may need to be tracked at a relatively detailed level.



Some Observations on the Workshop

With respect to the interchanges held during the workshop, at the end of the workshop, there appeared to be general agreement that the workshop was a productive exercise, given the time available, in better defining the DSM and illuminating potential issues. The presentations on the afternoon of the first day appeared to set the stage well for the more interactive breakout sessions during the second day.

When one assembles breakout groups for a short-duration workshop, there can be a concern that too small a group may reflect a fairly isolated point of view from more outspoken participants, whereas too large a group can make it difficult for all participants to contribute sufficiently, and to reach a consensus. It seemed that the size of the breakout groups (ranging from six to eleven) struck a good balance.

Finally, it appeared to be generally recognized that a 1.5-day workshop could provide only a limited starting point for specifying the boundaries and content of the DSM. Developing more detailed specifications on these will require a more concerted and sustained effort than can be done in a workshop setting.