Joint Space Operations Center (JSpOC) Mission System (JMS) Common Data Model: Foundation for Interoperable Data Sharing for Space Situational Awareness

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Abstract

The space situational awareness (SSA) data we access and use through existing SSA systems is largely provided in formats which cannot be readily understood by other systems (SSA or otherwise) without translation. As a result, while the data is useful for some known set of users, for other users it is not discoverable (no way to know it is there), accessible (if you did know, there is no way to electronically obtain the data) or machine-understandable (even if you did have access, the data exists in a format which cannot be readily ingested by your existing systems). Much of this existing data is unstructured, stored in nonstandard formats which feed legacy systems. Data terms are not always unique, and calculations performed using legacy functions plugged into a service-oriented backbone can produce inconsistent results.

The promise of data which is interoperable across systems and applications depends on a common data model as an underlying foundation for sharing information on a machine-to-machine basis. Machine-to-Machine (M2M) interoperability is fundamental to performance, reducing or eliminating time-consuming translation and accelerating delivery to end users for final expert human analysis in support of mission fulfillment. A data model is common when it can be used by multiple programs and projects within a domain (e.g., Command and Control [C2] Space Situational Awareness [SSA]).

AF Space Command/A5 (AFSPC/A5) directed the creation of the JMS Requirements Model starting with an evaluation of known requirements captured in the National Mission Threads as they applied to SSA. Over six years a conceptual model of data terms, definitions and relationships was created. The conceptual model was used to derive a logical model of data elements and attributes represented in Universal Markup Language (UML). The logical model was then used to generate an implementable physical representation (e.g., eXtensible Markup Language [XML] schema) which can be used by developers to build working software components and systems.

The JMS Requirements Model has been mapped to the JMS Concept Description Document (CDD) and has been approved by AFSPC/A5CN. The JMS Data Model logical and physical components (also known as the JMS Enterprise Model v1.0) have been registered in the DoD Metadata Registry under the C2 SSA Namespace and will be made available through bidders' libraries to contractors for both JMS and Space Fence. Harmonizing legacy JMS data interfaces is expected to take place incrementally during the next two years. As we add capabilities and services to JMS, the JMS Common Data Model will continue to be extended as needed to support new development.

Joint Space Operations Center (JSpOC) Mission System (JMS)

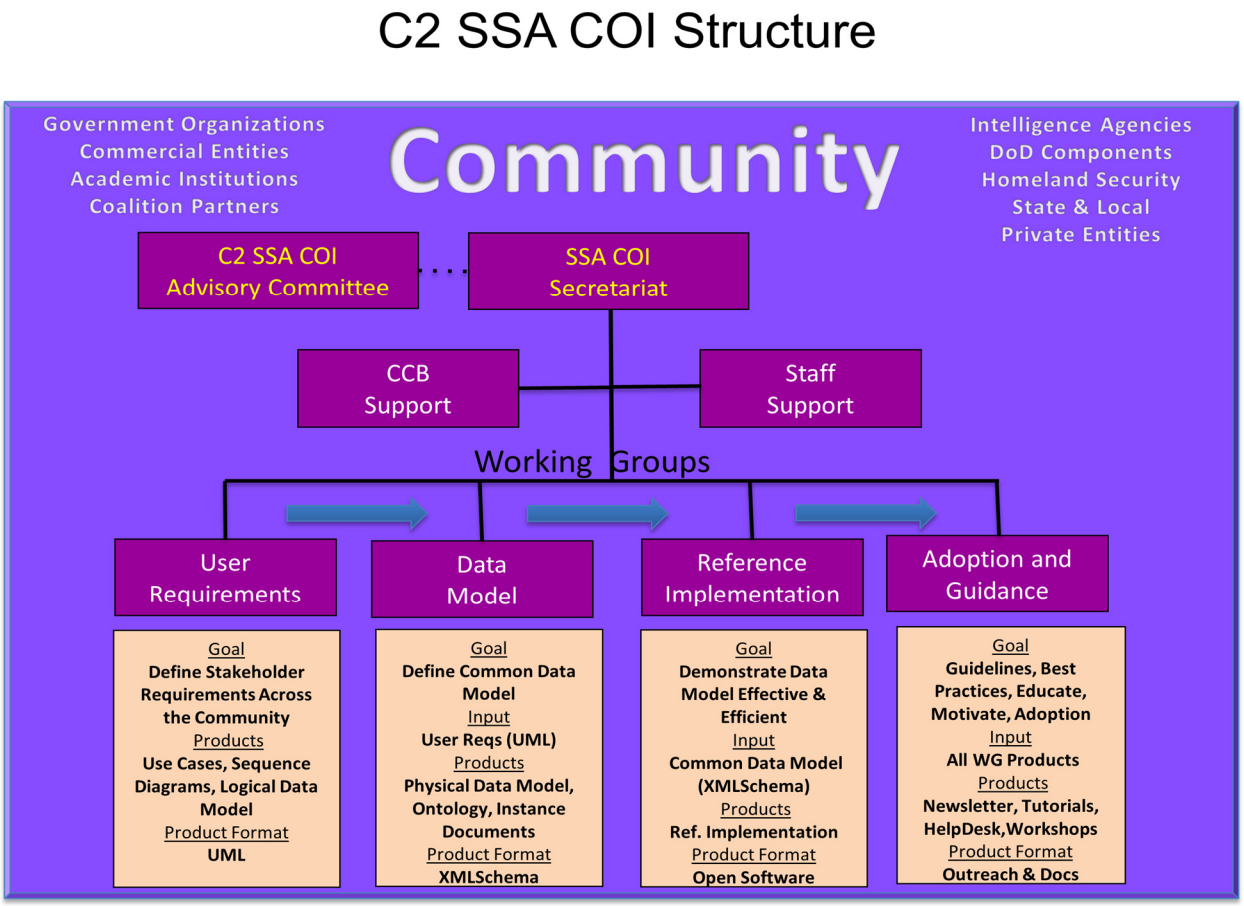
JMS is an Integrated, net-centric Space Situational Awareness (SSA) and Command & Control (C2) capability which will rapidly detect, track, & characterize objects of interest, using a near real-time high accuracy catalog. JMS provides timely space effects in support of joint tactical operations, identifying and exploiting traditional and non-traditional sources. The system performs space threat analysis, displays results via a user-defined operational

picture (UDOP), develops a space order of battle and conducts command and control (C2) of space forces in a dynamic environment.

C2 SSA Community of Interest (COI)

The goal of the Command & Control Space Situational Awareness (C2 SSA) Community of Interest (COI) is to ensure effective and efficient net-centric interoperability and sharing of all significant SSA data and services to authorized users. The C2 SSA COI provides a forum for organizations and entities to come together, develop interoperability solutions, including common standards, and address issues of community interest to support net-centric implementation of space C2 and SSA warfighting capabilities. The focus of the COI is on net-centric exposure and sharing of SSA and space C2 data required to monitor, assess, plan, and execute the intent of strategic, operational, and tactical commanders. Programs rely on the COI to help them identify, understand and resolve net-centric and data modeling issues. COI members understand these community needs, and are committed to ensuring community products and deliverables are achieved in a timely manner to meet program schedules.

Participation in the C2 SSA COI is designed to include all government or government-sponsored organizations or entities holding a significant stake in space satellite activities, including launch, maintenance, control, monitoring, tracking, conjunction, service providing, service using, decay, and response. Consequently, C2 SSA COI membership may include among others, representatives from the Department of Defense, civilian agencies including intelligence and homeland security, regional and local government agencies, coalition partners, commercial contractors, academic and private organizations. Although the membership is broad, the community is focused, with structures, deliverables, and processes all designed to ensure an agile, efficient accomplishment of community goals.



The C2 SSA COI mission includes the following tasks:

- Develop a common data model and vocabulary based on required C2 SSA capabilities and associated functions to share among Joint, Inter-governmental, Inter-agency and Multinational (JIIM) partners in planning and executing SSA and space C2 missions
- Provide oversight for the C2 SSA namespace on the DoD Metadata Registry to facilitate C2 SSA goals, ensuring community submissions and products are as visible, accessible, understandable, and interoperable as possible.
- Provide a forum for considering, exploring and developing C2 SSA net-centric initiatives and products within SSA and C2 communities to support on-going and future capabilities.
- Provide outreach to community members and facilitate adoption of COI standards and net-centric products.
- Coordinate as needed with all appropriate DoD and government agencies, civil and commercial organizations and international partners in carrying out the C2 SSA mission.
- Ensure that community products and deliverables are achieved in a timely manner to meet program schedules.

The COI has established a number of Working Groups to carry out its goals. These include the User Requirements WG which supports the definition of stakeholder requirements across the community; the Data Model WG which works with the User Requirements WG to define and maintain the COI Common Data Model; the Reference Implementation WG which builds working implementations of Common Data Model components for use by the community; and the Adoption and Best Practices WG which provides guidelines and best practice information to members, holds development workshops and ensures sharing of artifacts produced under the Reference Implementation WG.

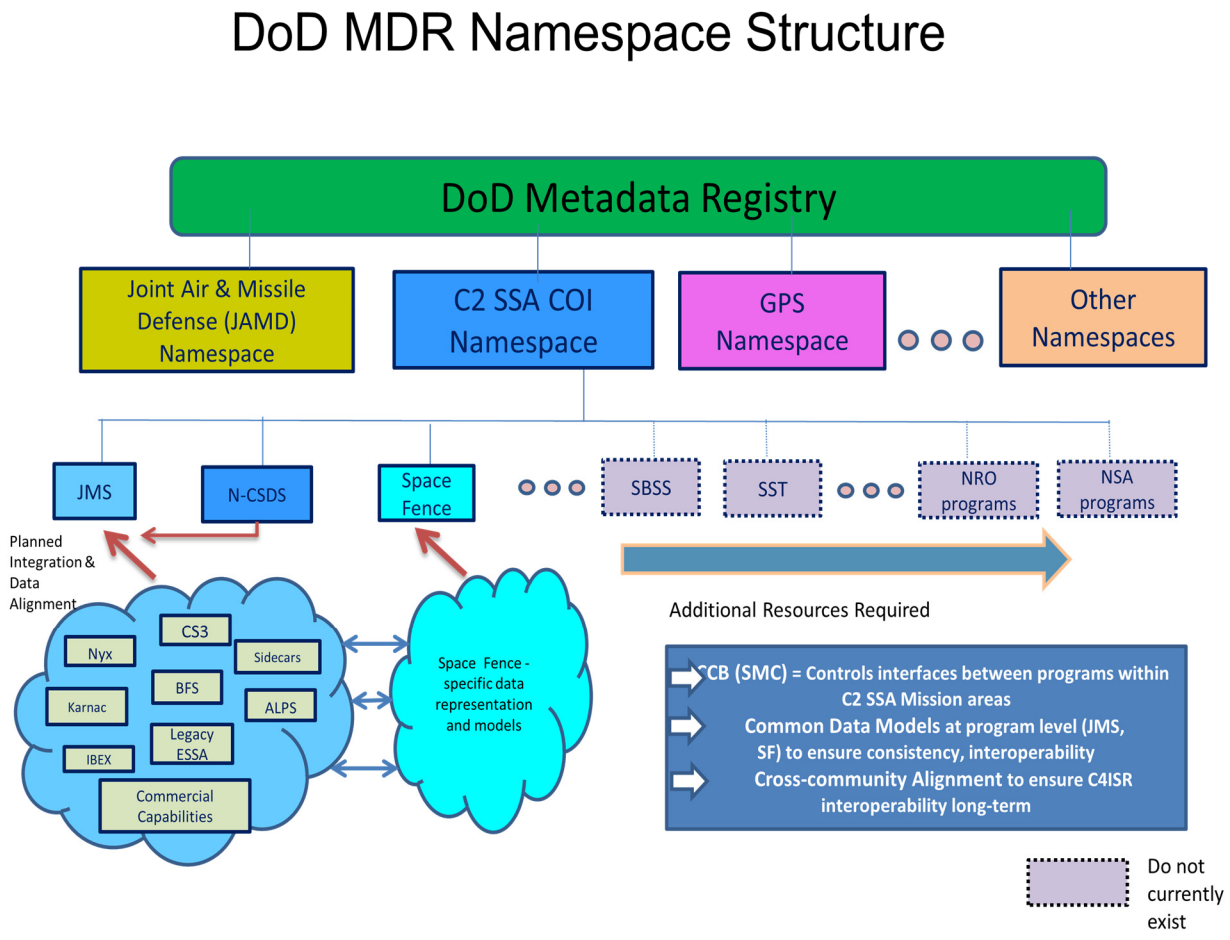
DoD Metadata Registry (MDR) C2 SSA COI Namespace Structure

The Metadata Registry (MDR) is established as the official DoD repository for data models, elements and XML schema which may be shared with authorized users. The MDR organizes its contents via Namespaces based on communities which have a need to share common information and artifacts. There are currently hundreds of communities represented in the MDR.

As noted in the DoD MDR Namespace Structure diagram below, the C2 SSA COI portfolio currently comprises JMS, Net-Centric Sensors and Data Sources (N-CSDS) and Space Fence programs. These programs require interoperable data exchanges to achieve success in related mission areas. The data products (data elements, attributes, data types, messages and XML schema) are produced by individual programs and/or created through negotiation across collaborating programs. Other related programs (shown grayed out) may eventually stand up a presence within the C2 SSA COI Namespace as they acquire a requirement to be net-centric.

The JMS cloud will provide access to a number of projects, applications and web services to accomplish mission responsibilities. These SSA capabilities (Nyx, Karnac, IBEX, BFS, ALPS, CS, legacy ESSA and various commercial capabilities) have all created data structures to support achievement of mission goals. These data structures are specific to the applications and services, and commonality of these structures is coincidental. Even where the data element is one common to multiple applications, attribute structure is not common so in sharing information, mediation or translation must be implemented. This approach works, however, the impact on system performance will grow over time as a factor of number of capabilities which must share information. In addition, there is no service orchestration across services and applications and duplication of subfunctions and procedures leads to system footprint growth and the very real possibility of inconsistent results from calculations.

The C2 SSA Namespace on the DoD Metadata Registry (MDR) is managed by the C2 SSA COI Secretariat. To more efficiently manage data model configuration control across the community, Space and Missile Center (SMC) has stood up a C2 SSA Configuration Control Board (CCB).

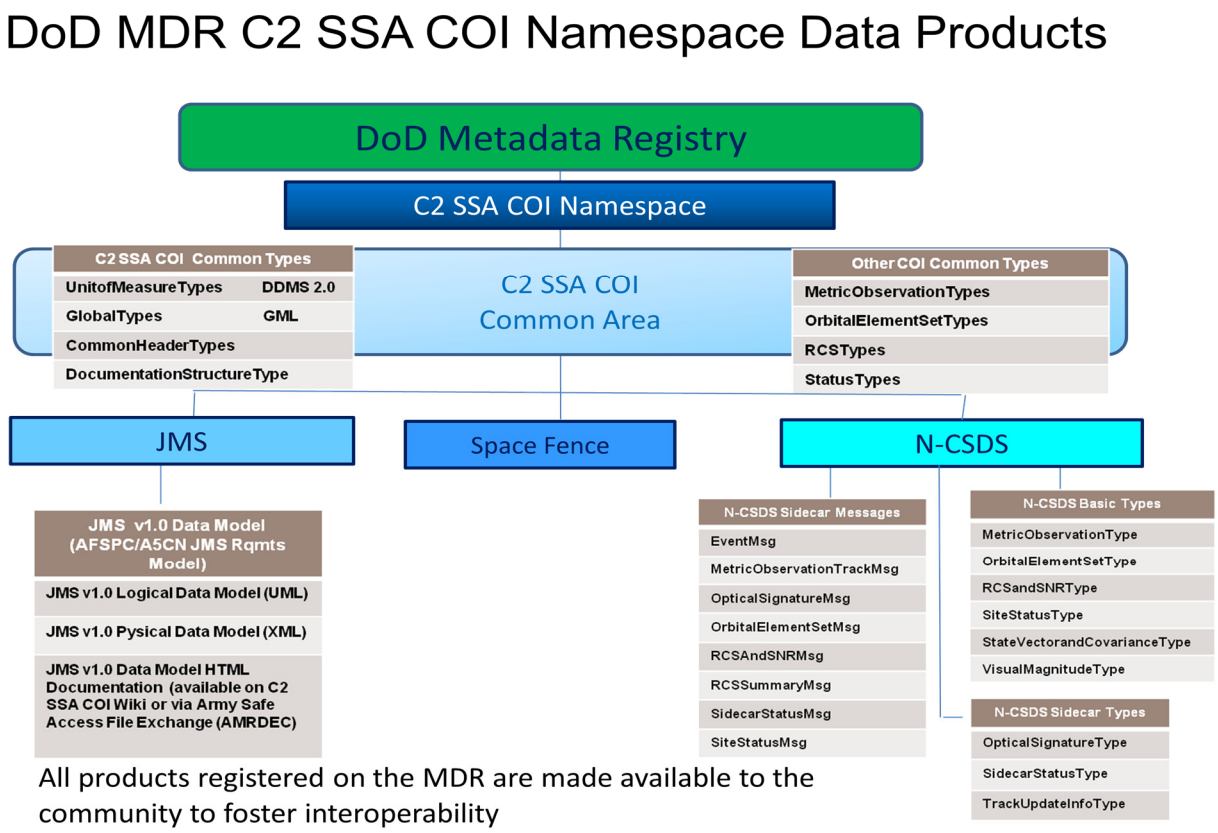


DoD Metadata Registry (MDR) C2 SSA COI Data Products

Programs within the C2 SSA COI have created and registered data products on the DoD MDR to share across the C2 SSA Community. Some of these projects have developed more formal data structures with more rigorous definitions and formally declared attributes, UML models and XML schema.

Net-Centric Sensors and Data Sources (N-CSDS) taps into legacy sensors and has implemented a net-centric "sidecar" or edge processor for making this information available to authorized users via publication / subscription (pub/sub). The N-CSDS program has defined structures used specifically for this information sharing. In the N-CSDS sub-namespace, the program has registered a number of basic data types as well as types and messages for sharing of optical information. In addition, N-CSDS proposed to the larger COI a set of types and standards deemed sufficiently common to the C2 SSA Community to be recommended for use by all COI members. The full COI adopted these types and standards as C2 SSA COI Common Types.

In addition to the N-CSDS data products, the JMS program has defined an Enterprise Data Model. The figure below, DoD MDR C2 SSA COI Namespace Data Products, illustrates those data products and the sub-namespaces under which they are registered. These products are made broadly available to members of the C2 SSA Community to foster interoperability.



JMS Enterprise Data Model v1.0

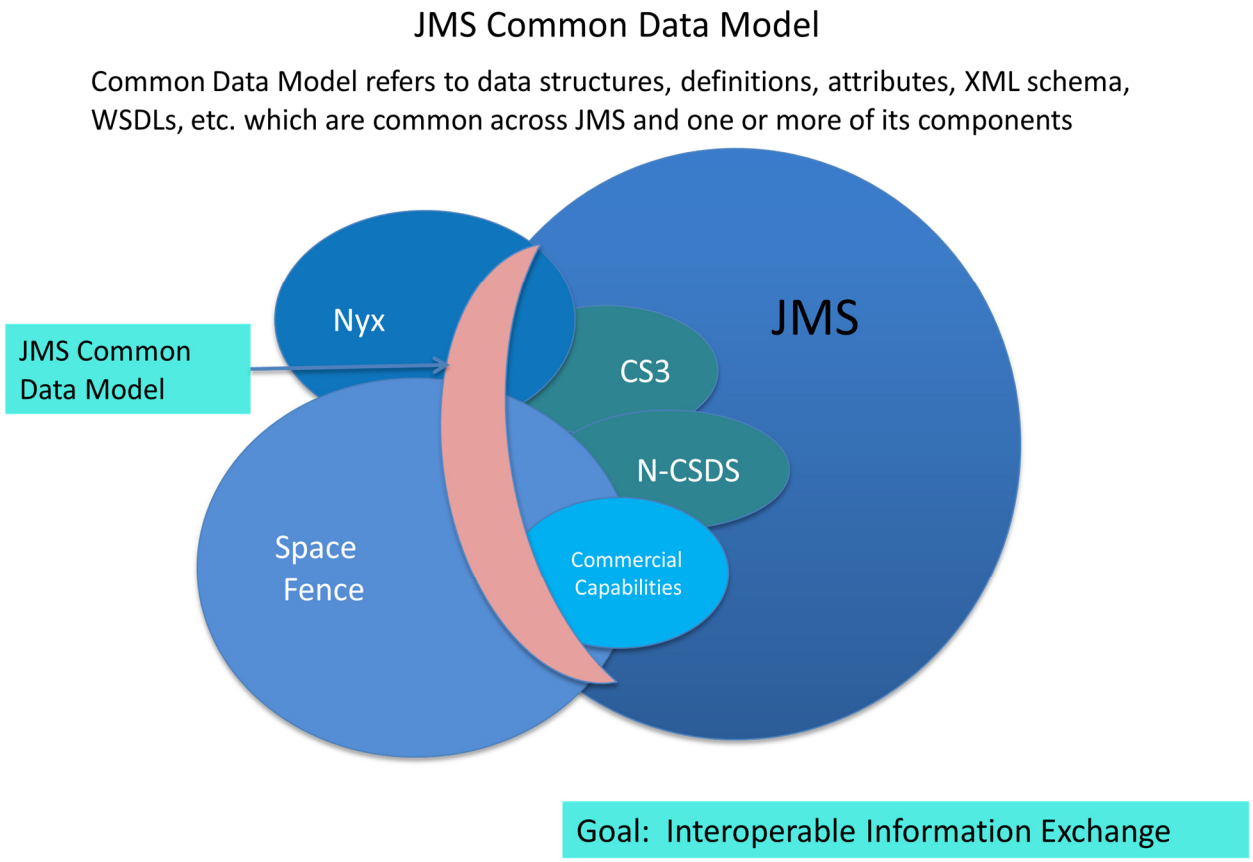
The JMS Enterprise Data Model v1.0 originated in a five-year effort under AFSPC/A5 to identify and capture all requirements for the JMS system. This work began with an analysis of the SSA portion of the National mission threads, and resulted in the development of a conceptual model of recognized terms, their definitions and relationships. All capabilities enumerated in the JMS Requirements Model were mapped to JMS CDD program requirements.

The JMS Requirements Model served as the conceptual data model for JMS. This conceptual data model was the foundation for the JMS Logical Data Model, a UML model which captures all required data elements and attributes and their relationships. Finally, the logical UML model is used to generate the JMS Physical Data Model, a set of XML schema which form the foundation for system implementation. The resulting model is now referred to as the JMS Enterprise Data Model v1.0 and provides a relational data framework for data consistency across the JMS enterprise. The JMS program has registered the JMS Enterprise Date Model, v1.0 in the JMS sub-namespace.

The JMS and N-CSDS data modeling teams are currently working with the Space Fence program to identify critical data exchanges and to modify existing UML and XML schema to facilitate the creation of new service and messaging interfaces which meet Space Fence program requirements.

JMS Common Data Model

The JMS Common Data Model is composed of the data structures, definitions, attributes, XML schema, message types, WSDLs which are common across JMS and one or more of its components. The goal of a common data model is to enable and support interoperability across programs through the ability to exchange information at system interfaces machine-to-machine.



Plan for Enterprise Data Model Harmonization and JMS Integration

JMS development has been divided into two increments, and these increments have in turn been divided into a series of Service Packs to facilitate an agile development, testing and delivery schedule. The JMS Enterprise Data Model framework will be integrated into JMS during Increment 2 development which will take place over the next two years, with integration of all JMS Functional Requirements Document (FRD) capability by the end of FY2014.

To successfully deliver JMS enterprise data framework under JMS Increment 2, the JMS data engineering team will first harmonize existing Increment 1 data structures with JMS Enterprise Data Model v1.0. For efficiency in achieving data interoperability, the team will focus on interfaces of JMS services and capabilities with other services and system capabilities, developing new service and messaging interfaces which are compliant with the Enterprise Data Model.

This work can be accomplished and integrated in an iterative manner during Increment 2 development / integration. Existing data element structure as well as XML schema and Web Services Definition Language (WSDLs) will be evaluated and redesigned, as needed for compliance with the JMS Data Model. Prototype services and messages will be developed and tested. Risk can be lowered by executing the new services in parallel with old ones for validation. Non-conformant services can be deprecated over time

Advantages of Implementing a Common Data Model

Creating a common data model will require an investment of considerable resources, depending on the size of the community and the scope of its mission requirements. However, the payoff can be large:

- Data elements within the common data model are normalized, reducing redundancy and providing consistent metadata structure to support reliable decision-making by operators
- Data structures within the model become consistent, reducing or eliminating the need for data translators, supporting distributed data stores, and enabling more efficient allocation to virtual machines (VMs)
- Web services based on common data take advantage of efficiencies in program structure, fostering improved system performance
- A common enterprise data framework supports data accuracy and the extension of system capabilities

Keys to Data Modeling Success

Although the JMS Enterprise Data Model development within the C2 SSA community has been underway for less than a year, the team has already learned a number of valuable lessons which we believe will greatly enhance our ability to be successful.

1. While there is an understandable tendency to want to mandate approaches, it is important to engage the community in an open, collaborative approach. Actively solicit and incorporate stakeholder feedback. Help the community see what it will gain by this collaboration (i.e., reduced sustainment expense and improved system performance).
2. Start with mission threads and build use cases that map to requirements; develop activity diagrams. Build a high quality team of data modelers and subject matter experts.
3. Stand up a working group within the community to build reference implementations to show your data model can be implemented and can provide efficient capability.
4. Create the minimum set of products to manage interoperability needs. Tailor processes to fit your resource constraints and focus on high priorities. Remember: Perfect is the enemy of Good. Research and identify tools to help you manage large volumes of information.
5. Don’t let the naysayers get you down. They are always there, but so are the folks who will be your allies. Be persistent.

Summary

- JMS current and planned component capabilities have created numerous data type packages and XML schema to meet baseline data exchange requirements for programs of record
  - JMS Enterprise Data Model v1.0 provides a framework for net-centric information exchange to ensure accuracy & performance
- The C2 SSA COI provides a forum for collaboration to foster interoperability across the community
  - C2 SSA COI provides data products and configuration management through the DoD MDR
- C2 SSA COI team members (PoR resources) are a coalition of the willing who welcome participation by all members of the community (DoD, Gov agencies, civil and commercial entities, Homeland Security, state and local entities, universities, coalition partners)