Modeling and Simulation (M&S) Metadata Management Recommended Practices Guide (RPG)

(Version 1.0 – 08 January 2024)

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1 Introduction

Metadata is a critical element in building, optimizing, and operationalizing the environment to ensure that data and metadata across an enterprise are of high quality and properly managed throughout its lifecycle. This document provides a set of recommended practices for managing Modeling and Simulation (M&S) metadata by the training community within the U.S. Air Force.

1.1 M&S Metadata Management Recommended Practices Guide (RPG) Overview

The following figure provides a mapping of the alignment of this document with respect to key Data and Metadata documents within the DoD and DAF.

Figure 1. Map of Alignment of Key DoD and DAF Data and Metadata Documents

The DoD Data Strategy supports the National Defense Strategy and Digital Modernization by providing the overarching vision, focus areas, guiding principles, essential capabilities, and goals necessary to transform the Department of Defense into a data-centric enterprise. Each military department publishes data implementation plans aligned with the DoD Data Strategy. The Department of the Air Force (DAF) Implementation Plan of the DoD Data Strategy provides a road map of actionable items to move forward within the Air Force. Metadata management plays a critical role in supporting the goals and objectives of data strategies and plans. Related to this, the DoD Chief Digital and Artificial Intelligence Officer issued

a DoD Metadata Guidance memorandum in March 2023 (with enclosed DoD Metadata Guidance, Version 1.0, January 2023) and the DAF is developing a Metadata Guidance document and has released a Data Fabric Guide that has extensive ties to metadata.

1.2 M&S Metadata Management RPG Purpose

This guide provides a framework, methodologies, processes, and common approaches for managing metadata across the M&S Training Community within the U.S. Air Force (USAF) by covering key aspects such as "the" what, why, who, and how of metadata management.

To understand **'what'** Metadata Management is, refer to **Annex 1**, which includes industry definitions, and delves into the role metadata categories play and the various types of resources described by metadata.

To understand **'why'** Metadata Management is important, refer to **Annex 2** and **Appendix D**, which delve into the significance of effectively managing metadata and highlights the value it can bring to organizations in terms of improved data governance, enhanced decision-making processes, and streamlined information retrieval.

To understand **'who'** is involved in Metadata Management, refer to **Annex 3** to understand the roles and responsibilities of data stewards, data officers, key stakeholders and others that impact the success of metadata management throughout the life cycle.

In regard to **'how'** - The USAF M&S OTTI community will apply the DoD's ten metadata requirements (see Appendix C – Phase 0) in addition to applying the recommended practices, procedures, actions, and timelines that must be followed for successful metadata management throughout the life cycle.

1.3 M&S Metadata Management RPG Scope

This document bins USAF M&S metadata management activities into five milestones (illustrated below) with outlines of the necessary steps and interactions needed to effectively implement metadata management IAW the DoD's ten metadata requirements that promote data visibility.

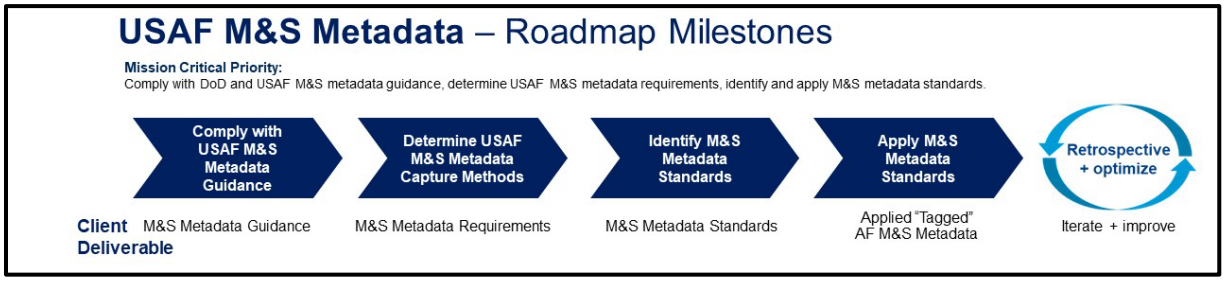

Figure 2. M&S Metadata Roadmap Milestones

2 Metadata Management (Milestone Requirements and Associated Tasks)

The five milestone requirements and associated tasks for M&S metadata management are described in the sections below.

2.1 M&S Metadata Guidance

- Ensure compliance with the DoD Data Strategy for overarching vision, guiding principles, essential capabilities, goals, and objectives to move the Department toward a data-driven / data-centric organization.

- Ensure compliance with the DAF I-Plan of the DoD Data Strategy to synchronize with DoD objectives to develop and utilize metadata standards and unique identifiers, allowing data integration by a common key.
- Ensure compliance with the DAF Data Services Reference Architecture document to provide clear guidance for designing, developing, implementing, and using Air Force Major Commands (MAJCOM) /Functional Data Platforms.
- Ensure compliance with the M&S Operational Training Data Concept Plan metadata lines of effort (LOEs).
- Establish guidance over metadata data processes, socialize M&S metadata guidance with leadership, and secure senior leadership buy-in.

2.2 M&S Metadata Requirements

- Work with MAJCOM and M&S training organization action officers to identify and confirm M&S metadata requirements by applying use case methodology.
- Specify user's inputs for metadata used to describe M&S resources helpfully to the DoD, Air Force, and international M&S community in discovering various types of M&S-related resources, including but not limited to models, simulations, simulation federations, M&S-related tools, datasets, services, and standards.
- Determine key M&S user roles for participation in M&S metadata use cases based on priority discovery of M&S assets listed above.
- Develop use cases that track M&S asset discovery practices and capture the layers and levels of metadata users need for informed decisions and share data across platforms.

2.3 M&S Metadata Standards

- Identify available M&S metadata standards to select the most relevant M&S metadata.
- Select and adhere to applicable M&S metadata standards to provide a uniform set of metadata to promote Visible, Accessible, Understandable, Linked, Trusted, Interoperable, and Secure (VAULTIS) data assets across DAF M&S data.
- Select the most appropriate M&S metadata to support M&S metadata requirements as documents in key user role use cases.

2.4 Applied / Tagged M&S Metadata

- Apply appropriate standard M&S metadata to allow M&S users to share, search and discover data based on M&S metadata standards.
- Increase the collection, tagging, and preservation of data, and metadata, from various formats, then apply appropriate standards to ensure it is available and useable for sharing and analytics.
- Create a table and matrix of M&S metadata based on the application of metadata by M&S asset or function to determine trends and usage.
- Determine gaps for M&S metadata requirements and provide feedback to the M&S Data Officer and the Discovery Metadata Specification for M&S Resources (DMS-MSR) for updating the metadata standard.

2.5 Continuous improvement through Iterate and Improve

- Track the use of M&S metadata for M&S asset discovery.
- Seek feedback on ways to improve M&S discovery effectiveness.
- Recommend M&S metadata corrections, adjust for future iterations, and submit changes to the DMS-MSR for metadata standards updates.
- Continue to update key M&S user roles and improve M&S metadata use cases.
- Plan and coordinate with senior M&S Data stakeholders for effective use of metadata standards.

3 Summary

In summary, metadata methodologies assist in registering data assets to facilitate discovery, access, and use of data. Exposing data directly from its authoritative source with clear and complete metadata speeds up the ability to understand and leverage the data for a specific use. This document is a supplement to the existing data policies to assist the OTTI community in managing M&S metadata by describing the milestone requirements and associated tasks for M&S metadata management and providing an associated set of recommended practices (detailed in Appendix C). Three annexes are included in this document to aid in the understanding of metadata management via coverage of metadata categories (Annex 1), the importance of metadata management (Annex 2), and the participants involved in metadata management (Annex 3).

Annex 1. Metadata

Department of Defense Instruction (DoDI) 8320.02, *Sharing Data, Information, and Information Technology (IT) Services in the Department of Defense* [DoD 2013] and the DoD Metadata Guidance Version 1.0 (2023) defines metadata as the "Information describing the characteristics of data, data or information about data, or descriptive information about an entity's data, data activities, systems, and holdings."

Annex 1.1 Descriptive vs. Structural vs. Administrative

Understanding Metadata [NISO 2004] defines three major categories of metadata, one of which has three subsets:

- Descriptive metadata describes a resource for purposes such as discovery and identification. It can include title, abstract, author, and keywords.
- Structural metadata indicates how compound objects are put together, like pages ordered to form chapters.
- Administrative metadata provides information to help manage a resource, such as when and how it was created, file type and other technical information, and who can access it. The National Information Standards Organization (NISO) breaks administrative into three sub-types:
    - Technical metadata, which identifies information necessary for decoding and rendering files.
    - Rights management metadata, which deals with intellectual property rights, and
    - Preservation metadata contains information needed to archive and preserve a resource.

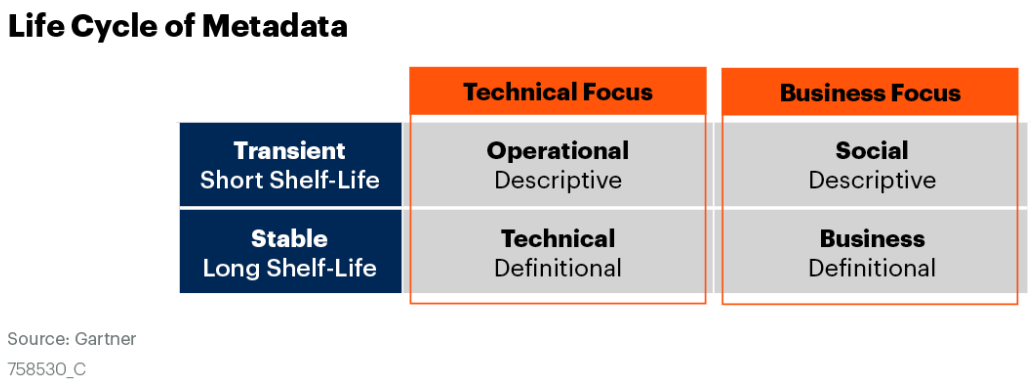

Figure 3. Lifecycle: Business vs Operational vs Technical Categories

Annex 1.2 Business vs. Operational vs. Technical

The Department of the Interior Metadata Implementation Guide - Framework for Developing the Metadata Component for Data Resource Management [Obuch 2018, pg. 3] cites three categories of metadata from prior sources:

- **Business Metadata:** The Data Management Association International [DAMA DMBOK 2017] defines business metadata in Mosley and others (2009, p. 262) as "...the business names, the definitions of subject and concept areas, entities, and attributes; attribute data types and other attribute properties; range descriptions; calculations; algorithms and business rules; and valid domain values and their definitions. Business metadata relates the business perspective to the

metadata user...” This is further explained in Early (2011, p. 166) as “of interest to business professionals [and] ideally defined by business data stewards.”

- **Operational Metadata:** Operational or administrative metadata are defined in Early (2011, p. 166) as “metadata that records lifecycle attributes of a resource, including acquisition, access rules, locations, version control [or] differentiation, lineage, and archival [or] destruction.”
- **Technical Metadata**: Early (2011, p. 167) defines technical metadata as the “physical characteristics of data found in a database, including physical names, data types, lengths, precision and scale of numeric data attributes, statistics, source location (lineage), location of data stores and interfaces, and code values. It may also include data about programs and other technology.”

Annex 1.3 Discovery vs. Structural vs. Semantic vs. Descriptive

The DoD has distinguished a difference between Discovery, Structural, Semantic and Descriptive Metadata.

- **Discovery Metadata**: DoDI 8320.02 [DOD 2013] defines discovery metadata as “a type of metadata that allows data assets to be found using enterprise search capabilities.” The M&S Simulation Community of Interest Discovery Metadata Specification (MSC-DMS) [DoD 2012] states that discovery metadata “is focused on that tagging of information assets so that an asset can be found and discovered.” Furthermore, citing the now-retired Department of Defense Discovery Metadata Specification (DDMS), the MSC-DMS defines discovery as “the ability to locate data assets through a consistent and flexible search.”
- **Structural Metadata**: DoDI 8320.02 defines structural metadata is used to “specify the format structure” of a data asset. The MSC-DMS states that structural metadata “is focused on describing the structure of information assets so that a qualified asset can be understood and used.”
- **Semantic Metadata:** DoDI 8320.02 defines semantic metadata as “specifying the meaning” which is defined further as “Information about a data asset that describes or identifies characteristics about that asset that convey meaning or context (e.g., descriptions, vocabularies, taxonomies)”.
  Descriptive Metadata: DoDI 8320.02 defines descriptive metadata as “providing amplifying or interpretive information”.

Annex 1.4 Types of M&S Resources Described by Metadata

The M&S Training community is expected to manage a significant number of metadata associated with M&S Resources. To help scope the M&S resources that various training organizations may want to consider when using and developing M&S, the following includes a list of M&S resources as noted in MSC-DMS [DoD 2012]. Note that the MSC-DMS specification is under revision to be updated and published as an international standard by the Simulation Interoperability Standards Organization (SISO).

- Software – To implement a model or simulation.
- Adjunct Tool – Software and/or hardware that is either used to provide part of a simulation environment or to transform and manage data used by or produced by a simulation environment.
- Federation – A named set of interacting federate applications, a common object model, and software infrastructure through which they communicate that are used to achieve some specific objective.
- Software Component – A software component used as part of M&S software. May be source code, binary or byte code, or remote procedures; can be used to construct models and/or provide functionality for simulation systems.
- Services – Implements a well-defined interface that delivers data or interactions in support of M&S
- Data – Data in M&S-usable format and data produced by M&S.
- Data Model – Structural meta-model for describing M&S data.
- Interface Model Specification – A well-defined agreement or capability, which, if implemented properly, will yield anticipatable results allowing applications (M&S software and adjunct tools),

federations, components and/or services to connect and communicate. Interfaces specifications include structures and/or classes including properties, methods, and/or events which serve to provide the well-defined agreement. Model Specifications might include a well-documented conceptual model.

- M&S Resource Document – A resource dependent document such as a requirements or design specification that specifies information related to an M&S resource.
- Using the RPG can help organizations in the M&S Training community to better understand the types of M&S resources that need to be managed and the associated metadata.

Annex 2. The Importance of Metadata Management

Annex 2.1 Strategic Purpose of Metadata Management

Effective metadata management is crucial for businesses to trust the context of their data and use it to support analytics. While there are many aspects of metadata management, data governance is the heart and soul. The USAF must provide guidance to enable data producers, consumers, and managers how to make data discoverable, accessible, and usable.

Annex 2.2 Rationale for Metadata Management

First, metadata management is mandated by the U.S. government. "Federal data policies, directives, and mandates require Authoritative Government Organizational Units and offices to implement Data Resource Management. This includes documenting and registering data assets to facilitate discovery, access, and use of agency data" using appropriate metadata methodologies [Obuch 2018]. Metadata management helps the DoD maximize the value of data for internal users and the public by improving knowledge of data quality, providing data transparency, reducing data redundancies, citing data sources, supporting data lifecycle management, and stressing the importance of reliable data for effective decisions. Exposing data directly from its authoritative source with clear and complete metadata speeds up the ability to understand and leverage the data for a specific use.

Data Discoverability and Understanding: Metadata management enables users to easily discover and understand the data within an organization. By providing descriptive metadata, such as data definitions, business glossaries, and data lineage information, users can quickly locate and comprehend relevant data assets.

Data Quality and Consistency: Effective metadata management helps ensure data quality and consistency. By capturing and maintaining metadata about data sources, transformations, and business rules, organizations can identify and address issues related to data accuracy, completeness, and reliability.

Data Governance and Compliance: Metadata management supports data governance initiatives by providing a framework for establishing policies, standards, and controls around data assets. It enables organizations to track data lineage, understand data ownership, and enforce data privacy and security requirements, thus ensuring compliance with regulatory and legal obligations.

Data Integration and Interoperability: Metadata management facilitates data integration and interoperability across different systems and applications. By documenting metadata about data formats, structures, and interfaces, organizations can streamline data exchange, enable data sharing, and support interoperability between diverse systems.

Data Analytics and Decision-Making: Effective metadata management enhances data analytics and decision-making processes. By capturing metadata related to data sources, data models, and data transformations, organizations can improve data accessibility, enable advanced analytics, and derive valuable insights for informed decision-making.

Data Lifecycle Management: Metadata management supports data lifecycle management by providing visibility into the various stages of data, from creation to archival or deletion. It helps organizations track data usage, understand data dependencies, and make informed decisions about data retention and disposal.

Annex 3. Metadata Management Participants

Annex 3.1 Participants involved with Metadata Management

Metadata management has a broad range of roles and responsibilities. The roles and responsibilities involved in managing metadata revolve around several primary USAF data "Persona" categories that include Data Leaders, Data Specialists, and Data Citizens, as illustrated in the figure below. These data personas assist in delineating groups to provide targeted training and enable an agency to measure its data readiness.

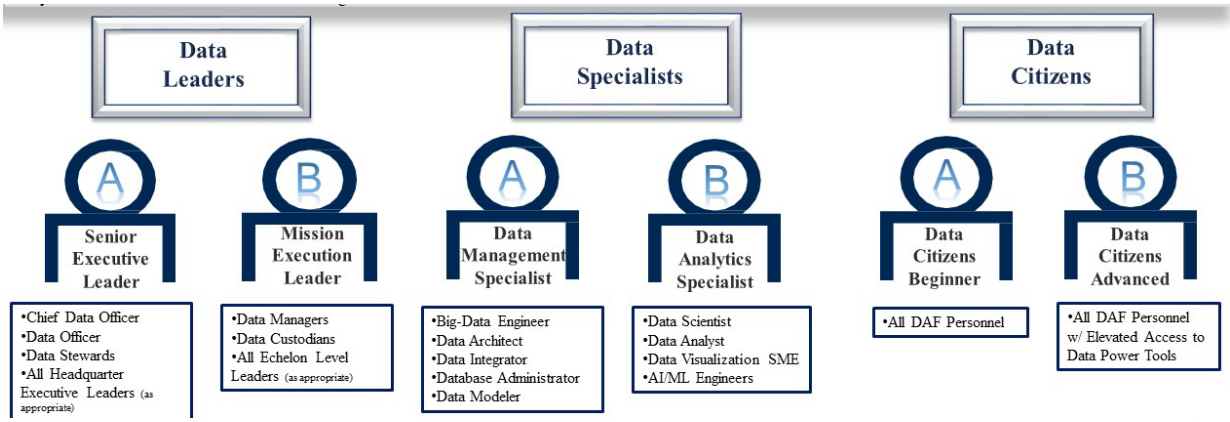

Figure 4. USAF Data Persona Categories

Annex 3.2 Data Leaders

Data Leaders drive data-centricity by making the data more easily visible, accessible, and standardized so that it can be leveraged as a strategic asset beyond the local mission area. Data Leaders include Senior Executives at the Headquarters level and Echelon levels. Working across domains to establish support of new enterprise policies, tools, and resources they ensure competitive advantage through data-driven decisions. Data leaders get organized into two groups: 1) The Data Executive Leaders including the Chief Data Officer, the Data Officer, Data Stewards, and all Headquarter Executive Leaders (as appropriate); and 2) The Mission Execution Leaders including Data Managers, Data Custodians, and all Echelon Level Leaders (as appropriate).

Annex 3.3 Data Specialists

Data Specialists deliver a baseline schema, map data lineage from origin to certification, and develop data into valuable business insights to inform the larger organizational objectives. Data Specialists include the Data Management Specialist, who is responsible for operations before the data is collected, and the Data Analytics Specialist, who is responsible for operations after the data is collected. The Data Analytics Specialist delivers expert support to their organization and the enterprise through a methodical approach to strengthen capability best posturing the DAF for mission success in the evolving digital warfighting landscape. Data specialists get organized into two groups: 1) The Data Management Specialists including Big-Data Engineer, Data Architect, Data Integrator, Database Administrator, and Data Modeler; and 2) The Data Analytics Specialists including the Data Scientist, the Data Analyst, the Data Visualization Subject Matter Expert (SME) and Artificial Intelligence (AI)/Machine Learning (ML) Engineers. [AFI 2021].

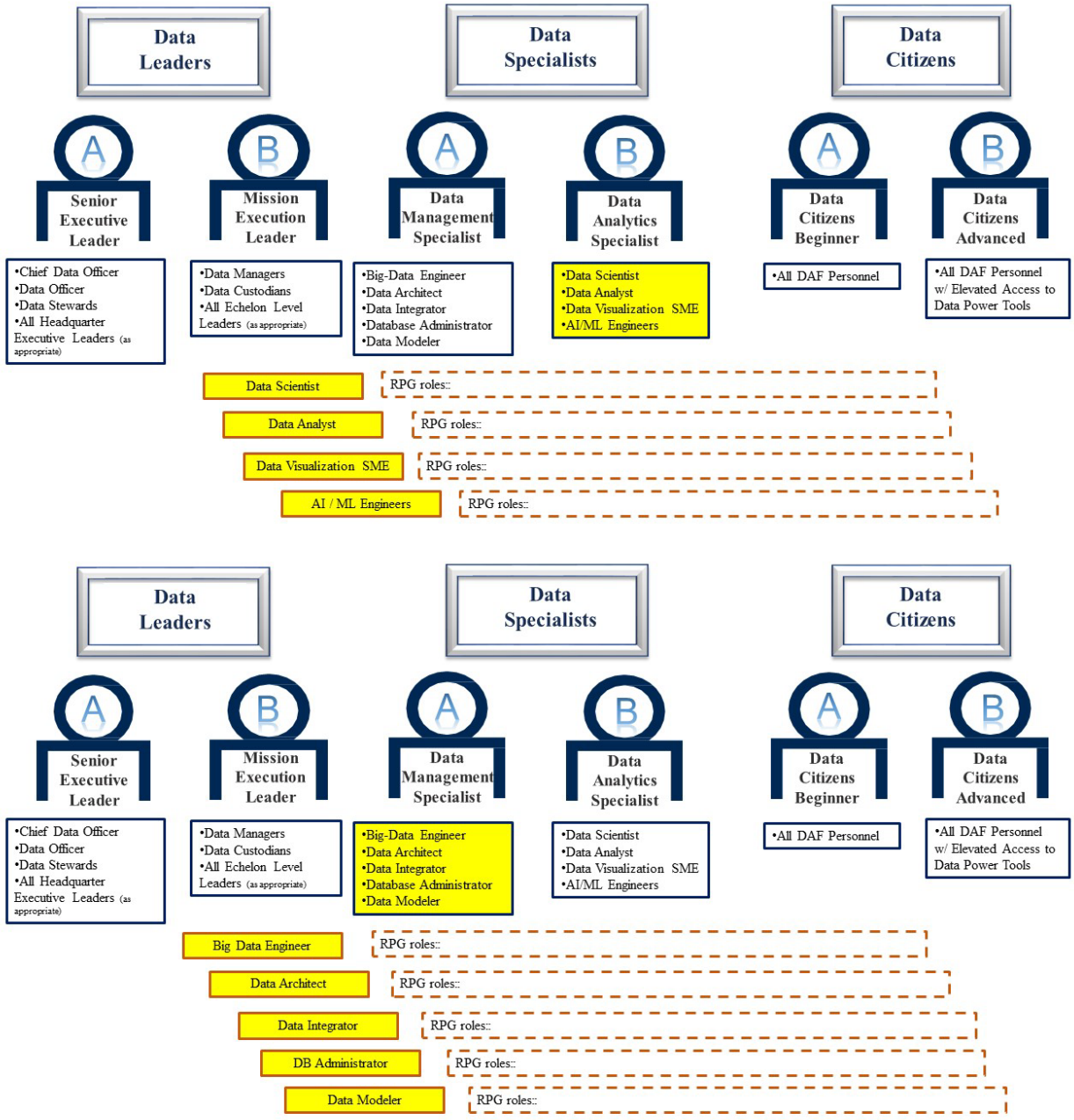

Figure 5. USAF Data Personas - Illustrating Relationship to Multiple RPG Roles

Annex 3.4 Data Citizens

Data Citizens create, collect, protect, and use data to perform work, collaborate with others, boost productivity, and address new challenges. Whether filling out electronic forms, operating digital machines at the Data Citizen Beginner level, or preparing powerful spreadsheets and dashboards to consolidate metrics for leadership at the Data Citizen Advanced level, all personnel must become Data Fluent to increase DAF readiness to win on the digital battlefield. [AFI 2021].

According to Knight (2021), "Data Stewardship falls under both strategies (plans of action designed to achieve an overall aim—or the "what") and tactics (actions planned to achieve a specific end—or the "how"). The combination of Data Stewardship's strategy/tactical decision-making patterns form models

and frameworks". The numerous tactical steps data stewards take to achieve the desired data management strategy require the support of multiple organizational roles.

Numerous roles affect an organization throughout the metadata life cycle, and these roles may fall under data stewardship or may be secondary or supplemental roles within the organization. All roles are important, but the roles and responsibilities of the data steward affect metadata governance throughout the organization. The RPG explores and recommends practices within four phases supported by a set of required associated roles and responsibilities aligned with the DAF Chief Data and AI Officer Chief Digital and Artificial Intelligence Office (CDAO) Personas. [AFI 2021].

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Appendix A. Vocabulary

Acquisition: Acquiring by contract with appropriated funds of supplies or services (including construction) by and for the use of the Federal Government through purchase or lease, whether the supplies or services are already in existence or must be created, developed, demonstrated, and evaluated. (https://www.acquisition.gov/far/subpart-2.1)

Agency Leadership: Team leaders of each relevant department, subcommittee etc.

Analytical Lab Personnel: Data scientists and technicians who collect data that is then used to support decision making and/or research. They store said data in an optimized read-only database and contrast that data with operational data used to support current processes. (Spacey, John. "6 Examples of Analytical Data". Simplicable. 24 February 2018. https://simplicable.com/new/analytical-data)

Application Developers: Software development professionals who create applications for operating systems or devices. ("Application Developer: Job Description, Duties and Requirements". Study. 19 December 2019.
https://study.com/articles/Application_Developer_Job_Description_Duties_and_Requirements.html)

Authoritative Government Organizational Units /Offices: Section of the Air Force

Authoritative Government Organizational Unit / Office Leadership: Group leaders who measure team performance and evaluate program effectiveness.

Authoritative Government Organizational Units /Office Scientists: Data scientists, public scientists and citizen scientists specifically involved with a particular section of the Air Force

Business Analysts: Consume QA/Aced and enriched (metrics, enrichment, analytic outputs) data products to create additional data products, reports, and/or Business Intelligence dashboards (visualization/presentation); will combine and select data products (pre-defined); may also create or flag simple metrics; not responsible for data quality or implementing analytical functions. (Data Services Reference Architecture 42519)

Business and Science Program/Mission Leads: People interested in the services and results of our program/mission. (“What is a Business Lead and Why are They Important?” Lead Squared. https://www.leadsquared.com/what-is-a-business-lead/)

Business Leads: Contact information for customers who would be interested in our database. (Wikipedia)

Business Representatives: Individual authorized to act on behalf of a company or corporation. (Chestnut, Dwight. "Definition of a Business Representative". Career Trend. 10 September 2019. https://careertrend.com/facts-6894838-definition-business-representative.html)

Center Directors: Directs and optimizes all the operation of servers, networks, and systems. Provides timely, accurate, and consistent technical infrastructure service and presentation to internal and external clients. Coordinates with other teams to identify and implement new systems to support business function at effective cost. ("Data Center Directory Salary in the United States". Salary. https://www.salary.com/research/salary/benchmark/data-center-director-salary)

Chief Data Officer (CDO): Senior executive responsible for utilization and governance of data across the organization. Their focus is on underpinning the strategy and direction of the business with data. Chief responsibilities include governing enterprise data, enabling operations, driving innovation, and supporting analytics. (Zetlin, Minda. "What is a Chief Data Officer? A Leader Who Creates Business Value from Data." CIO, 28 September 2020

Citizen Scientist: Individuals who voluntarily contribute their own time, effort, and resources toward scientific research in collaboration with professional scientists or alone. (scistarter.com/page/Citizen%20Science.html)

Communications Staff: Individuals responsible for clear communication between departments.

Consumer: Consume / view Business Intelligence dashboards (visualization/ presentation), including reports and metrics, interact through simple select/filter and visualization tool. (USAF Data Services Reference Architecture 2019)

Contractors: Any individual or other legal entity that is awarded a Federal Government contract or subcontract under a Federal Government contract. (https://www.ecfr.gov/current/title-29/subtitle-A/part-10/subpart-A/section-10.2)

Data Architects: Individuals responsible for designing, creating, deploying, and managing an organization's data architecture. They define how data will be stored, consumed, integrated, and managed by different entities and IT systems, as well as any applications using or processing that data. ("Data Architect." Technopedia. http://stage.web.techopedia.com/definition/29452/data-architect)

Data Collectors: Individuals who enter information into databases and ensure that data collection sources are accurate. ("What is a Data Collector?" ZipRecruiter. https://www.ziprecruiter.com/e/What-Is-a-Data-Collector)

Data Creators: Those who originate the reason for collecting data, ask the originating question that led to data collection, and sometimes oversee the data collection process. (Roger Peng. "What Should be Done When Data Have Creators?" SimplyStats. July 6th, 2018. https://simplystatistics.org/2018/07/06/data-creators/)

Data Engineer: Responsible for defining, building, and managing the essential services which ingest, validate, remediate, transform, and store physical data assets required for analytics or other data management functions. (USAF Data Services Reference Architecture 2019)

Data Governance Body: Team responsible for managing the availability, usability, integrity, and security of data in enterprise systems, based on internal data standards and policies that also control data usage. Typically made up of executives from all business units, they set data policies and standards and resolve issues. (Rouse, Margaret et. al. "What is Data Governance and Why Does it Matter?" TechTarget: Search Data Management. https://searchdatamanagement.techtarget.com/definition/data-governance)

Data Management Professionals: Include data architects, data modelers, database administrators, database developers, data quality analysts and engineers, data integration developers, data governance managers, data stewards, and data engineers, who with analytics teams to build pipelines and prepare data for analysis. (Rouse, Margaret, et. al. "What is Data Management and Why is it Important?" TechTarget: Search Data Management. https://searchdatamanagement.techtarget.com/definition/data-governance)

Data Manager: Responsible for handling database systems, and develop policies, ideas, procedures, and assign tasks to other employees. They interact across the company, from data entry clerks to corporate executives. They supervise assistants in data management, supervise data collection systems, manage data entry, ensure systems are operational, troubleshoot submission errors, prepare reports, and oversee general data activity. ("Average Data Manager Salary". Payscale. https://www.payscale.com/research/US/Job=Data_Manager/Salary)

Data Modelers: Individual who models data or documents software and business system designs, translating business needs into technical specifications. (Knight, Michelle. "What is a Data Modeler?" Dataversity. 16 September 2020. https://www.dataversity.net/what-is-a-data-modeler/)

Data Officers: An empowered designee selected by the directorate that will facilitate the sharing of DAF data across the enterprise. (AFI 33-XXX Enterprise Data Management)

Data Originators: Authorized individuals who transcribe data from source documents. ("Guidance for Industry: Electronic Source Data in Clinical Investigations". Good and Drug Administration. September 2013. https://www.fda.gov/media/85183/download)

Data Producers: User interface, system or device that collects data that's relevant to an organization. (Spacey, John. "Data Producer vs ata Consumer". Simplicable. 24 February 2017. https://simplicable.com/new/data-producer-vs-data-consume)

Data Professionals: Collective term for anyone with data skills. At a minimum, they are capable of cleaning, selecting, analyzing, and visualizing data. They can also be comfortable building machine learning models. ("What is a Data Professional exactly?" SkillsUP Lab. June 22, 2020. https://skillsuplab.nl/what-is-a-data-professional-exactly/)

Data Scientist: Use the basic infrastructure, along with analytical and data subject matter expertise, to extend analytical capabilities and pull Data Enrichment into more automated capabilities, acting as a narrow extension of the developer - familiar with the Data Operations, Storage, and querying tools. Provide analytical support to the Business Analyst by supporting development of queries, indices, analytical applications and approaches, new visualizations for Business Intelligence and automation of data enrichment, acting as a more technical extension of the Business Analyst. (Data Services Reference Architecture 42519)

Data Security Representatives: Individuals responsible for protecting databases from destructive forces and from unwanted actions of unauthorized users. (Summers, G. (2004). Data and databases. In: Koehne, H Developing Databases with Access: Nelson Australia Pty Limited. p4-5.)

Data Services Team (DST): Body that abstracts consumers from having to access or update multiple data sources and help maintain data integrity when consumers need to work with multiple data sources. They help build reusable data services that can be leveraged for multiple projects and initiatives. They help centralize metrics, monitoring, version management, reuse of data types, and enforce data visibility and access rules. (Narayanan, Vijay. "Introduction to Data Services". InfoQ. 19 May 2009. https://www.infoq.com/articles/narayanan-soa-data-services)

Data Steward: Subject-matter expert for one or more authoritative data sources. (AFI 33-XXX Enterprise Data Management)

Developer: Leverage the infrastructure to add capabilities; those who extend the basic infrastructure capabilities and add new base operations including support for moving data enrichment into the data ingestion topologies – comfortable operating at the command line and in an Integrated Development Unit: may also provide Data Scientist capabilities but is intended to focus on extension of the infrastructure. (USAF Data Services Reference Architecture 2019)

Executives: Officers, managing partners, or any other employees in management positions. (https://www.ecfr.gov/current/title-2/subtitle-A/chapter-I/part-170/subpart-C/section-170.315)

Freedom Of Information Act (FOIA): Federal law that requires full or partial disclosure of previously unreleased information and documents controlled by the US government upon request. Defines agency records subject to disclosure, outlines mandatory disclosure procedures, and defines exemptions to the statute. ("What is FOIA?" FOIA. https://www.foia.gov/about.html)

Grantees: an organization which has applied for financial assistance, and to which financial assistance is awarded under this Act. (https://www.ecfr.gov/current/title-45/subtitle-B/chapter-XIII/subchapter-D/part-

1336/subpart-A/section-1336.10)Investment Sponsors: Make investments for funds and performs requisite diligence. They're charged with generating additional value through management expertise or navigating private capital markets. ("90-Second Lesson: What Is a Sponsor, General Partner and Limited Partner in Private Equity?" Financial Poise. 23 September 2016. https://www.financialpoise.com/90-second-lesson-what-is-a-sponsor-gp-and-lp)

Key Authoritative Government Organizational Units and Office Personnel: Employees within a department whose skillset is suited for a relevant task.

Key Stakeholders: Individuals that have an interest in a company and can either affect or be affected by the business. (Chen, James; Gordon, Scott. "Stakeholder". Investopedia. 4 March 2020. https://www.investopedia.com/terms/s/stakeholder.asp)

Legal: Individuals who make sure each department's actions are permitted by law. (www.dictionary.com)

Lines of Business Representatives: Individuals authorized to an act behalf, or a particular product or service offered by a company. (Wikipedia)

Management: Individuals in charge of running teams and departments within a company or organization. (www.dictionary.com)

Metadata Creators: Individuals who capture original metadata, either by automated information processing or by manual work. (Wikipedia)

Metadata Management Leads: Team leaders who enable business users to search and identify information on key attributes in web-based user interface. (Kudikala, Nitin. "Metadata Management 101: What, Why and How". Talend. 7 September 2018. https://www.talend.com/blog/2018/09/07/metadata-management)

Metadata Technical Leads: Team leaders who keep track of system names, table names, table size, data types, values, and attributes. ("Metadata in DBMS - Overview and Types". The Crazy Programmer. https://www.thecrazyprogrammer.com/2019/12/metadata-in-dbms.html)

Modelers: Individuals who create conceptual representations of data objects and the associations between them for the data to be stored in a database. ("Data Modeling: Conceptual, Logical, Physical Data Model Types". Guru 99. https://www.guru99.com/data-modelling-conceptual-logical.htm)

Open Data Points of Contact: Liaisons for each government agency authorized to share data with other government entities. (https://www.data.gov/about)

Other: Anyone else involved in coordinating communications.

Principal Investigators: The single individual whom an organization that is carrying out a research project with DoD support designates as having an appropriate level of authority and responsibility for leading and directing the research intellectually and logistically, which includes the proper conduct of the research, the appropriate use of funds, and compliance with administrative requirements such as the submission of performance reports to DoD. (https://www.ecfr.gov/current/title-2/subtitle-B/chapter-XI/subchapter-A/part-1108/subpart-B/section-1108.295)

Privacy: Individuals who make sure department work is not observed or disturbed by anyone on the outside. (www.dictionary.com)

Program Administrators: Individuals who coordinate, direct, and manage services or programs. (Greenwood, Beth. "Program Administrator Job Description". Career Trend. 27 December 2018. https://careertrend.com/facts-6181849-program-administrator-job-description.html)

Program Managers: Responsible for delivery of output/product of the program, which will involve managing a portfolio of projects and programs. They coordinate the teams who are working on the various projects program management software. (Bridges, Jennifer. "Program Manager Responsibilities". Project Manager. 26 March 2018. https://www.projectmanager.com/training/program-manager-responsibilities)

Program Staff: Employees or individuals who by contract with the program provide a service that has the applicable competencies, qualifications, or certification required to provide the service. ("Program staff definition". Law Insider. https://www.lawinsider.com/dictionary/program-staff)

Project / Task Administrators: Professionals who organize the necessary team members and specialize in facilitating and analyzing projects under the supervision of a project/task manager. ("Project Administrator". Technopedia. 23 February 2017. https://www.projectmanager.com/training/program-manager-responsibilities)

Project / Task Managers: Individual in overall charge of the planning and execution of a particular project or task. (www.dictionary.com)

Project/Task Leads: Guides people throughout the project/task, is concerned with the overall outcome, has a vision in which they engage people, and adds value to the project/task and team. (Kurzawska, Kate. "The Difference Between Project Manager and Project Lead". Time Camp. 29 September 2017. https://www.timecamp.com/blog/2017/09/the-difference-between-project-manager-project-leader-2020)

Public Scientist: Conduct basic scientific research funded amongst the public, sometimes including the public. (Wikipedia)

Records Management: Code of Federal Regulations (CFRs) require all federal agencies to maintain records that document their activities, file records for safe storage and efficient retrieval, and dispose of records according to agency schedules. (

Scientists: Data scientists, public scientists, and citizen scientists.

Subject Matter Experts: Person with bona fide expert knowledge about what it takes to do a particular job. (https://www.opm.gov) System Administrators: This role responsible for setting up and maintaining a system or specific components of a system (e.g. for example, installing, configuring, and updating hardware and software; establishing and managing user accounts; overseeing or conducting backup and recovery tasks; implementing operational and technical security controls; and adhering to organizational security policies and procedures). (https://www.cisa.gov) (

System Manager: Oversee company's IT assets, and undergo many different tasks required to monitor and manage IT systems and resolve IT problems. (McCabe, Laurie. "What is Systems Management, and Why Should You Care?" Small Business Computing. https://www.smallbusinesscomputing.com/news/article.php/3928971/What-is-Systems-Management-and-Why-Should-You-Care.htm)

Web Administrators: Responsible for all aspects of keeping web-based content and design fresh, backed up, and fully functional. They typically work closely with clients to make sure they understand how they want their content to look and function. They may also make sure local networks are functioning properly. ("What is a Website Administrator?" Learn. https://learn.org/articles/What_is_a_Website_Administrator.html)

Appendix B. Acronyms

Abbreviation	Description
ABAC	Attribute Based Access Control
AFI	Air Force Instruction
AI	Artificial Intelligence
ALCTS	Association for Library Connections and Technical Services
API	Application Programming Interface
CDAO	Chief Digital and Artificial Intelligence Office
CDO	Chief Data Officer
CMMI DMM	Capability Maturity Model Integration's Data Management Maturity
COI	Community of Interest
DAF	Department of the Air Force
DAMA	Data Management Association
DDMS	Department of Defense Discovery Metadata Specification
DMSCO	DoD M&S Coordination Office
DMS-MSR	Discovery Metadata Specifications for M&S Resources
DMS-MSR PDG	Discovery Metadata Specification for M&S Resources Product Development Group
DoD	Department of Defense
DoDI	Department of Defense Instruction
DOI	Department of the Interior
DST	Data Services Team
ETL	Extract Transform Load
FOA	Field Operating Agency
FOIA	Freedom of Information Act
FVEY	Five Eyes Alliance
IT	Information Technology
M&S	Modeling and Simulation
MAJCOM	Major Command
MIG	Metadata Implementation Guide
ML	Machine Learning
MLS	Multi-Level Security
MSC-DMS	Modeling and Simulation Community of Interest Discovery Metadata Specification
MVP	Minimum Viable Product
NATO	North American Treaty Organization
NISO	National Information Standards Operation
OTI	Operational Training Infrastructure
OTTI	Operational Test and Training Infrastructure
OTTI RPG	Operational Test and Training Infrastructure Recommended Practices Guide
PBAC	Policy Based Access Control
PDG	Product Development Group
POC	Person/Point of Contact

QA/QC	Quality Assurance / Quality Control
RBAC	Role Based Access Control
SAF/CO	Air Force Chief Data Office
SISO	Simulation Interoperability Standards Organization
SME	Subject Matter Expert
USAF	United States Air Force
USGS	United States Geological Survey
UTC	Universal Time Coordinated
VAULTIS	Visible, Accessible, Understandable, Linked, Trusted, Interoperable and Secure data assets

Appendix C. Detailed Breakout for Recommended Practices

C.1 Overview

The M&S metadata management recommended practices are detailed below in four phases (phase 0 through phase 3). Note that phase 1 through phase 3 highly leverage material in the Department of the Interior (DOI) Metadata Implementation Guide, as the DOI-released material provides a metadata framework not found in existing DoD instruction and guidance.

C.2 Phase 0: DoD baseline required metadata fields (OTTI Interpretation)

The DoD metadata guidance identifies ten metadata requirements that promote data visibility. These ten requirements are intended as an initial common baseline (or Minium Viable Product (MVP)) and are not intended to be all encompassing. Below are the 10 DoD baseline required metadata fields that shall be applied at the most appropriate time between creation, but not later than the time of storage. Operational Test and Training Infrastructure (OTTI) metadata usage interpretation is included.

Metadata Field Description

Identifier – This is the M&S datasets unique identifier. It is either a numeric or alphanumeric catalog generated string that is associated with a single entity.

Authorization Reference – An M&S dataset is made authoritative based on its sources.

- The sources must be recognized as authoritative and trusted for its intended use (M&S).
- The sources must use trusted processes to compile the dataset.
- The sources' attributes are well known and documented.
- The sources are proven to be reliable, accurate and current.

The datasets authorization reference is a text description used by the action officers to justify the datasets usage to stimulate simulations and facilitate analytics.

Originator – The M&S dataset's author, producer, creator, and collector must be well documented. It must include OTTI organization information and enough contact information to ensure connectivity when required (PoC, email, phone, …).

Custodian – The data steward with authority to decide access to data based on enquiry. Decisions points:

- Clearance requirements are satisfied.
- There is well documented need-to-know based on usage to stimulate simulations and facilitate analytics.
- Verify that usage agreements are signed and verified when required.
- Training on proper data usage has been completed.

Data sharing directives must be adhered to. Proper, secure usage of datasets must be governed carefully. It must include OTTI organization information and enough contact information to ensure connectivity when required (PoC, email, phone, …).

DataItemCreateDateTime – Temporal metadata describes the datasets creation, usage, transformations, state changes, etc. In a timeline, it tells you about the datasets path through its life cycle from creation to archive. It must be store in Universal Time Coordinated (UTC) format. Every time the dataset is touched temporal data must be collected.

Description – This metadata established context for dataset usage. It should include a summation, abstraction, and detailed usage directions for both stimulating simulations and facilitating analytics. This metadata should be augmented over time to include dataset user's experiences.

Format – Formatting metadata describes how the dataset is to be consumed by the simulation and analytics. It should include which file/table/Application Programming Interface (API)/stream format is used, how it is made interoperable with other datasets and what predicates make the dataset selectable.

Safeguarding & Sharing (Entitlements Management)

Security Classification – This is part of Role-Based Access Control (RBAC) metadata; (lowest) unclassified data, (low) confidential data, (high) secret data and (highest) top secret data based on DoD security requirements.

Disclosure & Releasability – This metadata describes who has access to this dataset past classification towards releasability. Required one or more of three groups/categories to receive access to datasets:

- Countries (United States of America (USA), …)
- Organizations (North Atlantic Trade Organization (NATO) Countries, Five Eyes Alliance (FVEY), OTTI…)
- Communities (military, government, contractors, …)

Handling Restrictions – This metadata covers access controls that are not covered by classification and releasability. Examples are privacy controls, specific purpose, use limitations, authority (e.g., legislation, policy), personally identifiable information, law enforcement restrictions, medical restrictions (e.g., Individual Identifiable Health Information, Health Insurance Portability and Accountability), and licensing. Indicating no special handling restrictions is also valuable.

C.3 Phase 1: Getting Started

Identify Documentation Issues with Current Data Holdings (Practice 1.1)

Description

Plan and prioritize activities for metadata implementation and management, and to identify missing and incomplete metadata associated with existing data. (Obuch, 2018, p. 5)

Purpose

This can be implemented in stages based on Authoritative Government Organizational Units or office data priorities and resource constraints. The data holdings inventory and metadata gap analysis, along with Authoritative Government Organizational Units or office priorities and requirements, will help develop the metadata approach regarding standards, level of documentation, and methods. (Obuch, 2018, p. 5)

Pre-Conditions

The Authoritative Government Organizational Units or Office must have staff with the appropriate skills and knowledge necessary to facilitate the development and completion of the data inventory and metadata gap analysis, and formulate metadata requirements, priorities, and next steps. (Obuch, 2018, p. 5)

Responsibilities

Roles	Responsibilities
Data Leader / Senior Executive Leader (Data Stewards) **Data Specialist / Data Management Specialist (Data Managers)** **Data Specialist / Data Analytics Specialist (Data Scientists)** **Data Specialist / Data Management Specialist (Lines of Business Representatives)**	• Perform a baseline inventory of data and metadata holdings, including digital and paper materials, to facilitate the identification and prioritization of next steps in metadata implementation and management. • Review metadata records for completeness and robustness based on Authoritative Government Organizational Units or office business and science needs. • Review metadata elements and registration requirements. • Evaluate the completeness of metadata records to facilitate data discovery and sharing. • Gap Analysis.
Data Specialist / Data Analytics Specialist (Data Security)	• Perform a baseline inventory of data and metadata holdings, including digital and paper materials, to facilitate the identification and prioritization of next steps in metadata implementation and management. • Review metadata records for completeness and robustness based on Authoritative Government Organizational Units or office business and science needs. • Gap Analysis.
Data Leader / Mission Execution Leader (Records Management) **Data Leader / Mission Execution Leader (FOIA)** **Data Citizen / Data Citizen Advanced (Privacy)** **Data Citizen / Data Citizen Advanced (Legal)** **Data Citizen / Data Citizen Advanced (Communications)** **Data Leader / Mission Execution Leader (Acquisitions)** **Data Citizen / Data Citizen Advanced (Contracting Personnel)**	• Gap Analysis.

Measurements

1. The level of completion of the data inventory along with a metadata gap analysis across various program and mission areas.
2. A prioritized list of datasets that require additional metadata and documented next steps for furthering metadata management

Outputs

1. A prioritized inventory of data assets accompanied by a listing of corresponding metadata records that meets Authoritative Government Organizational Units or office organizational needs, as well as its level of completion.
2. A gap analysis report that describes the status of each dataset, its associated metadata record, and metadata type(Obuch, 2018, p. 5)

Scope Metadata Types (Practice 1.2)

Description/Purpose

Evaluate practices related to business, operational, and technical metadata. To address the extent of metadata that is needed to adequately document data to meet organizational needs, an assessment of the current level of documentation that exists for the metadata types is needed. all three types of metadata need to be included in this assessment, with organizational requirements driving of the level of documentation required for each metadata type.

Business Metadata

Business metadata are usually the first type of metadata to be developed. They provide a detailed description of data elements such as data element names, data types, data definitions, and data domain values. They provide information that promotes shared understanding of data, enhances data interoperability, and simplifies data integration. business metadata need to be reviewed and updated only if the actual database schema or entities changes. When creat-ing operational or technical metadata, the existing business metadata should be linked to the complete metadata record and not redefined.

Operational Metadata

Operational or administrative metadata provide information about how the data are being managed and used. These metadata include information on access rights, how and when the data were created, the currency or version of the data, and an indication of their overall quality. This type of metadata is important for supporting data and information-related processes associated with records man-agement, Data Leader / Mission Execution Leader (FOIA), Data Citizen / Data Citizen Advanced (Privacy), and Data Specialist / Data Analytics Specialist (Data Security). They can be used to create audit trails, which help with data-driven regulatory requirements related to Data Specialist / Data Analytics Specialist (Data Security) and access, the status of any Data Leader / Mission Execution Leader (FOIA) requests, and whether the data are currently available online or are archived. Operational or administrative metadata reduce overhead in data administration by providing adequate documentation relating to the current state of the data.

Technical Metadata

Technical metadata are often managed by personnel that are not directly responsible for the data. They should be created at the point where a database or dataset is designed or developed. They include information about physical implementation and delivery of the data such as the assigned Digital Object Identifier for the digital data publication, reference to the data-hosting site or service, the actual date of release, and any references to documentation relating to API if used for content delivery. (Obuch, 2018, pp. 5-6)

Pre-Conditions

This action requires executive support, adequate resources, and initial project approval to begin work. Staff must possess the necessary skills and have a clear understanding of their roles and responsibilities in the data and metadata lifecycle. (Obuch, 2018, pp. 5-6)

Responsibilities

Roles	Responsibilities
Data Citizen / Data Citizen Advanced (Data Originators) **Data Citizen / Data Citizen Advanced (Data Architects)** **Data Specialist / Data Management Specialist (Modelers)** **Data Citizen / Data Citizen Advanced (Subject Matter Experts)** **Data Leader / Senior Executive Leader (Data Stewards)**	• Identify and define business metadata types
Data Leader / Senior Executive Leader (Data Stewards) **Data Specialist / Data Management Specialist (Data Managers)** **Data Specialist / Data Analytics Specialist (Data Security) Representatives**	• Identify and define operational metadata types
Designers/Developers of Physical Implementation of Dataset **Publication Approvers** **Hosting Servers** **AP Developers** **Data Deliverers**	• Identify and define technical metadata types

Measurements

Business Metadata

To evaluate your organization's practices related to business metadata, answer the following questions: (Obuch, 2018, p. 6)

1. How does your organization capture data requirements for investments and projects?
2. Where are business metadata documented, and where are they stored for reuse for other projects? Are the business metadata available across the organization?
3. Who is responsible for the business metadata, and how are they shared within and outside of the organization(s)?
4. Are definitions or domain values for the same data ele-ment different between databases or datasets of similar theme or data domain?
5. Have standards been reviewed to ensure consistency and clarity regarding data definitions and relations across the organization?
6. Is there policy related to business metadata, including naming conventions?
7. Are all parties that create and use the data involved in developing the business metadata?
8. How well are your legacy databases documented with respect to metadata?

Operational Metadata

To evaluate your organization's practices related to operational metadata, review the following: (Obuch, 2018, pp. 5-6)

1. Who is responsible for operational metadata and the associated requirements?
2. How have operational metadata been captured, updated, stored, documented, and shared?
3. Are metadata elements consistently defined across all metadata needs?
4. How are operational metadata governed and managed?

Technical Metadata

To evaluate your organization's practices related to technical metadata, review the following: (Obuch, 2018, pp. 5-6)

1. How well is your organization capturing data hosting and data growth requirements for data capacity planning?
2. Who is responsible for the final completion and validation of the technical metadata?
3. Can a metadata governance process be developed around the final validation and acceptance of the entire metadata profile prior to release or publication?
4. Are those responsible for data hosting and Data Specialist / Data Analytics Specialist (Data Security) flagging the existence of metadata referencing proprietary and sensitive data that may require special attention to avoid public release or access to other metadata catalogs?
5. Does your organization have technical metadata standards?
6. Do you have technical metadata that link to the data dictionary and related business metadata?

Outputs

1. A list of potential associated metadata standards that meet the required level of documentation needed for each metadata type and source.
2. The required level of documentation needed for each type of metadata.
3. A prioritized list of datasets that may need additional documentation across the three metadata types.

Establish Roles and Identify Points of Contact (Practice 1.3)

Description

Authoritative Government Organizational Units or office leadership assigns key Data Specialist / Data Management Specialist (Data Management Professionals) to the appropriate tasks. (Obuch, 2018, pp. 6-7)

Purpose

Identification of representatives who oversee metadata-related activities is necessary to support and implement metadata management. This network of Metadata Specialist / Data Management Specialist (Data Professionals) serves as the foundation for implementing successful metadata management throughout the data lifecycle. (Obuch, 2018, pp. 6-7)

Pre-Conditions

The Authoritative Government Organizational Units or Office has the necessary executive support, staff availability, and resources to begin identifying and assigning roles for metadata implementation. (Obuch, 2018, pp. 6-7)

Responsibilities

Roles	Responsibilities
Data Leader / Senior Executive Leader (Chief Data Officer)	• Overarching agency policy, cross DAF coordination, strategy, standards, and guidance (templates), DAF motivation for compliance, evaluation metrics, technical tool guidance/toolbox. • Operational support regarding the DAF Metadata Catalog • Office of Management and Budget reporting of the DAF Enterprise Data Inventory. • Create and update implementation guide, metadata data quality, continuity, and legacy. Authoritative Government Organizational Units program level motivation for compliance. • Overall Sponsorship.
Data Specialist / Data Management Specialist (Data Managers)	• Support metadata and data management • Request funds regarding metadata and data management at the Program level. • Operational support (people, time, money).
Data Leader / Senior Executive Leader (Center Directors) **Data Specialist / Data Management Specialist (Data Managers)** **Data Leader / Mission Execution Leader (Open Data Points of Contact)**	• Support and implement metadata and data management. • Request funds regarding metadata and data management at the Unit and MAJCOM Program level. • Operational support (people, time, money). • Performance metrics.
Data Leader / Senior Executive Leader (Program Administrators) / Mission Execution Leader (Data Leader / Mission Execution Leader (Program Managers)) **Data Citizen / Data Citizen Advanced (Project/Task Administrators)** **Stakeholders** **Data Leader / Mission Execution Leader (FOIA)** **Data Leader / Mission Execution Leader (Records Management)**	• Support metadata and data management • Adherence to metadata and data standards, Quality Assurance / Quality Control (QA/QC), and overall metadata operational implementation within a project or task. • Request funds regarding metadata and data management at The Authoritative Government Organizational Units Program level. • Operational support (people, time, money). • Freedom of Information Act and Record Management coordination regarding published and unpublished data and information.

Roles	Responsibilities
Data Citizen / Data Citizen Advanced (Data Collectors) **Data Specialist / Data Management Specialist (Data Producers)** **Data Specialist / Data Management Specialist (Analytical Lab Personnel)** **Data Specialist / Data Management Specialist (Project/Task Managers)**	• Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task.
Data Specialist / Data Management Specialist (System Managers) **Data Leader / Senior Executive Leader (Data Stewards)** **Data Specialist / Data Management Specialist (Data Creators)** **Data Specialist / Data Management Specialist (Metadata Creators)**	• Operational support for metadata and data management at the Project and task level.
Data Citizen / Data Citizen Advanced (Contractors) **Citizen Data Specialist / Data Analytics Specialist (Data Scientists)**	• Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task that has a grant, contract, or external (citizen data science) data collection component.

Outputs

- List of Authoritative Government Organizational Units or Office points of contact with their associated roles and responsibilities.

Participate in Metadata Communities of Practice (Practice 1.4)

Description

Participating in metadata communities and groups can help those responsible for metadata gain knowledge of metadata methods, standards, and best practices implemented by others, and develop relations and lines of communication within and DAF Data Leader / Senior Executive Leader (Chief Data Officer), MAJCOMs, Functionals and Field Operating Agencies (FOAs) partners that facilitate the exchange of metadata knowledge.

Purpose

This action encourages internal and external metadata collaboration efforts. Sharing information will result in a more consistent and successful approach in managing metadata, often saving time and money.

Pre-Conditions

The success of this action is dependent on the ability of the DAF Data Leader / Senior Executive Leader (Chief Data Officer), MAJCOMs, Functionals and, FOAs to host metadata information sessions with external metadata groups and data domain representatives.

Responsibilities

Roles	Responsibilities
Data Leader / Senior Executive Leader (Agency Leadership) **Data Leader / Senior Executive Leader (Authoritative Government Organizational Units/Office Leadership)** **Data Specialist / Data Management Specialist (Data Management Professionals)** **Data Citizen / Data Citizen Advanced (Key Stakeholders)**	• Participate in relevant groups

Measurements

1. At least one information session hosted or attended per quarter.
2. List of relevant standards, processes, and procedures.

Outputs

1. List of standards, processes, and procedures used across these communities that may benefit the USAF.

2. List of potential avenues for metadata collaboration with groups that may have applicable sessions, presentations, or information exchange forums.
3. List of scheduled collaboration sessions to share experiences.

Develop Communication Study (Practice 1.5)

Description

Develop a shared or common dictionary to ensure consistent use of metadata related terms and definitions and enable coordination of metadata implementation efforts within and across authoritative government organizational units and offices. This is necessary to develop consistency and communicate the value of metadata and data management for the organization.

Purpose

Communicating metadata management requirements is an important aspect of implementation. Metadata implementation needs to be communicated to numerous roles that include Data Leader / Mission Execution Leader (Executives), Data Specialist / Data Management Specialist (System Managers), practitioners, and stakeholders. Communicating metadata management requirements highlights importance of metadata management for achieving mission goals, encouraging staff at all levels to engage in metadata management, integrating metadata management into the data lifecycle, managing change within the organization, and providing an overview of metadata management requirements, deliverables, and metrics for successful implementation. An important component to communication is to educate staff about metadata concepts using consistent terminology.

Pre-Conditions

Metadata has been adopted and an initial metadata management implementation guide is available.

Responsibilities

Roles	Responsibilities
Data Leader / Senior Executive Leader (Authoritative Government Organizational Units / Offices) **Air Force Chief Data Officer (DAF Data Leader / Senior Executive Leader (Chief Data Officer))** **Data Specialist / Data Management Specialist (DST)** **Data Specialist / Data Management Specialist (Communication Staff)** **Data Leader / Mission Execution Leader (Other)**	• Help coordinate communications

Measurements

1. Current presentation and fact sheet describing the metadata implementation effort within three months of management approval.
2. Conduct Survey to evaluate awareness and understanding of metadata and associated available resources.

Outputs

1. High-level presentation that can be modified to include specific Authoritative Government Organizational Units or office information as needed.
2. Fact sheet or other information sheet highlighting the value of implementing metadata management.
3. Communication Plan.

Identify Metadata Standards (Practice 1.6)

Description

A standards-based approach provides consistency in metadata across and between organizations for those who enter, manage, and use metadata. Standards facilitate data discovery and sharing and management of metadata in the USAF Metadata Catalog. Various metadata standards can be applied to data, and it is important to identify the most appropriate standard for reuse rather than to develop new standards.

Metadata standards specific to Modeling and Simulation (M&S) data must be applied. The SISO DMS-MSR Product Development Group (PDG) is developing a metadata standard to describe modeling and simulation (M&S) resources in a manner that will be useful to the international M&S community in discovering various types of M&S-related resources. These M&S resources include, but are not limited to, models, simulations, simulation federations, M&S-related tools, data sets, services, standards, and points of contact.

However, until the new SISO M&S metadata standard product is approved and published, the M&S community should apply the M&S COI Discovery Metadata Specification (MSC-DMS) developed under the U.S. DoD, and other previous metadata efforts upon which the new SISO standard is being built.

Purpose

Metadata standards help facilitate metadata creation, metadata and data management, and data publication across the USAF. This RPG addresses broad requirements for standards in support of data resource management. and offices should use applicable metadata standards and may recommend additional metadata requirements based on organizational requirements, standards, specifications, or formats developed within different communities (for example, earth science, financial, health, geospatial, and law enforcement) (Obuch 2018)

Pre-Conditions

Authoritative government organizational units and offices must have knowledgeable staff in place to identify applicable metadata standards. This requires knowledge of existing standards and how well they meet Authoritative Government Organizational Units or how they meet office data documentation requirements.

Responsibilities

Roles	Responsibilities
Data Leader / Senior Executive Leader (Data Stewards) **Data Specialist / Data Management Specialist (Lines of Business Representatives)** **Data Leader / Senior Executive Leader) (Data Offices) (w/ DAF Data Leader / Senior Executive Leader (Chief Data Officer) Assistance)**	• Responsible for identifying and implementing appropriate standards.

Measurements

1. List of applicable metadata standards that meet organization requirements.
2. Measure progress and extent of activity in Authoritative Government Organizational Units or offices regarding implementing the selected metadata standards.

Outputs

1. List of acceptable metadata standards that the Authoritative Government Organizational Units or Office will adopt and enforce.
2. Inventory of current metadata standards used in Authoritative Government Organizational Units or Office.
3. Plan for how metadata fulfills Federal requirements.

Select Data Management Tools (Practice 1.7)

Description/Purpose

1. 1. Business requirements and metadata standards drive the selection of tools and applications that best support overall metadata management goals and objectives. (Obuch, 2018, pp. 8-9)
2. 2. Metadata management tools and applications greatly improve the efficiency of overall metadata management. (Obuch, 2018, pp. 8-9)

Pre-Conditions

Adequate staff is available to formulate and select appropriate metadata tools and applications that meet metadata management requirements. Authoritative Government Organizational Units and offices engage with DAF Data Leader / Senior Executive Leader (Chief Data Officer), which can serve a coordinating function to maximize consistency. (Obuch, 2018, pp. 8-9)

Responsibilities

Roles	Responsibilities
Data Leader / Mission Execution Leader (Business Leads) **Data Specialist / Data Management Specialist (Data Managers)** **Data Leader / Senior Executive Leader (Data Stewards)** **Data Citizen / Data Citizen Advanced (Data Originators)** **Freedom of Information Act (Data Leader / Mission Execution Leader (FOIA))** **Data Specialist / Data Analytics Specialist (Data Security)** **Data Leader / Mission Execution Leader (Records Management)**	• Provide input into metadata requirements, standards, and selection of appropriate metadata tools and applications.
Data Specialist / Data Analytics (Metadata Technical Leads)	• Evaluate metadata requirements against existing metadata management tools and applications. • Create metadata management tools and applications only where none exist.
Data Leader / Senior Executive Leader (Chief Data Officer) **Data Specialist / Data Management Specialist (Data Services Team)**	• Coordinate and share information. • Promote the inventory of selected metadata tools and applications across the USAF.

Measurements

1. The percentage completion of an inventory of metadata tools and applications that best meet designated requirements.
2. Level of adoption and use of these tools across the authoritative government organizational units or office.

Outputs

1. List of requirements and standards that drive metadata tool and application selection process.
2. Authoritative government organizational units or Office inventory of metadata tools and applications that meet metadata management requirements. This inventory should include those already implemented throughout the USAF.

C.4 Phase 2: Implement and Manage Metadata

Create and Maintain Metadata (Practice 2.1)

Description

The purpose is to establish a repeatable approach to operationalize enterprise metadata management and meet Federal requirements for publishing metadata. (Obuch, 2018, p. 9)

Purpose

An organization creates or updates metadata using relevant standards and selected tools (see Use Case Priority 2 Select Metadata Management Tools). Maintaining an organization metadata catalog with metadata tags can (1) facilitate data community delineation and advanced metadata search for data discovery, data geographic location, and digital object identifiers, and (2) ensure minimum metadata requirements. A key component of this process is developing and maintaining business metadata.

Developing business metadata requires stakeholder engagement and buy-in across the organization, especially about consistent definitions for business and scientific terms. Once the terms are defined, they can be used across the organization for future data. Metadata and data release governance is important throughout the process of metadata creation and publication. Publishing metadata necessitates complete business, operational, and technical metadata based on Authoritative government organizational units or office needs, policies, and recommended best practices. For any data or metadata that might have sensitivity considerations, Authoritative Government Organizational Units and offices should consult with their Data Leader / Mission Execution Leader (Records Management), Data Leader / Mission Execution Leader (FOIA) staff, or other designated contacts responsible for proprietary data.(Obuch, 2018, p. 9)

Pre-Conditions

Authoritative government organizational units and Offices have identified staff with clear roles and responsibilities for this task. Standards, practices, and tools have been identified and are in place to support efforts related to this action. (Obuch, 2018, p. 9)

Responsibilities

Roles	Responsibilities
Authoritative Government Organizational Units / Office Scientists **Data Citizen / Data Citizen Advanced (Project/Task Administrators)** **Data Leader / Senior Executive Leader (Data Stewards)** **Data Specialist / Data Management Specialist (Data Creators)** **Data Specialist / Data Management Specialist (Data Producers)**	• Engage in metadata management implementation with assistance from other Authoritative Government Organizational Units or office representatives, as appropriate.

Measurements

1. Percent of datasets meeting the minimum population of standards-based metadata.
2. Percent of datasets with standards-compliant metadata.

3. Percent of metadata meeting or exceeding relevant quality standard(s).

Outputs

1. Metadata records with complete business, operational, and technical metadata for all authoritative government organizational units or office datasets.
2. Metadata records maintained in authoritative government organizational units or office metadata catalog or another application that can be published to the USAF Metadata Catalog.

Publish Metadata (Practice 2.2)

Description

The purpose is to increase data visibility and access through a consolidated index of metadata records. (Obuch, 2018, pp. 9-10)

Purpose

Once authoritative government organizational units or office has created complete metadata records, they should be published to the specified metadata catalog to create a searchable index of data assets. This metadata catalog provides a method to increase data visibility across the Department and for the public. Authoritative government organizational units or office might establish their own internal metadata catalog or partner to share metadata catalog technology. However, all and offices must register and publish metadata to the USAF Metadata Catalog, which was established by the USAF to facilitate a single source for all metadata (see Figure 9). In addition to being an enterprise-level source of metadata, the USAF Metadata Catalog system represents the source for USAF metadata provided to other catalogs (such as Data.gov). (Obuch, 2018, pp. 9-10)

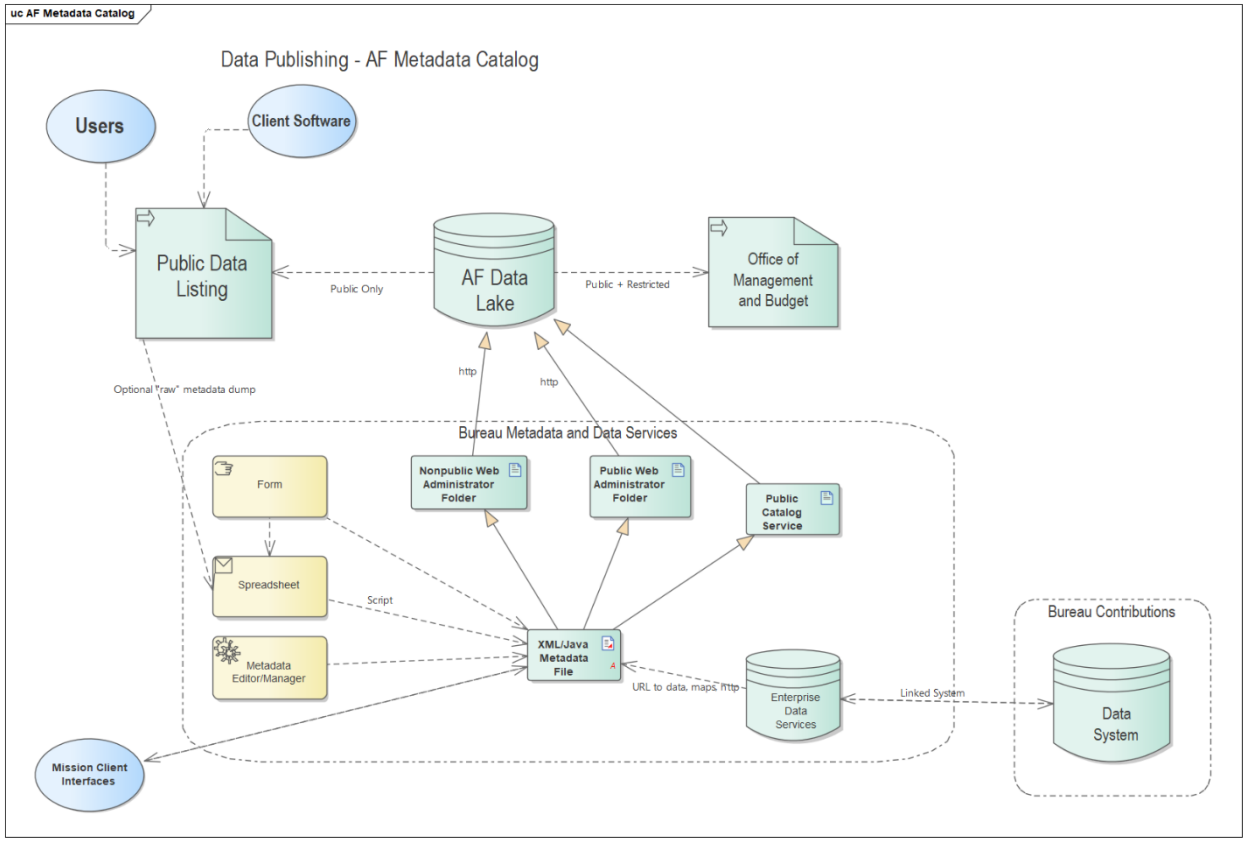

Figure 3. Publishing Metadata to the USAF Metadata Catalog

The DAF Data Leader / Senior Executive Leader (Chief Data Officer) provides support for implementation and maintenance of the USAF Metadata Catalog and ensures that there is the necessary staff with the technical capabilities to implement the USAF Metadata Catalog publishing procedures. (Obuch, 2018, pp. 9-10)

Authoritative government organizational units and offices need to prepare their respective meta-data prior to publishing them to the USAF Metadata Catalog. The following are items that each Authoritative Government Organizational units and Office should consider throughout the process: (Obuch, 2018, pp. 9-10)

1. Verify that all metadata records are designated appropri-ately as either public or nonpublic.
2. Validate currency, provenance, and links to the data to ensure metadata are accurate and trusted.
3. Adopt best practices and workflows about the external federated metadata catalog.
4. Ensure metadata requirements are included in, and being satisfied under, Authoritative Government Organizational Units or office grants, interagency or internal authoritative government organizational units' agreements, and contracts.
5. Metadata validation and data-quality checks should be completed prior to authoritative government organizational units or office publication. (Obuch, 2018, p. 10)

Responsibilities

Actors	Roles
DAF Data Leader / Senior Executive Leader (Chief Data Officer) **Data Specialist / Data Management Specialist (Data Governance Body)** **Data Specialist / Data Management Specialist (Data Services Team)**	• Provide technical tools and guidance with respect to the USAF Metadata Catalog and external metadata catalogs.
Data Leader / Mission Execution Leader (Key Authoritative Government Organizational Units/Office Personnel)	• Ensure that metadata publication is being executed in compliance with publication guidelines across the organization.

Output

Current USAF Metadata Catalog, with each metadata record flagged as public or nonpublic.

C.4 Phase 3: Improving Metadata Management

Evaluate Metadata Implementation (Practice 3.1)

Description

Evaluation may be needed when an authoritative government organizational unit or office considers improvement to its overall metadata management to prioritize the data domains and metadata areas that need improvement. Evaluations should be conducted on a recurring basis as part of metadata management. (Obuch, 2018, p. 11)

Purpose

Staff undertaking the evaluation must have sufficient knowledge of the organization and a clear understanding of the guidelines of metadata implementation. They should understand the questions that they are tasked with addressing and to whom the evaluation outcomes will be reported. For Organizations with existing metadata best practices and compliance standards, performance metrics and indicators need to be part of the organization's metadata management to enable adequate assessments. To evaluate user statistics, Data Specialist / Data Management Specialist (Data Creators) must be available to develop measurements to understand data consumption and use by internal users and cooperators and the public. Staff also needs support from web portal administrators to configure the proper analytical tools to capture web statistics and web survey responses. (Obuch, 2018, p. 11)

Pre-Conditions

Staff undertaking the evaluation must have sufficient knowledge of the organization and a clear understanding of the guidelines of metadata implementation. They should understand the questions that they are tasked with addressing and to whom the evaluation outcomes will be reported. For organizations with existing metadata best practices and compliance standards, performance metrics and indicators need to be part of the organization's metadata management to enable adequate assessments. To evaluate user statistics, Data Specialist / Data Management Specialist (Data Creators) must be avail-able to develop measurements to understand data consump-tion and use by internal users and cooperators and the public. Staff also needs support from web portal administrators to configure the proper analytical tools to capture web statistics and web survey responses. (Obuch, 2018, p. 11)

Responsibilities

Roles	Responsibilities
Data Leader / Senior Executive Leader (Authoritative Government Organizational Units/Office Leadership) **Data Specialist / Data Management Specialist (Data Creators)** **Data Leader / Mission Execution Leader (Metadata Management Leads)** **Data Specialist / Data Management Specialist (Web Administrators)** **Data Specialist / Data Management Specialist (Communications Staff)** **Data Leader / Senior Executive Leader (Data Stewards)**	• Develop metrics, surveys, and analyses to measure performance and participate in program evaluation.

Measurements

1. Ranking of the organization's data maturity level (see the capability maturity model integration's data management maturity capability levels (Capability Maturity Model Integration's Data Management Maturity (CMMI DMM)) and definitions in table 3).
2. Level of completion of recommendations to improve data maturity level based on identified metrics.
3. User statistics that indicate the number and type of end users, what data are being used, and how the data are being used.

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Table 3. Metadata management capability (maturity) levels of design structure matrix (DMS) (copyright CMMI Institute, 2014).

Level	Capability maturity indicators	Functional practices
1. Performed	Metadata documentation is developed, stored, and accessible.	Basic metadata documentation exists.
2. Managed	Metadata management follows a process, captures data interdependencies, and is used to perform impact analysis	Metadata process, interdependency documents, impact analysis, metadata architecture exist.
3. Defined	There is a metadata strategy promoted and maintained by governance. A metadata repository is populated with expanded metadata categories, management is centralized, and governance is integrally involved in development and maintenance of metadata.	Centralized functions, metadata strategy exists, and governance oversight is in place, process metrics are used, expanded architecture and implementation, architectural validation occurs.
4. Measured	An integrated meta-model is developed, metadata types and definitions are consistently applied, exchange data representation standards are addressed, metrics guide metadata improvements and quantitative objectives are developed and followed.	Integrated metadata model, consistent import, subscription, and consumption of data, metrics driven improvements, metric inspired additions, quantitative objectives, statistical analysis, exchange data standards
5. Optimized	Root cause analysis is performed to uncover problems, prediction models are used, quantitative objectives are derived from the metadata strategy and all changes are evaluated for impact, refined, and continuously improved.	Contribution to industry standards and best practices, adoption of industry standards and best practices. Data and metadata are seen as critical to long-term organizational survival.

Figure 4. Metadata Management Capability Levels of Design Structure Matrix (Obuch, 2018, p. 12)

Outputs

1. An evaluation that rates the maturity of metadata man-agement within the organization, and defines objectives and goals for organizational change.
2. A list of recommended approaches or activities that address perceived barriers to change, provide meaningful progress in the short term, and deliver successful outcomes in the long term.
3. A list of performance metrics and success indicators that are recommended for use by the organization's leadership to track progress.
4. Other recommended systems of metrics to focus time and energy and solve problems that may arise, for example, a list of metrics to track who is using the specific data being published, and how the data are being used.
5. Assignment of a person with a lead role and responsibility to be accountable to organizational management to follow up on recommendations and findings from the evaluation.

Develop and Enforce Metadata Quality Standards (Practice 3.2)

Description

The purpose is to provide consistently high-quality and robust documentation of data to conduct science and business activities and support authoritative government organizational units or office decision making. (Obuch, 2018, pp. 11-12)

Purpose

Metadata quality metrics indicate how well the metadata support program requirements, decision making, and current and future business demands. Validation helps assess the quality characteristics of the metadata, including their accuracy, completeness, currency, consistency, and integrity. The functions of metadata quality metrics and validation tools can be automated to process metadata more efficiently and consistently at the point of metadata creation. (Obuch, 2018, pp. 11-12)

Pre-Conditions

Data Specialist / Data Management Specialist (Data Professionals) need to have access to and engage with the authoritative government organizational units or office leads to document business requirements for metadata quality. Complete and functional metadata creation and validation tools need to be available to meet authoritative government organizational units or office metadata management requirements. End users will have received training on metadata quality require-ments and how to use metadata creation tools. (Obuch, 2018, pp. 11-12)

Responsibilities

Roles	Responsibilities
Business/Office Data Leader / Mission Execution Leader (Metadata Management Leads) **Data Leader / Mission Execution Leader (Business & Science Program/Mission Leads)** **Data Specialist / Data Management Specialist (Data Managers)** **Data Leader / Senior Executive Leader (Data Stewards)** **Data Specialist / Data Management Specialist (Metadata Creators)** **Data Leader / Mission Execution Leader (Open Data Points of Contact)** **Data Leader / Mission Execution Leader (Application Developers)**	• Obtain knowledge about metadata standards and how they are appropriately implemented.

Measurements

1. Approved and defined metadata quality metrics are implemented throughout the organization.
2. Metadata are scored against quality metrics.
3. Percentage of metadata that can be verified as authoritative.
4. Percentage of staff that has completed relevant training.
5. Adoption of approved metadata management tools.
6. Reduction of system-generated metadata quality exceptions.

Outputs

1. List of approved metadata quality requirements.
2. Metadata quality metrics.
3. Metadata authoring tool to help automate metadata QA/QC process and validation.
4. Approved metadata training program.
5. Metadata conversion tool to import and export metadata between standards.

Create Shared Metadata Infrastructure (Practice 3.3)

Description

The purposes are to create awareness and understanding of data and information resources, improve the value of the data and metadata implementation, and increase the efficiency with which metadata management requirements may be achieved by creating the necessary metadata management and content delivery infrastructure for federating metadata across the organization. Creating a single trusted source for organizational data enhances the user's ability to search, find, manage, and use authoritative government organizational units or office authoritative data on a routine basis. (Obuch, 2018, pp. 12-13)

Purpose

Roles and responsibilities, processes, and tools are defined and integrated into enterprise metadata management for collecting and executing metadata requirements. This includes all aspects of business, technical, and operational metadata. For example, authoritative government organizational units or office metadata catalog is created and maintained for managing unique references to authoritative data assets in a single access point and consistent view. The catalog includes a dashboard which addresses authoritative government organizational units or office needs for data search, discovery, and use. The catalog is a trusted source for accessing enterprise data that uses an agreed-upon business metadata repository (data dictionary) and serves as a shared medium of communication among all the organizational units. (Obuch, 2018, pp. 12-13)

Pre-Conditions

Authoritative government organizational units or office personnel must have the technical expertise for data and metadata management. Enterprise metadata management must also be integrated into business processes and functions, and receive enterprise support for continued process improvement and business system integration. Additionally, personnel must have technical expertise in installing, configuring, and running metadata catalog software, the computer server hardware necessary to run the catalog, and developer expertise required to facilitate the buildout of the catalog dashboard, metadata APIs, and any necessary tools and utilities. (Obuch, 2018, pp. 12-13)

Responsibilities

Roles	Roles
Data Specialist / Data Management Specialist (Data Professionals)	• Issue Guidance • Define Tasks • Establish business metadata requirements
Data Citizen / Data Citizen Advanced (Business Analysts)	• Create and maintain business metadata

Data Specialist / Data Management Specialist (Modelers) **Data Citizen / Data Citizen Advanced (Subject Matter Experts)**	
Data Leader / Senior Executive Leader (Data Stewards)	• Create and maintain business, technical, and operational metadata. • Support metadata functions and operational aspects of the catalog.
Data Citizen / Data Citizen Advanced (Program Staff)	• Create and maintain technical and operational metadata
Data Specialist / Data Management Specialist (Data Administrators) **Data Leader / Mission Execution Leader (Application Developers)**	• Stand up and operate the catalog
Data Leader / Mission Execution Leader (Executives) **Data Leader / Mission Execution Leader (Management)** **Data Specialist / Data Management Specialist (Investment Sponsors)**	• Support metadata functions and operational aspects of the catalog
Data Leader / Mission Execution Leader (Program Managers)	• Implement projects in compliance with guidance and best practices

Measurements

1. Increased number of records in the metadata catalog over time.
2. Percentage of lines of business contributing to and using the metadata catalog.
3. Average data catalog user session time to search, discover, and access data.
4. Number of projects or initiatives that reuse existing data.
5. Percentage of authoritative government organizational units or office data assets displayed in the catalog user interface.
6. Assessment of catalog content for uniqueness, relevance, and authority.
7. Percentage of metadata records that have been classified and tagged appropriately based on Data Specialist / Data Analytics Specialist (Data Security), Data Leader / Mission Execution Leader (Records Management), Data Leader / Mission Execution Leader (FOIA), Data Citizen / Data Citizen Advanced (Privacy), Data Citizen / Data Citizen Advanced (Legal), Data Citizen / Data Citizen Advanced (Communications), Data Leader / Mission Execution Leader (Acquisitions), and contracting administrative requirements.

Outputs

1. Standardized operating procedures, policies, protocols, governance, IT systems, and change management processes.
2. Documented workflow that cross-references Data Specialist / Data Analytics Specialist (Data Security), Data Leader / Mission Execution Leader (Records Management), Data Leader / Mission Execution Leader (FOIA), Data Citizen / Data Citizen Advanced (Privacy), Data Citizen / Data Citizen Advanced (Legal), Data Citizen / Data Citizen Advanced (Communications), Data Leader / Mission Execution Leader (Acquisitions), and contracting requirements.
3. A functioning metadata catalog infrastructure that provides critical metadata management capabilities to staff.
4. A harvest source for Authoritative Government Organizational Units or office metadata for publication to federated catalogs.

Increase Data Access and Usability (Practice 3.4)

Description

The purpose is to enable authoritative government organizational units and offices to make their data accessible, usable, understandable, and easily integrated in a specific context through customization of data

access and delivery mechanisms. An important ingredient to achieving open access for Federal data and metadata are standards for interoperability. (Obuch, 2018, pp. 13-14)

Purpose

Machines are programmed using API as a medium to access data. Standards for data access and transport help enable API interoperability and reuse. Metadata play an integral part in APIs by providing context to the data content and a gateway to intelligently access and display the data. For example, machines are programmed to obtain data from APIs for transformation into other usable formats or support web applications that (1) display data for various visualizations such as charts, graphs, maps, and map services, and (2) facilitate data download. APIs may also assist search and discovery through customized queries of metadata that can promote increased data reusability and integration across the organization. APIs are a relatively small investment that leverages the metadata investments of the government, enabling the development of numerous applications that exponentially multiply the number and kinds of access to data across the public, private, and government sectors. (Obuch, 2018, pp. 13-14)

Pre-Conditions

Authoritative government organizational units and offices need to have high-quality data and metadata that meet basic content and format standards to enable provision of data and information. In cases for which custom APIs will be created for serving Authoritative Government Organizational Units or office data, the requirements for serving data need to be understood and documented. API technical experts will need to work with the appropriate project team, Data Leader / Senior Executive Leader (Data Stewards) or creators, and Data Leader / Mission Execution Leader (Application Developers) to determine API requirements. For external audiences, the Authoritative Government Organizational Units and offices need to identify user communities that can be targeted for serving metadata and resulting data in a format that bests meets the end users' needs and expectations. Conducting a cost-benefit analysis of proposed APIs and using open-source standards to promote reusability and data interoperability will yield invest-ments that maximize overall benefit and favor the developer's recommendation to invest in new API technology. (Obuch, 2018, pp. 13-14)

Responsibilities

Roles	Responsibilities
Data Specialist / Data Management Specialist (Data Creators) **Data Leader / Senior Executive Leader (Data Stewards)** **Data Leader / Mission Execution Leader (Program Managers)** **Data Specialist / Data Management Specialist (Project/Task Leaders)** **Data Leader / Mission Execution Leader (Application Developers)**	• Identify requirements and development of APIs.

Measurements

1. APIs are registered in the USAF Metadata Catalog, using appropriate service level metadata documentation.
2. Percentage increase in the number of applications created and deployed.
3. Increased customer satisfaction.
4. Decreased user support requests.

Outputs

1. Strategic datasets are identified and prioritized for API development.
2. Open-source or community-maintained APIs are developed and implemented.
3. New API technology is created when API technology cannot be identified to support high priority requirements.
4. Policy and governance for API development, use, and dissemination.

Appendix D. Roles and Responsibilities

The table below associates roles with responsibilities and includes the associated reference for the action / practice that it supports. Note that these roles and responsibilities were extracted from the Department of the Interior Metadata Implementation Guide - Framework for Developing the Metadata Component for Data Resource Management (Obuch et al., 2018) and mapped to USAF metadata participants discussed in Annex 3 of this document..

This Table serves as a cross reference index for the roles throughout the document, but especially noted in the text and diagrams of practices / actions in Appendix C.

Roles - Split from Groupings	Responsibility Extracted and Associated	Practice / Action Number
Acquisitions	Gap Analysis	Practice 1.1. Identify Documentation Issues with Current Data Holdings
Agency Leadership	Participate in relevant groups.	Practice 1.4. Participate in Metadata Communities of Practice
Analytical Lab Personnel	Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task	Practice 1.3. Establish Roles and Identify Points of Contact
Application Developers (3)	Involved in the identification of requirements and development of APIs.	Practice 3.4. Increase Data Access and Usability
	Knowledgeable about metadata standards and how they are appropriately implemented.	Practice 3.2. Develop and Enforce Metadata Quality Standards
	Stand up and operate the catalog.	Practice 3.3. Create Shared Metadata Infrastructure
Authoritative Government Organizational Units / Offices	Help coordinate communications.	Practice 1.5. Develop Communication Strategy
Authoritative Government Organizational Units / Office Leadership (2)	Participate in relevant groups.	Practice 1.4. Participate in Metadata Communities of Practice
	Develop metrics, surveys, and analyses to measure performance and participate in program evaluation.	Practice 3.1. Evaluate Metadata Implementation
Authoritative Government Organizational Units/Office Scientists	Engaged in metadata management implementation with assistance from other Authoritative Government Organizational Units or office representatives, as appropriate.	Practice 2.1. Create and Maintain Metadata
Business Analysts	Responsible for creating and maintaining the business metadata.	Practice 3.3. Create Shared Metadata Infrastructure
Business and Science Program/Mission Leads	Knowledgeable about metadata standards and how they are appropriately implemented.	Practice 3.2. Develop and Enforce Metadata Quality Standards
Business Leads (2)	Provide input into metadata requirements, standards, and selection of appropriate metadata tools and applications.	Practice 1.7. Select Metadata Management Tools

Roles - Split from Groupings	Responsibility Extracted and Associated	Practice / Action Number
	Support metadata and data management. Request funds regarding metadata and data management at CDO Level. Operational support (people, time, money). Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task. Freedom of Information Act and Record Management coordination regarding published and unpublished data and information.	Practice 1.3. Establish Roles and Identify Points of Contact
Business Representatives	Responsible for identifying and implementing appropriate standards.	Practice 1.6. Identify Metadata Standards
Center Directors	Support and implement metadata and data management. Request funds regarding metadata and data management at The Authoritative Government Organizational Units Program level. Operational support (people, time, money). Performance metrics	Practice 1.3. Establish Roles and Identify Points of Contact
Chief Data Officer (CDO) (3)	Overarching agency policy, cross Authoritative Government Organizational Units and office coordination, strategy, standards, and guidance (templates), USAF motivation for compliance, evaluation metrics, technical tool guidance/toolbox. Office of Management and Budget reporting of the USAF Enterprise Data Inventory. Create and update implementation guide, metadata data quality, continuity, and legacy. Authoritative Government Organizational Units program level motivation for compliance. Overall Sponsorship.	Practice 1.3. Establish Roles and Identify Points of Contact
	Help coordinate communications.	Practice 1.5. Develop Communication Strategy
	Coordinate and share information and promote the inventory of selected metadata tools and applications across the enterprise.	Practice 1.7. Select Metadata Management Tools
Citizen Scientist	Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task that has a grant, contract, or external (citizen science) data collection component.	Practice 1.3. Establish Roles and Identify Points of Contact
Communications Staff (3)	Help coordinate communications.	Practice 1.5. Develop Communication Strategy
	Gap Analysis	Practice 1.1. Identify Documentation Issues with Current Data Holdings

Roles - Split from Groupings	Responsibility Extracted and Associated	Practice / Action Number
	Develop metrics, surveys, and analyses to measure performance and participate in program evaluation.	Practice 3.1. Evaluate Metadata Implementation
Contractors (2)	Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task that has a grant, contract, or external (citizen science) data collection component.	Practice 1.3. Establish Roles and Identify Points of Contact
	Gap Analysis	Practice 1.1. Identify Documentation Issues with Current Data Holdings
Data Architects	Provide much of the content for business metadata.	Practice 1.2. Scope Metadata Types
Data Collectors	Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task	Practice 1.3. Establish Roles and Identify Points of Contact
Data Creators (4)	Operational support for metadata and data management at the Project and task level.	Practice 1.3. Establish Roles and Identify Points of Contact
	Engaged in metadata management implementation with assistance from other Authoritative Government Organizational Units or office representatives, as appropriate.	Practice 2.1. Create and Maintain Metadata
	Involved in the identification of requirements and development of APIs.	Practice 3.4. Increase Data Access and Usability
	Develop metrics, surveys, and analyses to measure performance and participate in program evaluation.	Practice 3.1. Evaluate Metadata Implementation
Data Governance Body	Provide technical tools and guidance with respect to the OTTI Metadata Catalog and external metadata catalogs.	Practice 2.2 Publish Metadata
Data Management Professionals	Participate in relevant groups.	Practice 1.4. Participate in Metadata Communities of Practice
Data Manager (5)	Review metadata elements and registration requirements and evaluate the completeness of metadata records to facilitate data discovery and sharing based on Authoritative Government Organizational Units /office business and science needs. Perform a baseline inventory of data and metadata holdings, including digital and paper materials, to facilitate the identification and prioritization of next steps in metadata implementation and management. Gap Analysis.	Practice 1.1. Identify Documentation Issues with Current Data Holdings

Roles - Split from Groupings	Responsibility Extracted and Associated	Practice / Action Number
	Responsible for operational metadata - design and development of the physical implementation of the dataset and those involved with publication approval, hosting services, API development, and the delivery of the data.	Practice 1.2. Scope Metadata Types
	Provide input into metadata requirements, standards, and selection of appropriate metadata tools and applications.	Practice 1.7. Select Metadata Management Tools
	Support and implement metadata and data management. Request funds regarding metadata and data management at The Authoritative Government Organizational Units Program level. Operational support (people, time, money). Performance metrics	Practice 1.3. Establish Roles and Identify Points of Contact
	Knowledgeable about metadata standards and how they are appropriately implemented.	Practice 3.2. Develop and Enforce Metadata Quality Standards
Data Modelers	Responsible for creating and maintaining the business metadata.	Practice 3.3. Create Shared Metadata Infrastructure
Data Officers (with CDO Assistance)	Responsible for identifying and implementing appropriate standards.	Practice 1.6. Identify Metadata Standards
Data Originators (2)	Provide much of the content for business metadata.	Practice 1.2. Scope Metadata Types
	Provide input into metadata requirements, standards, and selection of appropriate metadata tools and applications.	Practice 1.7. Select Metadata Management Tools
Data Producers	Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task	Practice 1.3. Establish Roles and Identify Points of Contact
	Engaged in metadata management implementation with assistance from other Authoritative Government Organizational Units or office representatives, as appropriate.	Practice 2.1. Create and Maintain Metadata
Data Professions	Issue guidance, define tasks, and establish business metadata requirements.	Practice 3.3. Create Shared Metadata Infrastructure
Data Scientist	Review metadata elements and registration requirements and evaluate the completeness of metadata records to facilitate data discovery and sharing based on authoritative government organizational unit /office business and science needs. Perform a baseline inventory of data and metadata holdings, including digital and paper materials, to facilitate the identification and prioritization of next steps in metadata	Practice 1.1. Identify Documentation Issues with Current Data Holdings

Roles - Split from Groupings	Responsibility Extracted and Associated	Practice / Action Number
	implementation and management. Gap Analysis.	
Data Security Representatives (3)	Provide input into metadata requirements, standards, and selection of appropriate metadata tools and applications.	Practice 1.7. Select Metadata Management Tools
	Review metadata elements and registration requirements and evaluate the completeness of metadata records to facilitate data discovery and sharing based on authoritative government organizational unit /office business and science needs. Perform a baseline inventory of data and metadata holdings, including digital and paper materials, to facilitate the identification and prioritization of next steps in metadata implementation and management. Gap Analysis.	Practice 1.1. Identify Documentation Issues with Current Data Holdings
	Responsible for operational metadata - design and development of the physical implementation of the dataset and those involved with publication approval, hosting services, API development, and the delivery of the data.	Practice 1.2. Scope Metadata Types
Data Services Team (DST)	Help coordinate communications.	Practice 1.5. Develop Communication Strategy
	Coordinate and share information and promote the inventory of selected metadata tools and applications across the enterprise.	Practice 1.7. Select Metadata Management Tools
	Provide technical tools and guidance with respect to the OTTI Metadata Catalog and external metadata catalogs.	Practice 2.2 Publish Metadata

Roles - Split from Groupings	Responsibility Extracted and Associated	Practice / Action Number
Data Steward (13)	Review metadata elements and registration requirements and evaluate the completeness of metadata records to facilitate data discovery and sharing based on Authoritative Government Organizational Units /office business and science needs. Perform a baseline inventory of data and metadata holdings, including digital and paper materials, to facilitate the identification and prioritization of next steps in metadata implementation and management. Gap Analysis.	Practice 1.1. Identify Documentation Issues with Current Data Holdings
	Provide much of the content for business metadata.	Practice 1.2. Scope Metadata Types
	Responsible for operational metadata - design and development of the physical implementation of the dataset and those involved with publication approval, hosting services, API development, and the delivery of the data.	Practice 1.2. Scope Metadata Types
	Provide input into metadata requirements, standards, and selection of appropriate metadata tools and applications.	Practice 1.7. Select Metadata Management Tools
	Responsible for identifying and implementing appropriate standards.	Practice 1.6. Identify Metadata Standards
	Operational support for metadata and data management at the Project and task level.	Practice 1.3. Establish Roles and Identify Points of Contact
	Engaged in metadata management implementation with assistance from other Authoritative Government Organizational Units or office representatives, as appropriate.	Practice 2.1. Create and Maintain Metadata
	Involved in the identification of requirements and development of APIs.	Practice 3.4. Increase Data Access and Usability
	Develop metrics, surveys, and analyses to measure performance and participate in program evaluation.	Practice 3.1. Evaluate Metadata Implementation
	Knowledgeable about metadata standards and how they are appropriately implemented.	Practice 3.2. Develop and Enforce Metadata Quality Standards
	Responsible for creating and maintaining the business metadata.	Practice 3.3. Create Shared Metadata Infrastructure
	Create and maintain technical and operational metadata.	Practice 3.3. Create Shared Metadata Infrastructure
	Support metadata functions and operational aspects of the catalog.	Practice 3.3. Create Shared Metadata Infrastructure

Roles - Split from Groupings	Responsibility Extracted and Associated	Practice / Action Number
Executives (2)	Support metadata and data management. Request funds regarding metadata and data management at the Program level. Operational support (people, time, money).	Practice 1.3. Establish Roles and Identify Points of Contact
	Support metadata functions and operational aspects of the catalog.	Practice 3.3. Create Shared Metadata Infrastructure
Freedom Of Information Act (FOIA) (3)	Gap Analysis	Practice 1.1. Identify Documentation Issues with Current Data Holdings
	Support metadata and data management. Request funds regarding metadata and data management at CDO Level. Operational support (people, time, money). Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task. Freedom of Information Act and Record Management coordination regarding published and unpublished data and information.	Practice 1.3. Establish Roles and Identify Points of Contact
	Provide input into metadata requirements, standards, and selection of appropriate metadata tools and applications.	Practice 1.7. Select Metadata Management Tools
Grantees	Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task that has a grant, contract, or external (citizen science) data collection component.	Practice 1.3. Establish Roles and Identify Points of Contact
Investment Sponsors	Support metadata functions and operational aspects of the catalog.	Practice 3.3. Create Shared Metadata Infrastructure
Authoritative Government Organizational Units and Office Personnel	Provide technical tools and guidance with respect to the OTTI Metadata Catalog and external metadata catalogs.	Practice 2.2 Publish Metadata
	Ensure that metadata publication is being executed in compliance with publication guidelines across the organization.	Practice 2.2 Publish Metadata
Key Stakeholders	Participate in relevant groups.	Practice 1.4. Participate in Metadata Communities of Practice
Legal	Gap Analysis	Practice 1.1. Identify Documentation Issues with Current Data Holdings

Roles - Split from Groupings	Responsibility Extracted and Associated	Practice / Action Number
Lines of Business Representatives	Review metadata elements and registration requirements and evaluate the completeness of metadata records to facilitate data discovery and sharing based on Authoritative Government Organizational Units /office business and science needs. Perform a baseline inventory of data and metadata holdings, including digital and paper materials, to facilitate the identification and prioritization of next steps in metadata implementation and management. Gap Analysis.	Practice 1.1. Identify Documentation Issues with Current Data Holdings
Management	Support metadata functions and operational aspects of the catalog.	Practice 3.3. Create Shared Metadata Infrastructure
Metadata Creators	Operational support for metadata and data management at the Project and task level.	Practice 1.3. Establish Roles and Identify Points of Contact
	Knowledgeable about metadata standards and how they are appropriately implemented.	Practice 3.2. Develop and Enforce Metadata Quality Standards
Metadata Management Leads	Develop metrics, surveys, and analyses to measure performance and participate in program evaluation.	Practice 3.1. Evaluate Metadata Implementation
	Knowledgeable about metadata standards and how they are appropriately implemented.	Practice 3.2. Develop and Enforce Metadata Quality Standards
Metadata Technical Leads	Evaluate metadata requirements against existing metadata management tools and applications and create metadata management tools and applications only where none exist.	Practice 1.7. Select Metadata Management Tools
Modelers	Provide much of the content for business metadata.	Practice 1.2. Scope Metadata Types
Open Data Points of Contact	Support and implement metadata and data management. Request funds regarding metadata and data management at The Authoritative Government Organizational Units program level. Operational support (people, time, money). Performance metrics	Practice 1.3. Establish Roles and Identify Points of Contact
	Knowledgeable about metadata standards and how they are appropriately implemented.	Practice 3.2. Develop and Enforce Metadata Quality Standards
Other	Help coordinate communications.	Practice 1.5. Develop Communication Strategy
Principal Investigators	Support metadata and data management. Request funds regarding metadata and data management at the Program level. Operational support (people, time, money).	Practice 1.3. Establish Roles and Identify Points of Contact

Roles - Split from Groupings	Responsibility Extracted and Associated	Practice / Action Number
Privacy	Gap Analysis	Practice 1.1. Identify Documentation Issues with Current Data Holdings
Program Administrators	Support metadata and data management. Request funds regarding metadata and data management at CDO Level. Operational support (people, time, money). Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task. Freedom of Information Act and Record Management coordination regarding published and unpublished data and information.	Practice 1.3. Establish Roles and Identify Points of Contact
Program Managers (2)	Involved in the identification of requirements and development of APIs.	Practice 3.4. Increase Data Access and Usability
	Implement projects in compliance with guidance and best practices.	Practice 3.3. Create Shared Metadata Infrastructure
Program Staff	Create and maintain technical and operational metadata.	Practice 3.3. Create Shared Metadata Infrastructure
Project/Task Managers	Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task	Practice 1.3. Establish Roles and Identify Points of Contact
Project/Task Administrators (2)	Support metadata and data management. Request funds regarding metadata and data management at CDO Level. Operational support (people, time, money). Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task. Freedom of Information Act and Record Management coordination regarding published and unpublished data and information.	Practice 1.3. Establish Roles and Identify Points of Contact
	Engaged in metadata management implementation with assistance from other Authoritative Government Organizational Units or office representatives, as appropriate.	Practice 2.1. Create and Maintain Metadata
Project/Task Leads	Involved in the identification of requirements and development of APIs.	Practice 3.4. Increase Data Access and Usability
Public Scientist	Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task that has a grant, contract, or external (citizen science) data collection component.	Practice 1.3. Establish Roles and Identify Points of Contact

Roles - Split from Groupings	Responsibility Extracted and Associated	Practice / Action Number
Records Management (3)	Review metadata elements and registration requirements and evaluate the completeness of metadata records to facilitate data discovery and sharing based on Authoritative Government Organizational Units /office business and science needs. Perform a baseline inventory of data and metadata holdings, including digital and paper materials, to facilitate the identification and prioritization of next steps in metadata implementation and management. Gap Analysis.	Practice 1.1. Identify Documentation Issues with Current Data Holdings
	Support metadata and data management. Request funds regarding metadata and data management at CDO Level. Operational support (people, time, money). Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task. Freedom of Information Act and Record Management coordination regarding published and unpublished data and information.	Practice 1.3. Establish Roles and Identify Points of Contact
	Provide input into metadata requirements, standards, and selection of appropriate metadata tools and applications.	Practice 1.7. Select Metadata Management Tools
Scientists	Support metadata and data management. Request funds regarding metadata and data management at CDO and Program Levels. Operational support (people, time, money). Adherence to metadata and data standards, QA/QC, and overall metadata operational implementation within a project or task. Freedom of Information Act and Record Management coordination regarding published and unpublished data and information.	Practice 1.3. Establish Roles and Identify Points of Contact
Subject Matter Experts	Provide much of the content for business metadata.	Practice 1.2. Scope Metadata Types
	Responsible for creating and maintaining the business metadata.	Practice 3.3. Create Shared Metadata Infrastructure
System Administrators	Stand up and operate the catalog.	Practice 3.3. Create Shared Metadata Infrastructure
System Manager (2)	Responsible for operational metadata - design and development of the physical implementation of the dataset and those involved with publication approval, hosting services, API development, and the delivery of the data.	Practice 1.2. Scope Metadata Types
	Operational support for metadata and data management at the Project and task level.	Practice 1.3. Establish Roles and Identify Points of Contact

Roles - Split from Groupings	Responsibility Extracted and Associated	Practice / Action Number
Web Administrators	Develop metrics, surveys, and analyses to measure performance and participate in program evaluation.	Practice 3.1. Evaluate Metadata Implementation

Appendix E. Process Flow Diagrams for Recommended Practices

The following process flow diagrams correspond with the individual recommended practices discussed in Appendix C.

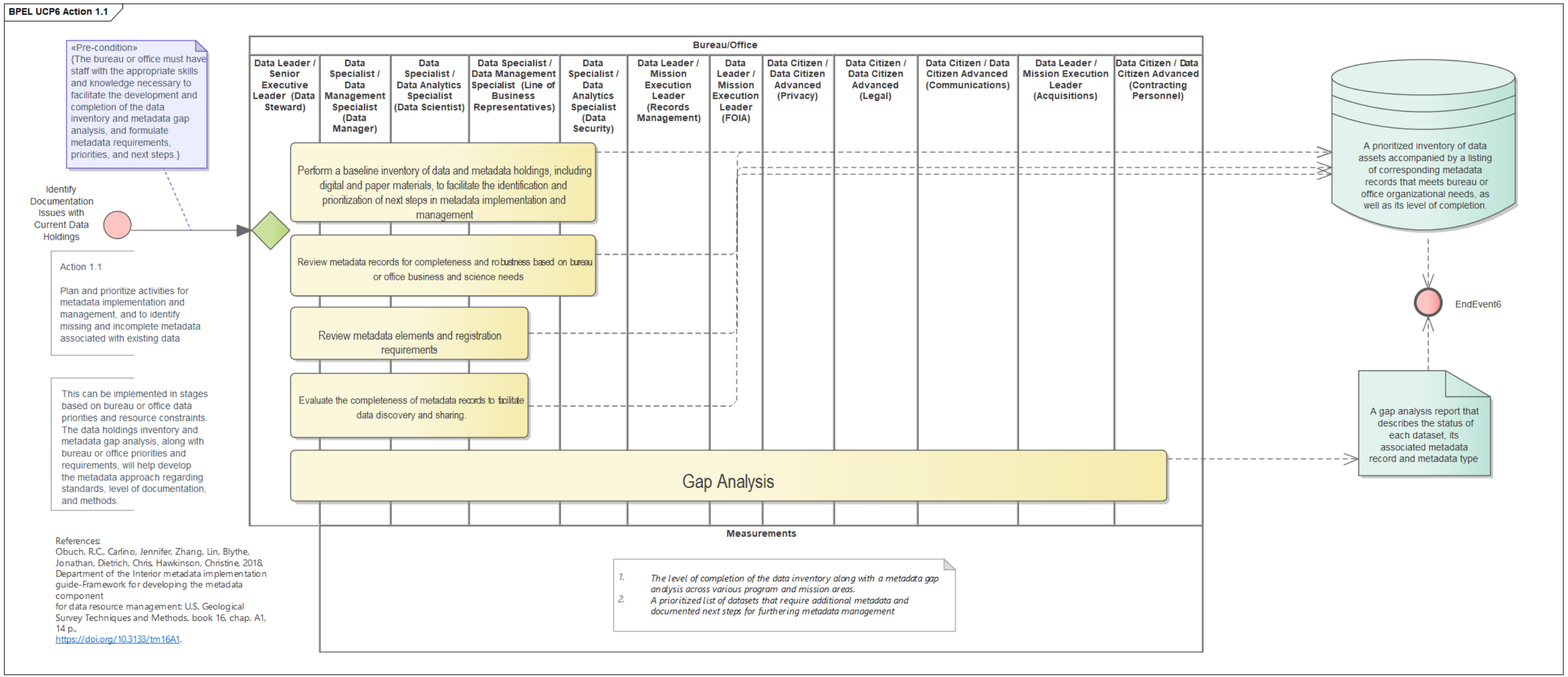

Figure E1. Identify Documentation Issues with Current Data Holdings (1.1)

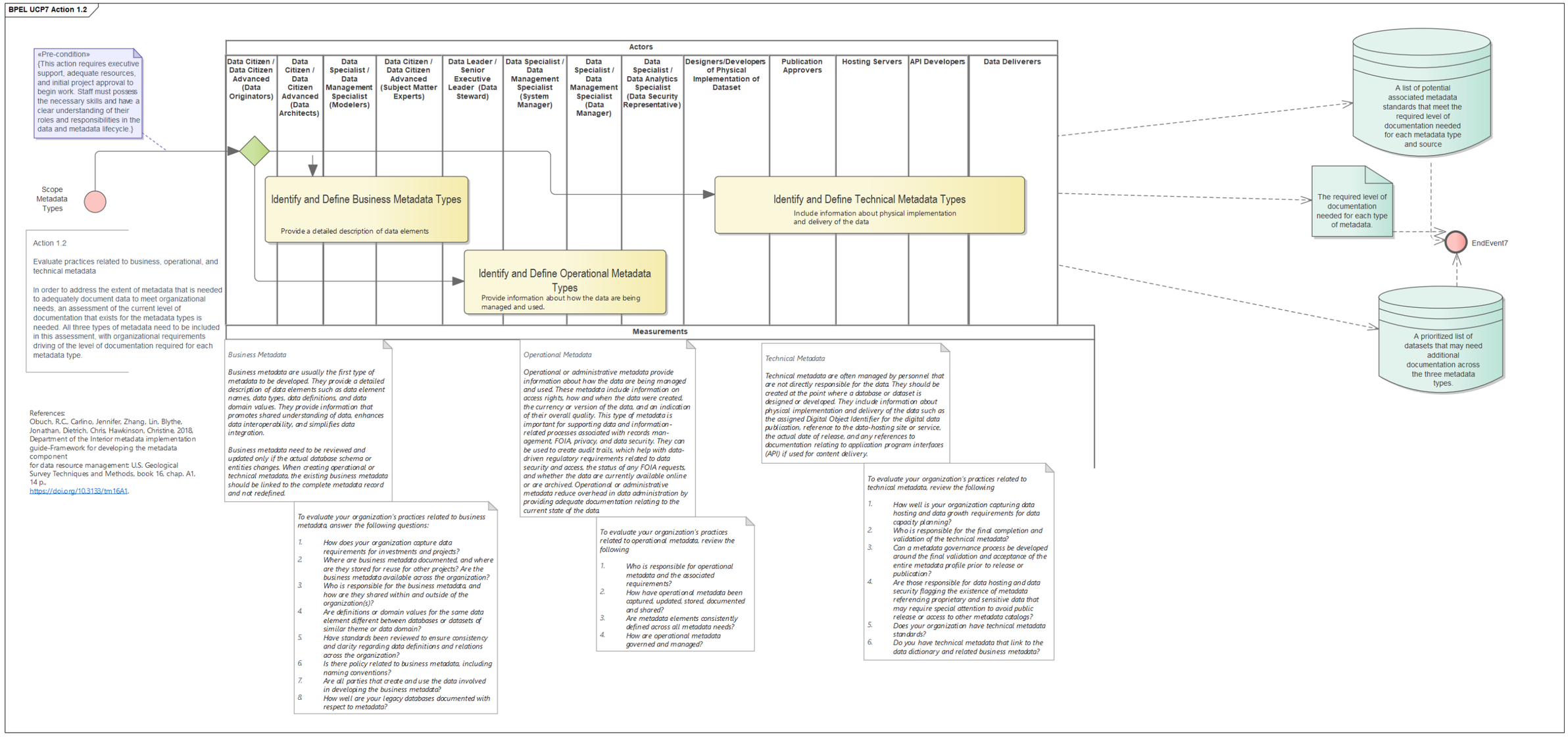

Figure E2. Scope Metadata Types (1.2)

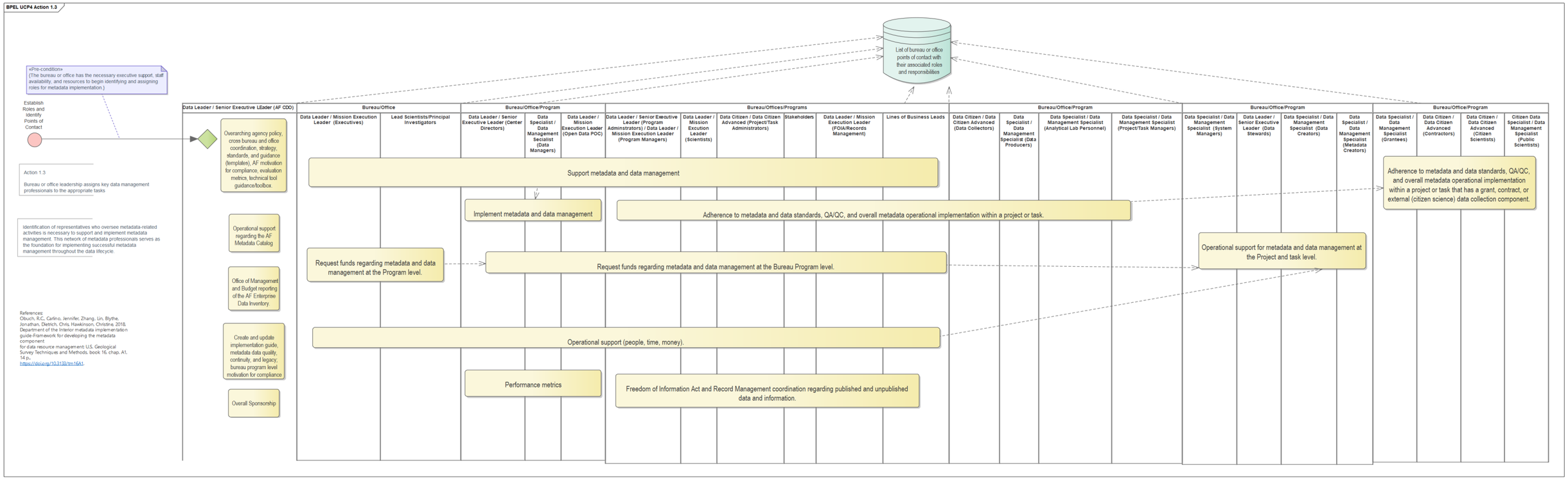

Figure E3. Establish Roles and Identify Points of Contact (1.3)

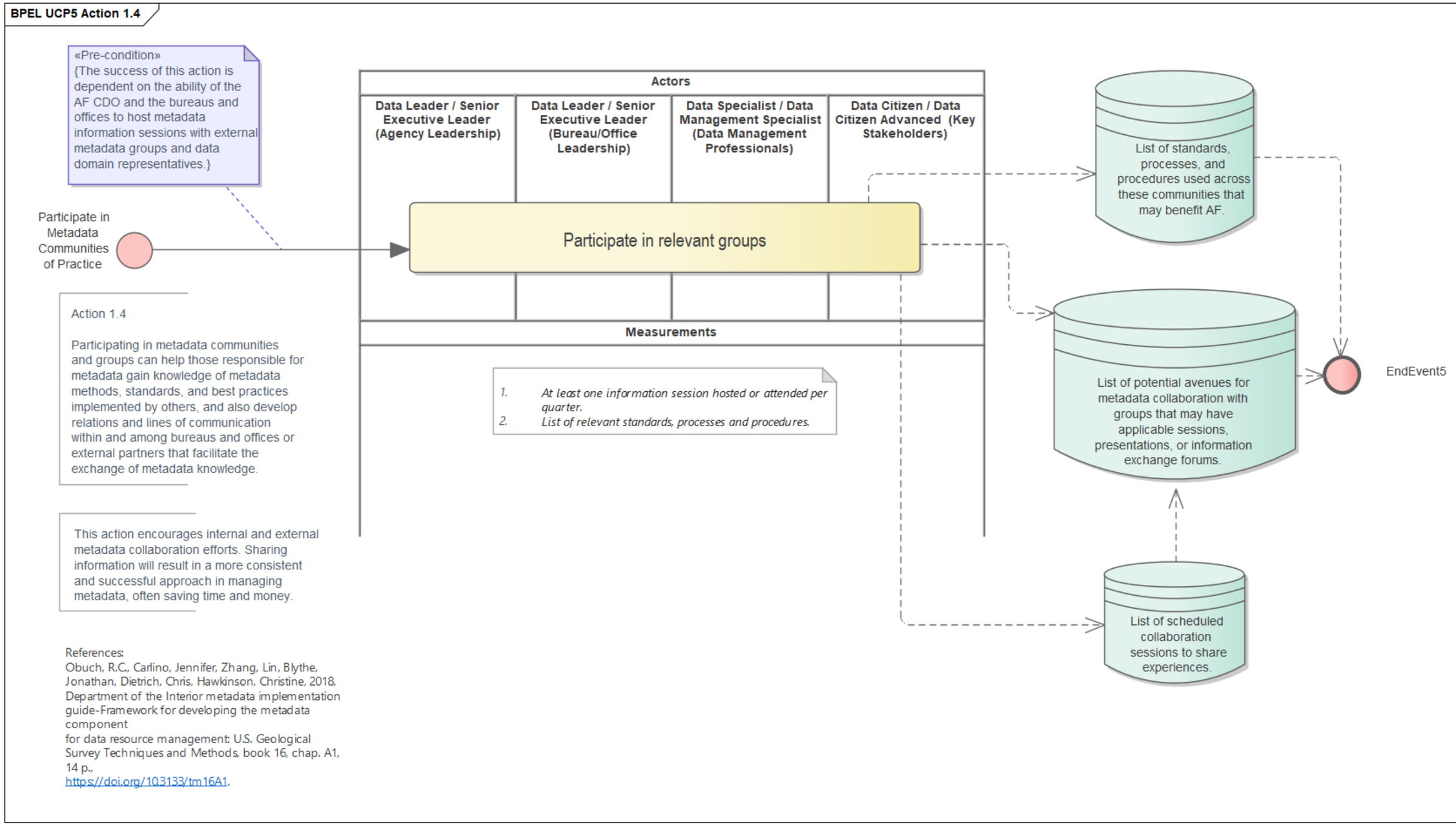

Figure E4. Participate in Metadata Communities of Practice (1.4)

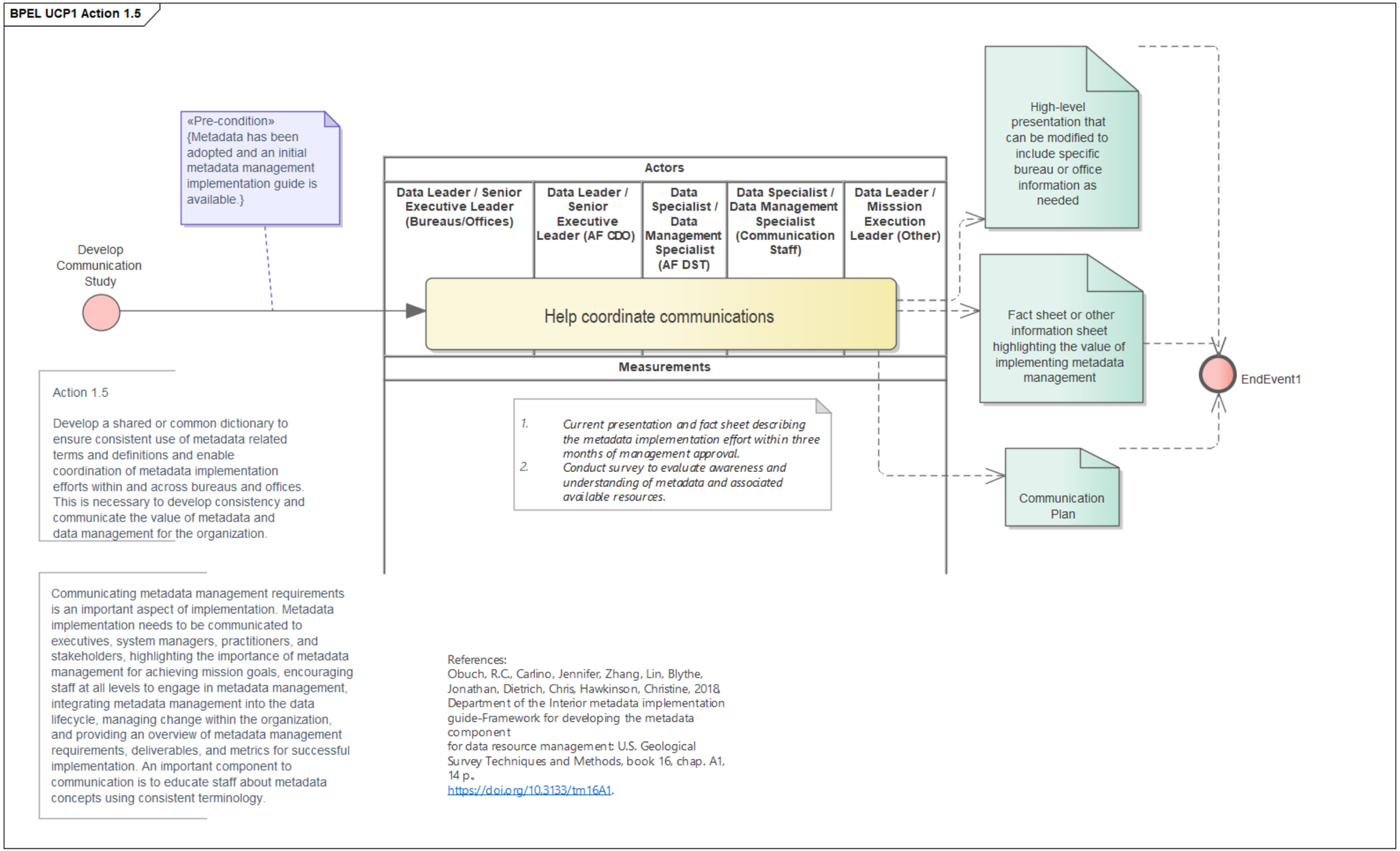

Figure E5. Develop Communication Strategy (1.5)

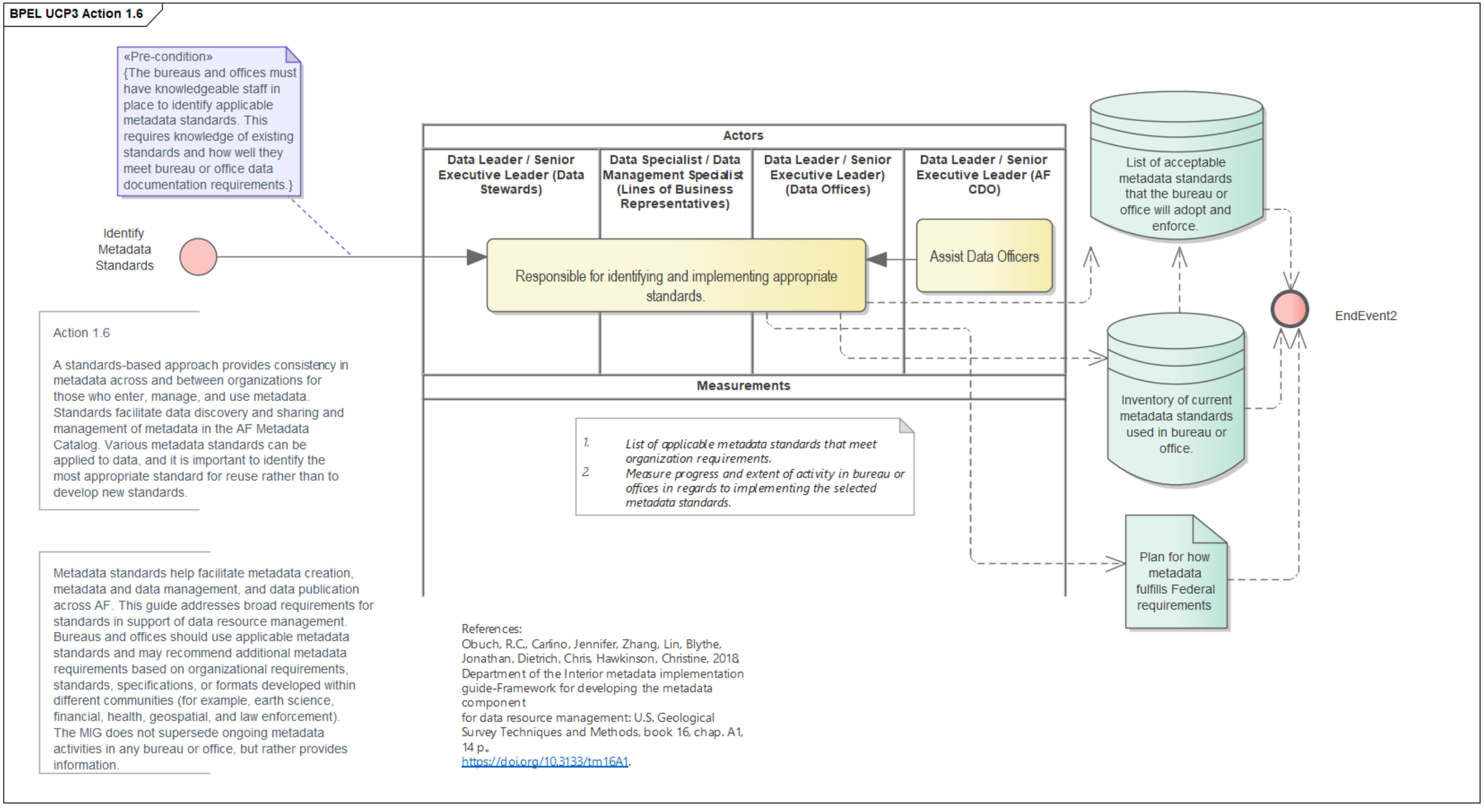

Figure E6. Identify Metadata Standards (1.6)

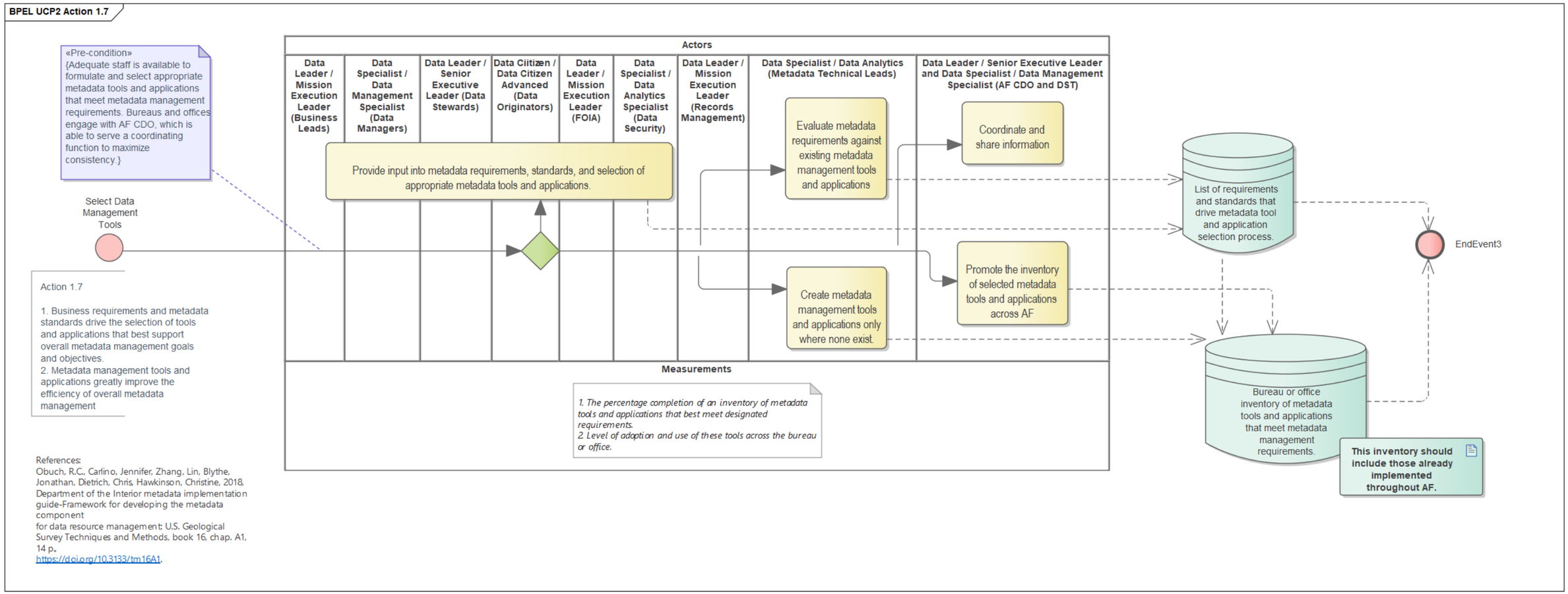

Figure E7. Select Data Management Tools (1.7)

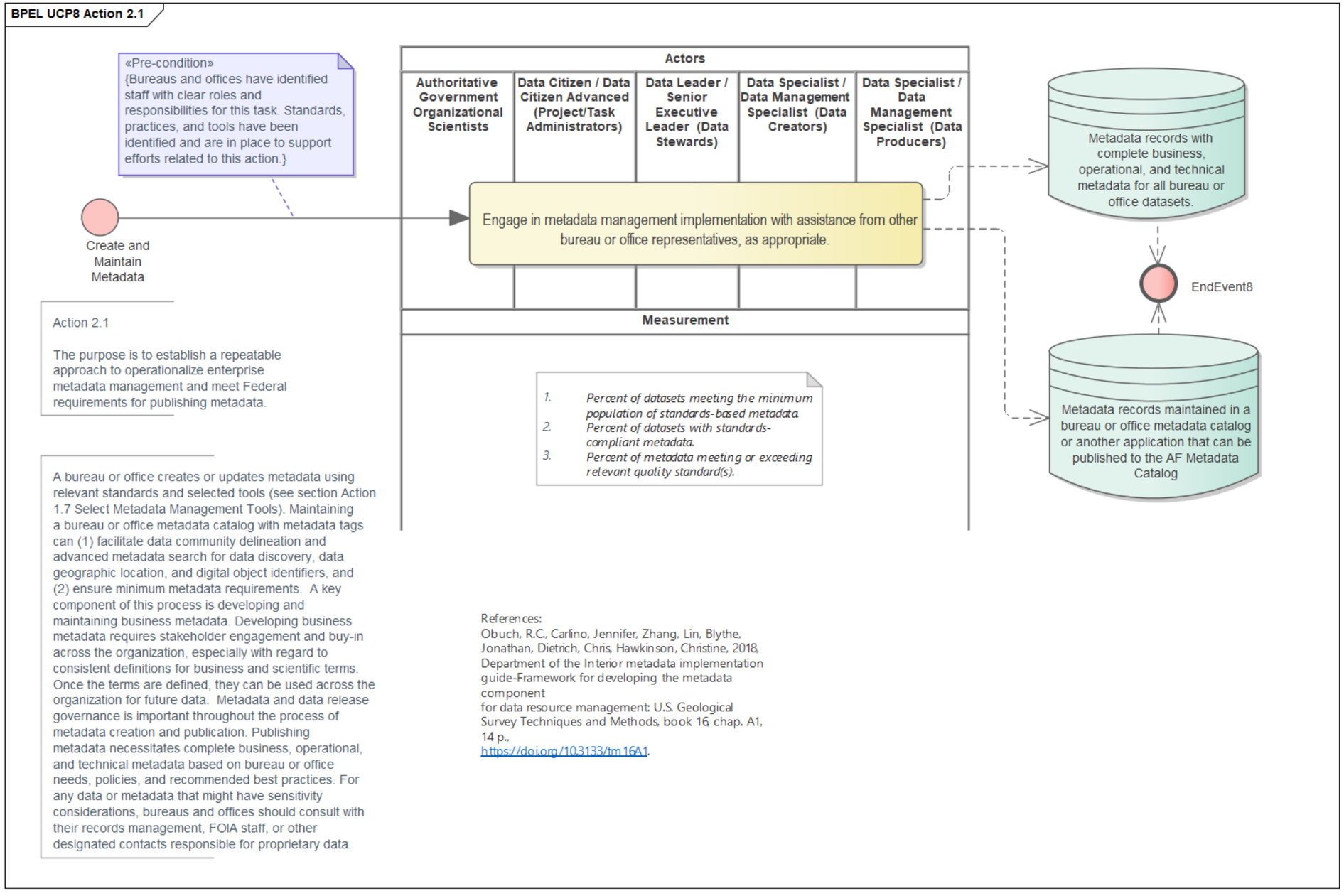

Figure E8. Create and Maintain Metadata (2.1)

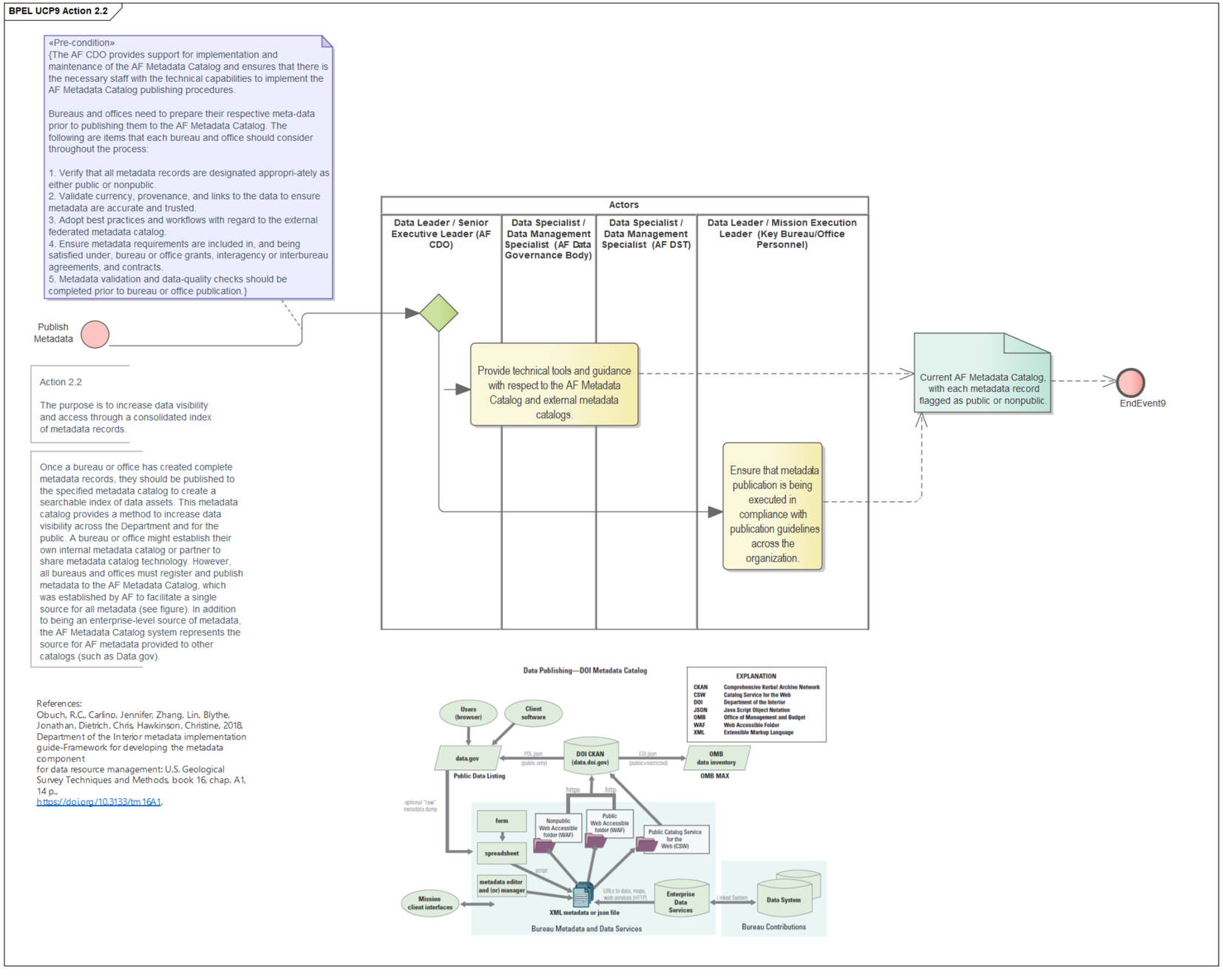

Figure E9. Publish Metadata (2.2)

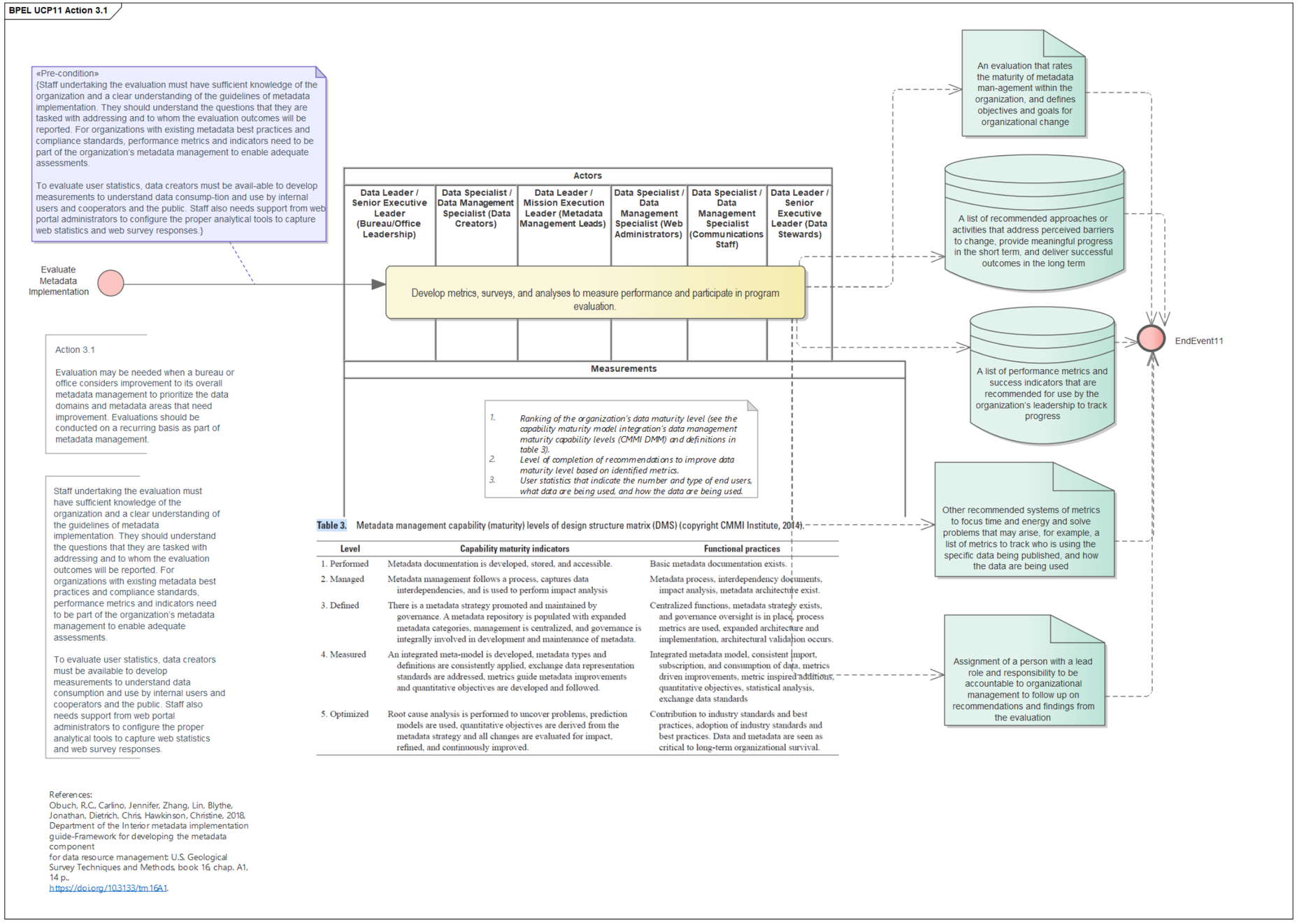

Table 3. Metadata management capability (maturity) levels of design structure matrix (DMS) (copyright CMMI Institute, 2014).

Level	Capability maturity indicators	Functional practices
1. Performed	Metadata documentation is developed, stored, and accessible.	Basic metadata documentation exists.
2. Managed	Metadata management follows a process, captures data interdependencies, and is used to perform impact analysis	Metadata process, interdependency documents, impact analysis, metadata architecture exist.
3. Defined	There is a metadata strategy promoted and maintained by governance. A metadata repository is populated with expanded metadata categories, management is centralized, and governance is integrally involved in development and maintenance of metadata.	Centralized functions, metadata strategy exists, and governance oversight is in place, process metrics are used, expanded architecture and implementation, architectural validation occurs.
4. Measured	An integrated meta-model is developed, metadata types and definitions are consistently applied, exchange data representation standards are addressed, metrics guide metadata improvements and quantitative objectives are developed and followed.	Integrated metadata model, consistent import, subscription, and consumption of data, metrics driven improvements, metric inspired additions, quantitative objectives, statistical analysis, exchange data standards
5. Optimized	Root cause analysis is performed to uncover problems, prediction models are used, quantitative objectives are derived from the metadata strategy and all changes are evaluated for impact, refined, and continuously improved.	Contribution to industry standards and best practices, adoption of industry standards and best practices. Data and metadata are seen as critical to long-term organizational survival.

Figure E10. Evaluate Metadata Implementation (3.1)

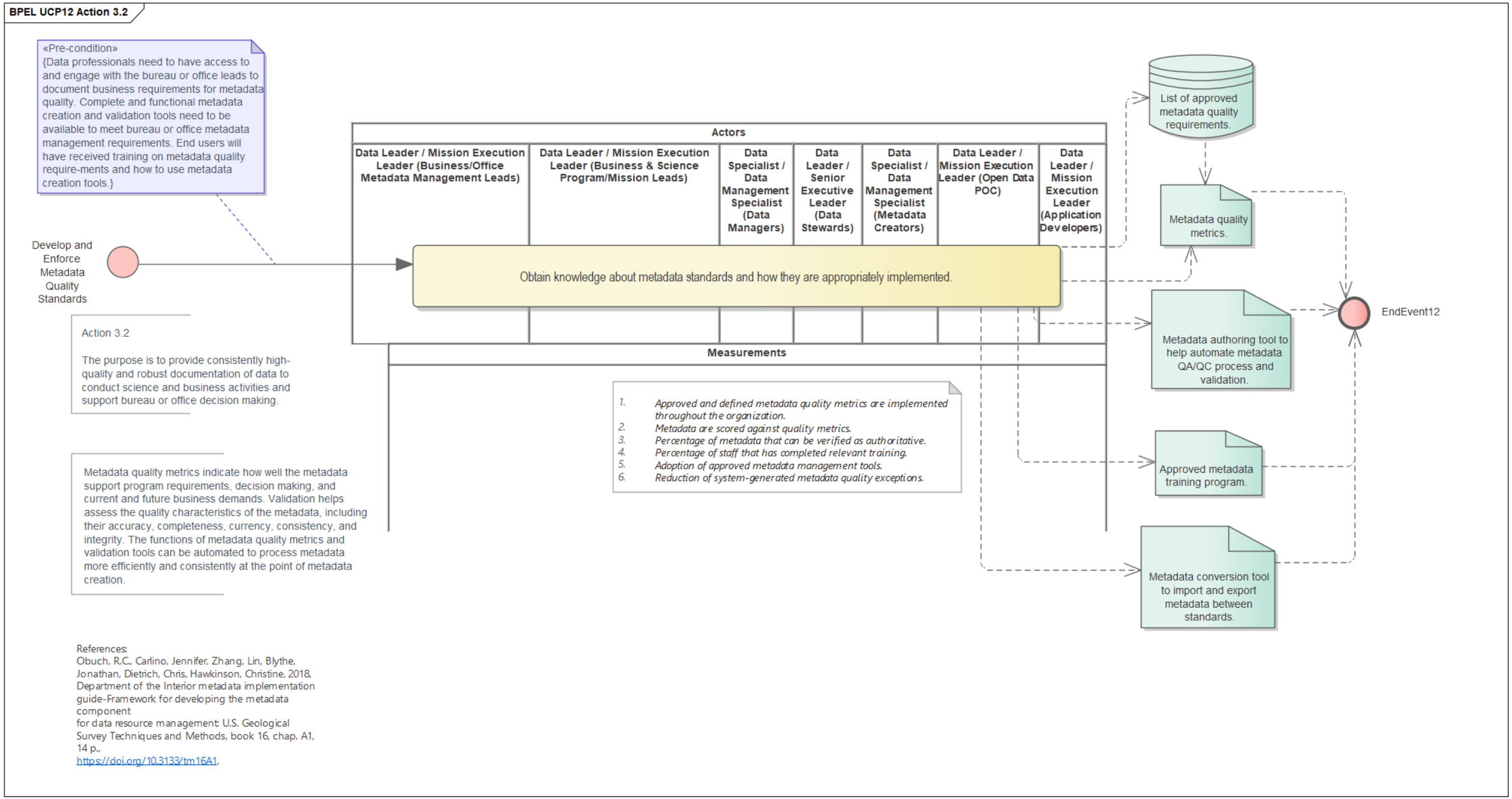

Figure E11. Develop and Enforce Metadata Quality Standards (3.2)

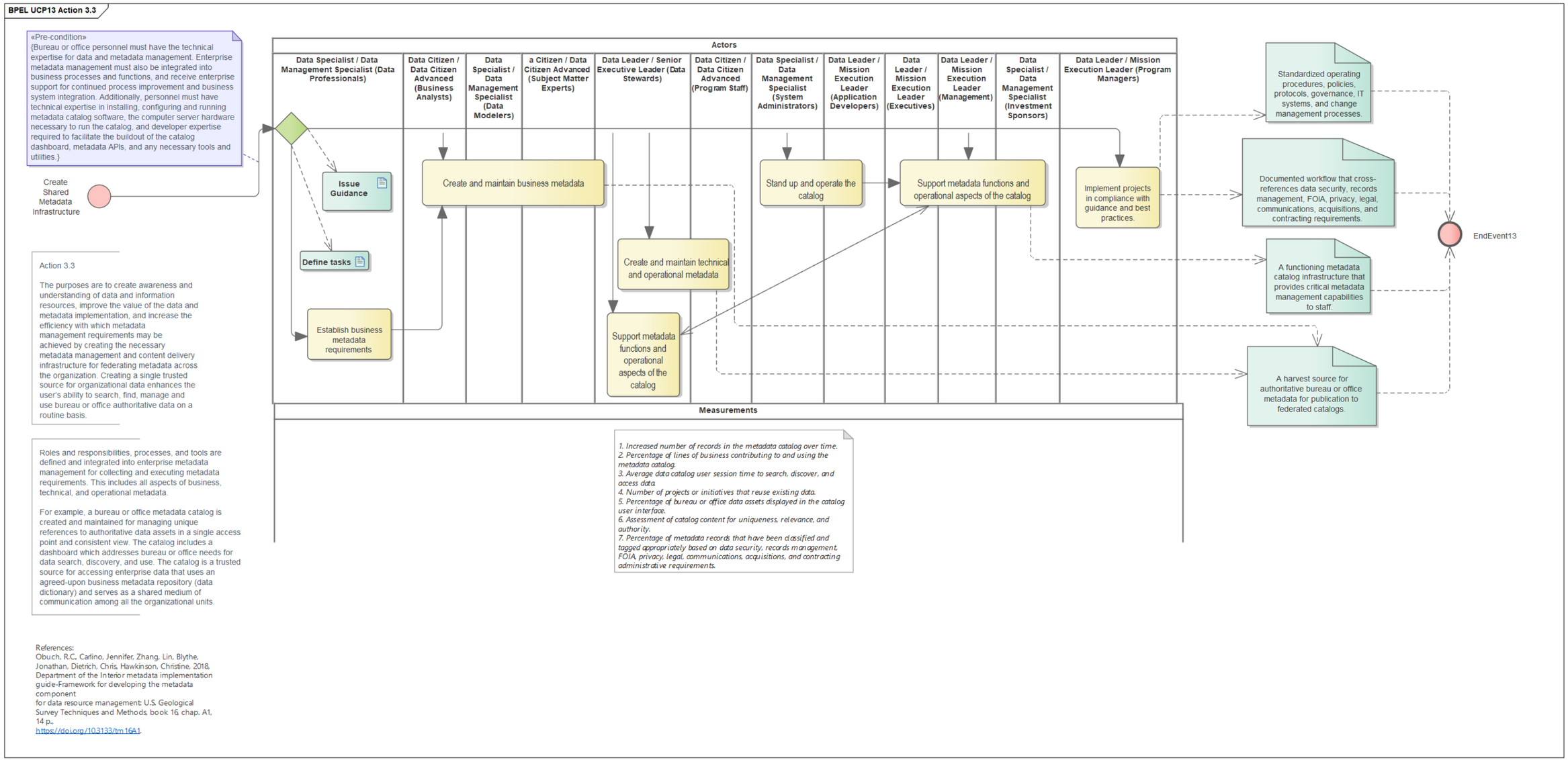

Figure E12. Create Shared Metadata Infrastructure (3.3)

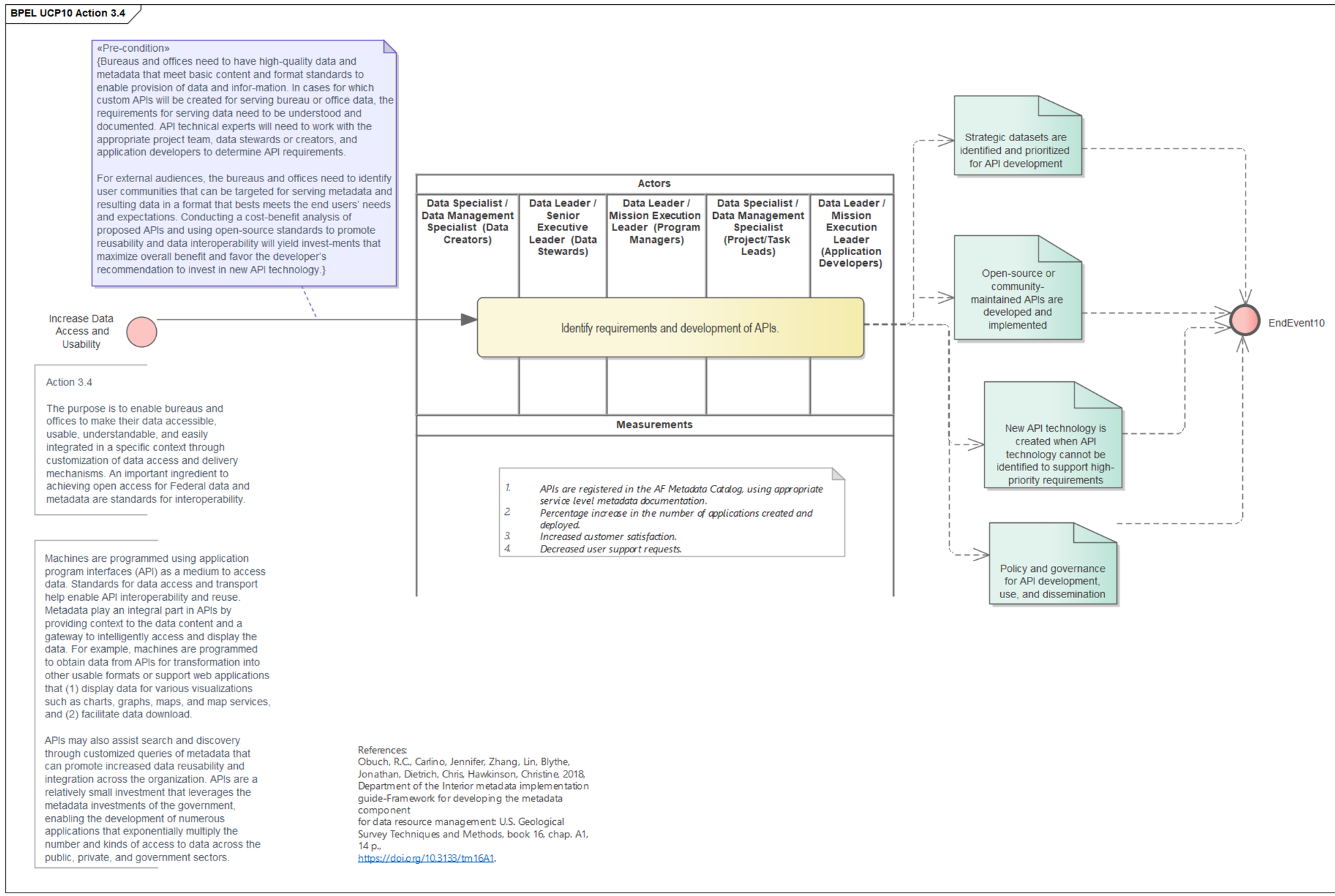

Figure E13. Increase Data Access and Usability (3.4)