Army Unified Data Reference Architecture

From the
Assistant Secretary of the Army for Acquisition, Logistics, and Technology
and
Army Chief Information Officer

V 1.1

September 6, 2024

Revision History

Version	Release Date	Revision Description	Released By
0.1	26 OCT 2022	Initial draft of data product description.	Mr. Dan Andrew ASA(ALT), DASA(DES)
0.2	31 MAR 2023	Addition of a logical grouping of mesh and domain services with a functional decomposition.	Mr. Dan Andrew ASA(ALT), DASA(DES)
0.3	15 SEP 2023	Addition of data domain and governance sections, and updates from industry recommendations on Version 0.2.	Mr. Dan Andrew ASA(ALT), DASA(DES)
1.0	22 MAR 2024	Initial version coordinated between DASA(DES) and CDAO Staffs.	Dr. David M. Markowitz Chief Data and Analytics Officer YOUNG J. BANG Principal Deputy, ASA (Acquisition, Logistics and Technology)
1.1	06 SEP 2024	Updates to 1.0 include refinements and clarifications to align with the DoD Metadata Guidance, revised order of select service activities, and updates to corresponding activity diagrams.	Ms. Velissa Postadan ASA(ALT), DASA(DES)

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1. Unified Data Reference Architecture (UDRA) Description

1.1. Challenge

The U.S. Army's current data architecture is complex and focused on networks, systems, and message protocols for moving and sharing data. This architectural focus creates excessive data duplication and retention, reduces data sharing, and impedes data-driven decision dominance. The Army must transition from its current network/systems-centric architecture to become a data-centric force. Faster on-demand data delivery to decision makers will enable accelerated mission execution and success, as directed by the Secretary of the Army.[1]
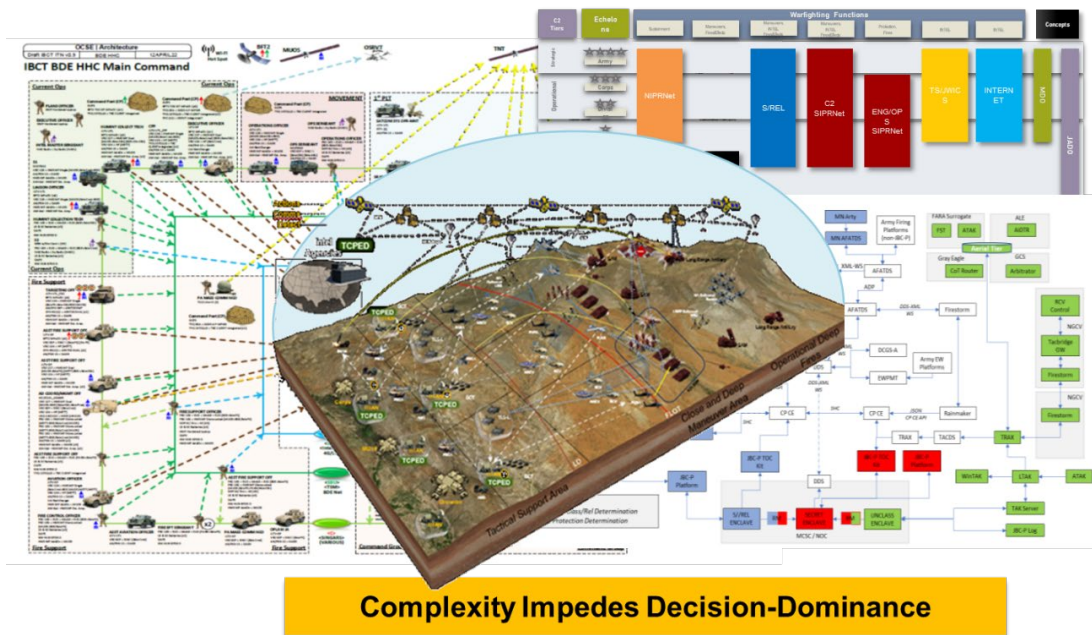
Figure 1. Present Data Architecture Complexity Impedes U.S. Army's Decision-Dominance

1.2. Unified Data Reference Architecture

To address this challenge, the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT)) Deputy Assistant Secretary of the Army (DASA) for Data, Engineering, and Software (DES) has defined this Unified Data Reference Architecture (UDRA). This UDRA introduces data mesh principles to flatten and simplify the Army's data architecture, streamline data product sharing across mission partners, and support data-driven decision making at greater speed and scale.

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[1] *Secretary of the Army Message to the Force*, 8 February 2022.

This UDRA aligns with *DoD Data Strategy* goals, the Department of Defense (DoD) Chief Digital and Artificial Intelligence Officer (CDAO) data mesh approach, the U.S. *Army Data Plan*, and the *Decision-Driven Data Concept of Operations (CONOPS)*. [2,3,4,5] This UDRA provides the means to meet Soldiers' needs for data by incorporating feedback mechanisms to drive data product content and quality. It describes and defines services for self-service data product discovery and consumption. This UDRA includes transport-agnostic data exchanges that support the full range of networks at all echelons, reducing replication and persistence of data. It also leverages federated governance and enables automated enforcement of global and local governance policies. This UDRA decentralizes responsibility and authority for data products to improve data quality and scale the Army's ability to share data products between data domains. Ultimately, this UDRA will guide acquisition of data-centric capabilities and increase the Army's effectiveness as part of a combined/joint warfighting force.

Generally speaking, UDRA is a concept and is not a system or Program of Record (PoR). However, as a reference architecture, this UDRA provides PoRs and Program and Product Managers (PMs/PdMs) with guidance on right and left boundaries for the design and implementation of solutions (including people, procedures, technology, and tradeoffs) which deliver required capabilities to the warfighter. This UDRA further defines the data ecosystem identified in the *Decision-Driven Data CONOPS,* and UDRA-compliant contract language will apply to new capability development and acquired industry solutions. This UDRA will provide the standard for measuring solution compliance and conformance.

The Army CDAO and Army Data Board are responsible for the Army's data governance organization and policies. Nothing in this UDRA is intended to contradict or supersede their policies and guidance. This UDRA provides a reference architecture based on data mesh principles to enable efficient and effective execution of Army CDAO data governance. Specifically, Computational Governance enables systems to perform automated enforcement of the policies established by proper data governance authorities.

1.3. Key Terms and Definitions

This section includes key terms and definitions arranged in conceptual order. Additional detail and terms are provided in Appendix F.

Data Ecosystem – The collection of people, processes, and tools needed to produce Soldier-driven domain-owned data products enabling analytics needed for decision dominance. (Source – Collaborative effort between ASA(ALT)/DASA(DES) and Training and Doctrine Command (TRADOC)/Mission Command Center of Excellence (MCCoE), 2022)

Data Mesh – A data architecture based on a federated and decentralized approach to analytical data production, management, and sharing. It is characterized by federated governance, self-

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[2] *DoD Data Strategy*, 30 Sep 2020.
[3] *Improving Data Quality*, DoD CDAO, February 2023.
[4] *Army Data Plan*, October 2022.
[5] *Decision-Driven Data CONOPS*, Version 1.0, 6 July 2023.

service infrastructure platforms, treating and providing data as a product, and autonomous data domains which are responsible for their data.

Data Domain – An organization[6] having specific functional expertise which produces data products to share information with consumers and may consume data products produced by other data domains. Army implementation of a data domain is defined by Army governance. The designated Mission Area Data Officer identifies data domains within the mission area and assigns a Data Steward to provide governance and policy controls over that domain.

Data Set – A collection of related data items without the required curation and packaging for use in the data mesh. In the UDRA, a data product team uses their domain-owned and other data set(s) to produce data products that satisfy the information needs of their consumers.[7]

Data Product – Logically pre-packaged data and associated metadata produced to satisfy consumers' mission or business demand. Data products are designed to be high quality, easy to use, self-describing and computationally governed.

Mesh Services – A collection of automated services for the production, consumption, orchestration, and interoperable sharing of data products.

Data Platform – A set of modular open system technologies and infrastructure used to securely manage data within a domain. Data platforms enable data domains to produce, expose, retrieve, and consume data mesh-conforming data products.

Computational Governance – The automated enforcement of governance policies through the application of computational methods.

End-User Device – An individual computer, workstation, or a mobile device used by commanders, staff, or Soldiers to obtain and utilize the data product(s) for their intended purpose in support of decision making.

1.4. Guiding Principles

As a guiding philosophy, this UDRA is Soldier-driven[8], domain-owned, and data product based to accelerate the operational tempo of people, processes, technology, and governance policy

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[6] This could constitute a subset of an organizational unit or an aggregation of organizational units as established by the CDAO and Army Data Board.

[7] A data product differs from a data set in that a data product has been curated by the data owning subject matter experts (SMEs) to contain the information needed to support specific decisions. This information payload is packaged with metadata and the description fields that are defined by the domain owner. Sharing data products instead of data sets allows the data owner to better control what data is exposed and how it is used. Additionally, consumers receive only the information they need with established quality control.

[8] Soldier-driven, here, means U.S. Army Soldiers are empowered to make decisions and operate their platforms that both create and utilize data products across this UDRA. See the *Decision-Driven Data CONOPS* for more details on data empowering Soldiers.

enforcement to enable faster data-driven decision making and mission execution. This UDRA is based on the guiding principles outlined below.

- Information and data are produced, exchanged, and consumed across the Army enterprise in the form of discoverable data products which align with *DoD Data Strategy* Visible, Accessible, Understandable, Linked, Trusted, Interoperable, and Secure (VAULTIS) goals.

- Data products are available for consumption by consumers on a self-service basis.

- Data product production and hosting are decentralized rather than centralized.

- Data product design and schemas are owned and controlled by the data domain which produces the data product.

- Data product metadata is tightly coupled to the data product and includes all information needed to discover, select, retrieve, and effectively consume and use the data product.

- Data products will be produced and improved in response to consumer demand and feedback.

- Data product production, consumption, and orchestration for interoperable sharing will be transport-agnostic to support a full range of networks.

- Data products can be produced by processing and aggregating source data and/or data products produced by other data domains.

- Consumers do not persist, duplicate, or share the data products they receive. However, a data domain may create aggregate data products that are derived from source data and upstream data products.

- Computational Governance will enable automated enforcement of data governance policies.

- Service implementations will be consistent with a modular open systems approach and will be based on open standards for application programming interfaces (APIs).

These UDRA principles will evolve rather than remain static. As updates to this UDRA are developed, additional principles may be identified, defined, approved, and implemented.

2. Data Mesh Description

2.1. User Story: Data Mesh is Simple

This "Data Mesh is Simple" story highlights the actors, components, and processes that are required for adapting the data mesh concept to the Army data architecture. When applying this concept to support Army missions, the key actor is the decision maker or commander. This actor drives the data product demand signal with his/her/their questions and data needed to make informed decisions. This data need or demand signal is highlighted in the *Decision-Driven Data CONOPS*.

Governors (human and computational) are required for efficient and effective application of data mesh principles in the Army data architecture. Human governors, at both the data mesh and local data domain levels, are responsible for defining the policies that govern data products. Policies are encoded in machine readable form to enable computational governors to perform automated policy enforcement. The governance policies to support data product production, consumption, orchestration, and overall sharing of data products across the data ecosystem are stored and available for discovery and retrieval as necessary.

Producer data domains use data sources and/or data products to synthesize new data products and make them available for data product consumption. Data products are consumed by obtaining and utilizing them (e.g., by analyzing and/or displaying) to support the decision maker or commander.

The envisioned key functions, actors, and roles of the UDRA data mesh concept are depicted in Figure 2.
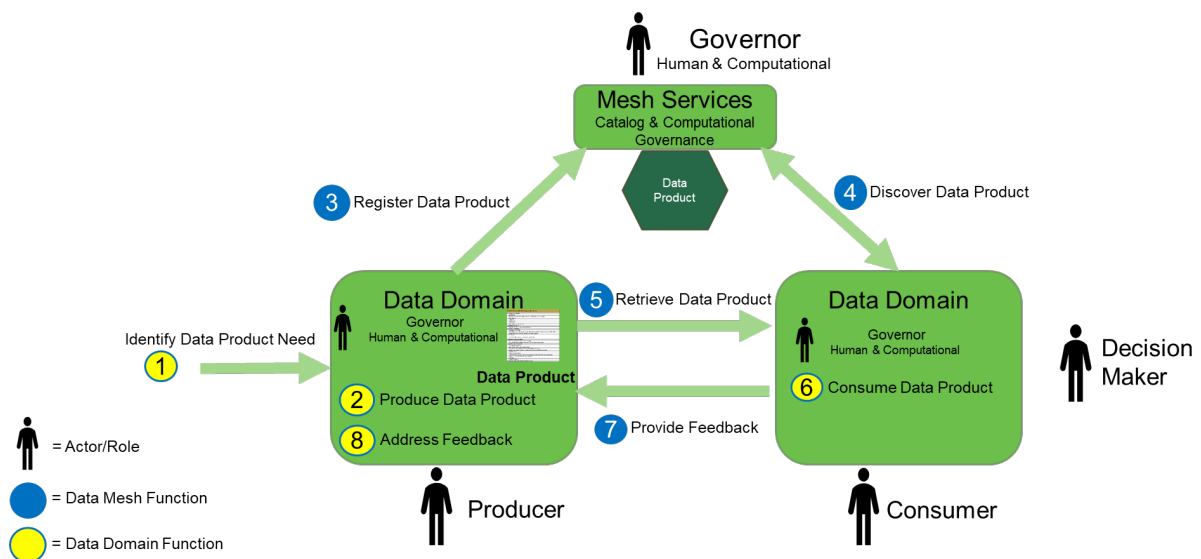
Figure 2. Data Mesh Key Functions, Actors, and Roles

The primary goal of the data mesh services is to enable production, consumption, orchestration, and interoperable sharing of data products within the data ecosystem. The process shown above illustrates how the services and activities of data product production, consumption, and orchestration interact with each other to exchange and consume data products. The following paragraphs are numbered to relate them to the illustration above, but the numbering is not meant to prescribe constrained sequential execution of the individual steps or that this is the only possible sequence of data product exchange activities.

2.1.1 Identify Data Product Need (1)

The decision maker requires data to make informed decisions. This prompts their staff – the consumers – to begin the process of searching for data products to meet the decision maker's need. This is in line with the *Decision-Driven Data CONOPS* and aligns well with the military decision making process and published Army doctrine.

2.1.2 Produce Data Product (2)

When it receives a request for a new data product, the producer data domain may use sensor feeds, stored data sets, information streams, and existing data products produced internally or by external data domains to meet the requested data need. These data sources and data products are collected, curated, transformed, and packaged into a data product. The resulting data product consists of both the data needed to satisfy the demand signal and the complete metadata describing and governing the data product.

2.1.3 Register Data Product (3)

The producing data domain registers that data product with the data product discovery service and catalogs it for subsequent discovery by potential consumers. Registering the data product does not move the data product to a centralized location. Data products remain within the data domain that produces them. Registering the data product provides identifying and descriptive metadata for data product discovery. The required metadata and additional description fields are provided in Table 1 and Table 2 of Section 3, and examples of each are illustrated in Appendix B.

2.1.4 Discover Data Product (4)

When a consumer determines a need for data/information, they will begin the discovery process within the data catalog. Data product discovery may be automated (e.g., employ artificial intelligence or machine Learning-based methods) or manual (e.g., the consumer performs a search or query for data products by title, producing data domain, keywords, or other criteria). In either case, the consumer receives metadata about candidate data products which may meet their needs. The consumer then reviews the data products; and if satisfactory options are found, the consumer selects and retrieves the data products for their consumption or use. If no satisfactory existing data product(s) are discovered, the consumer will generate a request for a new data product.

2.1.5 Retrieve Data Product (5)

The data domain's data platform or the end-user device retrieves the relevant information from the data product's metadata-specified endpoint at the producer data domain.

2.1.6 Consume Data Product (6)

Upon receipt, the data product will either be consumed by a data domain to synthesize new data products, and/or consumed by end users for analysis, visualization, and decision support. New data products are subsequently registered and shared for consumption.

2.1.7 Provide Feedback (7)

Providing data product feedback is critical to the data mesh concept. The consumer informs the producer data domain when/if the quality of the data product does not match service level objectives, or improvements to the data product are needed. If policies for conformance, verification and/or validation of the data product have been defined, then this feedback will be automated, to the maximum extent possible, via computational governance.

2.1.8 Address Feedback (8)

The feedback provided by a consumer is addressed by the producer data domain. Feedback may be about the quality, timeliness, or other data product characteristics that require improvement or adjustment. The producer data domain will determine and take the appropriate course of action that may include responses such as correcting the data product, updating the data product's service level objectives, or enhancing the data product.

An operationally relevant description of the above data mesh activities supporting an Army mission is provided in Section 5 (service activities) and Appendix D (activity diagrams).

3. Data Product Description

3.1. Defining a Data Product

A key principle of the UDRA data mesh concept is "data as a product." The producer data domain typically produces a data product in response to a data product need identified by a commander (decision maker). As defined in subsection 1.3 (*Key Terms and Definitions*), a data mesh-conforming data product is a logically pre-packaged set of required metadata, description fields, and a subset of data containing information (known as payload data) needed for a commander's decision making.

A data product differs from a traditional data set with its accompanying metadata and in the way that it is managed. A data product's lifecycle is driven by "product-oriented thinking," mirroring the way consumer products are offered commercially. It is designed to meet or exceed the needs of its consumer. It is maintained and improved based on consumer feedback, and can be recalled if found to be faulty. This is a mindset change that transcends the act of attaching metadata to a data set and exposing or sharing that data set.

UDRA-conforming data products comply with mandated Army Data Services Requirements (DSRs)[9] and achieve the *DoD Data Strategy* VAULTIS goals through inclusion of the required metadata fields. In addition to the required metadata, a set of extensible description fields are available to the producing data domain for enhancing a data product's useability, discoverability, and computational governance. Use of these fields is determined by the data domain's data governance policies. Lastly, an UDRA-conforming data product includes payload data that contains the information needed to support a specific decision and is retrieved directly from a producer data domain by a consumer. Figure 3 illustrates these three parts of a data product.

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[9] Secretary of the Army, Memorandum, subject: *Mandatory Implementation of Army Data Services Requirements*, dated 10 April 2020.
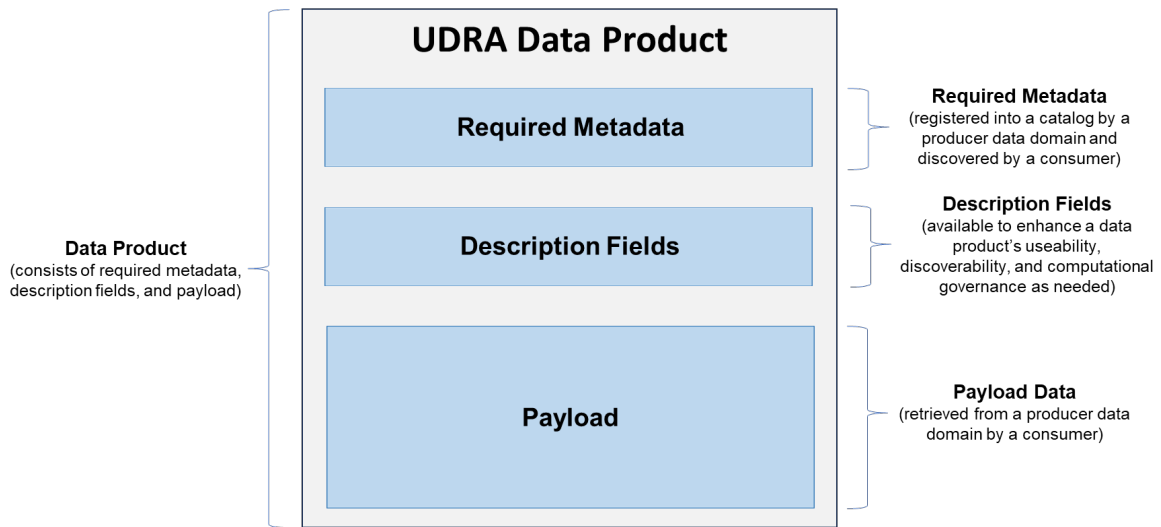
Figure 3. UDRA Data Product View

A data product's required metadata, description fields, and payload are created and maintained by a data domain. A detailed data domain description is provided in Section 4.

Data products are developed for use by decision makers to answer immediate needs as well as for analysis, visualization, and/or aggregation into other data products. Data products may be analyzed or curated subsets of data, reports, documents, machine learning models, or other modes and forms of data which support decision making. Data domains register their data products so that users can intuitively and autonomously discover, understand, retrieve, and ingest data products for exploitation. Data products expose data using open standards and formats to maximize interoperability across data domains. However, there are situations where data domains may produce data products only for their own internal use. Such data products are not registered for discovery and consumption by other data domains.

In addition, data products are:

- Owned and produced by a data domain which consumes one or more sources of data or data products or both.

- Shared directly with data users/consumers.

- Adherent to a set of usability characteristics.

- Independent in that they have their own lifecycle and model which are managed independently of other data products.

A data product may be a result of the conflation of authoritative data products from more than one contributing data domain. In this case, the data domain conducting and managing the conflation is the owner of the output data product.

Although a data product's metadata is registered in a catalog to support discovery of the data product, the data product's payload is hosted by the producing data domain. The data product catalog supports the registration and discovery of each individual data product.

Given potential multiple interpretations of the term "metadata," it is important to note that this UDRA considers metadata and the extensible description fields to be integral parts of the data product. Data domain-specified extensions to the description fields are also considered to be integral parts of the data product. A summary of the required metadata is listed in Table 1, and a summary of the description fields is listed in Table 2. Additionally, examples of each are provided in Appendix B.

3.2. Data Product Metadata and Amplifying Description Fields

Since metadata standards are abundant and mature, UDRA applies the *DoD Metadata Guidance* to specify required metadata fields and the approved DoD standards and specifications registered in the DoD Information Technology Standards Registry (DISR) for data product description fields and payloads. Solutions implementing UDRA should maximize the use of existing data models, specifications, and data encodings to maintain interoperability across DoD solutions.

UDRA recommends that data domains consider using the Information Security Markup (ISM)[10] combined with the Information Resource Metadata (IRM) to fully tag data product payloads. Lacking direct support of these standards, this UDRA specifies a subset of metadata fields required to register a data product for discovery by consumers.

Additional amplifying description fields will be used to enhance data product useability, discoverability, and computational governance. The description fields may be extended to meet specific needs determined by a data domain. For example, a field such as "*geospatialCoverage*" could be included in a geospatially referenced data product. Required metadata and description fields must be tightly coupled to the data product payload (by value or reference), to ensure usability and consistency with the data product.

> *To illustrate data product metadata, a real-life analogy to a can/bottle of soda/pop can be considered. When the can is held, the entire data product is being held. The liquid inside the product is the payload or content. The can that holds the liquid is the container, and the writing on the can describes what is inside (metadata for the consumer). By looking closely at the labeling on the container, various information can be discovered such as nutritional facts about the content, ingredients, who the product is distributed by and their location, and the location where the product was produced as well as a sell by date (indicating the duration of the product's life) and a bar code providing a unique identifier for the product. The size or volume of the content/soda and the*

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[10] Information Security Marking Metadata (ISM - https://www.dni.gov/index.php/who-we-are/organizations/ic-cio/ic-technical-specifications/information-security-marking-metadata) and/or Information Resource Metadata (IRM - https://www.dni.gov/index.php/who-we-are/organizations/ic-cio/ic-technical-specifications/information-resource-metadata), last accessed 5 September 2024

calories per serving can also be discovered on the label. All this information is provided for the consumer to be able to make data-driven decisions relevant to the consumption of this product.

The following guidance and assumptions apply to both the metadata and description fields describing data products for this UDRA.

- Required metadata and description fields are integral components of each data product regardless of whether they are physically stored and transmitted with the data.

- The amount of unique or custom metadata extensions for a given data product will be minimized to the extent feasible.

- Some data mesh-specific metadata may develop over time and, hence, not be fully populated at data product inception (e.g., usage history and patterns). Metadata specification / definition versioning will be necessary.

- Data Domains will update the metadata for their data products as the data in a data product is refreshed or extended.

- Adopted, modified, or developed metadata will be defined for maximum commonality across the Army Business, Intelligence, Enterprise Information Environment, and Warfighter mission areas and sub-domains.

- Metadata adopted, modified, or developed by this UDRA will be harmonized with existing Army enterprise metadata specifications.[11]

- Data domain-specific metadata extensions may be defined by data domains (data product owners). Such extensions may be added to the data product's description fields and made available to discovery services.

- Metadata translation/mediation service(s) may eventually be required to provide full Joint and Coalition interoperability. A universal metadata standard is not a practical objective.

- Certain metadata field content may have security or privacy requirements. If so, these requirements are expected to be addressed by the data product discovery services/catalogs that should provide field-level access control for any sensitive data product metadata.

A data product in this UDRA's data mesh will include the required metadata itemized in Table 1. Examples of these metadata fields are described in Appendix B.

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[11] Per Army Chief Information Officer (CIO) memorandum, Subject: *Army Data Governance Roles and Responsibilities*, 2 April 2024, Army Data Stewards can define and approve metadata requirements.

UDRA Data Product

Required Metadata

ApiEndpoint (Output Port)	**DisclosureAndReleasability**	**Originator**
AuthorizationReference	**Format**	**SecurityClassification**
CreationDateTime	**HandlingRestrictions**	Version
Custodian	**Identifier**	
Description	Name	

Description Fields

ApiProtocol	FileSizeQuantity	Provenance
CheckSum	GeospatialCoverage	SearchKeywordTags
ConformsToStandard	InputPort	ServiceLevelMetrics
DataQualityMetrics	LogicalDataModel	ServiceLevelObjective
Documentation	MaturityLevel	TemporalCoverage
DomainDescriptionElements	MetadataBinding	UsageAgreement
ExpirationDateTime	PhysicalDataSchema	UsageSummary
Feedback	PointOfContact	

Payload

Bold = Required by DoD Metadata Guidance

Figure 4. UDRA Data Product Metadata, Description Fields, and Payload

Table 1. Data Product Required Metadata Summary

Characteristic	Definition
apiEndpoint (output port)	The uniform resource identifier (URI) source of the data product.
authorizationReference	The particular documented legal basis for mission activities associated with the creation, retention, and use of a resource.
creationDateTime	Date and time on which the data product was created to include when a data product came under government control (i.e., acquisition of third party data, etc.)
custodian	An entity (organization) legally responsible for making decisions related to the data product (e.g., records management, declassification, eDiscovery, FOIA search.), releasing the information, the intellectual content of the product.
description	Provides an overview of the contents of the data product (e.g., summary, abstract, table of contents).
disclosureAndReleasability	Information pertaining to countries, organizations, or communities approved to receive the resource.

format	The media type of the data product.
handlingRestrictions	Limitations not related to classification or releasability, such as controlled unclassified information designations.
identifier	A universal unique identifier (UUID) such as a 128-bit label that uniquely identifies the data product.
name	The abbreviated title or name of the data product.
originator	An entity (organization) primarily responsible for generating the data product (i.e., data domain). For DoD, originator is synonymous with author, creator, producer, and collector.
securityClassification	An indicator identifying the highest level of classification contained within a resource.
version	The version of the data product.

The data product's description fields are summarized in Table 2. Data domains are encouraged to use these fields as needed for supporting the data product needs. Examples of these fields are provided in Appendix B.

Table 2. Data Product Description Field Summary

Characteristic	Definition
apiProtocol	The API protocol required to access the data product.
checksum	The checksum (including a generated hash value and the hash algorithm utilized to calculate the hash value of the data product) for validating the data product using the specified cryptographic hash algorithm in big endian.
conformsToStandard	The set of labels identifying any standards with which the data product is conformant.
dataQualityMetrics	The data quality metrics specify the measurement factors by which the data product's quality will be evaluated.
documentation	The documentation specifies a URI reference to the data product documentation.
domainDescriptionElements	The domain description elements are name/value pairs that provide domain-specific data product characteristics.
expirationDateTime	Date and time on which the data product expires and is no longer current.
feedback	Feedback that was shared by the consumer regarding the data product.
fileSizeQuantity	The size of the electronic version of the data product in units of kilobytes (kB).
geospatialCoverage	Geographic place name and/or coordinates with geometry (e.g., point, area, or volume) on or about the Earth with respect to the World Geodetic System 1984 (WGS 84) coordinate reference system and a geodetic datum describing the coverage of the data product.
inputPort	Describes the interface(s) of one or more data source input(s) for the data product.

Characteristic	Definition
logicalDataModel	The logical data model specifies a URI reference to the logical model that defines the structure and semantics of the data product.
maturityLevel	The lifecycle state of the data product.
metadataBinding	The metadata binding specifies a method chosen to attach, detach, or apply a hybrid approach of metadata with the payload.
physicalDataSchema	The physical data schema specifies a URI reference to the schema that defines the physical data models for the data product.
pointOfContact	A person or organization who can be contacted to obtain more information about a data product.
provenance	The provenance specifies a set of functional relationships for the data product to its sources and related resources. This can include relationships to other data products, references, and materiel sources (e.g., sensors).
searchKeywordTags	The search keyword tags specify a set of labels that characterize the semantics, usage, categorization, or applicability of the data product that facilitate its discovery by a data consumer.
serviceLevelMetrics	The service level metrics specify the characteristics by which conformance to the elements of the service level agreement are evaluated. For example, the minimum throughput value of the data product from the data producer.
serviceLevelObjective	The service level objective specifies a set of measurable characteristics that comprise the service level agreement which defines how the data product is to be provided by the data producer to the data consumers.
temporalCoverage	The subject-matter coverage in terms of one or more periods of time in Coordinated Universal Time (UTC). E.g., For a data product collected by a sensor, the start and end times describing the period of time when the data was collected.
usageAgreement	The usage agreement specifies a reference to the contractual details for the use of the data product.
usageSummary	The usage summary specifies a list of organizations that have consumed the data product along with the date and time at which the data product was consumed by each organization.

This UDRA recognizes three families of approaches for associating data product metadata with the data product payload itself. These approaches, described as attached, detached, and hybrid (a combination of attached and detached approaches), entail competing considerations which require tradeoffs or compromises.

In all three approaches, all required metadata and the populated description fields are registered with and available from the discovery service/catalog(s). In case of attached, every transmission of the data product payload from the producer data domain is also accompanied by the full set of required metadata and populated description fields. With detached, a generally applicable approach, transmission of the data product payload from the producer data domain does not include either the data product's required metadata or the populated

description fields. In case of hybrid, transmission of the data product payload from the producer data domain is accompanied by a select subset of required metadata and populated description fields.

4. Data Domain Description

This section provides a detailed description of a data domain. The description includes a discussion on what is a data domain, its key components, data domain types, notional data domains, and a data domain's roles and operations.

4.1. Defining a Data Domain

A data domain is an organization with specific functional expertise that may produce data products to share information with other data domains and may consume data products produced by other data domains. As a result, a data domain can be a data product producer and/or a consumer.

Guiding Principles:

- Data domains own the data products they produce and define the handling / releasability and accessibility for consumption (e.g., via APIs).

- Data domains are responsible for managing the resources needed to produce and maintain their data products (e.g., personnel, storage, computational, bandwidth, and quality of service (QoS)).

- The roles (personas) for data domain governance and data product development are as defined by the Army CDAO's *Army Data Governance Roles and Responsibilities* memo.

Data Domain Functions:

- **Producer** – create and maintain data products throughout the lifecycle of the data product.

- **Consumer** – discover data products and use them in various analytical, product development, and visualization activities.

- **Governance** – define and enforce data governance policies and data quality among data product producers in compliance with Army CDAO policy.

- **Platform Infrastructure** – provide a data platform for data product producers and consumers that enables data product discovery, development, governance, and observability.

Note: Data platforms are often hosted in a cloud environment to utilize elastic processing power and vast amounts of storage. However, a data platform is not always required to visualize and/or combine data products. Visualization of data products can also be performed by end-user devices.

4.2. Data Domain Components

A data domain consists of the various components described below.

- **Data Product Team** – The personnel within a data domain assigned responsibilities in support of the production and maintenance of a data product. The Data Product Team organization and management is determined by the domain's data governance organization.

- **Data Product Production Services** – provide support for data product development and consumption needs as well as computational governance (includes automation that enforces contracts and rights, sovereignty, events, data policies and guarantees, service level agreements (SLAs)/Service Level Objectives (SLOs)).

- **Data Products and their boundaries / interfaces** – this is detailed in Section 3 (Data Product Description) discussions of *apiProtocol*, *inputPort*, and *apiEndpoint* (*output port*).

- **Data Platform** – the infrastructure and set of modular open system technologies used to securely manage data. Data platforms enable the Army to produce, expose, retrieve, and consume data products. The Army has identified several approved Data Platforms for enterprise use (see the Army Data Platforms Guidance Memorandum).

4.2.1. Data Product Orchestration

Data product orchestration is accomplished by a data domain acting in combinations of the following roles:

Producing Data Domain –A data domain that leverages data from authoritative primary sources and sensors to build the data products they produce.

Aggregating Data Domain – A data domain that consumes data products from other data domains to produce new data product based on expert analysis of the aggregated data.

Figure 5 is an illustrative example of how data domains produce required data products while consuming and aggregating other data products.
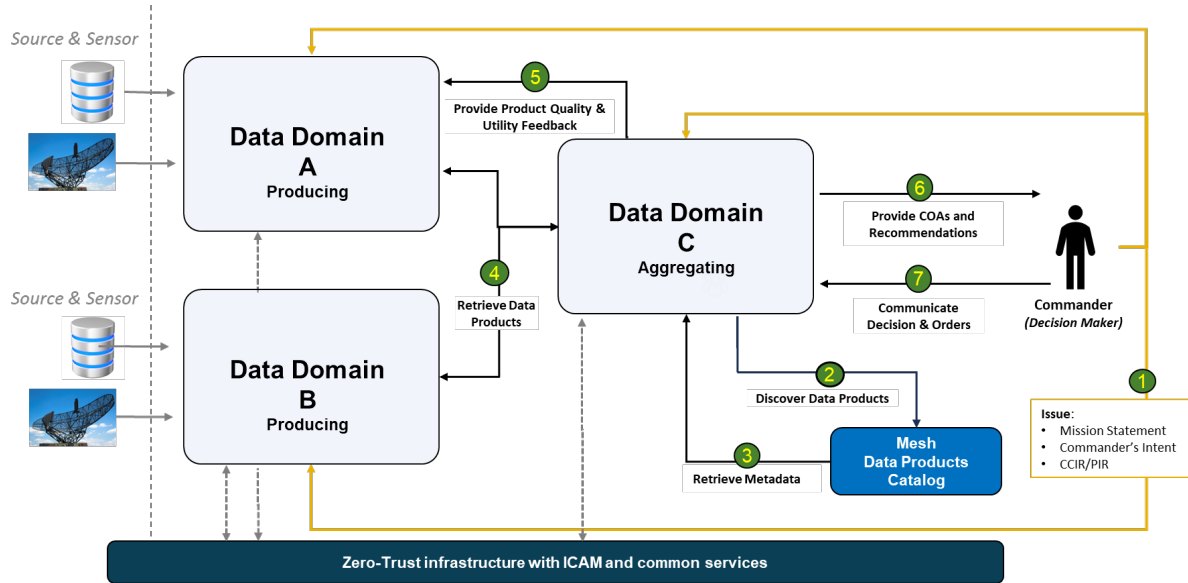
Figure 5. Data Product Orchestration

The data domain is responsible for data integrity and for monitoring the health, quality, and performance of the data pipelines, processes, and systems constituting their data platform hosting their data products.

4.3. Roles and Operations

The eight-step data mesh services process in Section 2 discussed three primary roles for supporting specific operations of this UDRA's data mesh concept: producer, consumer, and governor.

The operations performed by data domains acting in the producer and consumer roles that support data mesh-governed functions for adherence to this UDRA's data mesh principles are listed below. Note that these lists of operations are not comprehensive. Rather, they provide illustrative examples of typical expected operations for the producer and consumer roles.

Producer role operations:

- Identify data product need (from reviewing the request).
- Access data product discovery service.
- Produce data product.
- Consult governance repository for data product governance adherence.
- Register data product (provide metadata and data product description fields).
- Address feedback.
- Update data product.

Consumer role operations:

- Access data product discovery service.

- Discover data products.
- Initiate a demand signal (if a required data product is not available).
- Follow computational governance policies.
- Retrieve metadata (of identified data product).
- Retrieve data product.
- Consume data product.
- Provide data product feedback.

Computational aspects of the governance are discussed in Section 6 (Computational Governance).

5. Service Activity Descriptions

This section provides a description of UDRA services that support data mesh operations. It details the decomposition of these services into discrete activity functions that are needed to support the data mesh operational use cases and provides a set of identified processes that have been decomposed into activities which are needed to support certain functions in the data domain operational use cases.

5.1. Services and Service Descriptions

A set of automated services for supporting the data mesh operations is identified and discussed in this subsection. These services enable the production, consumption, orchestration, and interoperable sharing of data products while satisfying requirements such as:

- Service security – access controls, encryption, etc.
- Service interoperability – interoperability with other services and data products, standards, and protocols.
- Service availability – availability and reliability of the service relative to SLAs, SLOs, and Army policies.

The following subsections describe this UDRA's services in more detail.

5.1.1. Production Service

A collection of automated activities that enable a data domain to prepare, package, facilitate registering (i.e., publish) data products designed for consumption (as a whole or as a component) by consumers via data mesh services.

5.1.2. Orchestration Service

A collection of activities that enable producer and consumer interactions regarding data products, including receiving, storing, and updating data needs for data product producers. This service registers data products after data product identifier generation and enables discovery of data products. It manages data product-associated notifications to consumers, stores data product usage and access history and enables querying usage metrics, and captures and stores consumer feedback and provides a feedback report on the data products consumed.

5.1.3. Consumption Service

A collection of activities and tooling that enables data domains and/or end users (e.g., a commander, warfighter, or business system user) to consume and/or aggregate data products. These include support for discovery and retrieval, visualization, analysis, data management, and providing feedback to add value to data products.

5.1.4. Access Management Service

A collection of activities to validate, authenticate, and authorize data product requests and responses. This may include enforcement of data product policies such as expiration date/time, and it integrates with data product usage and metrics.

5.1.5. API Brokerage Service

A collection of activities to support handling and routing API requests to different data product endpoints by managing service endpoint information. API gateway functions and policies provide a domain-level response to specific API requests.

5.1.6. Computational Governance Service

A collection of activities to support automated policy checking, monitoring, and feedback as well as security, privacy, sovereignty, and interoperability reporting for data products. Computational governance also enables consumer data domain-level verification of data products' conformance with federated governance policies and enforces producer data domain management of data product provenance and lineage.

These services are discussed in detail in the following sections via service and activity descriptions and in the use case activity diagrams provided in Appendix D. The services that have been identified for data domains and the data mesh are believed to be sufficient, but this will be validated by testing implementations through the Unified Data Reference Implementation (UDRI) and Innovation Exchange Lab (IXL).

5.2. Service Decomposition and Activity Descriptions

The above services' descriptions and operations are summarized in this subsection, and Figure 6 illustrates how they have been decomposed into discrete activity functions needed to support the data mesh operational use cases.

It is recognized that as data mesh implementation is realized and matures, additional services and functionality may be required to complement the current logical grouping of services.
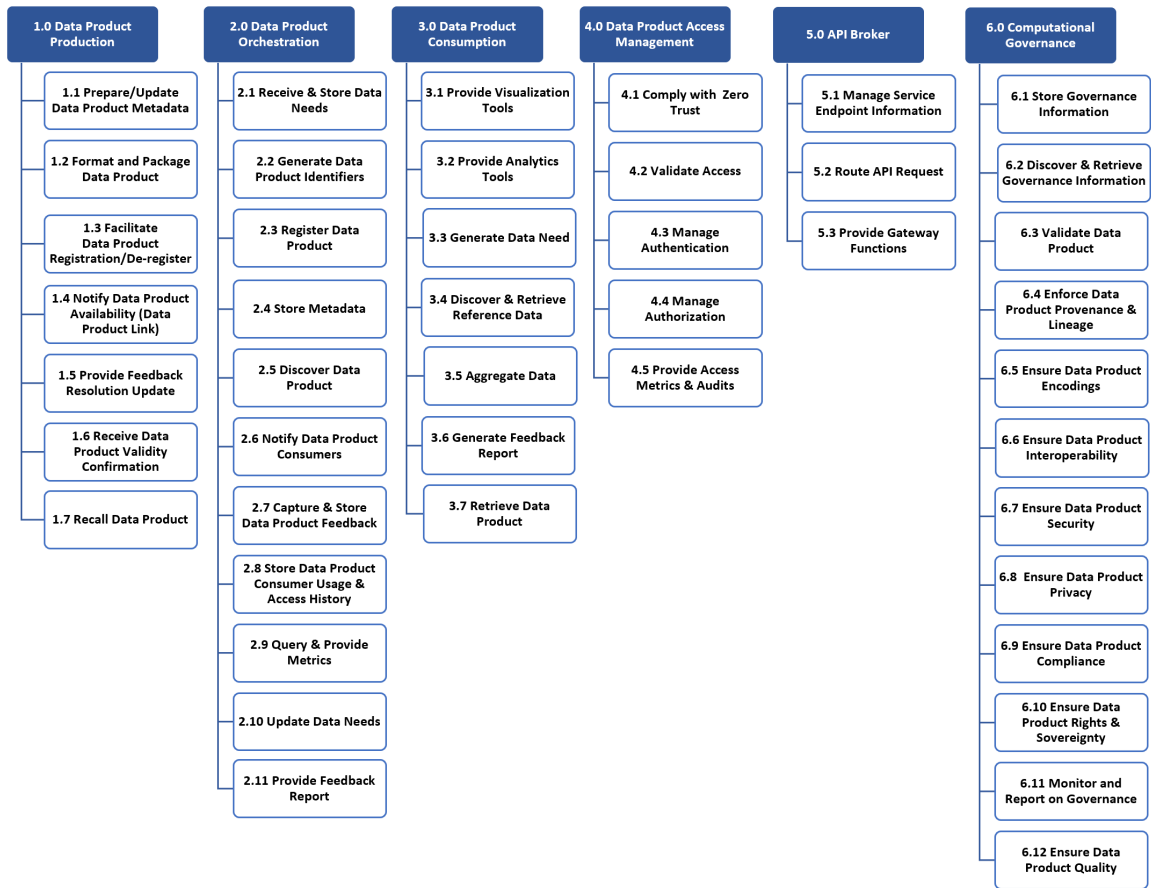
1.0 Data Product Production	2.0 Data Product Orchestration	3.0 Data Product Consumption	4.0 Data Product Access Management	5.0 API Broker	6.0 Computational Governance
1.1 Prepare/Update Data Product Metadata	2.1 Receive & Store Data Needs	3.1 Provide Visualization Tools	4.1 Comply with Zero Trust	5.1 Manage Service Endpoint Information	6.1 Store Governance Information
1.2 Format and Package Data Product	2.2 Generate Data Product Identifiers	3.2 Provide Analytics Tools	4.2 Validate Access	5.2 Route API Request	6.2 Discover & Retrieve Governance Information
1.3 Facilitate Data Product Registration/De-register	2.3 Register Data Product	3.3 Generate Data Need	4.3 Manage Authentication	5.3 Provide Gateway Functions	6.3 Validate Data Product
1.4 Notify Data Product Availability (Data Product Link)	2.4 Store Metadata	3.4 Discover & Retrieve Reference Data	4.4 Manage Authorization		6.4 Enforce Data Product Provenance & Lineage
1.5 Provide Feedback Resolution Update	2.5 Discover Data Product	3.5 Aggregate Data	4.5 Provide Access Metrics & Audits		6.5 Ensure Data Product Encodings
1.6 Receive Data Product Validity Confirmation	2.6 Notify Data Product Consumers	3.6 Generate Feedback Report			6.6 Ensure Data Product Interoperability
1.7 Recall Data Product	2.7 Capture & Store Data Product Feedback	3.7 Retrieve Data Product			6.7 Ensure Data Product Security
	2.8 Store Data Product Consumer Usage & Access History				6.8 Ensure Data Product Privacy
	2.9 Query & Provide Metrics				6.9 Ensure Data Product Compliance
	2.10 Update Data Needs				6.10 Ensure Data Product Rights & Sovereignty
	2.11 Provide Feedback Report				6.11 Monitor and Report on Governance
					6.12 Ensure Data Product Quality

Figure 6. Service Activity Decomposition

Table 3 includes the service decomposition to include all activities and their descriptions.

Table 3. Service Decomposition with Activity Descriptions

Service Name	Activity ID	Activity Name	Activity Description
1.0 Data Product Production	1.1	Prepare/Update Data Product Metadata	Coordinates preparing (when creating a data product) and updating metadata of a data product that has already been registered. This activity also supports any curation needs for metadata.
	1.2	Format and Package Data Product	Producer data domain formats and packages a data product as per the expected standards for data product hosting.
	1.3	Facilitate Data Product Registration/De-register	Coordinates the registration and de-registration of a data product to manage the lifecycle of a data product

Service Name	Activity ID	Activity Name	Activity Description
	1.4	Notify Data Product Availability (Data Product Link)	Producer data domain notifies consumer of the availability of a data product upon its creation so that the consumer may access the payload and validate it.
	1.5	Provide Feedback Resolution Update	Provide producer's resolution updates for the consumer provided feedback.
	1.6	Receive Data Product Validity Confirmation	Producer data domain receives confirmation of the data product's validation by the consumer as per the exchanged need.
	1.7	Recall Data Product	Coordinates the recall of a data product which includes invoking an activity to send a notification to all consumers of the data product. It is coordinated to manage the lifecycle of a data product.
2.0 Data Product Orchestration	2.1	Receive & Store Data Needs	Receives and stores data product needs as captured and analyzed by the producer data domain.
	2.2	Generate Data Product Identifiers	Generate a UUID and assign it to a new data product being registered.
	2.3	Register Data Product	Registers a data product into the catalog for its discovery.
	2.4	Store Metadata	Stores metadata of a data product being registered into a repository of registered data products.
	2.5	Discover Data Product	1) Discovers a data product registered into the catalog in response to a search query. 2) Provides consumers with the ability to discover the existence and metadata of registered data products from across the data mesh; metadata supports registered data products being visible, accessible, understandable, and trusted. 3) Provides, with the use of machine learning (ML), capabilities including text analytics and natural language processing (NLP), text and metadata analysis.
	2.6	Notify Data Product Consumers	Sends a notification to all consumers of the data product, for example, when it has been recalled, along with the reason(s) provided by the producer.
	2.7	Capture & Store Data Product Feedback	Capture feedback information from consumers who have used a given data product and store the feedback information with data product.
	2.8	Store Data Product Consumer Usage & Access History	Store consumer usage information of data products and who (consumer) has discovered and retrieved a data product.

Service Name	Activity ID	Activity Name	Activity Description
	2.9	Query and Provide Metrics	Query, search and prepare, including assembly, analysis and provide data product metrics reports.
	2.10	Update Data Needs	Producer data domain updates the data needs store with the latest status.
	2.11	Provide Feedback Report	Provide assembled feedback report to the data product producer.
3. Data Product Consumption	3.1	Provide Visualization Tools	Tools for representing data in visual form such as graphs, charts, and maps.
	3.2	Provide Analytics Tools	Tools to support data analysis and extract insights for potential areas of improvements, trend analysis, and similar.
	3.3	Generate Data Need	Generate the data requirements following the determination and initiation of a data product demand signal.
	3.4	Discover & Retrieve Reference Data	Discover and retrieve the required reference data. May utilize ML capabilities including text analytics and NLP to enable advanced search capabilities.
	3.5	Aggregate Data	Offers the functionalities for consuming multiple data products while ensuring the aggregating data is managed in accordance with computational governance policies established for different classification levels.
	3.6	Generate Feedback Report	Generate the data product feedback report from the captured customer information about the product.
	3.7	Retrieve Data Product	Retrieves metadata for a registered data product from a repository of registered data products. Also, retrieves the data product's payload from the producer data domain's repository.
4.0 Data Product Access Management	4.1	Comply with Zero Trust	Supports adopting zero trust principles to plan Data Product Access Management infrastructure and workflows.
	4.2	Validate Access	Provides controls to verify that only legitimate users have access to data products.
	4.3	Manage Authentication	Offers management of the process of verifying the users/API for data product access.
	4.4	Manage Authorization	Offers management of the process of granting what specific data products and associated processes an authenticated user/API has access to.
	4.5	Provide Access Metrics & Audits	Provides access management metrics and access management audit functionalities for data product access operations reducing any access management risks.
5.0 API Broker	5.1	Manage Service Endpoint Information	Supports the management of hostnames / uniform resource locator (URL) to enable reaching the right resource in data mesh.

Service Name	Activity ID	Activity Name	Activity Description
	5.2	Route API Request	Offers consistent acceptance and secured handling of API calls to forward to respective endpoints.
	5.3	Provide Gateway Functions	Offers the functions enabling managing API requests, applying policies, and routing them appropriately.
6.0 Computational Governance	6.1	Store Governance Information	Stores governance information (such as directives, standards, and policies) related to the data mesh operations.
	6.2	Discover & Retrieve Governance Information	Discovers the presence of stored governance information and its retrieval.
	6.3	Validate Data Product	Validates whether a data product adheres to global standards as defined and expected by the federated governance. Ensure Data Product provides documentation to discover and access – and followed global conventions for metadata information. This activity invokes other governance activities as necessary.
	6.4	Enforce Data Product Provenance & Lineage	Enforces data product's provenance and data lineage. The provenance and lineage can help the producer domain manage the data products as it flows from the Producer domain to consumers and help the data domain understand the source of the curated data sources, the data, that they are using.
	6.5	Ensure Data Product Encodings	Ensure data product is encoded (semantics and syntax) and described encoding standards.
	6.6	Ensure Data Product Interoperability	Ensure data product is usable by and between (polyglot) domain data sets through standardizations and harmonization rules as set by the governor.
	6.7	Ensure Data Product Security	Ensure data product meets security aspects of standards expected by the global governance. For example, enforcing a uniform way to access the actual data product in a secure way such as a role-based access and managed by the domain.
	6.8	Ensure Data Product Privacy	Ensure data product's privacy including data protection as expected. Includes encryption.
	6.9	Ensure Data Product Compliance	Ensure data product is compliance with applicable laws and regulations.
	6.10	Ensure Data Product Rights & Sovereignty	Ensure data product's rights and sovereignty are as expected.
	6.11	Monitor and Report on Governance	Monitor governance-related aspects and provide governance-based automated metrics and feedback reporting (e.g., data product quality, data product error identification, and severity).

| Service Name	Activity ID	Activity Name	Activity Description
	6.12	Ensure Data Product Quality	Ensures data product's accuracy, completeness, conformity, consistency, uniqueness, integrity, as well as age, prioritization, and initial condition as appropriate.

5.3. Domain Process Decomposition and Activity Descriptions

Figure 7 illustrates a set of identified processes, which currently require manual or semi-manual interactions. These processes are decomposed into activities that are needed to support certain functions in the data domain operational use cases. Incremental data mesh implementations / improvements and availability of more advanced automation are expected to advance these processes toward full automation. Additional functionality may also be required to complement these processes.

The data domain processes' descriptions are provided in Table 4.

Table 4. Data Domain Process Descriptions

Process ID	Process Name	Process Description
1	Determine & Initiate a Demand Signal	A set of activities to assist the commander (decision maker) and their support staff in identifying a data product need.
2	Business Understanding	A set of activities that a producer data domain performs to analyze the need, determine the domain responsibility, determine action, and communicate the decision with the commander (decision maker) and/or their support staff that provided the need. It also takes steps for assessing the data domain situation with respect to data product objectives, developing a project plan, and assembling a team for the development.
3	Data Understanding	A set of activities the producer data domain conducts for identifying the data needed, engaging with the data owners as needed, and collecting the data needed.
4	Data Product's Usage Review	An activity that assists the consumer in understanding the retrieved data product's usability prior to its proper use.
5	Consume & Leverage Data Product	An activity that helps the consumer in properly visualizing and analyzing the data product to enable the end user's decision making.
6	Feedback Understanding & Resolution	A set of activities that both producer data domains and the consumers leverage in understanding the feedback, sharing a resolution update, and responding to each other as appropriate towards a resolution.
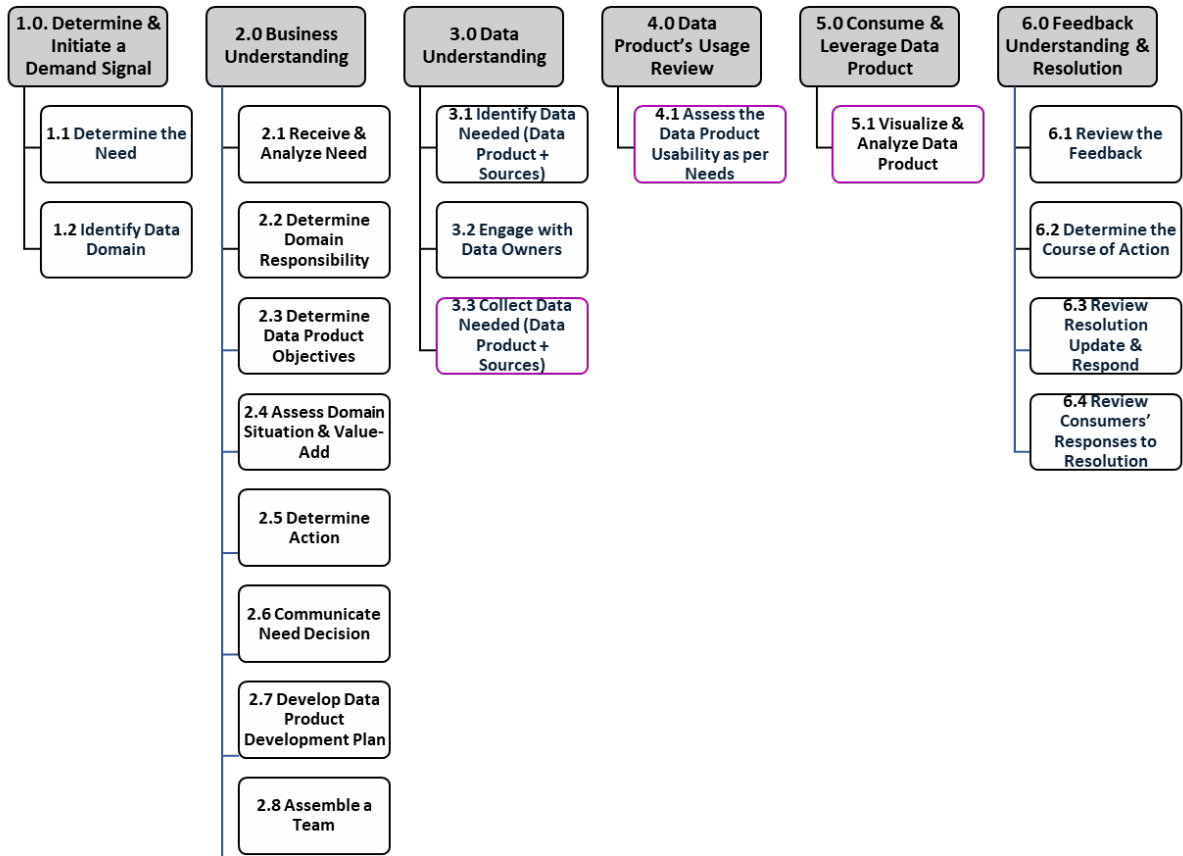
Figure 7. Decomposition of Domain Processes

The data domain processes' activities and their descriptions are provided in Table 5. Note that, as applicable, the activity descriptions reference use cases (UCs) detailed in Appendix D.

Table 5. Data Domain Process Activity Descriptions

Process Name	Activity ID	Activity Name	Activity Description
1. Determine & Initiate a Demand Signal	1	Determine the Need	Determine the need from consulting with doctrine. Need may include specifics from artifacts such as a Mission Statement, Commander's Intent, Guidance, and CCIR (Commander's Critical Information Requirement)/PIR (Priority Intelligence Requirement).
	2	Identify Data Domain	The Army has identified many producer data domains by the data products that they are responsible for developing and managing. In some cases, governance information may contain guidance that helps identify an appropriate domain.

Process Name	Activity ID	Activity Name	Activity Description
2. Business Understanding	1	Receive & Analyze Need	The producer data domain receives the need from the commander (decision maker) and/or their support staff and acknowledges receipt of the need and conducts initial analysis of the data needs.
	2	Determine Domain Responsibility	The producer data domain then determines if it is responsible for producing the data product. The producer data domain may consult governance in determining its responsibility. This communication with the commander (decision maker) and/or their support staff may either take place synchronously and/or asynchronously depending on the situation and demand.
	3	Determine Data Product Objectives	The producer data domain determines the data product objectives following a thorough understanding of the need. Any major constraints, limitations, and/or dependencies may be considered in producing the data product. This analysis and validation are helpful in determining the action.
	4	Assess Domain Situation & Value-Add	The producer data domain assesses their domain situation in respect to resource availability, data product requirements, and objectives, with any known risks and contingencies. The producer data domain analyzes the value-add (impact) of the data product development with respect to the cost-benefit. The producer data domain may identify any critical success factors and define success criteria.
	5	Determine Action	The producer data domain determines the actions that need to be taken when responding to the demand signal initiated by the commander (decision maker) and/or their support staff.
	6	Communicate Need Decision	The producer data domain communicates the decision taken to the commander (decision maker) and/or their support staff in response to the demand signal initiated.
	7	Develop Data Product Development Plan	The producer data domain develops a detailed data product development plan for the data product development.
	8	Assemble a Team	The producer data domain assembles a team consisting of required roles and responsibilities as needed and planned for the development of a data product.
3. Data Understanding	1	Identify Data Needed (Data Product + Sources)	Once the data need is established, data needs are derived and identified in the form of data products and/or data sources that are required for the creation of a data product.

Process Name	Activity ID	Activity Name	Activity Description
	2	Engage with Data Owners	To learn and confirm the understanding of the data sources and data products as inputs, producers may connect and communicate with the data owners (particularly with the owners of the data sources that are not available as data products yet) as needed to create the data product.
	3	Collect Data Needed (Data Product + Sources)	The producers collect data in the form of data products and data sources as required to create the data product. Collection also involves, for example, the understanding of access and protection requirements, tracking of provenance, and expiration of data.
4. Data Product's Usage Review	1	Assess the Data Product Usability as per Needs	Consumer / producer data domain assesses the data product's usability as per the needs (demand signal) for awareness of the context and/or in determining the proper use of the data product with accurate expectations.
5. Consume & Leverage Data Product	1	Visualize & Analyze Data Product	The data product consumer (commander (decision maker) + support staff) consumes and leverages the data product as produced / aggregated by the data product producer domain with data product management tools, enabling analytics, and visualization of the data products.
6. Feedback Understanding & Resolution	1	Review the Feedback	After receiving the feedback as provided from the consumer (*UC07 – Provide Feedback*), the data product producer domain reviews the feedback for understanding.
	2	Determine the Course of Action	On reviewing the feedback and understanding the feedback details, the data product producer domain determines a course of action for feedback resolution.
	3	Review Resolution Update & Respond	The consumer receives and reviews the feedback resolution update as communicated by the data product producer domain and responds accordingly.
	4	Review Consumers' Responses to Resolution	The data product producer domain receives and reviews the consumer's responses to the previously sent resolution and acts accordingly. If consumer has accepted a resolution, the producer data domain takes an appropriate action. Otherwise, if the resolution is not accepted, the producer is expected to follow up with the consumer to find an amicable resolution.

6. Computational Governance

The Army CDAO and Army Data Board provide the necessary federated governance required to support the federated data mesh governance model. This URDA describes Computational Governance as the automated enforcement of governance policies through the application of computational methods. It addresses the application of algorithms in digital information systems that automate policy enforcement, verification, and validation.

This UDRA leverages the guidance for defining the roles and responsibilities for data stewardship as provided by the *DoD Data Strategy and the* Army CIO's *Data Governance Roles and Responsibilities*.

6.1. Computational Governance for Policy Conformance

Data domains, defined and authorized by the Army CDAO and Army Data Board, provide the governance policies and the UDRA computational governance mesh services, which together enable the application of data governance to achieve accountability throughout the entire data product lifecycle.

The following *computational governance* actions are required to support the enforcement of computational governance policies.

- Perform computational execution (i.e., implementation) of global controls, standards, and policies set by the CIO/CDAO.
- Ensure consistency, interoperability, and quality throughout the mesh by implementing:
  - o Standards as code.
  - o Policies as code.
  - o Incentives as code.
  - o Automated scripts and tests.
- Automate monitoring (i.e., manage risk early in the lifecycle of data and throughout).
- Send automated alerts and notifications as appropriate.
- Measure the network effect (based on the usage of data).

This UDRA does not specify governance policies for each of these activities because they are the responsibility of the Army Data Governance Structure established by the CDAO. This UDRA does require data platforms and end user devices to follow data mesh policies and federated data governance practices in support of these activities. Computational governance ensures that data product production and consumption follows the required policies at policy decision points (PDPs) by validating policies at pre-determined gates or policy enforcement points (PEPs). An example of this computational governance is the use of automated validation to ensure the completeness of data product metadata during a data product's registration.

Data domains manage data (performing activities such as collecting and inventorying data; maintaining integrity and security; and transferring and monitoring data) that they own per their

own requirements. For example, a data domain may define, PDPs/PEPs that add value by collecting data quality metrics throughout a data product's lifecycle.

As the federated governance body approves enterprise PEPs or PDPs that apply to the data mesh, they will be instituted using computational governance services for the data mesh concept.

Where computational governance detects a breached SLA or SLO for a data product, automated default actions or behaviors may be taken. The default actions or behaviors may be defined and enforced at the data mesh or data domain level or at both levels.

6.1.1. Automated Policy Enforcement

Computational governance service provides automated policy enforcement. In combination with the data product characteristics enumerated in the data product metadata and description fields, computational governance ensures compliance with the seven VAULTIS goals in the *DoD Data Strategy.* This is illustrated in Figure 8. Policies approved at both the data mesh (federated governance) and data domain levels will be implemented using computational governance service activities. The PDP for a policy is triggered when an activity enters a PEP. Policy enforcement aspects for each of the VAULTIS goals are discussed in detail in Appendix C.
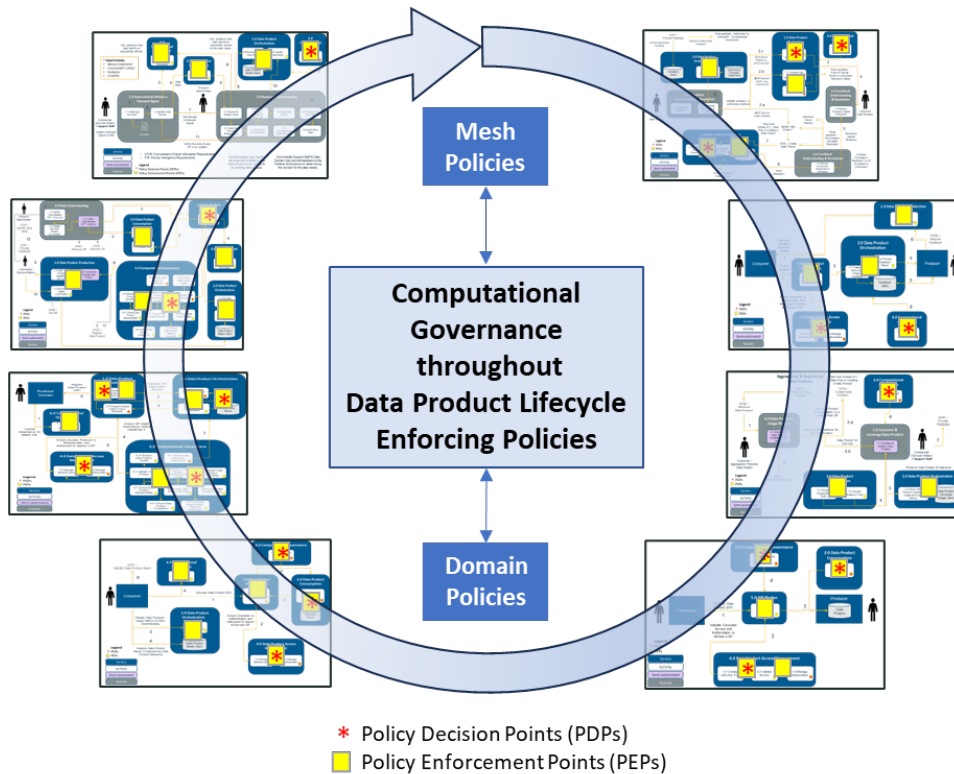

* Policy Decision Points (PDPs)
☐ Policy Enforcement Points (PEPs)

Figure 8. Automated Policy Enforcement Ensures VAULTIS Compliance

6.1.2. Examples of Application of Computational Governance to Data Products

An example of data product computational governance is the enforcement of a data product's period of validity. In some cases, a data product is only valid until it expires. As a result, data domains set the lifespan of the data products that they develop and share with consumers. The data product metadata field "creationDateTime" and description field "expirationDateTime" may be used to specify the lifespan of a data product from inception to expiration. When a data product reaches or exceeds its expiration, consumers that have received and used the data product will need to terminate use of the data product. The contents of the expired data product will no longer be persisted in data domains/environments.

Data product governance also addresses the visibility aspect of the VAULTIS goals by ensuring that previously registered data products are not discoverable or available once they have expired. Expired data products will either be de-registered so that they are no longer discoverable, or identified as an expired data product so that they are not retrievable. If an expired data product has already been retrieved, governance will prevent further use by consumers.

These examples of computational governance promote the trustworthy aspect of the VAULTIS goals in that data product consumers must adhere to the "usageAgreement" that specifies terms of use for the data product. This includes adherence to the service level objective and service level agreement.

6.1.3. Policy Violations

There are two examples of PEPs where a policy violation can delay the registration of a data product:

1) When a policy violation is found in a data product prior to registration, the data product will not be registered until it adheres to policies; this would occur during *UC02 – Produce Data Product.*

2) If a policy violation is found during the process of registration, again it will not be registered, and the producing data domain will be notified; this would occur during *UC03 – Register Data Product*.

However, if computational governance raises a flag from its scan for some reason, depending on the severity of the policy violation, a priority will be assigned to the violation and an action be taken by the computational governance service at that PDP, and the appropriate role / dashboard for the producer data domain will be notified.

Depending on the severity of the policy violation, a data product may be de-registered. In the case of a violation of any policy at a PEP, the computational governance service would implement any authorized PDP action and notify the data product owner so that the violation can be appropriately addressed.

Appendix A – Acronyms

Term	Definition
ACM	Airspace Coordination Measure
ADB	Army Data Board
ADP	Army Doctrine Publication
ADS	Authoritative Data Source
AI	Artificial Intelligence
API	Application Programming Interface
AR	Army Regulation
ASA(ALT)	Assistant Secretary of the Army for Acquisition, Logistics and Technology
ATO	Air Tasking Order
C2	Command and Control
CAL	Critical Asset List
CCIR	Commander's Critical Information Requirement
CCL	Combat Configured Load
CDAO	Chief Digital and Artificial Intelligence Officer
CDO	Chief Data Officer
CIO	Chief Information Officer
CNSSP	Committee on National Security Systems Policy
COA	Course of Action
COG	Center of Gravity
CONOPS	Concept of Operations
COO	Combined Obstacle Overlay
COP	Common Operating Picture
DAL	Defended Asset List
DAMA	Data Management Association
DASA	Deputy Assistant Secretary of the Army
DDIL	Denied, Degraded, Intermittent, Limited

DES	Data, Engineering and Software
DISR	DoD Information Technology Standards Registry
DMBoK	Data Management Body of Knowledge
DoD	Department of Defense
DoDI	Department of Defense Instruction
DPDS	Data Product Descriptor Specification
DSR	Data Service Requirement
FA	Field Artillery
FIPS	Federated Information Processing Standard
FOIA	Freedom Of Information Act
FRAGO	Fragmentary Order
FSCM	Fire Support Coordination Measure
GUID	Globally Unique Identifier
HPTL	High-Payoff Target List
HTML	HyperText Markup Language
HVT	High-Value Target
IANA	Internet Assigned Numbers Authority
IC	Intelligence Community
ICAM	Identity, Credential, and Access Management
IETF	Internet Engineering Task Force
IL	Impact Level
IPB	Intelligence Preparation of the Battlefield
IR	Interagency Report
IRM	Information Resource Metadata
ISM	Information Security Markup
ISO	International Organization for Standardization
IXL	Innovation Exchange Lab
JP	Joint Publication
JSON	JavaScript Object Notation

JSON-LD	JSON for Linking Data
kB	kilobytes
MADO	Mission Area Data Officer
MCCoE	Mission Command Center of Excellence
METL	Mission Essential Task List
ML	Machine Learning
MOE	Measure of Effectiveness
MOP	Measure of Performance
NIST	National Institute of Standards and Technology
NLP	Natural Language Processing
OOB	Order of Battle
OPORD	Operations Order
OPSEC	Operational Security
OPTEMPO	Operational Tempo
PdM	Product Manager
PDP	Policy Decision Point
PEP	Policy Enforcement Point
PIR	Priority Intelligence Requirement
PM	Program, Project, or Product Manager
PoR	Program of Record
QoS	Quality of Service
RDF	Resource Description Framework
RFC	Request For Comment
RIP	Relief In Place
RSS	Really Simple Syndication
SHA	Secure Hash Algorithm
SHS	Secure Hash Standards
SLA	Service Level Agreement
SLO	Service Level Objective

SME	Subject Matter Expert
SP	Special Publication
TOA	Transfer Of Authority
TRADOC	Training and Doctrine Command
TSS	Target Selection Standards
UAP	Unified Action Partner
UC	Use Case
UDRA	Unified Data Reference Architecture
UDRI	Unified Data Reference Implementation
UI	User Interface
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
URN	Uniform Resource Name
UTC	Coordinated Universal Time (UTC)
UUID	Universally Unique IDentifier
VAULTIS	Visible, Accessible, Understandable, Linked, Trusted, Interoperable, and Secure
W3C	World Wide Web Consortium
WARNO	Warning Order
WGS	World Geodetic System

Appendix B – Data Product Metadata and Description Fields

B.1   Data Product Required Metadata Examples

Table 6. Data Product Required Metadata Examples

Characteristic	Definition / *Example*

apiEndpoint (output port)	*https://60thgpc.army.mil:123/geoserver/map_products/coo/zagros_mtns_125k.pdf*
	
	scheme ":" ["//" authority] path ["?" query] {"#" fragment]
	  where scheme = { https, ldap, mailto, news, tel, telnet, urn }
	  authority = [userinfo] host [":" port]
	
	(See IETF RFC 3986 URI.)

authorizationReference	*Document Title: AR 525-95 Army Geospatial-Intelligence and Geospatial Information and Services* *Document Date: 26 July 2022*
creationDateTime	*2017-02-01T11:01:32Z* *(Format: YYYY-MM-DDTHH.mm.ss.SSSZ* *YYYY = Year; MM = Month, DD = Day; T = Time Marker (always T); HH = Hour, mm = Minute; ss = Seconds; SSS = fractions of seconds; Z = UTC Time indicator (always"'").)* *(See ISO 8601.)*
custodian	*Organization Name: US Army 60th Geospatial Planning Cell* *Physical Address: 116 Lakeview Pkwy, Wiesbaden, Germany.* *Telephone Number: 757-555-5555* *Email Address: yyyy.yyyyyyy.yy.civ@mail.mil* *(optional) Point of Contact Name: John Doe* *(optional) Point of Contact Role: Geospatial Engineer*
description	*This Combined Obstacle Overlay for the Zagros Mountains, Iraq has a map scale of 1:250K and includes DTED 2 shaded relief. It provides a basis for identifying ground avenues of approach and mobility corridors by integrating obstacles to vehicular movement (e.g., built-up areas, slope, soils, vegetation, hydrology) into one overlay. The overlay depicts areas that impede movement (severely restricted and restricted areas) and areas where friendly and threat forces can move unimpeded (unrestricted areas).*
disclosureAndReleasability	*Disclosure: No disclosure restrictions*

	Releasability: Open to the Public
format	*application/pdf* *(See the Internet Assigned Numbers Authority (IANA) registry of approved media types at https://www.iana.org/assignments/media-types/media-types.xhtml last accessed 5 September 2024) E.g., application/vnd.nitf (See IETF RFC 6838.)*
handlingRestrictions	*Handling Type: None*
identifier	*acdef012-8d4c-4e0a-8c6b-142a43b10c33* *(32 hexadecimal digits x 4 bits per digit = 128 bits; shown with four hyphens and digits as follows 8-4-4-4-12 for a total of 36 characters.) (See IETF RFC 4122 UUID v4.)*
name	*Combined Obstacle Overlay of the Zagros Mountains, Iraq, 1:250K Scale*
originator	*Organization Name: US Army 60th Geospatial Planning Cell* *Physical Address: 116 Lakeview Pkwy, Wiesbaden, Germany.* *Telephone Number: 757-555-5555* *Email Address: yyyy.yyyyyyy.yy.civ@mail.mil* *(optional) Point of Contact Name: Jane Doe* *(optional) Point of Contact Role: Geospatial Engineer*
securityClassification	*Classification: UNCLASSIFIED* *Classification Reference Document Title: Chairman's Instruction XYZ* *Organization Name: Joint Chiefs of Staff* *Organization Address: 1400 Defense Pentagon, Washington, DC* *Organization Email: xxxx.xxxxx.xx.xxxxx@mail.mil* *Retention Date: 2030-08-05*
version	*v 1.02 Release A*

B.2 Data Product Description Field Examples

Table 7. Data Product Description Field Examples

Characteristic	Definition / *Example*

apiProtocol	{
	  "description": "The API exposed by the Observability Port that exposes data product logs",
	  "specification": "openapi",
	  "version": "3.1.0",
	  "definition": {
	    "mediaType": "text/json",
	    "$href": "https://mycompany.com/api/v1/planes/utility/logging-services/openapi.json"
	  },
	  "externalDocs": {
	    "mediaType": "text/html",
	    "$href": "https://spec.openapis.org/oas/v3.1.0"
	  }
	}

checksum	hashAlgorithm: SHA-256 hashValue: f3fa7347a4e1ac83153e8086dfe00b53bf7f665b99a9683c390bca713fd71880 (Examples of alternative hash algorithms include: SHA-224, SHA-256, SHA-384, SHA-512, SHA-512/224, SHA-512/256, SHA3-224, SHA3-256, SHA3-384, SHA3-512) (See FIPS PUB 180-4 Secure Hash Standard (SHS) for recognized secure hash algorithms.)
conformsToStandard	Standard Identifier: ISO 32000 Standard Title: ISO 32000-2:2020. Document management – Portable Document Format – Part 2: PDF 2.0, Dec 2020
dataQualityMetrics	Name: Conformity Definition: Data sets follow agreed upon internal policies, standards, procedures, and architectural requirements Unit: Percent Value: 100%
documentation	https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ATP%203-34x80%20FINAL%20WEB.pdf (See IETF RFC 3986 URI.)
domainDescriptionElements	Name: (blank) Definition: (blank) Value: (blank) Data Type: (blank) Unit: (blank)

Characteristic	Definition / *Example*
expirationDateTime	*2023-02-01T11:01:32Z* *(Format: YYYY-MM-DDTHH.mm.ss.SSSZ (ISO 8601)* *YYYY = Year; MM = Month, DD = Day; T = Time Marker (always T); HH = Hour, mm = Minute; ss = Seconds; SSS = fractions of seconds; Z = UTC Time indicator (always 'Z').)*
feedback	*https://60thgpc.army.mil/feedback/form.html* *(See IETF RFC 3986 URI.)* *The reference may point to 0 or more feedback submissions with each submission having a structure similar to the following example of one record:* *Submitter: John Doe* *Organization: 101st Airborne Division* *Feedback: The Combined Obstacle Overlay was helpful for navigating the Zagros Mountains.* *Submitted: 2022-02-01T11:01:32Z*
fileSizeQuantity	*2,965*

geospatialCoverage	*Geographic Name: Zagros Mountains, Iraq*
	
	PolygonArea:
	 VertexPoint: (1)
	  latitudeCoordinate: 33.766898127964794
	  longitudeCoordinate: 48.082834354051904
	 VertexPoint: (2)
	  latitudeCoordinate: 32.79103508294807
	  longitudeCoordinate: 48.082834354051904
	VertexPoint: (3)
	  latitudeCoordinate: 32.79103508294807
	  longitudeCoordinate: 48.94718149244212
	VertexPoint: (4)
	  latitudeCoordinate: 33.766898127964794
	  longitudeCoordinate: 48.082834354051904
	
	(See MIL-STD-2401 DoD WGS84.)
	
	NOTE: Example abstracts away implementation concerns which includes but is not limited to:
	  • *IETF Geographic JSON (GeoJSON)*
	  • *OGC Coverage JSON (covjson)*
	  • *OGC Geography Markup Language (GML)*
	  • *OGC Keyhole Markup Language (KML)*

Characteristic	Definition / *Example*
inputPort	*https://60thgpc.army.mil:123/geoserver/map_products/tds/features.fgdb* *scheme ":" ["//" authority] path ["?" query] {"#" fragment]* *where scheme = { https, ldap, mailto, news, tel, telnet, urn }* *authority = [userinfo] host [":" port]* *(See IETF RFC 3986 URI.)*
logicalDataModel	*(Null)* *(See IETF RFC 3986 URI.)*
maturityLevel	*Final* *(Values = { Draft, Final, Obsolete })*
metadataBinding	*Detached* *(Values = { Attached, Detached, Hybrid })*
physicalDataSchema	*(Null)* *(See IETF RFC 3986 URI.)*
pointOfContact	*Physical Address: 116 Lakeview Pkwy, Wiesbaden, Germany.* *Telephone Number: 757-555-5555* *Email Address: yyyy.yyyyyyy.yy.civ@mail.mil* *Point of Contact Name: Jane Doe* *Point of Contact Role: Geospatial Engineer*
provenance	*Functional Association Code: IsDerivedFrom* *Identifier: 4e1d59f1-dbb6-4076-8d55-98dc9b4d3493* *Name: Digital Terrain Elevation Data Level 2 (DTED 2)* *Functional Association Code: IsDerivedFrom* *Identifier: 412bde37-f750-4f94-bbfe-e8443f4f2dfb* *Name: 60th GPC Theater Geospatial Database Baseline* *Functional Association Code: Supersedes* *Identifier: 412bde37-f750-4f94-bbfe-e8443f4f2dfb* *Name: Combined Obstacle Overlay for the Zagros Mountains* *Functional Association Codes = {Cancels, Graphically depicts information contained in, Is an amendment to, Is derived from, Is modification of, Provides authority for, References, Supersedes, Supplements}*
searchKeywordTags	*Zagros; Iraq; Obstacle; Overlay; COO; Map; Geospatial*
serviceLevelMetrics	*Name: Availability* *Definition: Actual Data Product availability as a percentage of time* *Unit: Percent* *Value: 99.98%*

Characteristic	Definition / *Example*
serviceLevelObjective	*Name: Availability* *Definition: Objective Data Product availability as a percentage of time (e.g., available 99.65% of the time = less than 5 minutes of unavailability every 24 hours)* *Unit: Percent* *Value: 99.65%*

temporalCoverage	*Time Period:*
	  Start Date Time: 2017-02-01T11:01:32Z
	  End Date Time: 2017-02-02T11:01:32Z

usageAgreement	*This Combined Obstacle Overlay is unclassified and may be used for official use by any U.S. DoD user or Coalition mission partner.*
usageSummary	*https://60thgpc.army.mil/usagesummaries/form.html* *(See IETF RFC 3986 URI.)* *The reference may point to 0 or more usage summary submissions with each submission having a structure similar to the following example of one record:* *Organization: 101st Airborne Division* *(optional) User: John Smith* *Used Date Time: 2022-02-01T11:01:32Z*

Appendix C – Automated Policy Enforcement of VAULTIS Goals

The subsections below describe how UDRA computational governance can be used with automated policy enforcement to ensure data products comply with the VAULTIS goals shown in Figure 9.
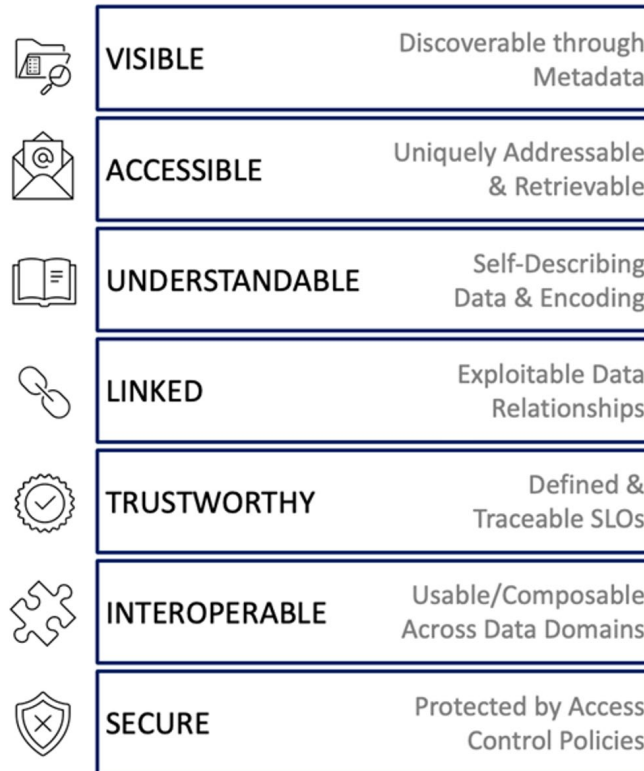

Figure 9. UDRA Enablement of VAULTIS Goals

C.1   Data is Visible

Data products, created by producer data domains, will be published (registered) and made available (visible) for their discoverability and consumption by authorized end users/data domains. The inability to discover data products may lead to duplication of data products. Data domains will implement required metadata standards and leverage the data management tools as necessary to generate and prepare metadata in support of data product registration to improve visibility.

Producer data domains will leverage services to register, search/query, and discover data products. Consumers of data products will leverage services to search/query to discover data products.

A computational governance automated PEP to confirm all UDRA data product metadata required for visibility (e.g., *name and description*) are defined will be used, in part, to confirm a data product is visible in compliance with the *Data is Visible* VAULTIS goal.

C.2   Data is Accessible

Data products, once registered and discovered, must be accessible to privileged/authorized data domains and consumers when access is attempted for their retrieval (through APIs). At the same time, the data products are protected from unauthorized data domains through permissions as per policies and access controls by leveraging data platform and/or services as necessary.

Data domains control data product access and sharing through reusable APIs.

A computational governance automated PEP to confirm all UDRA data product metadata required for access (e.g., *apiEndpoint* (*output port*)) are defined will be used in part to confirm a data product is accessible in compliance with the *Data is Accessible* VAULTIS goal.

C.3   Data is Understandable

Data products must be produced in a standardized manner as per the processes and standards, and utilizing a common data syntax and semantic metadata, and data dictionaries (including a vocabulary and taxonomy) so that the consumers should be able to recognize the data product content (syntax and semantics), business vocabularies (terms), context, and its applicability.

When more than one version of a data product is available in the data product catalog, their consumers should be able to distinguish the distinct nature and difference in value by reviewing their metadata.

A computational governance automated PEP to confirm all UDRA data product metadata required for understanding (e.g., *name, version, and description*) are defined will be used to confirm a data product is understandable in compliance with the *Data is Understandable* VAULTIS goal.

C.4   Data is Linked

Data products are built on/leveraging linked data approaches/standards to enable consumers to be able to link and cross-reference data products. UDRA utilizes globally unique identifier (GUID).

A computational governance automated PEP to confirm all UDRA data product metadata required for traceability (e.g., *identifier*) are defined will be used to confirm a data product is linked in compliance with the *Data is Linked* VAULTIS goal.

C.5   Data is Trustworthy

Data products are built by applying all appropriate data quality management techniques, leveraging authoritative data sources, leveraging tools/services as appropriate, and maintaining

data records (as per processes and policies for traceability) so that their consumers can trust all aspects of data products (such as protection, provenance/data-origin, lineage/pedigree metadata, and integrity) with high confidence.

Within a data product, the provenance description field specifies the origin of the data product. Producer data domain may capture and manage provenance information one hop back so that it does not result in capturing and storing an unknown number of hops back. For example, the origin (one hop back) could be a data product, a raw or transformed data source (but not a data product), or a database (e.g., table, row within a table).

A lineage service informs how data flows from a source to a destination. Considering the interplay between data domains and automated services, it will be important to thoroughly plan how these systems will coordinate with each other. However, analyzing the data observability tools to assist with this lineage challenge is not the focus of this document.

A computational governance automated PEP to confirm all UDRA data product metadata required for trust (e.g., *authorizationReference, custodian, and originator*) are defined will be used, in part, to confirm a data product is trustworthy in compliance with the *Data is Trustworthy* VAULTIS goal.

The third objective of the trustworthy VAULTIS goal is "Executes data quality management techniques (assess and enhance)" to address the data quality. Data quality is one of the critical factors for the data domains as it impacts the quality of the data products developed and delivered and, thereby, impacts the commander's/user's decision and the mission. As a result, data (domain) owners periodically assess the quality of the data sets that they own. Their assessment may lead to categorizing their data sets at different levels of quality over time.

There are several factors that could impact data quality – these include but are not limited to accuracy, completeness, conformity, consistency, uniqueness, integrity, as well as age, prioritization, and initial condition. Therefore, data quality dimensions are relative; and owners assess the dimensions across the data's lifecycle. Table 8 provides sample assessment questions for each of the data quality dimensions.

Table 8. Data Quality Dimensions

Data Quality Dimension	What it Means?	Example Assessment Questions
Accuracy *(a.k.a. correctness)*	Data that correctly reflects proven, true values or the specified action, person, or entity. Accuracy includes data structure, content, and variability.	• How frequently do values fail to align to their assigned format? • How frequently do data values match ground truth? • How is error measured? Is it tolerable for the specified purpose?
Completeness	The data present at a specified time contain the expected information or statistics, as measured at the data set, row, or column level.	• Is there known data that would make the set more complete? • Does the data set contain sufficient breadth of information to contextualize the data for its purpose?

Data Quality Dimension	What it Means?	Example Assessment Questions
		• What fields in the data expect some null values? • How often are null values present?
Conformity	Data sets follow agreed upon internal policies, standards, procedures, and architectural requirements.	• Does the data's format match the applicable standard(s)? • Is the data set architecture published and available?
Consistency *(a.k.a. Uniformity)*	The degree to which a value is uniformly represented within and across data sets.	• Are there other data sets that reference values in this data set? • Are there discrepancies?
Uniqueness	Ensures there is a one-to-one alignment between each observed event and the record that describes such an event.	• Are there other Authoritative Data Sources that serve the same function? • Are there duplicate records in this data set?
Integrity	A data set's pedigree, provenance, and lineage are known and aligned with relevant business rules.	• Are there opportunities for data to be tampered with, misreported, degraded, corrupted, poisoned, or otherwise altered during the collection, storage, processing, or transmission processes? • Does the data cleaning process result in data that can be trusted?
Timeliness	Measures the time between an event occurring and the data's availability for use.	• How frequently do supported data consumers require updates? • Does the data purpose require reduced latency? • Was the data product delivered on time? • Was there an agreed upon time for delivery?

This UDRA's description fields include fields such as *serviceLevelObjective, serviceLevelMetrics,* and *checksum* for data product integrity in support of data product quality.

C.6   Data is Interoperable

Data products will be built using standardized data representation formats; providing common semantic meaning; and implementing (and documenting) appropriate data exchange specifications, data standards, and formats so that the data products are machine-readable, available for consumption, and easily exchanged.

A computational governance automated PEP to confirm all UDRA data product metadata required for interoperability (e.g., *format*) will be used in part to confirm a data product is interoperable in compliance with the *Data is Interoperable* VAULTIS goal.

C.7 Data is Secure

Data products will be protected at the required level of granularity by applying approved standards for security markings, handling restrictions, and records management. Data products will be protected from unauthorized access, manipulation, and use by applying appropriate access controls (e.g., role-based, attribute-based, purpose-based, relationship-based) and allowing data access and sharing to only authorized users (leveraging Identity, Credential, and Access Management (ICAM) services). As an example, to enforce access controls that may be time-based, it may be necessary to either restrict access to certain data products or allow for policy exceptions.

Producer data domains will assess factors such as data sensitivity, access levels, classification criteria, and other criteria to define and enforce access policies applicable to data used in preparation of the data products they produce.

Data domains define/develop and implement all required classification and control markings and content and record retention rules. They will bind access and handling restriction metadata to data product/metadata in an immutable manner as well as implement data loss prevention approaches to prevent unintended release and disclosure of data.

Data platforms hosting data are required to be compliant with DoD security policies and instructions, such as DoD Instruction (DoDI) 8500.01, *Cybersecurity*, DoDI 8531.01, *DoD Vulnerability Management*, and to be compliant with Committee on National Security Systems Policy (CNSSP) 22, *Information Assurance Risk Management Policy for National Security Systems*, National Institute of Standards and Technology (NIST) Special Publication (SP) 800-39, Managing Information Security Risk, and NIST SP 800-37, *Risk Management Framework*.

Encryption-at-rest, in-motion, in-use; signatures; and management of cryptographic public/private keys must be leveraged as needed, in accordance with, and as required by, NIST 800-53 and applicable risk management frameworks.

Data domains will leverage services to audit data product access, use, and disposition. The Federated Governance Board may assign policy development responsibility to appropriate data mesh participants. Access control policies are intended for automatic execution unless there are approved exceptions.

A computational governance automated PEP to confirm all UDRA data product metadata required for security (e.g., *Classification* and *handlingRestrictions*) are defined will be employed. The automated PEP will also have the ability to calculate and report data product security to provide evidence of data product compliance with the *Data is Secure* VAULTIS goal.

Computational governance must also enforce global and domain-defined governance policies regarding secure and controlled transfers of data across security domains (e.g., Cross Domain), including Impact Levels (ILs).

Appendix D – Use Case Activity Diagrams

Following the decomposition of services and processes into a set of activities, this UDRA applies them to key functions (discussed in the "Data Mesh is Simple" user story presented in subsection 2.1) in the form of activity diagrams. These functions, in the context of activity diagrams, are referred to as use cases (UCs) and are listed in Table 9.

Table 9. Activity Diagrams for Functions

Activity Diagrams for Functions
UC01: Identify Data Product Need
UC02: Produce Data Product
UC03: Register Data Product
UC04: Discover Data Product
UC05: Retrieve Data Product
UC06: Consume Data Product
UC07: Provide Feedback
UC08: Address Feedback

The following subsections detail the use cases listed in Table 9, including an outline of the flow of events for each and concluding with an activity diagram illustrating the flow of events for each of the eight UCs. The sequence of activities depicted on each activity diagram is notional and alternative sequences of activities are possible depending on, for example, the use case, dependencies between activities, and/or variations of implementations. Similarly, use case variations are possible. For example, "Discovery of Data Product," after de-registration and/or recall of a data product, may require a different activity sequence. Activities coinciding with anticipated policy enforcement points (PEPs) and/or policy decision points (PDPs) are also highlighted in the diagrams.

D.1 UC01 – Identify Data Product Need

Title: UC01 – Identify Data Product Need

Description: A user (human) as a consumer identifies a need for a data product that is currently not available or that requires an update. The data product need is documented and submitted to a producer data domain for adjudication of the request.

Actors:

- Consumer – The user (human or service) of mesh services and data content from a data domain that performs or supports warfighting functions.

- Producer – The user of mesh services responsible for the generation, registration, management, and analysis of data products for a data domain.

Dependent Use Cases:

- None.

Preconditions:

- Consumer is authenticated. ("Data Product Access Management" Service 4)

- Consumer has either an end-user device or data platform with tools suitable for the use of visualizing data products.

- Producer has a data platform suitable for the management of data in the producer's data domain.

- Consumer has a data product need currently not available or only partially available via the mesh services.

Post Conditions:

- Consumer data product need has been received by the producer.

- Producer has made a determination regarding the disposition of the data product need.

Flow of Events:

1) The consumer identifies a data product need. (Activity 1.1)

2) The consumer verifies they have identified the correct data domain for the data product need. (Activity 1.2)

3) The governance repository is queried to discover and retrieve information about data domains to identify/verify the appropriate data domain for the data product need. (Activity 6.2)

4) The consumer data product need is generated for submission to the producer data domain. (Activity 3.3)

5) The consumer data product need is provided to and received by the identified producer data domain. (Activity 2.1)

6) The data product need is stored in the data product needs repository. (Activity 2.1)

7) An acknowledgement that the producer received the data product need is provided to the consumer.

8) If there are any doubts about the identified producer data domain being responsible for the data product need, the governance repository is queried to discover and retrieve information about data domains to identify/verify the appropriate data domain. (Activity 6.2)

9) The producer data domain analyzes, validates, and determines actions regarding the data product need and continues developing the data product development plan and assembling a team. (Activities 2.1 - 2.5 and 2.7 - 2.8)

10) The data product need is updated in the data product needs repository. (Activity 2.10)

11) The producer data domain notifies the consumer of the decision. (Activity 2.6)

12) Governance relevant usage and metrics are monitored and reported via computational governance. (Activity 6.11)
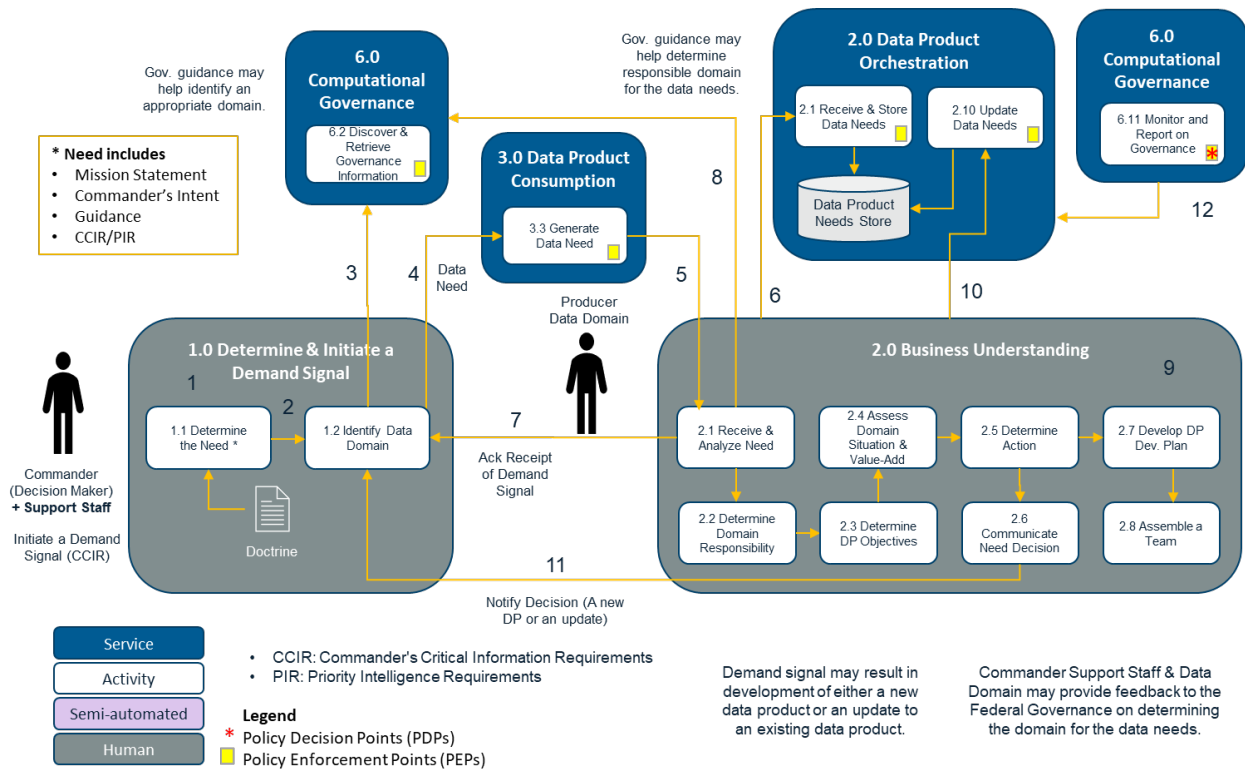
Scenarios with Alternative Flow of Events:

None.

Additional References:

None.

Use Case Diagram:

Figure 10. Use Case Activity Diagram: UC01 – Identify Data Product Need

D.2   UC02 – Produce Data Product

Title: UC02 – Produce Data Product

Description: A producer data domain creates a data product and registers it with metadata for discovery and retrieval of the data product.

Actors:

- Consumer – The user (human or service) of mesh services and data content from a data domain that performs or supports warfighting functions.

- Producer – The user of mesh services responsible for the generation, registration, management, and analysis of data products for a data domain.

Dependent Use Cases:

- UC03 – Register Data Product.
- UC04 – Discover Data Product.
- UC05 – Retrieve Data Product.
- UC06 – Consume Data Product.

Preconditions:

- Consumer is authenticated. ("Data Product Access Management" Service 4)
- Consumer has either an end-user device or data platform with tools suitable for the use of data products in the consumer's data domain.
- Producer has a data platform suitable for the management of data in the producer's data domain.
- Consumer has a data product need currently not available via the mesh services or the producer has determined the need (from receiving the guidance through doctrine and/or governance repository) to create the data product.

Post Conditions:

- Producer has registered a new data product that meets the need of the consumer.

Flow of Events:

1. The producer data domain conducts data understanding of an identified data product need. This includes identifying the data needed for the data product, including data sources, engaging with data owners (as needed), and collecting the data needed. UC04 can be used to discover data products, and UC05 can be used to retrieve data products to support this activity. (Activities 3.1 - 3.3 and reference *UC04 – Discover Data Product* and *UC05 – Retrieve Data Product*)

2. (optional) Reference data can be discovered and retrieved to support Activity 3.3. (Activity 3.4)

3. The producer data product team designs the data product, transforms data (as needed), converts data formats (as needed), and curates the data for the new data product. The team performs modeling, testing, and evaluation of the data product. If needed, the team repeats any development steps based on data product model test and evaluation results. Finally, the producer data product team prepares the data product metadata. Metadata is updated when the data product is updated after its creation. (Activity 1.1)

4. The governance repository is queried to discover and retrieve information for proper preparation of the data product's metadata. (Activity 6.2)

5. The unique identifier for the data product is generated. (Activity 2.2)

6. The producer data domain manages data for the data product using data product management tools. (Activity 3.5)

7. The data product is validated against computational governance policies. The data product is validated against policies including those for metadata, provenance, lineage, encoding(s), interoperability, security, privacy, compliance, rights and sovereignty, and quality (Activities 6.3 - 6.10 and 6.12). Governance relevant usage and metrics are monitored and reported via computational governance. (Activity 6.11)

8. The data product is formatted and packaged prior to notifying the consumer and registration. (Activity 1.2)

9. The consumer that requested the data product and/or identified the originating data need is notified of the data product availability. (Activity 1.4)

10. The producer data domain receives confirmation regarding whether the data product meets the data need. This confirmation is used to update the data need in the data product needs store. (Activities 1.6 and 2.10)

11. The data product is registered by the producer data domain (reference *UC03 – Register Data Product*).

12. The consumer provides feedback on the data product (reference *UC07 – Provide Feedback*).

Scenarios with Alternative Flow of Events:

- Update data product – start at any of the steps (e.g., #1, #3, #4) as required by the nature of the update.

Additional References:
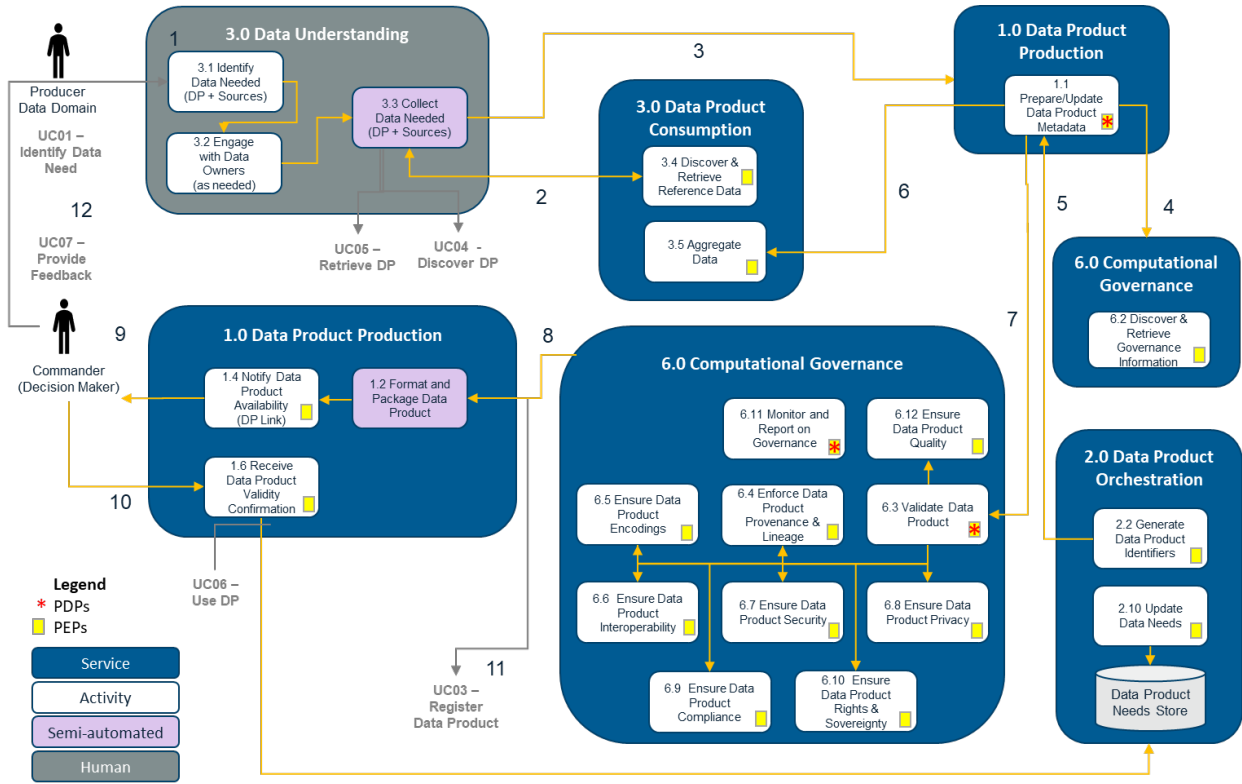
None.

Use Case Diagram:

Figure 11. Use Case Activity Diagram: UC02 – Produce Data Product

D.3   UC03 – Register Data Product

Title: UC03 – Register Data Product

Description: A producer data domain registers a data product in the data product discovery service/catalog by providing the metadata that was created and validated as compliant with the applicable governance policies.

Actors:

- Producer – The user of mesh services responsible for the generation, registration, management, and analysis of data products for a data domain.

Dependent Use Cases:

- None.

Preconditions:

- Producer has a data platform suitable for the management of data in the producer's data domain.

- Producer has a data product created and ready to register (reference *UC02 – Produce Data Product*).

- Availability of a catalog with access rights for a producer to be able to register a data product.

Post Conditions:

- Producer has confirmation that the data product has been registered.
- Consumers can discover the data product registered by the producer.

Flow of Events:

1) Producer's data domain consults governance repository for information to assist the registration of the data product. (Activity 6.2)

2) The producer begins the registration of a data product. (Activity 1.3)

3) The producer is authenticated for permissions to register a data product. (Activities 4.3 and 4.4)

4) The data product is validated against computational governance policies before registration. The data product is validated against policies including those for metadata, provenance, lineage, encoding(s), interoperability, security, privacy, compliance, rights and sovereignty, and quality. In the event of a validation failure, any error messages will be shared with the producer. (Activities 6.3 - 6.10 and 6.12)

5) The validated data product's curated metadata is registered in the catalog. (Activities 1.1, 1.3, and 2.3)

6) The data product metadata is stored in the data product catalog metadata store. (Activity 2.4)

7) Governance relevant usage and metrics are monitored and reported via computational governance. (Activity 6.11)
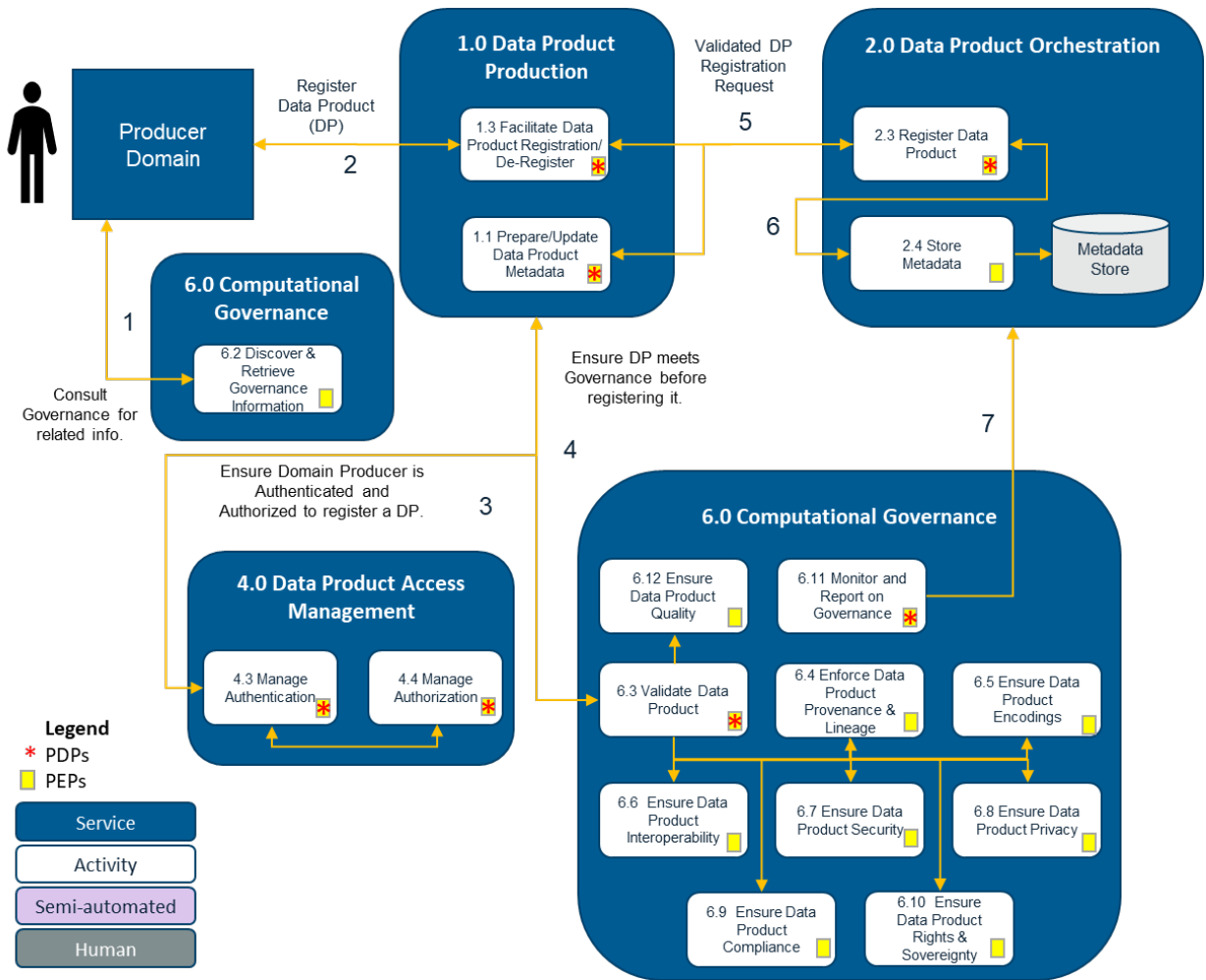
Scenarios with Alternative Flow of Events:

None.

Additional References:

None.

Use Case Diagram:

Figure 12. Use Case Activity Diagram: UC03 – Register Data Product

D.4 UC04 – Discover Data Product

Title: UC04 – Discover Data Product

Description: A user (human or service) as a consumer searches for and discovers a data product.

Actors:

- Consumer – The user (human or service) of mesh services and data content from a data domain that performs or supports warfighting functions.

Dependent Use Cases:

- None.

Preconditions:

- Consumer is authenticated. ("Data Product Access Management" Service 4)
- Consumer has either an end-user device or data platform with tools suitable for visualizing data products.
- Consumer has a need for a data product currently registered and discoverable.

Post Conditions:

- Consumer has discovered a data product for use or consumption.
- Consumer has been provided the metadata that includes an endpoint address for retrieving a data product.

Flow of Events:

1) The consumer begins a search for a data product and discovers data product metadata that includes an endpoint address for the retrieval of a data product. (Activity 2.5)

2) The consumer is authenticated for permissions to search and discover data products. (Activities 4.3 and 4.4)

3) The data product metadata is retrieved from the data product catalog metadata store. (Activity 3.7)

4) Information about the producer data domain(s) and the products that they generate in the governance repository may be used to assist discovery. (Activity 6.2)

5) Information about product usage metrics may be used to assist discovery or determine the relevancy of the data product discovered. (Activity 2.9)

6) Information about data product needs from the data product needs store may be used to assist discovery or determine relevance of data product discovered. (Service 2)

7) Governance relevant usage and metrics are monitored and reported via computational governance. (Activity 6.11)

8) In the event an appropriate data product is not discovered, see *UC01 – Identify Data Product Need*.
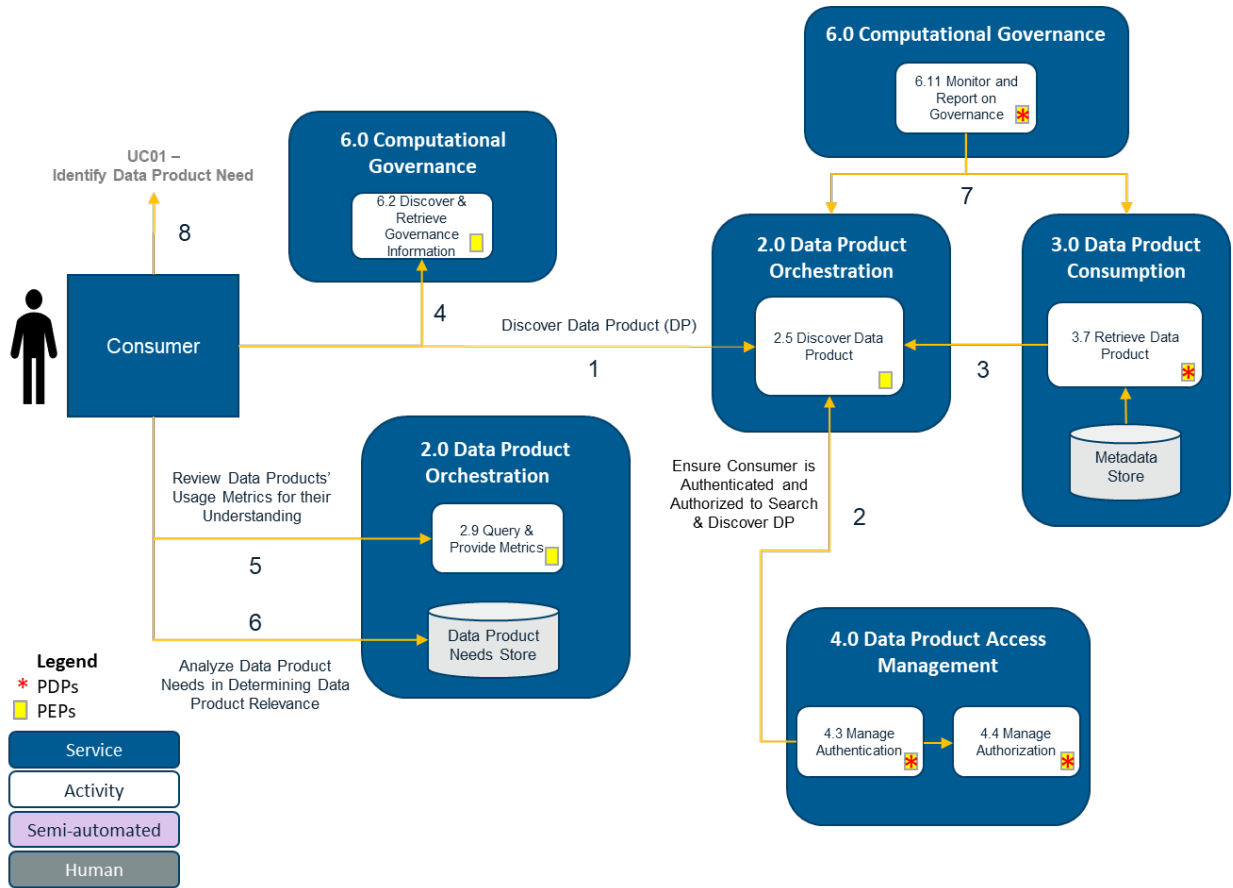
Scenarios with Alternative Flow of Events:

None.

Additional References:

None.

Use Case Diagram:

Figure 13. Use Case Activity Diagram: UC04 – Discover Data Product

D.5   UC05 – Retrieve Data Product

Title: UC05 – Retrieve Data Product

Description: A user (human or service) at a consumer data domain retrieves a discovered data product for use or for consumption to support decision making.

Actors:

- Consumer – The user (human or service) of mesh services and data content from a data domain that performs or supports warfighting functions.

Dependent Use Cases:

- None.

Preconditions:

- Consumer is authenticated. ("Data Product Access Management" Service 4)

- Consumer has either an end-user device or data platform with tools suitable for visualizing data products.

- Consumer has a need and has discovered a data product with metadata that contains an endpoint address (reference *UC04 – Discover Data Product*).

Post Conditions:

- Consumer has retrieved a data product for use or consumption.

Flow of Events:

1) The consumer submits the endpoint address of a data product to the API broker. (Activity 5.2)

2) The end user of the consumer is authenticated for permissions to retrieve the requested data product. (Activities 4.1, 4.2, and 4.4)

3) The consumer's request is routed to retrieve the data product from the producer data domain's repository and the consumer receives the data product's payload. (Activity 3.7)

4) Governance relevant usage and metrics are monitored and reported via computational governance. (Activity 6.11)

Scenarios with Alternative Flow of Events:

None.

Additional References:
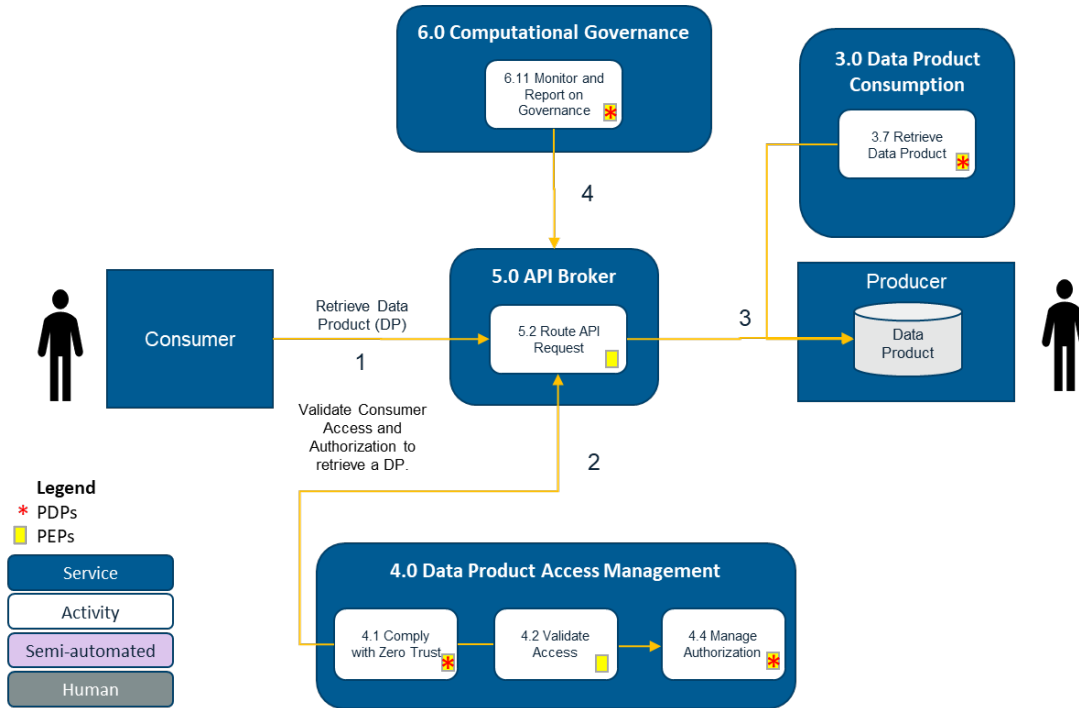
None.

Use Case Diagram:

Figure 14. Use Case Activity Diagram: UC05 – Retrieve Data Product

D.6   UC06 – Consume Data Product

Title: UC06 – Consume Data Product

Description: A user (human or machine) as a consumer discovers (searches for) and retrieves a suitable data product for use in creating a derived data product or for consumption to support decision making.

Actors:

- Consumer – The user (human or service) of mesh services and data content from a data domain that performs or supports warfighting functions.

Dependent Use Cases:

- UC02 – Produce Data Product.
- UC03 – Register Data Product.
- UC05 – Retrieve Data Product.
- UC07 – Provide Feedback.

Preconditions:

- Consumer is authenticated. ("Data Product Access Management" Service 4)

- Consumer has either an end-user device or data platform with tools suitable for visualizing data products.

- Consumer has discovered a data product currently available via the mesh services.

Post Conditions:

- Consumer's need has either been met or has not been met.
- Consumer may provide feedback to the producer of the data product.

Flow of Events:

1) The consumer assesses a retrieved data product for usability to meet the consumer data domain's needs. (Activity 4.1)

2) The consumer may provide feedback to the producer data domain as a result of this assessment (reference *UC07 – Provide Feedback*).

3) If the data product meets the consumer needs, there are two possibilities:

   a) The data product is used for aggregation to create a new data product (reference *UC02 – Produce Data Product*). Following this data flow, the new data product would eventually be registered and retrieved (reference *UC03 – Register Data Product* and *UC05 – Retrieve Data Product*), restarting this flow of events at step 1.

   b) The data product is used for visualization and/or analysis. (Activity 5.1)

4) Data product consumption tools may be used for the use of the data product. (Activities 3.1 and 3.2)

5) The consumer usage and access history are stored. (Activity 2.8)

6) Governance relevant usage and metrics are monitored and reported via computational governance. (Activity 6.11)

7) The consumer end user (e.g., commander (decision maker) and support staff) may provide feedback on the data product (reference *UC07 – Provide Feedback*).

Scenarios with Alternative Flow of Events:

None.

Additional References:

None.

Use Case Diagram:

Figure 15. Use Case Activity Diagram: UC06 – Consume Data Product

D.7 UC07 – Provide Feedback

Title: UC07 – Provide Feedback

Description: A user (human or service) as a consumer identifies feedback for a data product. The data product feedback is documented and submitted to the producer data domain for adjudication.

Actors:

- Consumer – The user (human or service) of mesh services and data content from a data domain that performs or supports warfighting functions.

- Producer – The user of mesh services responsible for the generation, registration, management, and analysis of data products for a data domain.

Dependent Use Cases:

- None.

Preconditions:

- Consumer has either an end-user device or data platform with tools suitable for visualization of data products.

- Producer has a data platform suitable for the management of data in the producer's data domain.

- Consumer has attempted to retrieve, retrieved, and/or used a data product from the producer's data domain (reference *UC05 – Retrieve Data Product* and *UC06 – Consume Data Product*).

Post Conditions:

- Consumer has provided data product feedback to the producer of a data product.
- Producer has received data product feedback from the consumer of a data product.

Flow of Events:

1) The consumer provides feedback for a data product. (Activity 3.6)

2) The consumer is authenticated for permissions to provide feedback for the data product. (Activities 4.3 and 4.4)

3) The consumer's feedback for the data product is stored. (Activity 2.7)

4) The consumer's feedback report is provided to the producer data domain. (Activity 2.11)

5) Previously stored data product feedback may be retrieved by the producer data domain to inform the generation of a resolution update. Any updates to the producer data domain resolution on the feedback report for the data product are also stored. (Service 2.0)

6) The producer data domain provides a resolution update on the feedback report for the data product. (Activity 1.5)

7) The consumer receives the resolution update from the producer data domain on their feedback report for the data product. (Activity 1.5)

8) Governance relevant usage and metrics are monitored and reported via computational governance. (Activity 6.11)

Scenarios with Alternative Flow of Events:

None.

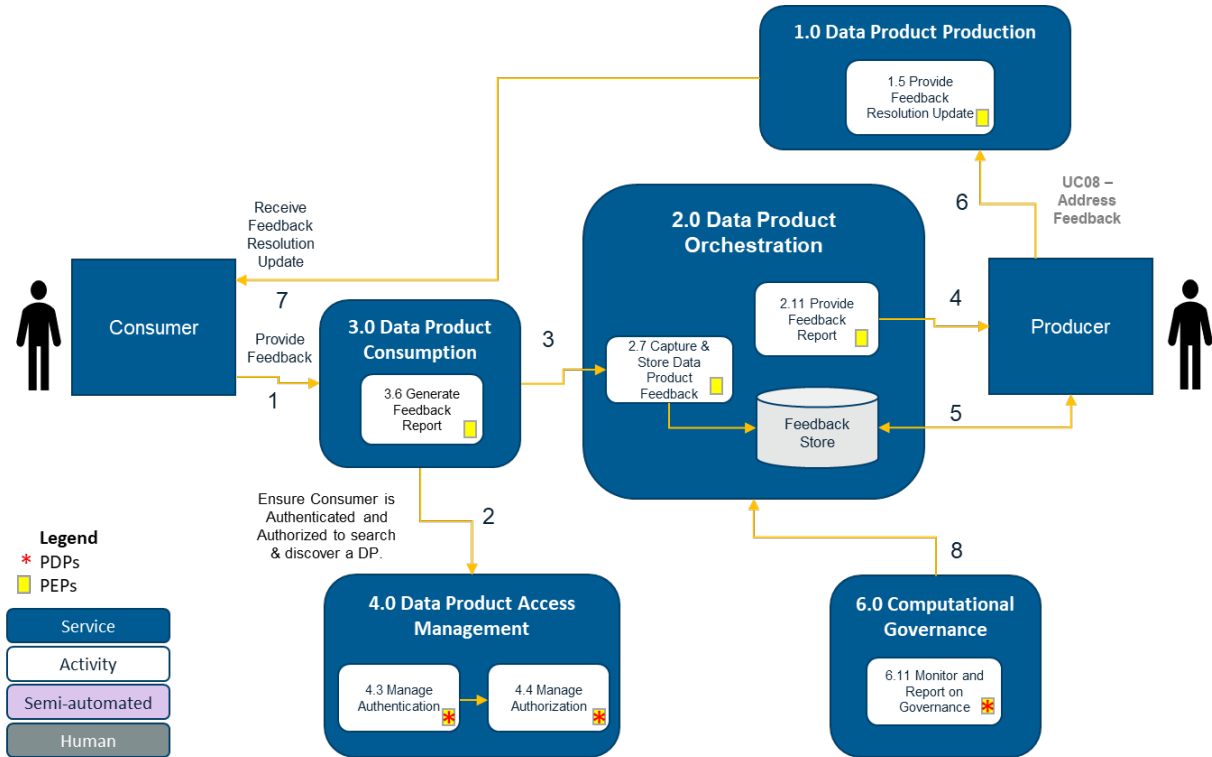**Additional References:**

None.

Use Case Diagram:

Figure 16. Use Case Activity Diagram: UC07 – Provide Feedback

D.8 UC08 – Address Feedback

Title: UC08 – Address Feedback

Description: A producer data domain for a data product receives and addresses feedback to enhance the value and relevance of the data product.

Actors:

- Consumer – The user (human or service) of mesh services and data content from a data domain that performs or supports warfighting functions.

- Producer – The user of mesh services responsible for the generation, registration, management, and analysis of data products for a data domain

Dependent Use Cases:

- UC02 – Produce Data Product.
- UC03 – Register Data Product.
- UC07 – Provide Feedback.

Preconditions:

- Consumer is authenticated. ("Data Product Access Management" Service 4)

- Consumer has either an end-user device or data platform with tools suitable for the use of data products in the consumer's data domain.

- Producer has a data platform suitable for the management of data in the producer's data domain.

- Consumer has provided feedback on a data product managed by the producer.

Post Conditions:

- Producer has adjudicated feedback on a data product from a consumer.

- Consumer has received a resolution update in response to their feedback on the subject data product from the producer.

- Producer has addressed the feedback as per the resolution.

Flow of Events:

1) The producer data domain reviews feedback for a data product retrieved from the feedback store. (Activity 6.1)

2) A course of action (COA) is determined for the feedback. Metrics for consumer usage of the data product may inform the COA. There are three flows of events from this point. (Activities 6.2 and 2.9)

   a) The producer data domain determines the data product requires an urgent update (reference *UC02 – Produce Data Product*). After this step, proceed to 2.c.

   b) The producer data domain determines the data product requires a recall. The data product is delisted and recalled. (Activities 1.3 and 1.7) After this step, proceed to 2.c.

   c) The producer data domain provides a resolution update in response to the feedback on the data product to the consumer. (Activity 1.5)

3) Governance relevant usage and metrics are monitored and reported via computational governance. (Activity 6.11)

4) The consumer receives the resolution update for the feedback on the data product and reviews it. (Activity 6.3)

5) The consumer responds to the resolution update from the producer data domain. The response is received by the producer data domain and reviewed. (Activity 6.4) If the resolution is not accepted by the consumer, the producer and consumer may continue an exchange to derive at an agreeable resolution. Based on review of the consumer's response, the producer data domain may also determine the data product requires an update and/or a new data product is needed (reference *UC02 – Produce Data Product*). Further analysis, such as advanced cause analysis, may also be needed prior to making a determination.

6) The provided data domain resolution update and response from the consumer are stored in the feedback store. (Service 1.0)

7) In the event that a modification of data product and/or metadata was required to address the feedback, the data product metadata is updated; and the data product consumers are notified of the update. (Activities 1.1 and 1.4)

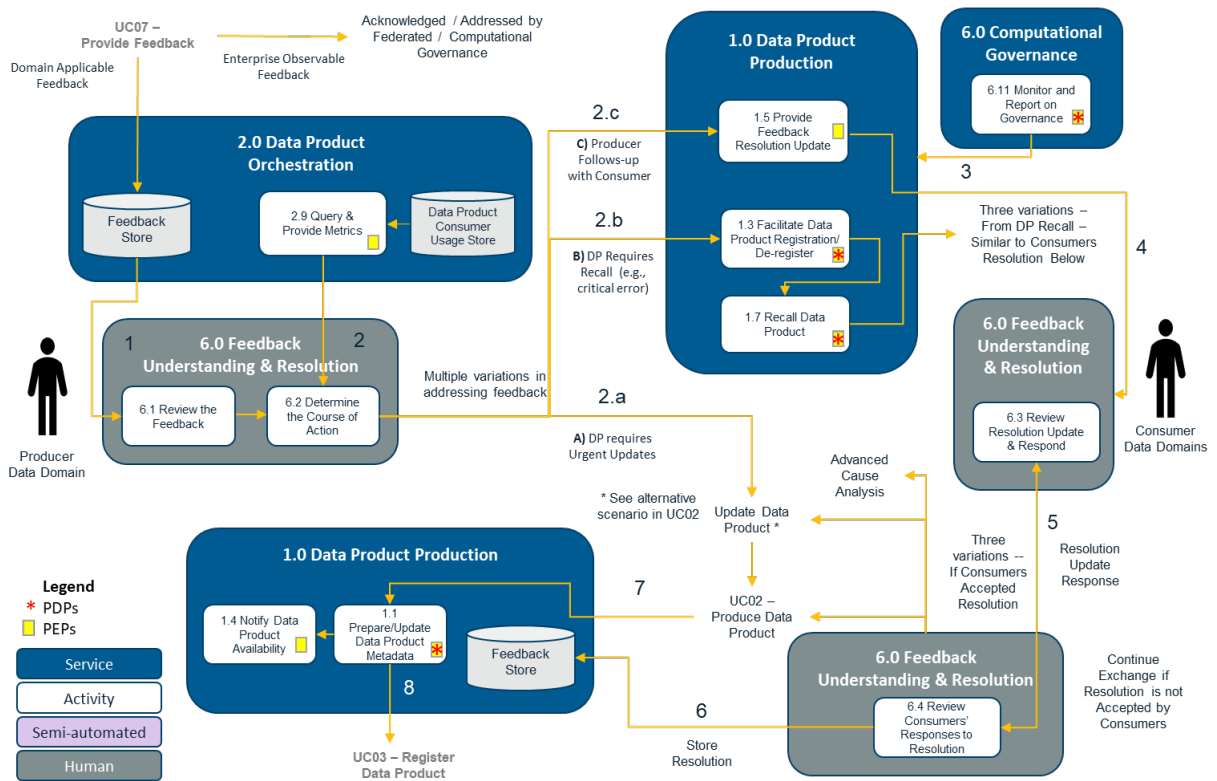8) Any updates that require registration of the data product will be registered.

Scenarios with Alternative Flow of Events:

None.

Additional References:

None.

Use Case Diagram:

Figure 17. Use Case Activity Diagram: UC08 – Address Feedback

Appendix E – Army Mission Operational Relevance

The Army data mesh concept does not change the way the Army conducts operations. The data mesh concept is adapted as part of this UDRA to align with how the Army trains and operates.

The recently completed analysis of the Mission Command Capability Development Integration Directorate helped identify the data products utilized within the Corps echelon that enable the commander's decision making. The analysis included an assessment comparing the level of effort expended by manually entering data within each data product to the level of effort expended for the same task using automation to determine the amount of efficiency that can be gained from further automating the product and its associated processes. Using the Corps Mission Essential Task List (METL) and other doctrinal references, data products necessary to speed Corps decision making were identified. Those products were categorized by:

- Warfighting functions
- Unified Action Partner (UAP) requirements
- Commander requirements

The questions that were derived from doctrine and the METL were viewed as minimum information requirements and an example set is listed below:

- Where are my units?
- Where are my Joint partners?
- Where (and who) are my allies and UAPs?
- What are US Forces doing?
- What are Joint and Coalition partners doing?
- What is the enemy doing?
- Where are we at risk?
- Where is the enemy at risk?
- What/where can we exploit?
- What are the follow-on actions? (8–24–48 hours)

Figure 18 provides an example of the data products, producers, and consumers supporting the Corps Commander in the Shaping Operations METL (simplified for the purpose of understanding).

In some cases of data product sharing, it is necessary to duplicate data for use off-line or in denied, degraded, intermittent, limited (DDIL) network environments. Implementing this UDRA's mesh services through the data product discovery process will help facilitate the automated replication of data products to prevent mission-critical loss due to kinetic strikes and will improve relief in place/transfer of authority (RIP/TOA) knowledge management preservation for an area of operation.
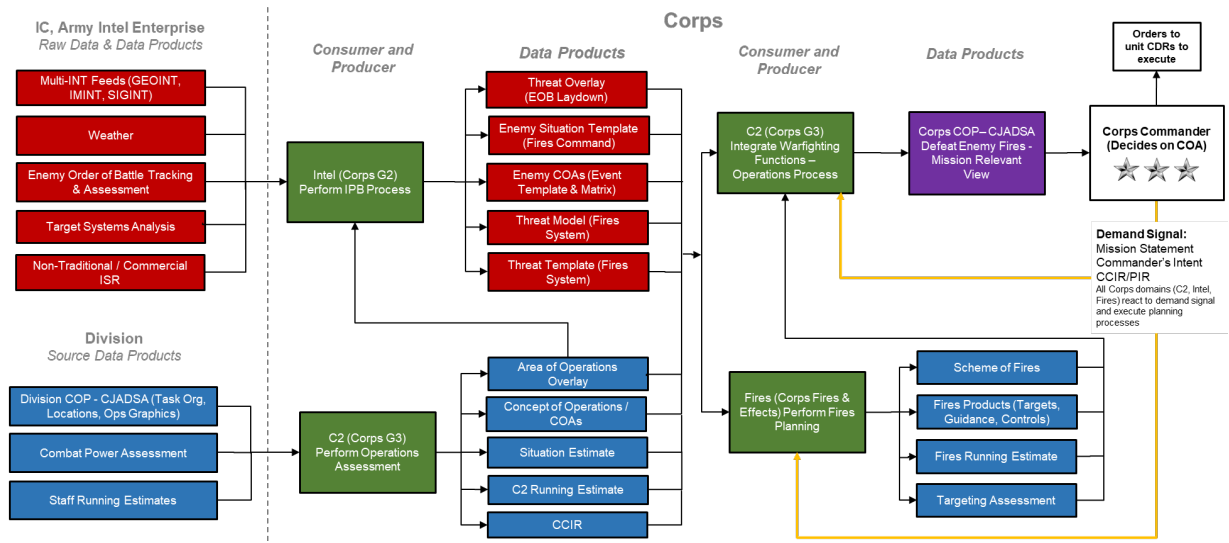
Figure 18. Example Data Products, Producers, Consumers, and Decision Makers

E.1 Notional Data Domain and Data Product Examples

The Army is organized around the warfighting functions for which people are trained to carry out specific tasks related to collecting data and information and synthesizing products. Example begins by naming the notional warfighting functions as a set of producer data domains.

In the Warfighter Mission Area, the Army is organized and fights around the warfighting functions of mission command, fires, intelligence, movement and maneuver, protection, and sustainment. For illustrative purposes, Figure 19 provides a notional data domain structure of the Army Warfighting Mission Area.[12] These notional producer data domains are organized based on their warfighting function and mission needs. This notional example is provided to assist with understanding the data mesh concept described in this UDRA only. The data domains and data products identified below do not represent official Army policy.

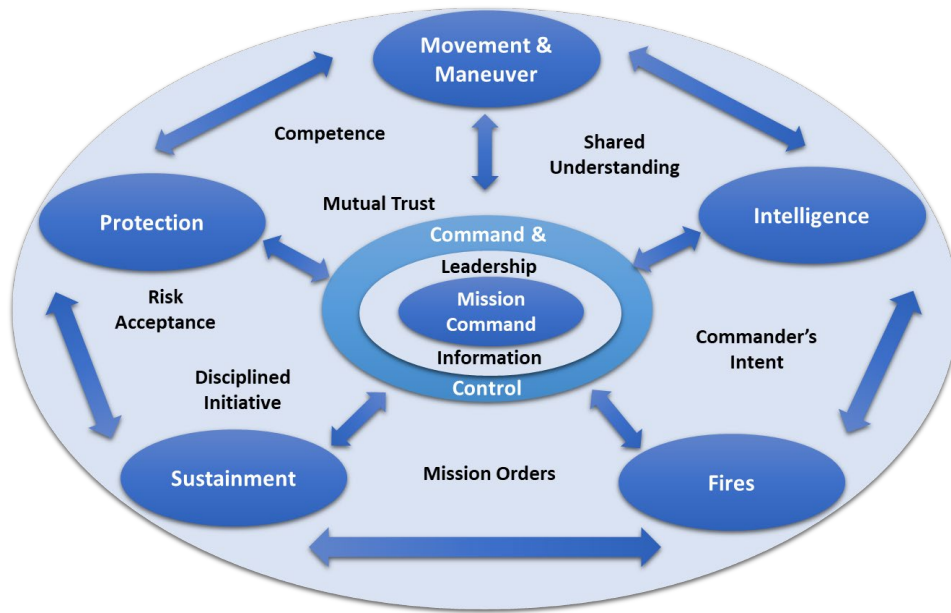[12] *Army Doctrine Publication (ADP) 3-0, Operations, 31 July 2019*.

Figure 19. Notional Data Domains of the Army Warfighting Mission Area

Mission Command and Control (C2)

The command-and-control warfighting function is the related tasks and a system that enable commanders to synchronize and converge all elements of combat power.

Movement and Maneuver

The movement and maneuver warfighting function is the related tasks and systems that move and employ forces to achieve a position of relative advantage over the enemy and other threats.

Intelligence

The intelligence warfighting function is the related tasks and systems that facilitate understanding the enemy, terrain, weather, civil considerations, and other significant aspects of the operational environment.

Fires/Effects

The fires warfighting function is the related tasks and systems that create and converge effects in all domains against the adversary or enemy to enable operations across the range of military operations.

Sustainment

The sustainment warfighting function is the related tasks and systems that provide support and services to ensure freedom of action, extended operational reach, and prolong endurance. These include:

- Logistics
- Financial Management
- Personnel Services
- Health Service Support

Protection

The protection warfighting function is the related tasks and systems that preserve the force so the commander can apply maximum combat power to accomplish the mission.

Notional examples of data products produced by each of the notional producer data domains are illustrated in Table 10.

Table 10. Notional Data Products and Producer Data Domains

Notional Data Product Examples	Producer Data Domain
• **Commander's Planning Products and Estimate of Situation** • **Commander's Critical Information Requirement (CCIR)** • **Knowledge Management Plan** • **Assessment Plan (Measure of Performance (MOP) / Measure of Effectiveness (MOE))** • **Warning Order (WARNORD), Operations Order (OPORD), Fragmentary Order (FRAGO)** • **Consolidated Ops Graphics** • **Common Operating Picture (COP)** • **Rehearsals (Combined Arms)**	Command & Control
• **Scheme of Maneuver** • **Task Organization** • **Key Terrain** • **Combined Obstacle Overlay** • **Cross-Country Mobility** • **Helicopter Landing Zones** • **Current Ops Estimate**	Movement & Maneuver
• **Fires Products (High-Payoff Target List (HPTL), Target Selection Standards (TSS), Airspace Coordination Measure (ACM), Air Tasking Order (ATO))** • **Fires Support Tasks** • **Field Artillery (FA) Organization for Combat** • **Fire Support Coordination Measures (FSCMs)** • **Targeting Assessment**	Fires
• **Intelligence Preparation of the Battlefield (IPB) (Order of Battle (OOB), weaknesses and peculiarities, activities and capabilities, and courses of action (COAs))** • **Collection Plan** • **Assessment of Enemy Center of Gravity (COG) and Effects of Friendly Ops**	Intel

Notional Data Product Examples	Producer Data Domain
• **High-Value Target (HVT) Lists** • **Center / Centers of Gravity** • **Threat Deception and Denial Efforts**	
• **Scheme of Protection** • **Threats, Hazards, and Prevention Measures** • **Critical Asset List (CAL)/ Defended Asset List (DAL)** • **Air and Missile Threats** • **Rear Area Security / Critical Security Plans** • **Operational Security (OPSEC) Measures**	Protection
• **Concept of Support** • **Combat Configured Loads (CCLs) of Essential Items Required for Operational Tempo (OPTEMPO)** • **Supplies Required for Branches or Sequels**	Sustainment

E.2   DDIL Considerations

Although this UDRA applies the data mesh concept to a data abstraction layer that is network/transport agnostic, operations in DDIL network environments focus heavily on network-centric concepts.

The Army data mesh must function to the maximum extent possible in DDIL environments. To do so, data domains and end users will require some local data processing capabilities and services during periods of DDIL operations. Commanders and staff executing the mission in a DDIL environment will need the capability to conduct limited data mesh activities and transactions among accessible domains until a reliable connection to the Army Enterprise at sufficient scale can be re-established.

UDRA-compliant solutions must consider the mission itself and the environment in which the mission will be executed. The objective of the *Decision-Driven Data CONOPS* is to create a data ecosystem that will allow every data domain to access data products for mission success. This does not imply that "all data to all people" is the intended objective. Rather, it reflects that "the right data product to the right consumer at the right time" is needed for mission success.

This UDRA provides a mesh data architecture that flattens and distributes the current data architecture while supporting the Army's typical echelon of command structure. It does so by leveraging data products, data domains, and mesh services to orchestrate data product sharing. Data products are shared across the enterprise with data domains producing derived or aggregated data products as well as producing data product consumers who employ data products for analysis and visualization to support decision makers.

As previously mentioned, this UDRA is designed to be network/transport agnostic. Data product consumers will discover data products via an enterprise or mesh-level global discovery

service/catalog when it is available. In all cases, data products required for decision makers' mission needs will be obtained directly from the data domain that produced the product(s). When the network is not available, the data domain platforms and end-user devices will still require adequate sensor systems and mission command capabilities to satisfy the echelon of command decision makers' data product needs. During such periods, the produced data products will be registered locally, within the data domain, and data product discovery will failover to queries distributed to reachable data domains. When network connections are restored, those data products are expected to then be registered at the enterprise or mesh level.

The data abstraction layer (data mesh) services will not eliminate or solve DDIL challenges. Data abstraction layer services rely on multi-path, robust, and resilient network transport and infrastructure services from the cloud to the edge in order to support mission operations.

Forthcoming UDRA implementation guidance will provide more details on mesh implementation strategies for supporting both the enterprise and DDIL environments.

Appendix F – Terms of Reference

Authoritative Data Source (ADS) – A recognized or official data-production source (with a designated mission statement, source, or product) that publishes reliable and accurate data for subsequent use by customers. An ADS may be the functional combination of multiple, separate data sources. (AR 25-1)

Computational Governance – The automated enforcement of governance policies through the application of computational methods.

Data Domain – An organization.[13] having specific functional expertise which produces data products to share information with consumers and may consume data products produced by other data domains. Army implementation of a data domain is defined by Army governance. The designated Mission Area Data Officer identifies data domains within the mission area and assigns a Data Steward to provide governance and policy controls over that domain.

Data Ecosystem – The collection of people, processes, and tools needed to produce Soldier-driven domain-owned data products enabling analytics needed for decision dominance. (Source – Collaborative effort between ASA(ALT)/DASA(DES) and TRADOC/MCCoE, 2022)

Data Governance – DoD data governance provides the principles, policies, processes, frameworks, tools, metrics, and oversight required to effectively manage data at all levels, from creation to disposition. (DoD Data Strategy, 2020)

Data Management – 1. The development, execution, and supervision of plans, policies, programs, and practices that deliver, control, protect, and enhance the value of data and information assets throughout their lifecycles. (DAMA DMBOK) 2. The process of creating a basis for posting, sorting, identifying, and organizing vast quantities of data available to DoD. (AR 25-1, Jul 2019)

Data Mesh – A data architecture based on a federated and decentralized approach to analytical data production, management, and sharing. It is characterized by federated governance, self-service infrastructure platforms, treating and providing data as a product, and autonomous data domains which are responsible for their data.

Data Platform – A set of modular open system technologies and infrastructure used to securely manage data within a domain. Data platforms enable data domains to produce, expose, retrieve, and consume mesh-conforming data products.

Data Product – A pre-packaged set of data and metadata produced to satisfy consumers' mission or business demand. Data products are designed to be high quality, easy to use, self-describing and computationally governed.

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[13] This could constitute a subset of an organizational unit or an aggregation of organizational units as established by the CDAO and Army Data Board.

Data Set – 1. A collection of related data items without the required curation and packaging for use in the mesh. In this UDRA, a data product team uses their domain-owned and other data set(s) to produce data products that satisfy the information needs of their consumers. (ASA(ALT) DASA(DES)) 2. One or more data objects that share common properties and characteristics and are managed as a unit. (Intelligence Community (IC) Data Management Lexicon)

End-User Device – An individual computer, workstation, or a mobile device used by commanders, staff, or soldiers to obtain and utilize the data product(s) for their intended purpose in support of decision making.

Federated Governance – A data governance model in which mesh-level policies and practices are defined centrally and executed by mesh services and decentralized data domains, which are decision makers within their domains for all other affairs. (Adapted from the book titled *Data Mesh In Action*)

Mesh Services – A collection of automated services for the production, consumption, orchestration, and interoperable sharing of data products.

Metadata – Information describing the characteristics of data; data or information about data; or descriptive information about an entity's data, data activities, systems, and holdings. (DoD Metadata Guidance)

Policy Decision Point (PDP) – A system entity that makes authorization decisions for itself or for other system entities that request such decisions. (NIST IR 7657)

Policy Enforcement Point (PEP) – A system entity that requests and subsequently enforces authorization decisions. (NIST IR 7657)

Appendix G – List of References

1. *Secretary of the Army Message to the Force*, 8 February 2022.

2. *DoD Data Strategy*, 30 Sep 2020.

3. *Improving Data Quality*, DoD CDAO, February 2023.

4. *Army Data Plan*, October 2022.

5. *Decision-Driven Data Concept of Operations*, Version 1.0, 6 July 2023.

6. Memorandum, subject: *Army Data Governance Roles and Responsibilities*, Army CIO, 2 April 2024.

7. Secretary of the Army, Memorandum, subject: *Mandatory Implementation of Army Data Services Requirements*, dated 10 April 2020.

8. *DoD CDO Data Stewardship Guidebook*, V 1.0, October 2021.

9. Data Product Descriptor Specification https://dpds.opendatamesh.org/specifications/dpds/1.0.0/, last accessed 5 September 2024.

10. Army Regulation (AR) 25-1, *Army Information Technology*, 15 July 2019.

11. NIST Interagency Report (IR) 7657, *A Report on the Privilege (Access) Management Workshop*, 30 March 2010.

12. NIST Special Publication (SP) 800-53, *Security and Privacy Controls for Information Systems and Organizations*, Rev. 5.1.1, September 2020 (inc. updates as of 7 November 2023).

13. NIST FIPS PUB 180-4, *Secure Hash Standards (SHS),* August 2015.

14. Internet Engineering Task Force (IETF) Request For Comment (RFC) 3986, *Universal Resource Identifier (URI): Generic Syntax*, January 2005.

15. IETF RFC 4122, *A Universally Unique IDentifier (UUID) URN Namespace*, July 2005.

16. IETF RFC 6838, *Media Type Specifications and Registration Procedures*, January 2013.

17. International Organization for Standardization (ISO) 8601-1:2019, *Data and time - Representations for information interchange Part 1: Basic rules*, February 2019.

18. MIL-STD-2401 (Notice 1)*, DoD World Geodetic System (WGS)*, 31 March 2004.

19. DoDI 8500.01, *Cybersecurity*, 14 March 2014, Incorporating Change 1, Effective 7 October 2019.

20. DoDI 8531.01, *DoD Vulnerability Management*, 15 September 2020.

21. CNSSP 22, *Policy on Information Assurance Risk Management for National Security Systems*, January 2012

22. NIST SP 800-37, *Risk Management Framework*, Revision 2, December 2018.

23. NIST SP 800-39, *Managing Information Security Risk*, March 2011.

24. *The Intelligence Community Lexicon*, January 2022.

25. *A Holistic Framework for Managing Data Analytics Projects*; May 15, 2020; https://www.elderresearch.com/blog/holistic-framework-for-managing-data-analytics-projects, last accessed 5 September 2024.

26. *Army Doctrine Publication (ADP) 3-0, Operations*, 31 July 2019.

This technical data deliverable was developed using contract funds under Basic Contract No. W56KGU-18-D-0004.