

National Environmental  
Satellite, Data, and  
Information Service

National Centers for Environmental Information

# Enabling an Iterative, Open Science Transformation to the Geoverse with a Federated Knowledge Mesh

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Charm City

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# Where To? Geoverse Semantics in Context

- A democratized 'system of systems' powered in large part by machine to machine communication
  - Systems may be 'smart agents'
- An ecosystem in which all users can both consume and contribute information
- A federated trust-based framework for realizing universally useful understanding

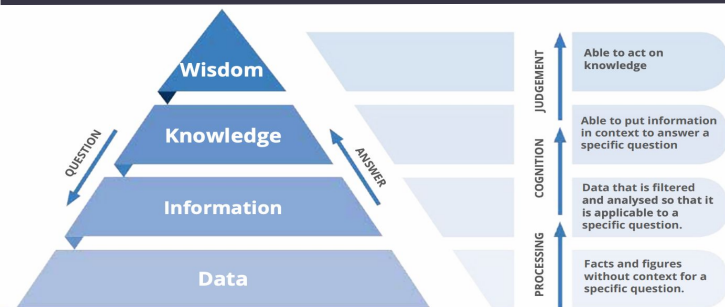
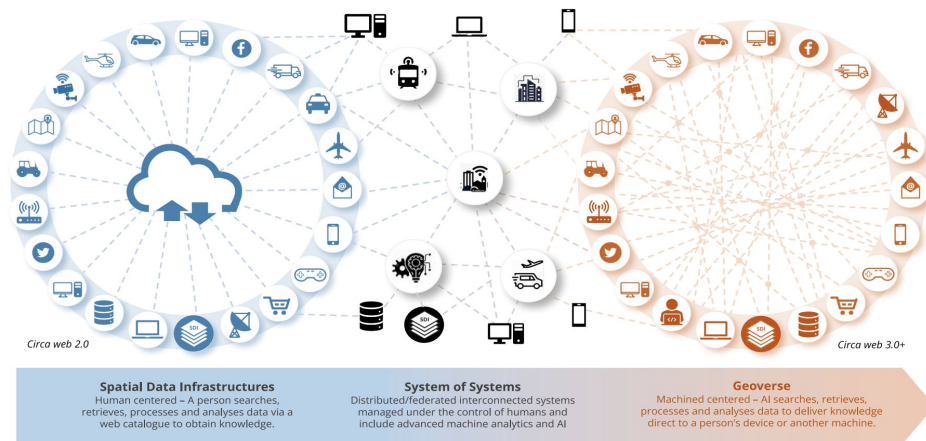
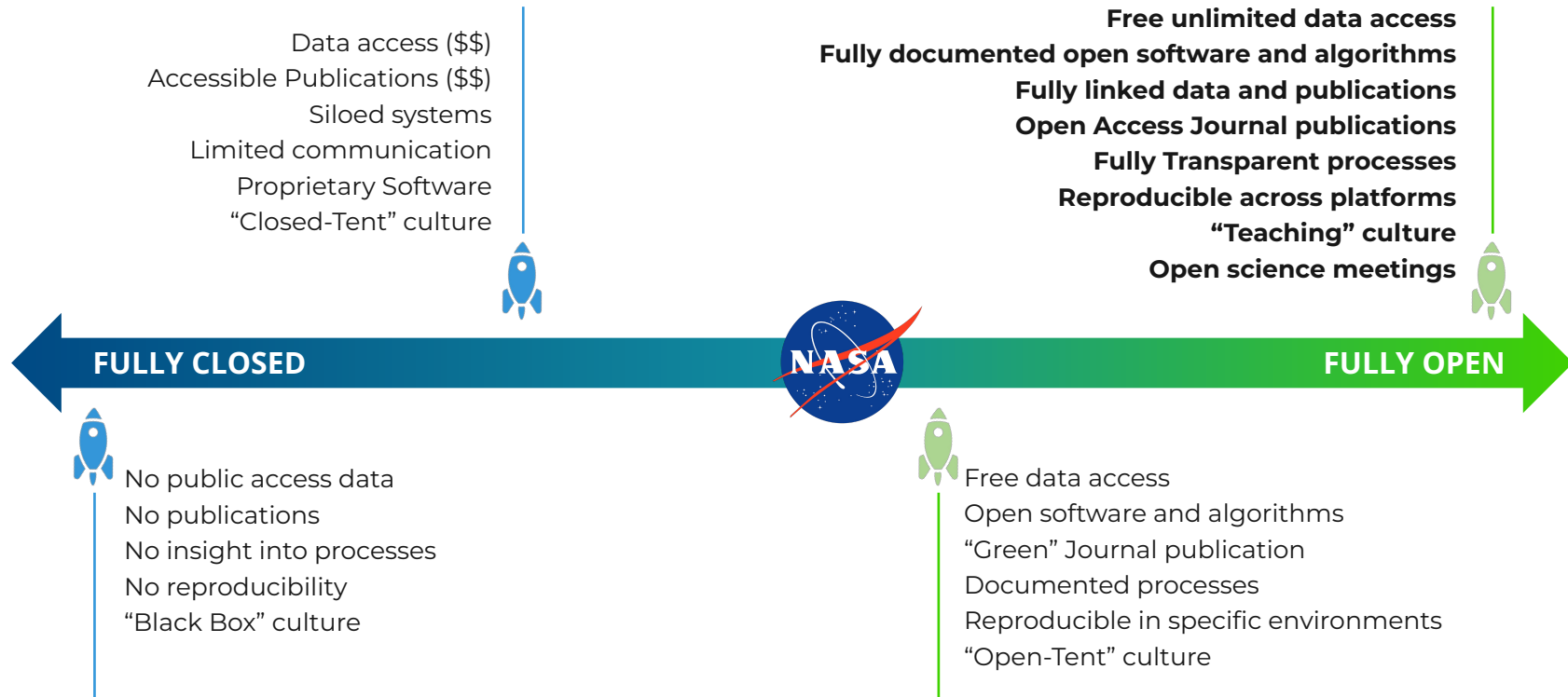


Figure 4. From data to information, knowledge and wisdom. Adapted from DIKW Model for knowledge management and data value extraction.

Strategic Pathway Elements	Spatial Data Infrastructures	Future Geospatial Information Ecosystem
Standards Governance and Policy	A commitment to assess, establish, and maintain a common standards framework	A commitment to adopt standard models for knowledge representation
Technology and Data Interoperability	Voluntary standards for data and technology	Anticipatory regulations, FAIR data and human-centered standards for knowledge creation
Compliance Testing and Certification	Regular assessments, training, government mandates, performance metrics, testing and certification	Regulatory sandboxes, proof of concepts and incentives for deploying and scaling 4IR technologies
Community of Practice	Sharing and leveraging data and technology standards	Inclusive and participatory roles in data vocabularies, digital twins, and other 4IR standards development

Figure 12. Standards Strategic Pathway – the Step Change

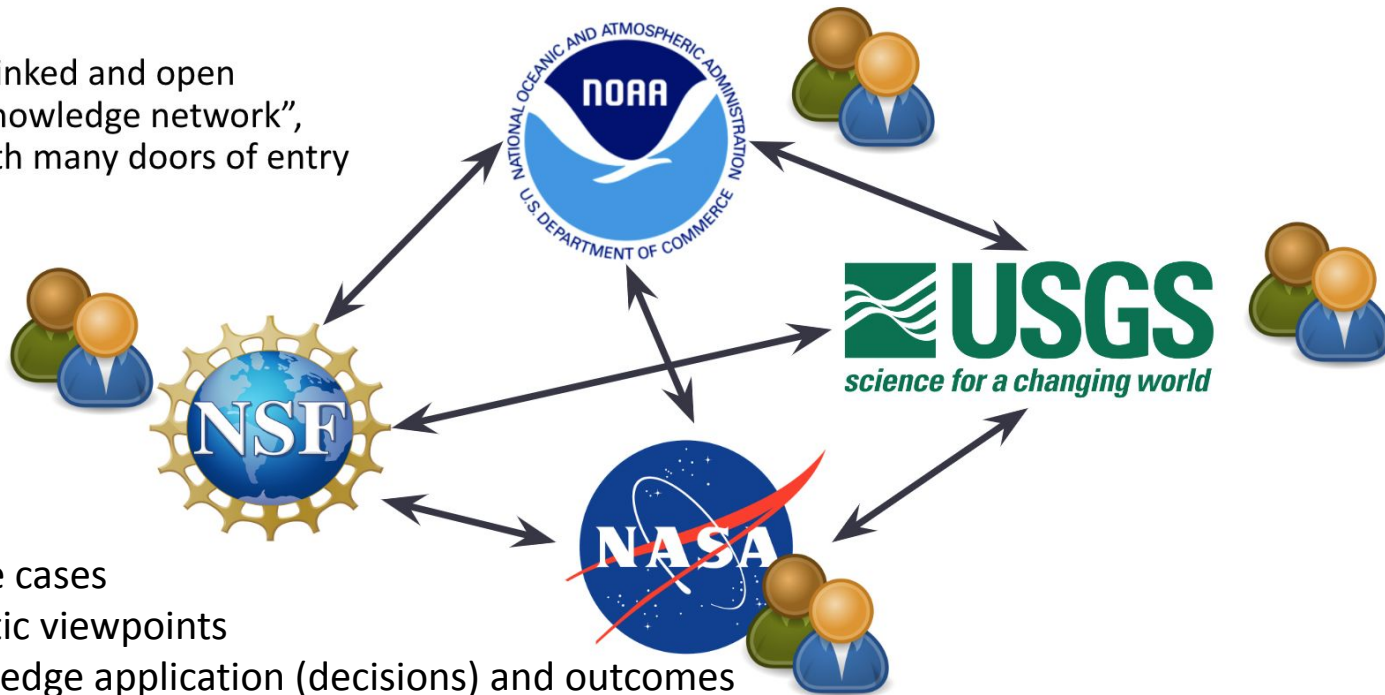
# What is “Open Science”?



Source: [C. Gentemann \(2022, NOAA EDM Workshop presentation\)](#)

# Toward an Open Ecosystem of Trusted Open Ecosystems

A linked and open  
“knowledge network”,  
with many doors of entry



More coverage in use cases

Providing more holistic viewpoints

Ability to track knowledge application (decisions) and outcomes



# What success means to constituents

## **Meg, a Coastal Resident and Environmental Enthusiast:**

Meg is a resident living on Hilton Head Island with a deep interest in the environment. She talks to the system through her Alexa to gain insights into local marine life, weather patterns, and pollution levels using real-time weather updates, satellite imagery from NASA, and environmental data from NOAA. She can report environmental concerns directly to the EPA with full provenance for investigation.

## **Bart, a Commercial Fisherman:**

Bart relies on accurate and timely information for successful operations in the Gulf. He uses an integrated ship dashboard to make predictions and get updates that help him make informed decisions about optimal fishing locations, avoiding adverse weather conditions, and ensuring sustainable practices. The system enables Bart by combining NOAA's fisheries data, NASA's satellite-based ocean temperature maps, and USGS coastal mapping. Bart sometimes asks the system to explain predictions and give alternative assessments. When needed, Bart further uses the system for direct communication with relevant federal agencies for licensing, regulatory updates, and emergency assistance.

## **Gertie, an Emergency Response Coordinator:**

Gertie requires immediate access to comprehensive information while monitoring wildfires in Colorado. A multi-modal system interface connects them to real-time weather updates, NASA's disaster monitoring, and USGS geological data. Gertie is enabled to coordinate evacuation plans with local and regional authorities and monitor emerging outcomes in real-time.

## **Holden, a Tourism and Recreation Planner:**

Holden aims to create enjoyable experiences for visitors to the Chesapeake Bay. As Holden crafts tailored experiences for his clients, he converses with the system to understand seasonal trends, identify ideal locations, and, shape events accordingly.

## **Elias, a Public Health Researcher:**

Elias is a public health researcher studying coastal communities and relies on diverse data sources. He uses a portal to access and fuse information from health, environmental quality, and satellite record databases to help identify potential health risks and patterns based on air and water quality. He uses context to understand ideal methods of engagement with local communities to provide evidence-based recommendations for improved public health outcomes.



# What success means to the workforce

## **Buffy, a NOAA Archivist:**

Buffy needs to efficiently manage and organize a vast number of heterogeneous datasets in the Archive. Through her government portal Buffy accesses and catalogs data. She uses the marketplace to add quality matrix checking, link related datasets, or create new collections and views on the data. She develops, shares, and evolves standard templates and expressions for providers to use and assesses adoption.

## **Munir, a NOAA Data Manager:**

Munir's job is to coordinate marine data flows between providers and consumers. He uses the system API to help build, monitor, and communicate data pipelines, while ensuring data quality. He uses the API in his own software to achieve on-demand data retrieval in specific formats for generating comprehensive data reports. He contributes his techniques back to the marketplace as reusable templates for use by other data managers.

## **Marilyn, a NOAA Data Scientist:**

Marilyn uses the system daily to access diverse datasets for research and analysis to relate societal indicators to climate change. The system provides here facilitates seamless integration of datasets from NOAA, NASA, USGS, EPA, and NIH. She leverages user and system access data to quickly develop and test new models for improving user experience; the system automatically shares what she creates for reuse by others.

## **Aditi, a NOAA Physical Scientist:**

Aditi builds authoritative climate data records at NOAA. She leverages the system to explore what has been done before, what findings have been made, and what things might need further research. She leverages on-demand data retrieval for existing products in desired formats to try new modeling and simulation techniques. The data and products she produces are made available to the system.

*Not pictured: System Administrators; Data Operators; Policy Analysts; etc.*



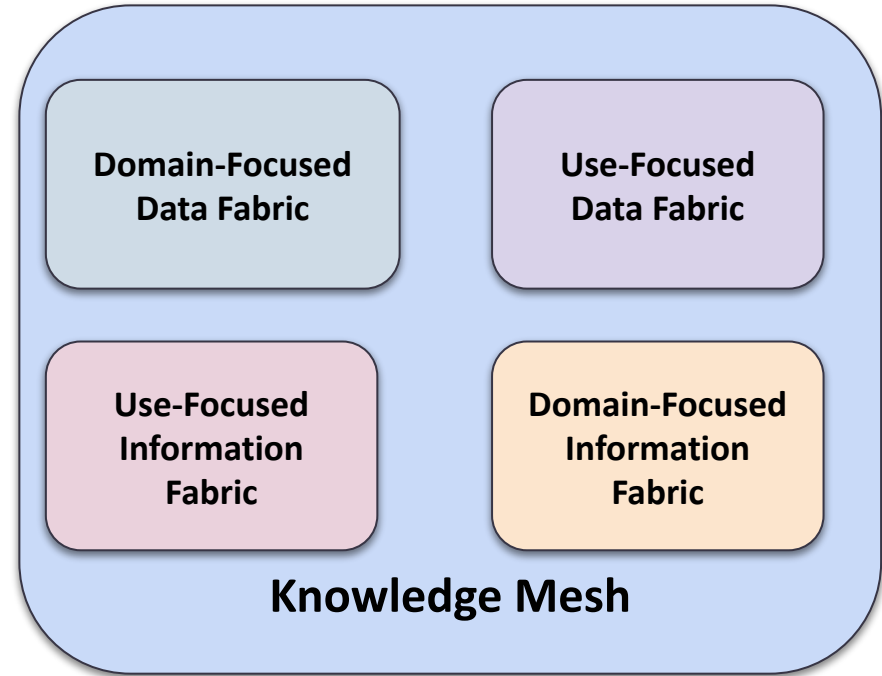


# Terminology - Mesh vs Fabric?

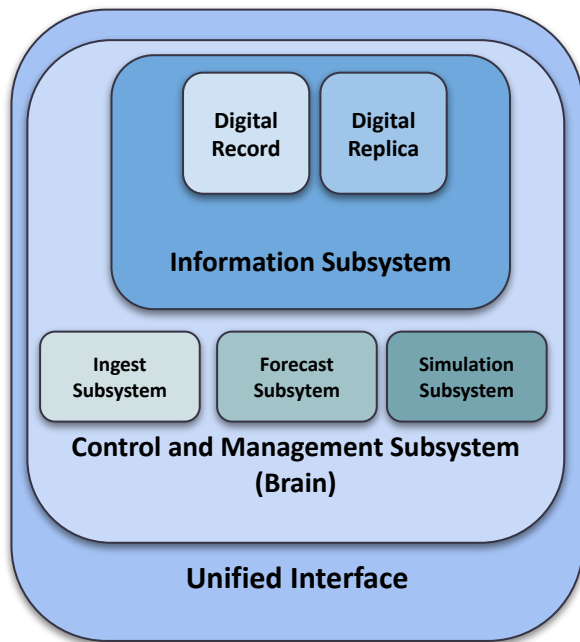
It's fuzzy, but very basically,

- **Fabric** - centralized governance, focused community, focused access patterns
- **Mesh** - decentralized control, community of communities, integrated access patterns

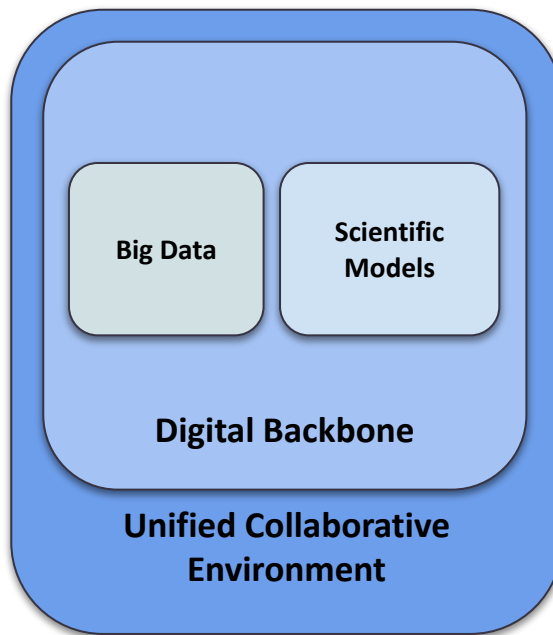
We need capabilities of both, and are seeing this need emerge in next-gen motifs.



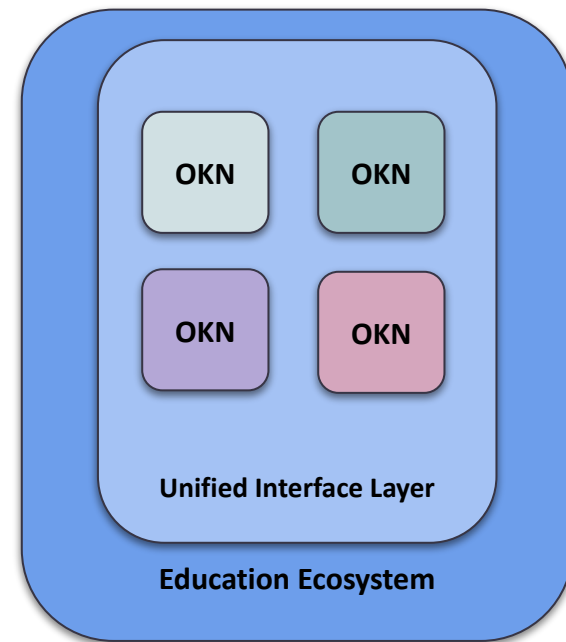
# Emerging Motifs in the Next-Gen Landscape



Earth System Digital Twin  
(ESDT)



European Digital Twins of the Ocean Ecosystem  
(DTO)



Prototype Open Knowledge Network  
(Proto-OKN)



# OISS ConOps

Data Managers, Data Scientists, Physical Scientists, Operators, Researchers

## Open Information Stewardship Service

### General Notes

- Processes are user defined, API validates
- Executable task business logic is either user provided, through CI/CD or is a remote API call to run in federation; may be long running and/or human-in-the-middle (HITM)
- All Tasks publish to Metadata Bucket on Task resolution
- Process Requests shown are inbound or outbound and made by passing a predefined message to API to trigger predefined process

### GUI Submission System

Process Request

Task UBL

Process Request

### Enterprise Metadata

Source Metadata WAFs

Web 3.0 Crawler User

AUI Task UBL

### Metadata Management Microservices

Harvest/Resolve Xlink  
Transformations  
Models  
Inference  
Validation  
Reports  
Assessments

Task UBL

### Science and Development Microservices

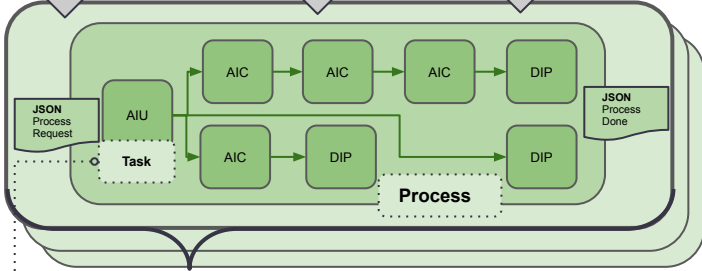
Models  
Algorithms  
Systems  
APIs

Task UBL

### Data Management Microservices

Models  
Validations  
Transformations  
Deliveries  
Reports

Task UBL



**Metadata Bucket**  
Denormalized  
Hierarchical  
Fully Linked  
JSON-LD

**Enterprise Interoperability Framework**  
Mesh API

**Data Bucket**  
Hierarchical  
Archive Submissions  
Product Outputs  
Diverse Format

Task

User Business Logic (UBL)

Web 3.0 Metadata Record (AUI/AIC/DIP)

Data Crawler User

### Internal Community Catalog

Specific Data Formats  
e.g. 19115-2 ISO  
Capabilities  
ElasticSearch Index

DIP Task UBL  
Process Request

### External Community Catalog

Specific Data Formats  
e.g. UMM-{C,G}  
Capabilities  
Metadata Transform

DIP Task UBL  
Process Request

### Foundation Model Endpoint

Multi-Context Prompts

Process Request

Geospatial System

Linked Data System

Catalog

Digital Twin

Cooperative Endpoints

DIP Task UBL

### Resource Marketplace

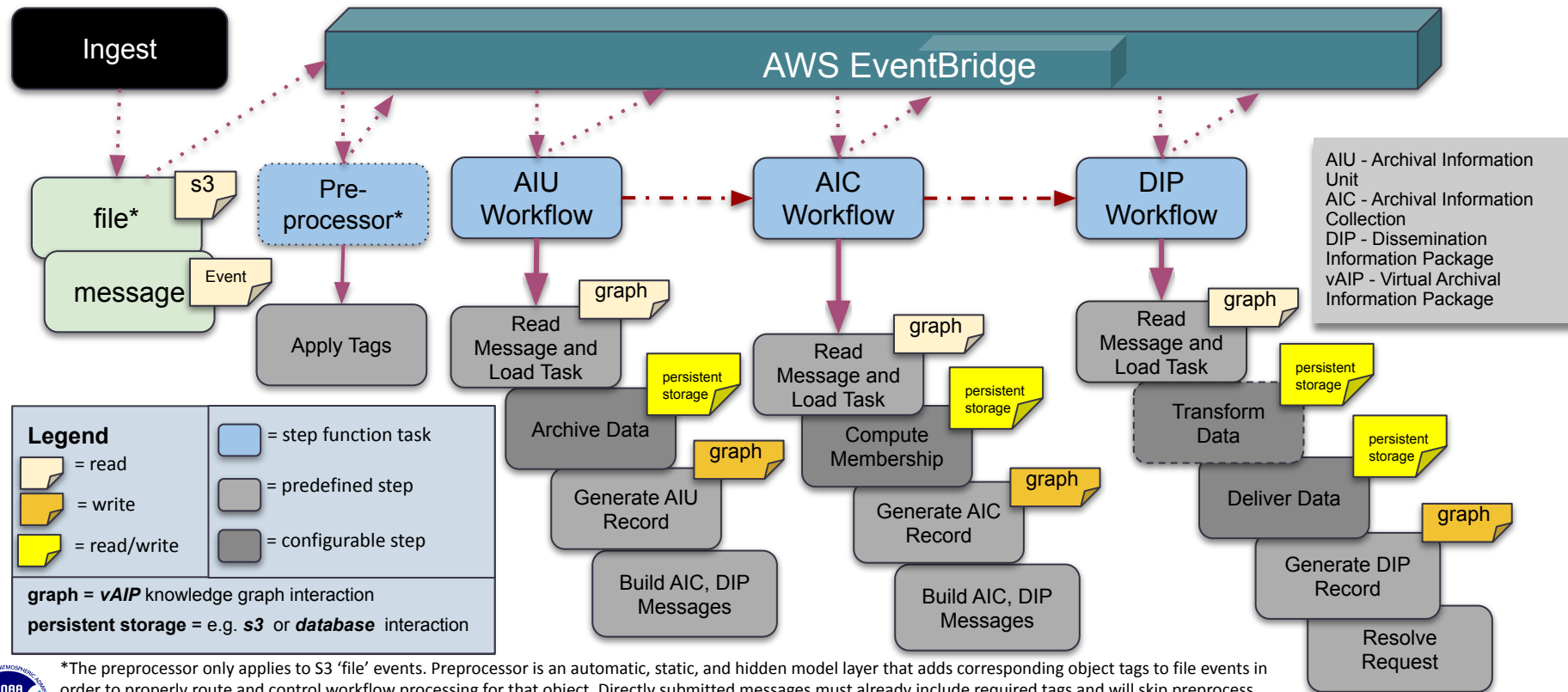
### Market System

DIP Task UBL

Process Request

Browse API Access

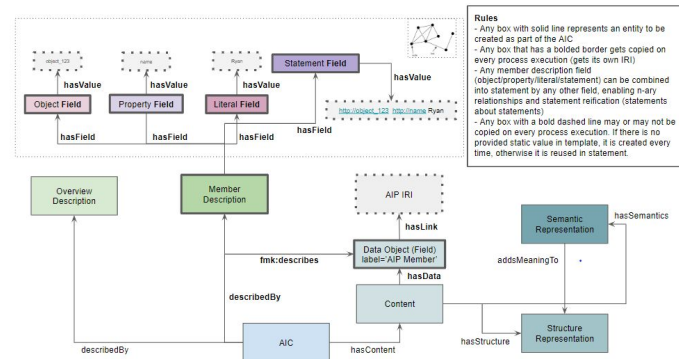
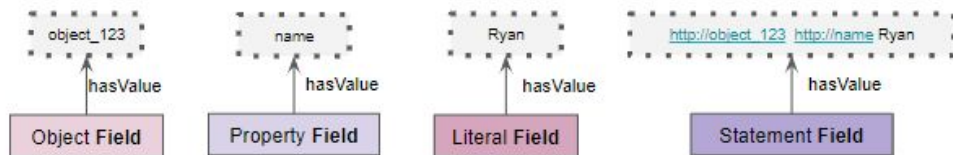
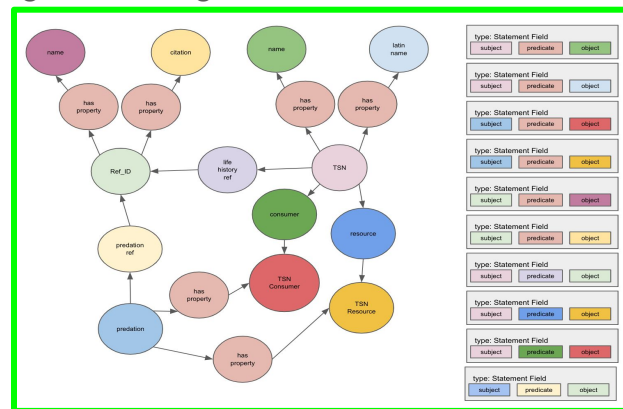
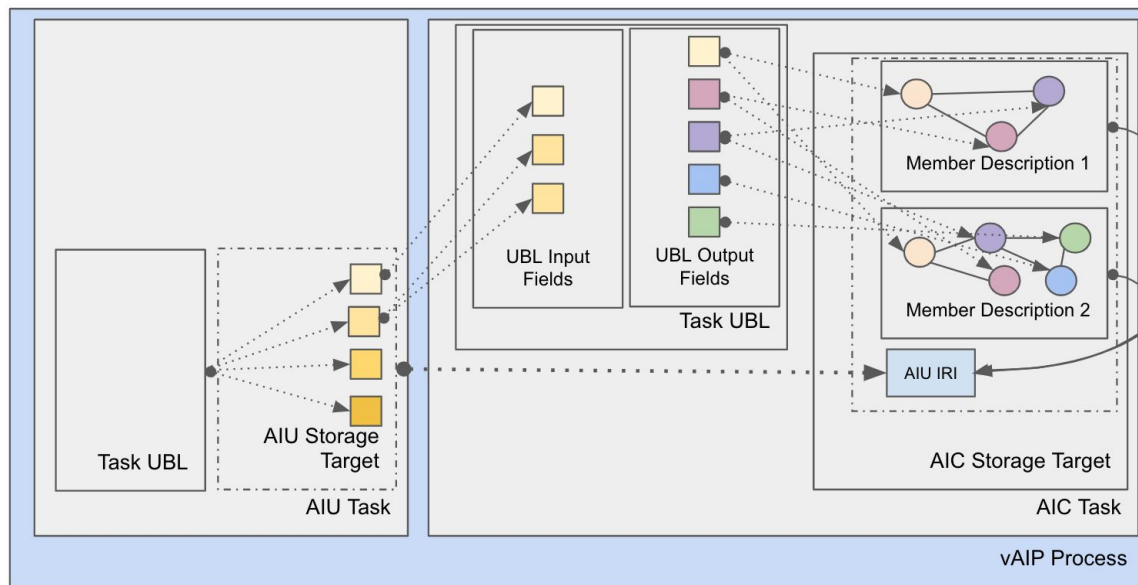
# Massive Real-time Concurrency, Small Footprint



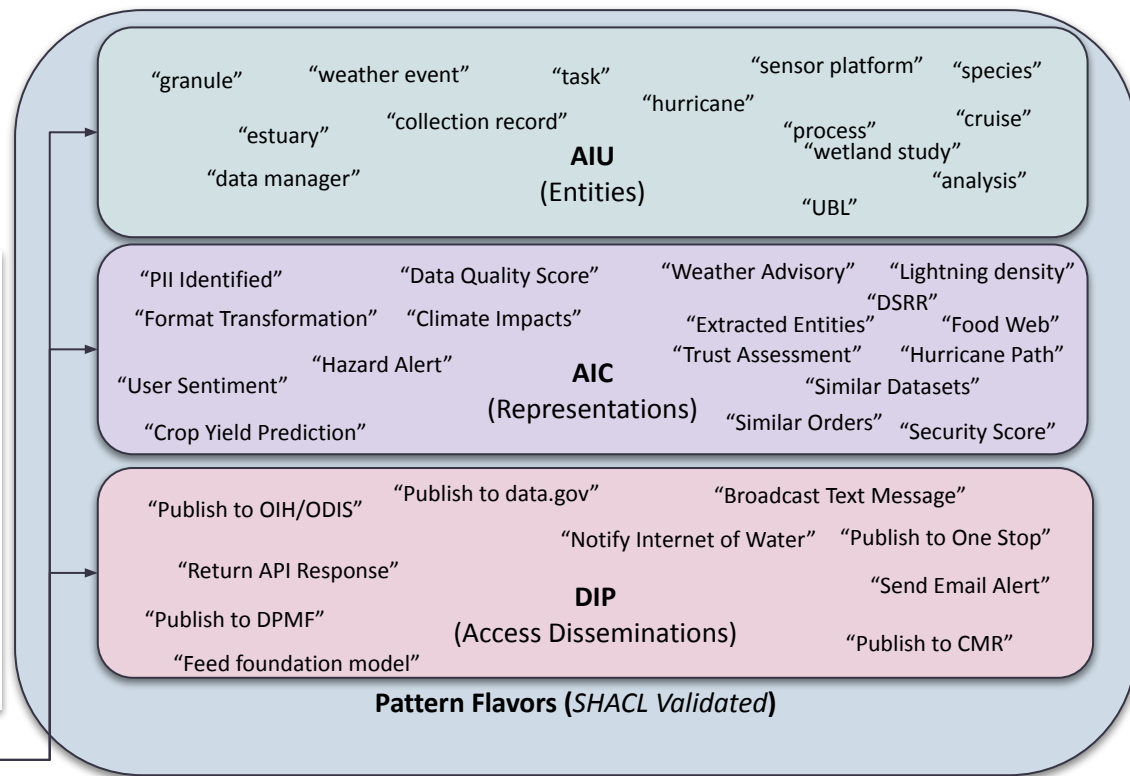
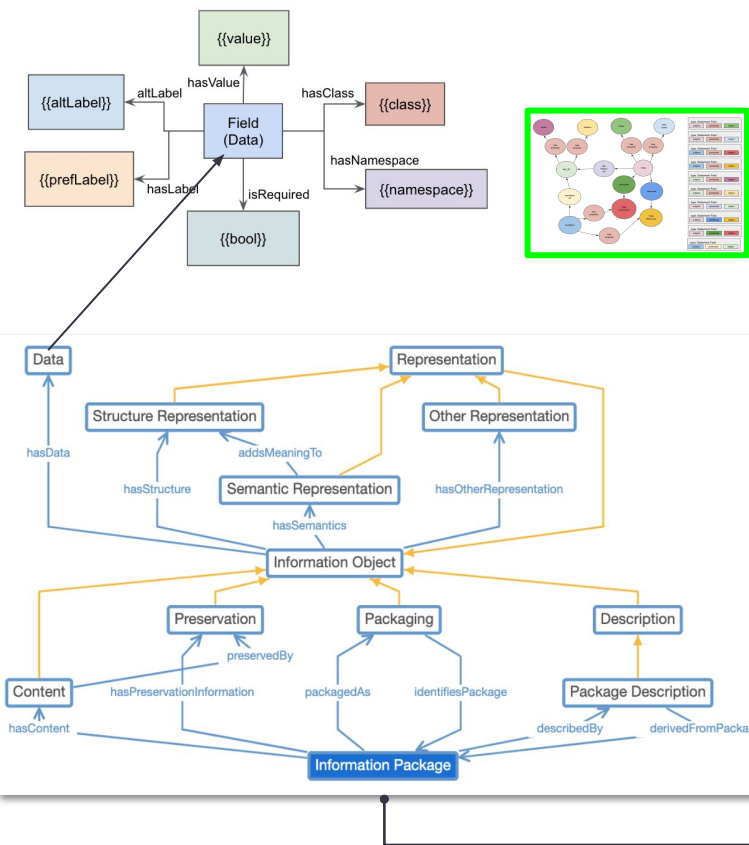
\*The preprocessor only applies to S3 'file' events. Preprocessor is an automatic, static, and hidden model layer that adds corresponding object tags to file events in order to properly route and control workflow processing for that object. Directly submitted messages must already include required tags and will skip preprocess.

## Enormous Amounts of Trusted, High Quality, Fully Contextual, and Regularized Data

Links; texts; documents; input/output parameters for functions; video; audio; biological; ecological; etc.



# OISS Motifs



# Motif Search Spaces

Motifs (subgraphs) are

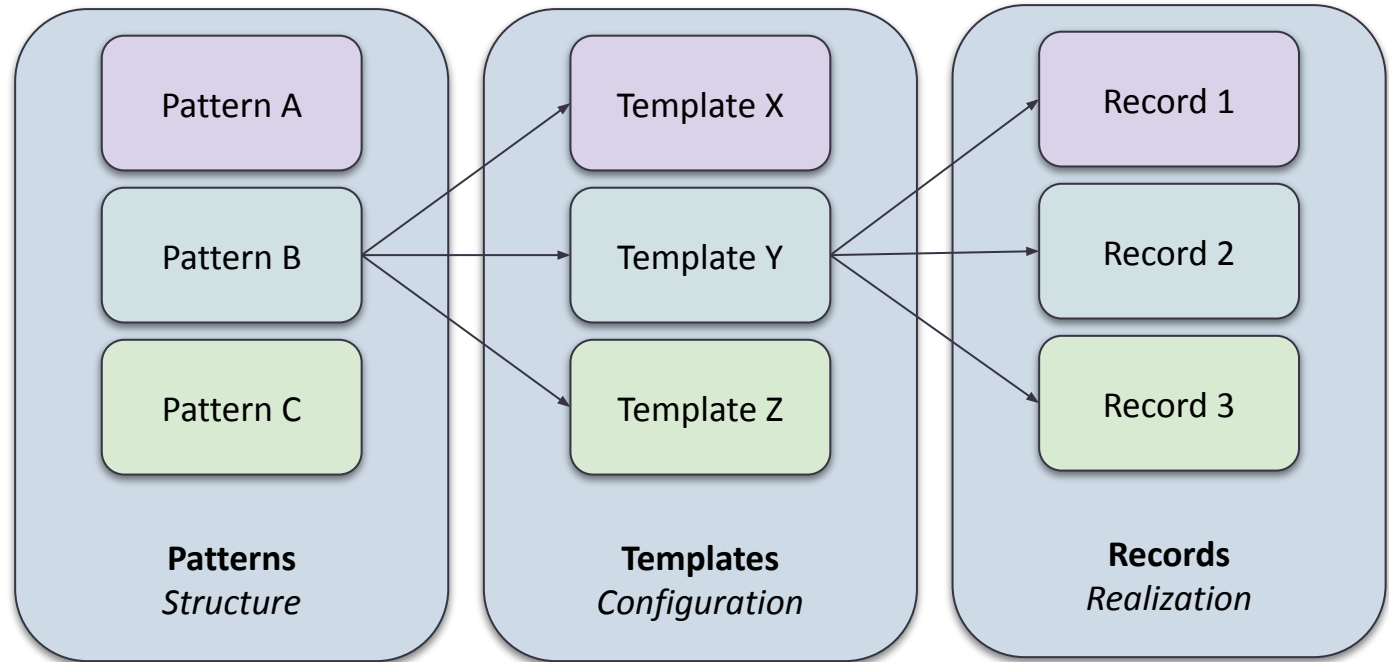
enablers for:

- Stable API interfaces
- Optimized searches
- Feature models
- Visualizations

All OISS **explicit motifs** are  
**OAIS Information Packages**  
Reference model defined user  
patterns.

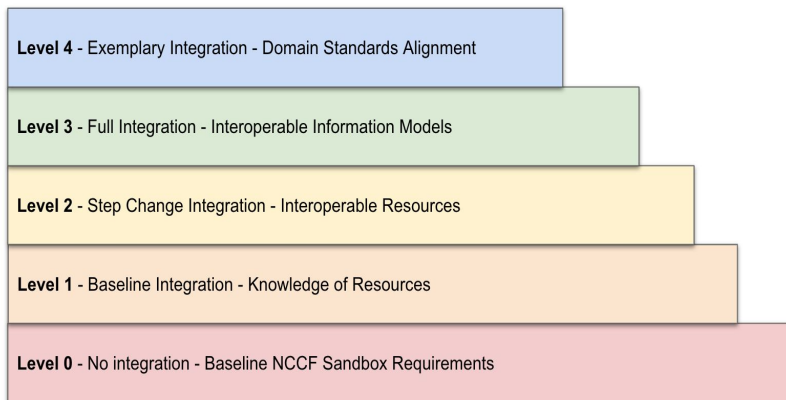
Each explicit motif has  
different SHACL  
characteristics - for example,  
**AICs support n-ary**  
**relationships** in their member  
descriptions.

These are the motifs that are  
defined and known - there are  
other motifs emergent in the  
system data due to its linked  
data nature



# Enabling Iterative Transformation at NOAA

## Open Information Stewardship Service (OISS) Integration Maturity Scale



## NCEI Levels of Stewardship



NOAA  
Information  
Purview

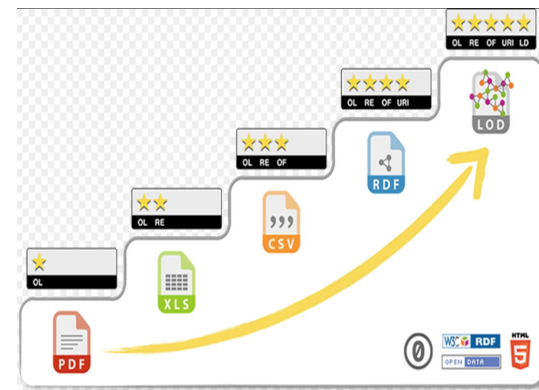


Recursive Stepwise Integration



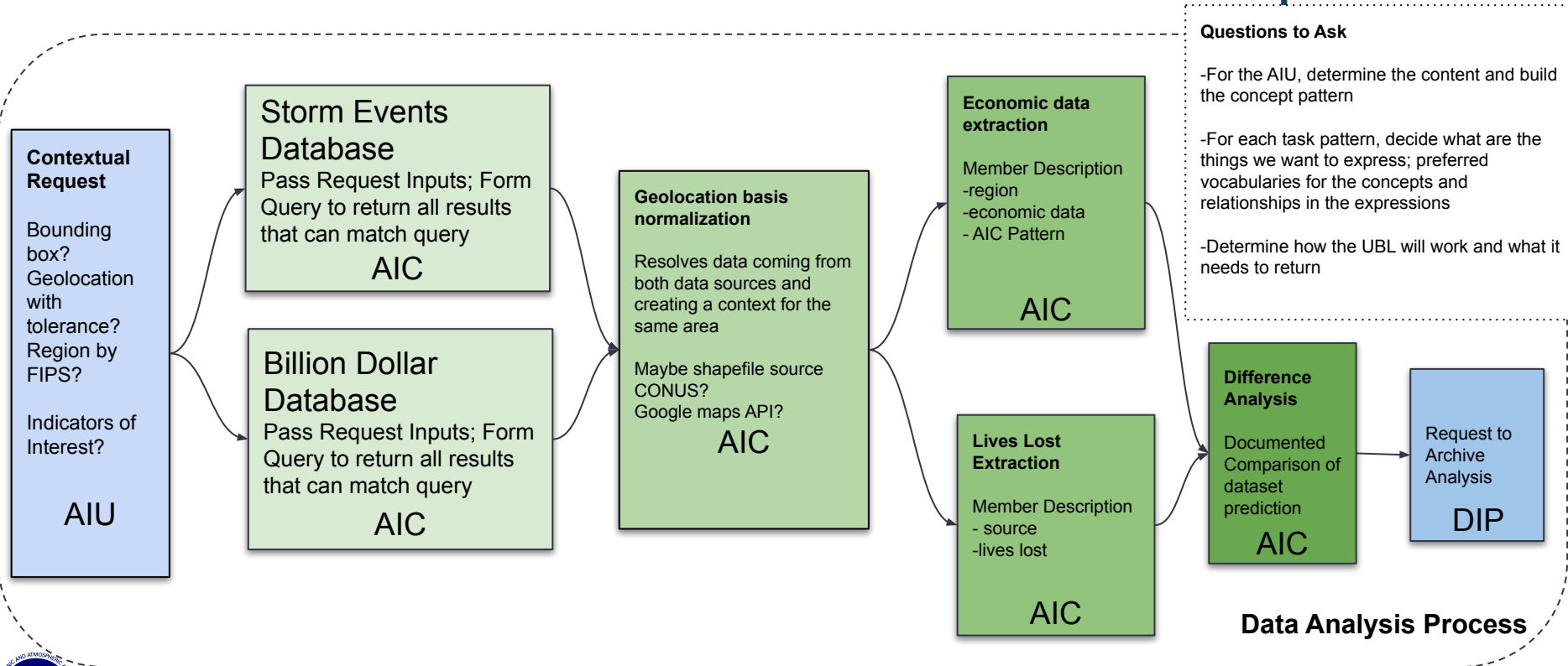
Iterative Increases to Openness

## 5 Star Linked Open Data

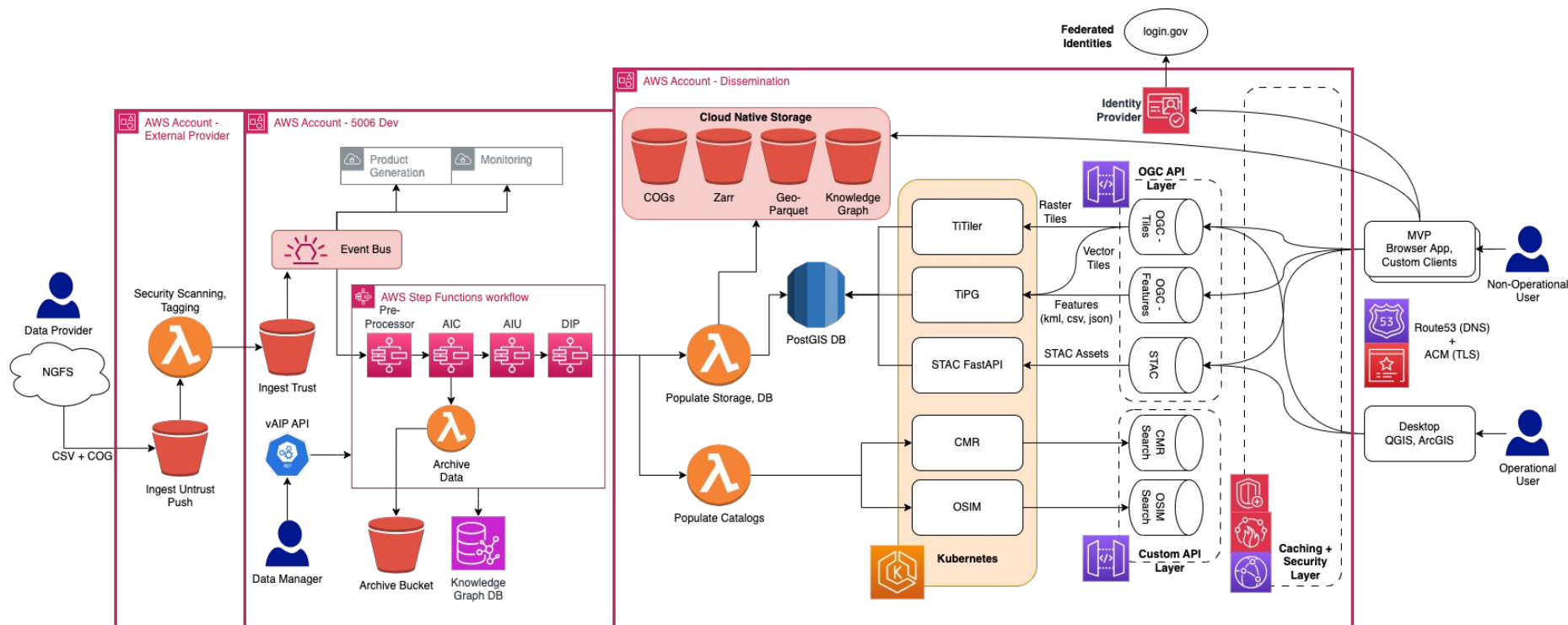




# OAR-NCEI Societal Data Partnership



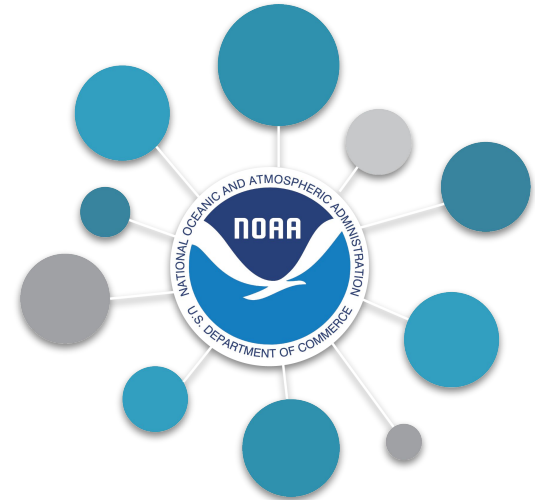
# Multi-transform and Multi-access for Wildland Fire Storefront



→  
Arrow Direction represents  
network connection initiation

# Current Activities

- **Seeding the mesh** with early adopter processes and resources
  - Lots of data streams and system integrations being onboarded or planned - Nexrad, CCOR, OISST, Faraday Cup, Extended Continental Shelf, Passive Acoustic Data, IGRA, World Ocean Database, etc.
- Developing and delivering **educational materials** for mesh adoption and maturation
  - Jupyter notebooks; trainings; ‘teaching to fish’ with the API and using the JSON-LD files and various data formats that are produced
- Identifying **beneficial partnerships** and **integration pathways**
  - E.g. across NOAA LOs; with NASA AIST and CNES in Digital Twin contexts; with NSF in OKN contexts; with OIH/ODIS in specific Ocean datastream contexts
- Developing **access processes** using **advanced AI/ML**
  - E.g. use of Retrieval Augmented Generation (RAG) to build out **conversational discovery** and access Processes; automated metadata normalization
- Building out the **marketplace**
  - Working with users to build out system resources for sharing

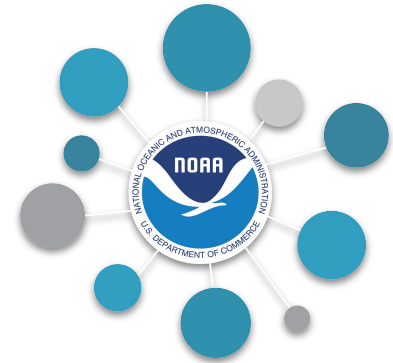


# Backups



# Mesh Highlight Summary

- Provides a full capability **metadata layer** as an **enterprise orchestration** service
  - Supports all **Digital Twin Earth Framework requirements** as specified by the DTE-FS
  - Maps as an AIST ESDT Architecture
  - Satisfies NARA requirements, intrinsic and largely automated support for PARR 2.0, FAIR, CARE, TRUST
  - As **cheap** as possible - cost optimized **at full capability**
  - As **flexible** as possible - any process, entity, expression, or access pattern; any user code in any compute context; agile reference architecture for re-implementation
    - Allows evolutionary growth in all exposed aspects
  - As **simple** as possible - no message adapters, pip install, small purposeful API
- Emphasizes **facts** and **traceability**
  - Everything is data; process is data; full provenance at the task level published in real-time on every process event
- Enables **definition** and **contextualization** of **anything** (entities, transformations, disseminations)
  - Inbound and outbound processes are the same; capturing use information; semantic records of function call inputs and outputs for model training; only running on request; API definition of everything
  - Provides a Motif basis for everything in larger connected context - **Motifs are critical** for enabling analyses
- Enables easy and automatable **intra-agency** and **inter-agency** interoperability
  - Process lets us connect with (and trace) federated APIs; supports interoperability with legal and regulatory requirements; private data
  - Open participation
- Supports **exploitation by Next-Gen capabilities** - multimodal foundation models, virtual reality environments, 'Spatial Computing'
- Guards against future migrations (**assumes eventual sunset up front**) - everything is data, no 'code-lock'

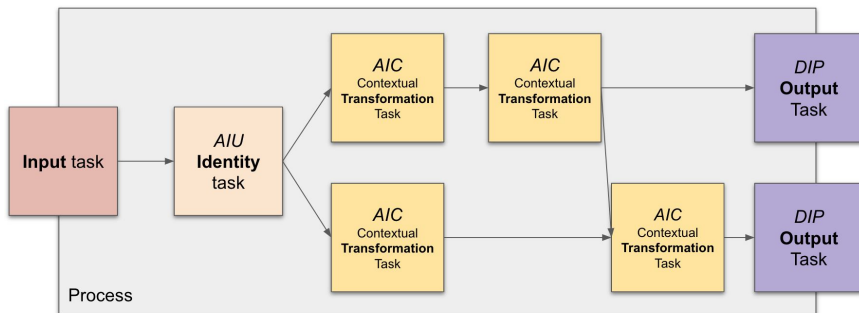


# Linked Independent Information Models

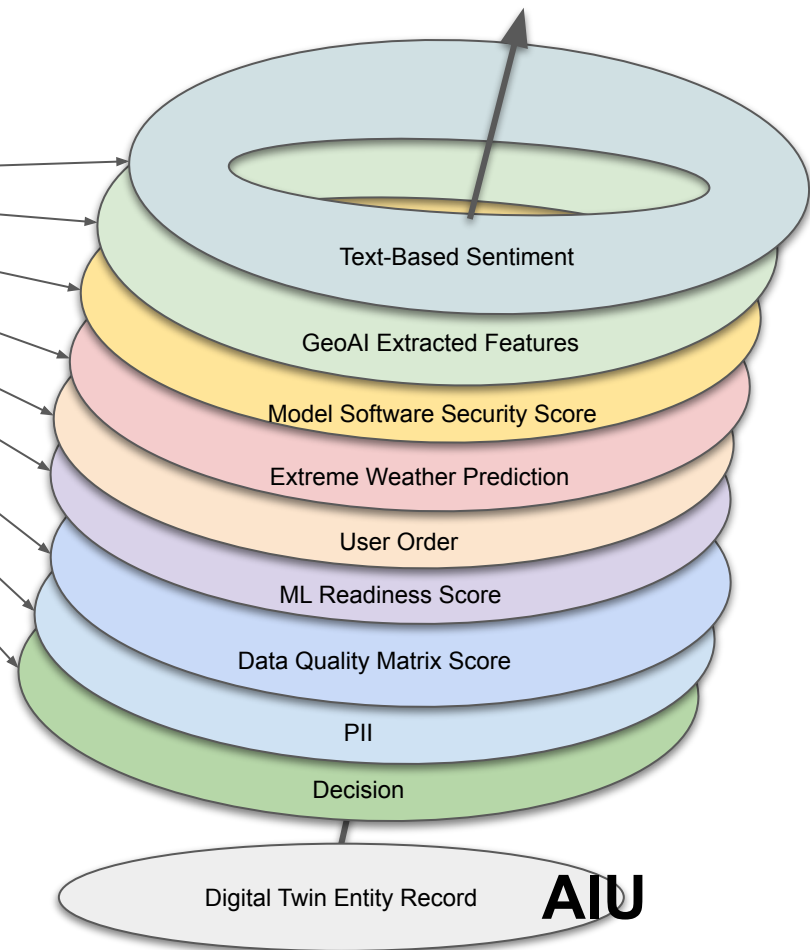
- Structured KOS
- FAIR
  - Findable
  - Accessible
  - Interoperable
  - Reusable
- CARE
  - Fine-grain access rights
  - Legal Interoperability
- **Knowledge Graph** held
- Independent spaces
- API Discovery/Document Browsing

**AIC**

The **AIC** provides controlled access to the 'full graph' of semantically encoded data, information, and knowledge, allowing users authorized by associated Access Rights policy to define AICs that implement Patterns using one or more of any preexisting, well-defined ontologies available on the semantic web (e.g. [SSN](#), [SOSO](#), [Schema.org](#), [SensorML](#), [Dublin Core](#), [GCMD](#), etc.), and/or make use of newly minted, user defined ontologies that are constructed and published automatically on AIC Pattern deployment for system-wide discovery and reuse.

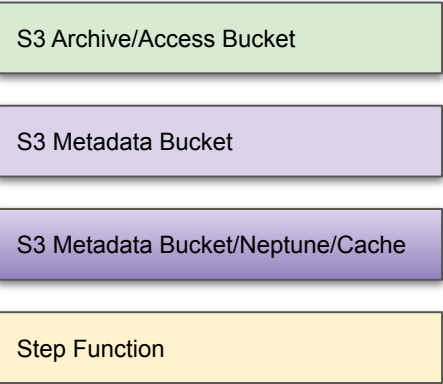


**DIP**





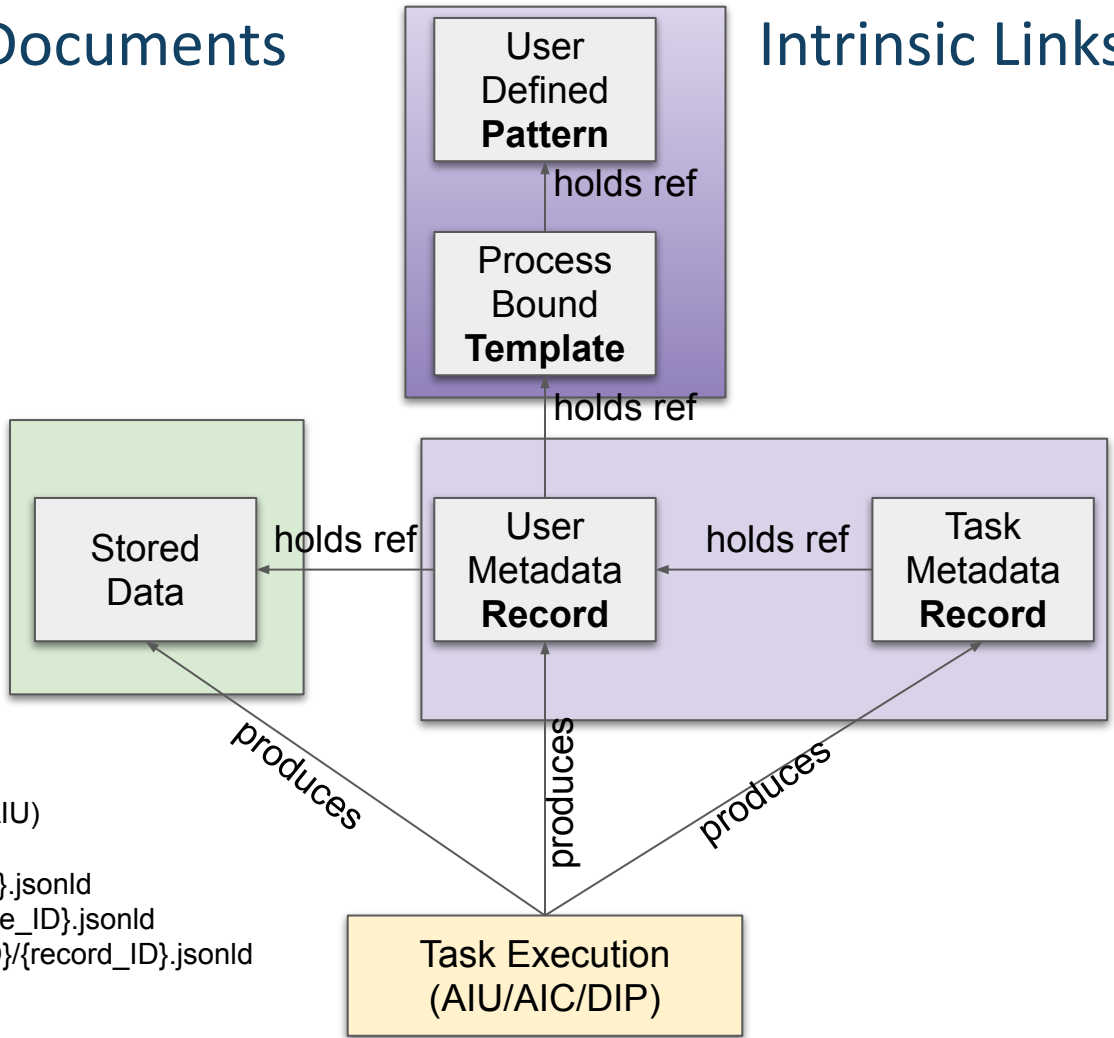
# AIU/AIC/DIP Metadata Documents



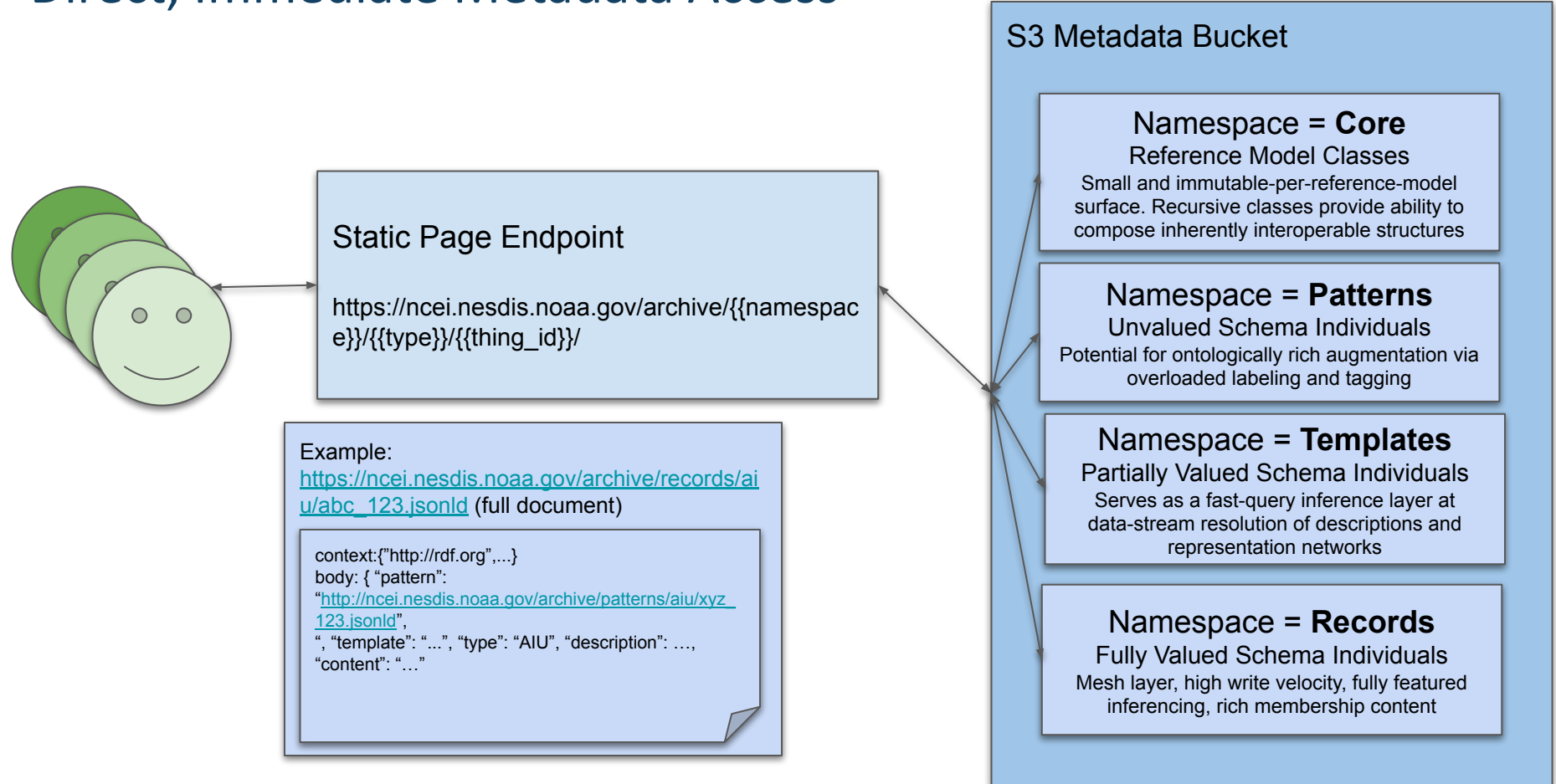
Metadata Bucket Hierarchy (example layout for AIU)

s3://patterns/storage/aiu/{pattern\_ID}/{pattern\_ID}.jsonld  
s3://templates/storage/aiu/{template\_ID}/{template\_ID}.jsonld  
s3://records/storage/aiu/{template\_ID}/{record\_ID}/{record\_ID}.jsonld

# Intrinsic Links



# Direct, Immediate Metadata Access



# Creating a Pattern

```
pattern = ontology.IdentityStoragePattern(session, "Granule")
```

Create a new pattern (here, AIU)

```
reference = pattern.add_reference("Archive PID", field={'title': 'Value', 'is_link': False})
semantic = reference.add_semantic_representation("Description")
structure = reference.add_structure_representation("Format")
semantic.node.addsMeaningTo.append(structure.node)
```

Add AIP-required information objects^

- Content
- Descriptive Information
- Packaging
- PDI
- Reference
- Fixity
- Access Rights
- Context\*
- Provenance\*

```
checksum = pattern.add_fixity("Checksum", field={'title': 'Value', 'is_link': False})
checksum.add_extra_representation("Purpose")
checksum_semantic = checksum.add_semantic_representation("Definition")
checksum_structure = checksum.add_structure_representation("Format")
checksum_semantic.node.addsMeaningTo.append(checksum_structure.node)
```

```
file_content = pattern.set_content("File", field={'is_link': True})
file_semantic = file_content.add_semantic_representation("File Schema")
file_structure = file_content.add_structure_representation("File Format")
file_semantic.node.addsMeaningTo.append(file_structure.node)
file_content.add_extra_representation("Decoding Software")
file_content.add_extra_representation("Visualization Software")
```

```
desc = pattern.add_description("Product Description")
desc.add_semantic_representation("Product Description Semantic Rep")
desc.add_structure_representation("Product Description Structure Rep")
```

Add representation IOs to each IO

- structure
- semantic
- 'extra' (other)

```
ar1 = pattern.add_access_rights("Distribution License")
ar1.add_semantic_representation("Distribution License Semantic Rep")
ar1.add_structure_representation("Distribution License Structure Rep")
```

Notes - Can add any number of Fields (DOs) per IO

Fields are semantic (classed and namespaced) links or values

\*Automatically satisfied, but user can extend

^Can add greater or equal to the Information Package Subtype (AIU/AIC/DIP) Requirements



# Creating a Process (Pattern to Workflow)

```
process = ProcessTemplate(session, purpose="E2E Granule Process", utility="Test process template")
process_namespace = process.namespace

## Initialize the IdentityStorageTemplate using a premade pattern
granule_pattern = granule(session)
aiu_template = IdentityStorageTemplate(session, source_pattern=granule_pattern)

task = IdentityTaskTemplate(session, target=aiu_template, purpose="E2E Granule AIU Task", utility="Test task tem")
process.set_aiu_task(task)
ubl = UBLTemplate(session, namespace=task.namespace)
task.set_ubl(ubl)

# This sets the AWS ARN for the step function executing this task (the aiu-workflow step function)
task.set_packaging_field(packaging="Resource Identifier", field="Value", value="arn:aws:states:us-east-1:560271376700:stateMachine:E2E Granule AIU Task")

## Set the AWS ARN for the UBL step function that gets executed in the AIU Task (archive-data)
## This is required in order for the AIU Workflow to call its UBL
ubl.set_packaging_field(packaging="Resource Identifier", field="Value", value="arn:aws:states:us-east-1:560271376700:stateMachine:E2E Granule UBL Task")

## Now we add all the input fields to the UBL
# The inputs below here are all "hardcoded" at the UBLTemplate level
archive_file_lambda_arn = ubl.add_input("Archive File ARN", value="arn:aws:lambda:us-east-1:560271376700:function:create_archive_file_lambda")
create_uuid_lambda_arn = ubl.add_input("Create UUID ARN", is_required=False, value="arn:aws:lambda:us-east-1:560271376700:function:create_uuid_lambda")
destination_prefix = ubl.add_input("Destination Prefix", value="copy")
destination_key = ubl.add_input("Destination Key", is_required=False, value="")
destination_bucket = ubl.add_input("Destination Bucket", value="nccf-dev-archive-us-east-1-560271376700")
algorithm = ubl.add_input("Checksum Algorithm", value="MD5")
retention = ubl.add_input("Retention Time", value=20)
ubl.add_input("Archive Status", is_required=False, value="")
```

→ Create a Process (template)

→ Add Tasks (AIU/AIC/DIP)

→ For each Task, specify what we're storing (Pattern), and how to produce it (UBL - user business logic)

→ For UBL, specify the 'field map' - what goes in, what comes out

→ For a Task Pattern, optionally specify static values

→ Connect Task Internally (UBL key to key matching)

→ Connect Tasks externally (Pattern to UBL matching)

# Dynamic Resource Analysis During Creation

```

1 <?xml version="1.0"?>
2 <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
3   xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
4   xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
5   xmlns:owl="http://www.w3.org/2002/07/owl#"
6   xml:base="https://ncei.noaa.gov/vaip/pattern/storage/aiu/6b587130-829e"
7   xmlns="https://ncei.noaa.gov/vaip/pattern/storage/aiu/6b587130-829e-42"
8   xmlns:core="https://ncei.noaa.gov/vaip/core#"
9   xmlns:core2="http://www.w3.org/2004/02/skos/core#"
10
11 <owl:Ontology rdf:about="https://ncei.noaa.gov/vaip/pattern/storage/aiu/6b58713"
12
13 <core:ArchivalInformationUnit rdf:about="https://ncei.noaa.gov/vaip/pattern/sto
14 <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#NamedIndividual"/>
15 <core:hasContentInformation rdf:resource="https://ncei.noaa.gov/vaip/pattern/
16 <core2:prefLabel rdf:datatype="http://www.w3.org/2001/XMLSchema#string">weath
17 </core:ArchivalInformationUnit>
18
19 <core:ContentInformationObject rdf:about="https://ncei.noaa.gov/vaip/pattern/st
20 <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#NamedIndividual"/>
21 <core:hasDataObject rdf:resource="https://ncei.noaa.gov/vaip/pattern/storage/
22 <core:hasDataObject rdf:resource="https://ncei.noaa.gov/vaip/pattern/storage/
23 <core2:prefLabel rdf:datatype="http://www.w3.org/2001/XMLSchema#string">extre
24 <core2:altLabel rdf:datatype="http://www.w3.org/2001/XMLSchema#string">foreca
25 <core2:altLabel rdf:datatype="http://www.w3.org/2001/XMLSchema#string">model<
26 <core2:altLabel rdf:datatype="http://www.w3.org/2001/XMLSchema#string">data d
27 </core:ContentInformationObject>
28
29 <core:DigitalObject rdf:about="https://ncei.noaa.gov/vaip/pattern/storage/aiu/6
30 <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#NamedIndividual"/>
31 <core2:prefLabel rdf:datatype="http://www.w3.org/2001/XMLSchema#string">event
32 <core:hasLink rdf:datatype="http://www.w3.org/2001/XMLSchema#string">{{d2dfab
33 </core:DigitalObject>
34
35 <core:PhysicalObject rdf:about="https://ncei.noaa.gov/vaip/pattern/storage/aiu/
36 <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#NamedIndividual"/>
37 <core2:prefLabel rdf:datatype="http://www.w3.org/2001/XMLSchema#string">event
38 <core:hasValue rdf:datatype="http://www.w3.org/2001/XMLSchema#string">{{e0f98
39 </core:PhysicalObject>

```

resource.serialize()

```
1 print(granule.example(ancestors=True))
```

✓ 0.0s

Archival Information Unit(ancestor 0): An example of an AIU might be a granule; a file containi

Archival Information Package(ancestor 1): An example of an archival information package might b

Information Package(ancestor 2): An information package might be a SIP that represents a proces

resource.example()

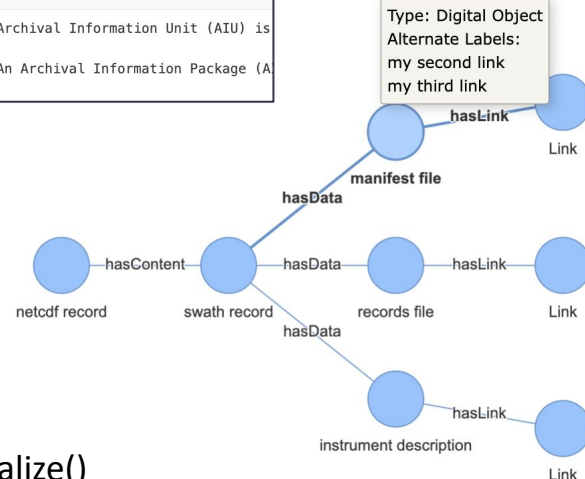
```
1 print(granule.definition(ancestors=True, limit=1))
```

✓ 0.0s

Archival Information Unit(ancestor 0): An Archival Information Unit (AIU) is

Archival Information Package(ancestor 1): An Archival Information Package (A

resource.definition()

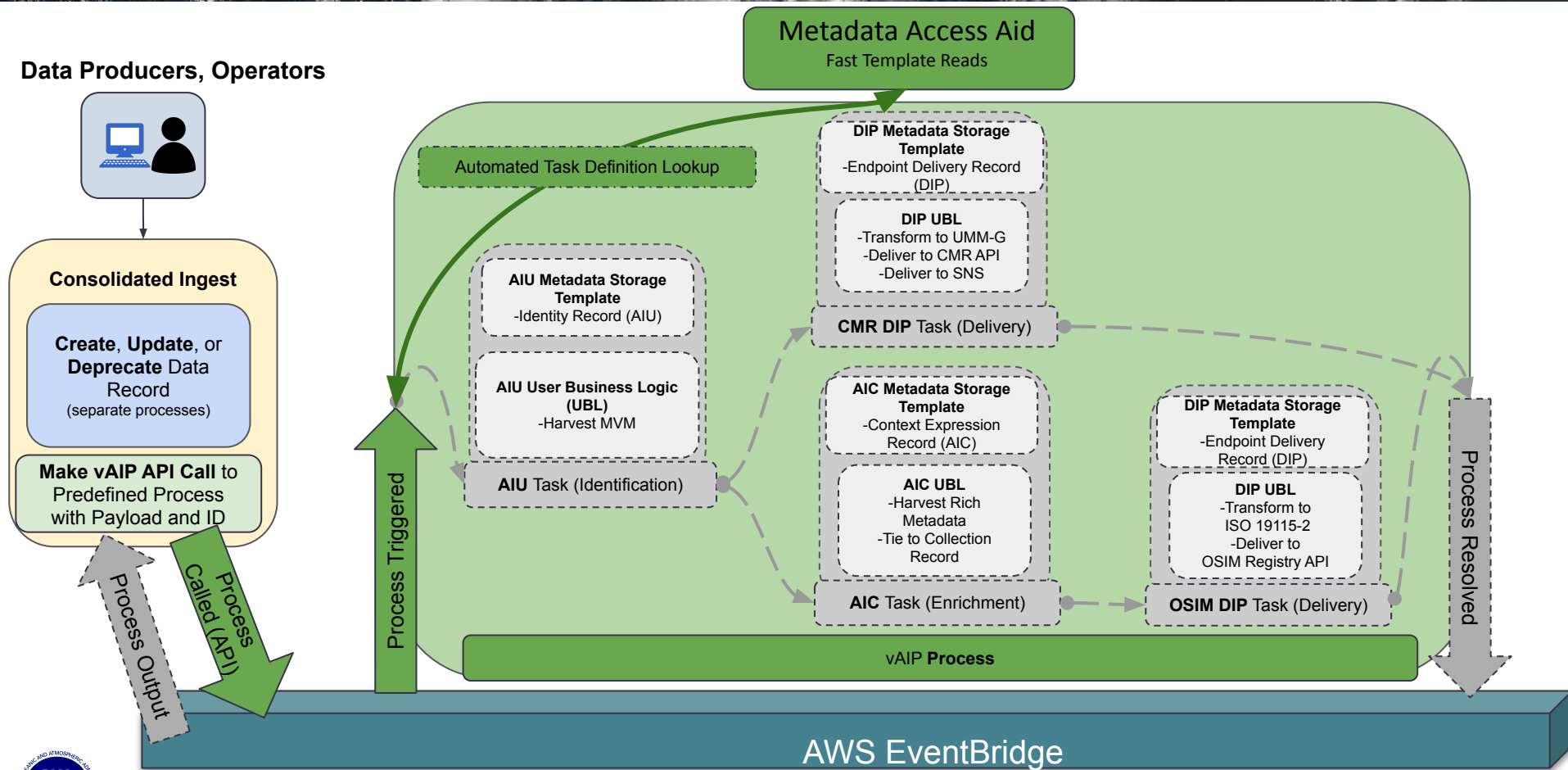


resource.visualize()

*note: expanded and improved analytic capability is on the backlog as a higher order API library*

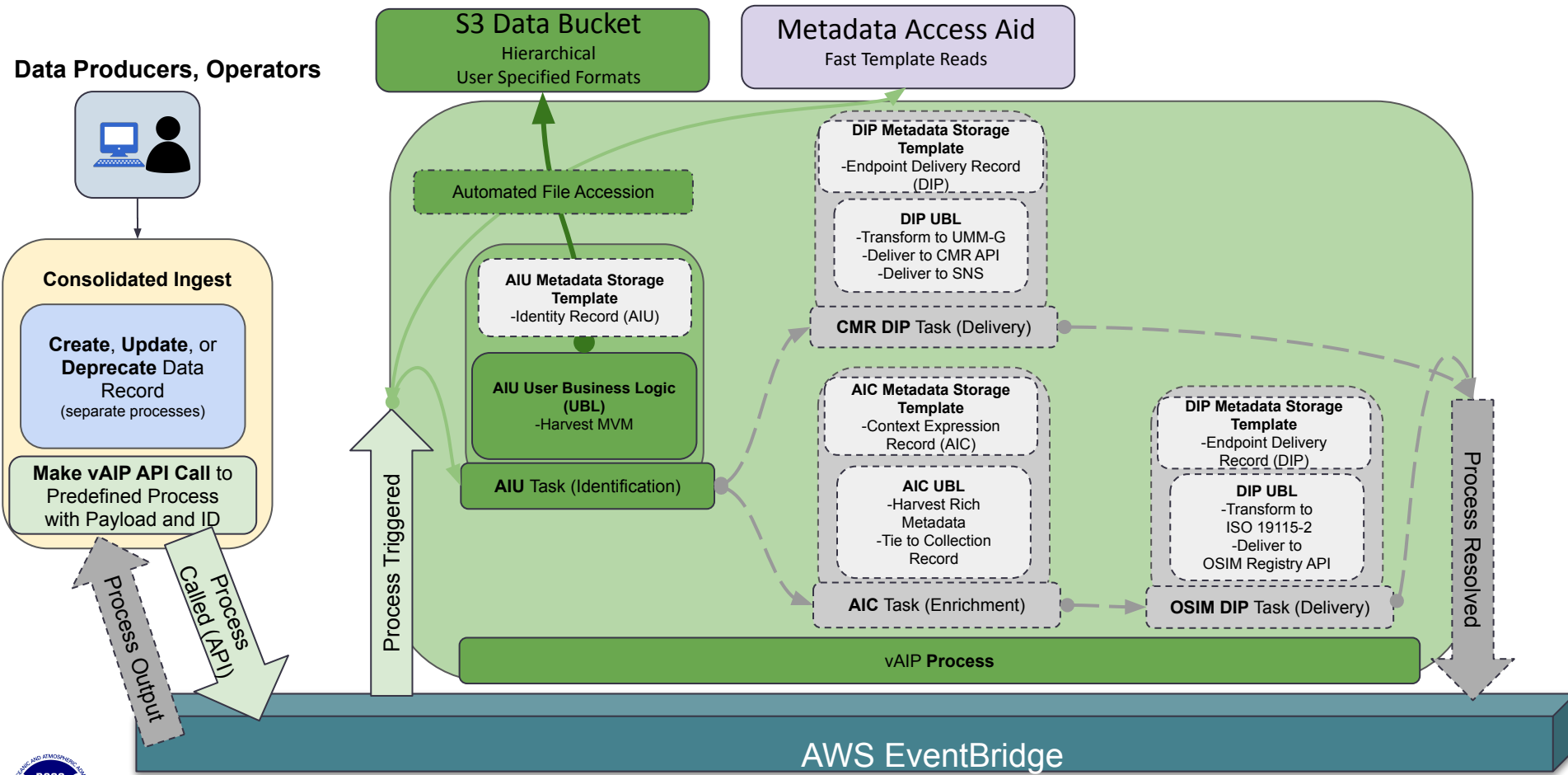


## Data Producers, Operators





# Data Producers, Operators



## Data Producers, Operators



### Consolidated Ingest

Create, Update, or Deprecate Data Record  
(separate processes)

Make vAIP API Call to  
Predefined Process  
with Payload and ID

Process Output

Process Called (API)

### S3 Data Bucket

Hierarchical  
User Specified Formats

### Metadata Access Aid

Fast Template Reads

### S3 Metadata Bucket

Hierarchical, Interoperable  
Denormalized JSON-LD Record Documents

Automated Metadata Record Generation and Storage

**AIU Metadata Storage Template**  
-Identity Record (AIU)

**AIU User Business Logic (UBL)**  
-Harvest MVM

**AIU Task (Identification)**

**DIP Metadata Storage Template**  
-Endpoint Delivery Record (DIP)

**DIP UBL**  
-Transform to UMM-G  
-Deliver to CMR API  
-Deliver to SNS

**CMR DIP Task (Delivery)**

**AIC Metadata Storage Template**  
-Context Expression Record (AIC)

**AIC UBL**  
-Harvest Rich Metadata  
-Tie to Collection Record

**AIC Task (Enrichment)**

**DIP Metadata Storage Template**  
-Endpoint Delivery Record (DIP)

**DIP UBL**  
-Transform to ISO 19115-2  
-Deliver to OSIM Registry API

**OSIM DIP Task (Delivery)**

**vAIP Process**

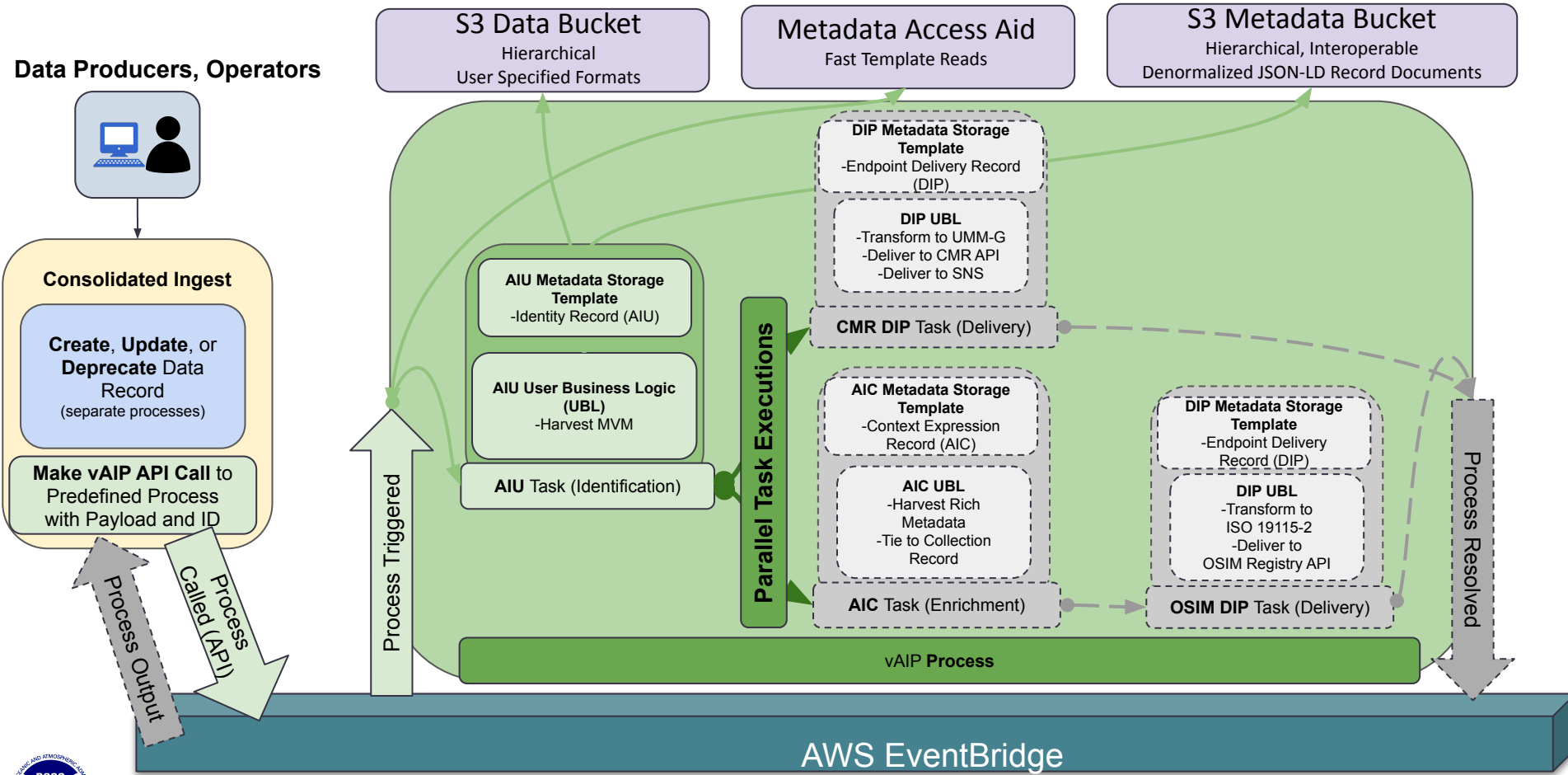
Process Triggered

Process Resolved

AWS EventBridge



# Data Producers, Operators



## Data Producers, Operators



### Consolidated Ingest

Create, Update, or Deprecate Data Record  
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Make vAIP API Call to Predefined Process with Payload and ID

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### S3 Metadata Bucket

Hierarchical, Interoperable  
Denormalized JSON-LD Record Documents

#### AIU Metadata Storage Template

-Identity Record (AIU)

#### AIU User Business Logic (UBL)

-Harvest MVM

#### AIU Task (Identification)

#### DIP Metadata Storage Template

-Endpoint Delivery Record (DIP)

#### DIP UBL

-Transform to UMM-G  
-Deliver to CMR API  
-Deliver to SNS

#### CMR DIP Task (Delivery)

#### AIC Metadata Storage Template

-Context Expression Record (AIC)

#### AIC UBL

-Harvest Rich Metadata  
-Tie to Collection Record

#### AIC Task (Enrichment)

#### Partial Request Resolution

#### DIP Metadata Storage Template

-Endpoint Delivery Record (DIP)

#### DIP UBL

-Transform to ISO 19115-2  
-Deliver to OSIM Registry API

#### OSIM DIP Task (Delivery)

vAIP Process

Process Triggered

Process Resolved

Asynchronous Response (Ignore or Use)

AWS EventBridge



## Data Producers, Operators



### Consolidated Ingest

Create, Update, or Deprecate Data Record  
(separate processes)

Make vAIP API Call to  
Predefined Process  
with Payload and ID

Process Output

Process Called (API)

### S3 Data Bucket

Hierarchical  
User Specified Formats

### Metadata Access Aid

Fast Template Reads

### S3 Metadata Bucket

Hierarchical, Interoperable  
Denormalized JSON-LD Record Documents

#### AIU Metadata Storage Template

-Identity Record (AIU)

#### AIU User Business Logic (UBL)

-Harvest MVM

#### AIU Task (Identification)

#### DIP Metadata Storage Template

-Endpoint Delivery Record (DIP)

#### DIP UBL

-Transform to UMM-G  
-Deliver to CMR API  
-Deliver to SNS

#### CMR DIP Task (Delivery)

#### AIC Metadata Storage Template

-Context Expression Record (AIC)

#### AIC UBL

-Harvest Rich Metadata  
-Tie to Collection Record

#### AIC Task (Enrichment)

#### DIP Metadata Storage Template

-Endpoint Delivery Record (DIP)

#### DIP UBL

-Transform to ISO 19115-2  
-Deliver to OSIM Registry API

#### OSIM DIP Task (Delivery)

vAIP Process

Process Triggered

Process Resolved

Asynchronous Response (Ignore or Use)

AWS EventBridge



# Common Service - Ordering System

## Access Order Broker - Superset of Order Fulfillment Systems

