Solution Architecture Document

TGS MDIO OSDU INTEGRATION

TGS-MDIO

Table of Contents

1. EXECUTIVE SUMMARY

The TGS MDIO OSDU Integration project incorporates the MDIO format as an advanced alternative for seismic data management within the OSDU Seismic DMS ecosystem. Additionally, the project enables current MDIO data clients to adopt OSDU by integrating MDIO applications with the Seismic DMS. The solution provides:

- **MDIO Data Storage**: Integration of the MDIO format alongside SEGY for efficient seismic data storage and retrieval.
- **Automated Data Conversion**: Workflows for converting SEGY data into MDIO format, streamlining ingestion processes and supporting advanced workflows.
- **Data Management Tools**: Improved and new utilities for managing and transferring seismic datasets, enabling scalable and efficient operations.
- **Seamless MDIO Integration**: Enhancements to MDIO applications to enable direct interaction with the OSDU Seismic DMS, facilitating adoption by current MDIO data clients.
- **Expanded Data Format Support**: Support for additional seismic data formats, giving users greater flexibility to choose formats and plan migrations from legacy to modern standards at their own pace.

This project extends the capabilities of the OSDU Seismic DMS, offering users more options for managing seismic data and a structured path to transition from legacy formats to advanced alternatives like MDIO.

2. INTRODUCTION

2.1 Definitions, Acronyms, Abbreviations

Term	Definition
OSDU	Open Subsurface Data Universe, an industry-standard data platform designed for energy data management and collaboration.
OSDU Seismic DMS	A subsystem of OSDU focused on seismic data management, enabling efficient ingestion, storage, and retrieval of seismic datasets.
OSDU CSP	Cloud Service Provider-specific implementation of OSDU, providing deployment and operational capabilities tailored to a particular cloud platform.
OSDU Instance	A specific deployment of OSDU on a finite cloud or on-premises environment, based on a CSP-specific OSDU implementation.
SEGY	Legacy seismic data format commonly used in the energy industry.
MDIO	Multi-Dimensional Input/Output format for seismic data, introduced by TGS. It also refers to the MDIO Python application, which supports writing, reading, seeking, and analyzing seismic data in MDIO format. The application works with various storage systems using fsspec-compatible filesystem implementations.
SDFS	Storage Driver for Seismic DMS, an fsspec filesystem implementation created during this project to enable seamless interaction with seismic datasets stored in OSDU Seismic DMS.
SDUTIL	An existing command-line utility within the OSDU Seismic DMS ecosystem for managing seismic datasets. Upgraded as part of this project to enhance its capabilities.
SDFS-UTIL	A new command-line utility created in this project to facilitate seismic data transfers leveraging the SDFS filesystem.
Airflow DAG	Directed Acyclic Graph for automating workflows, used to orchestrate seismic data ingestion and processing pipelines.
E&P	Exploration and Production activities related to energy resource discovery and management.

2.2 Solution Architecture Document Scope

The scope includes:

- Integration of MDIO as an additional seismic data format within the OSDU Seismic DMS.
- Development of workflows for SEGY-to-MDIO data conversion.
- Enhancements to existing tools (**SDUTIL**) and creation of new utilities (**SDFS-UTIL**) for seismic data management and transfer.
- Compatibility and alignment with OSDU Core Services, including compliance with its governance and data access principles.

This project represents TGS's contribution to the OSDU community, introducing MDIO as a modern seismic data format option and providing tools and workflows to enhance seismic data management within the platform.

2.3 Solution Architecture Stakeholders

Stakeholder Side	Stakeholder Role	Stakeholder Name	Contacts	Architectural Work Request Reasons
TGS	SEO	Charles Nguyen	charles.nguyen@tgs.com	Oversee alignment with TGS's seismic data goals.
TGS	Solution Architect / Developer	Altay Sansal	altay.sansal@tgs.com	Develop MDIO and ensure alignment with Seismic DMS.
TGS	DevOps	Mohammad Nuruzzaman	mohammad.nuruzzaman@tgs.com	Deploy and maintain cloud-native infrastructure.
TGS	Project Manager	Santhkumar Rajendran	santhkumar.rajendran@tgs.com	Coordinate project milestones, delivery, and resource allocation.
EPAM	Solution Architect I	Rostislav Dublin	rostislav_dublin@epam.com	Define and maintain solution architecture for scalability, performance, and OSDU compliance.
EPAM	Delivery Manager	Yaraslau Sushchyk	yaraslau_sushchyk@epam.com	Ensure timely integration and delivery of MDIO solution within OSDU environment.
EPAM	Backend Developer	Santiago Ortiz	santiago_ortiz@epam.com	Implement features for storing, retrieving, and converting seismic data with MDIO.
EPAM	Backend Developer	Vadzim Kulyba	vadzim_kulyba@epam.com	Contribute code enabling MDIO integrations, ensuring system stability and performance.
EPAM	Infrastructure Engineer	Igor Zimovets	igor_zimovets@epam.com	Manage Kubernetes, CI/CD, and infrastructure supporting MDIO-OSDU integration.

3. CONTEXT

3.1 Technology Strategy

References:

- OSDU Technology Roadmap (https://community.opengroup.org/groups/osdu/platform/-/wikis/Core-Services-Overview)
- Seismic DMS Suite Wiki (https://community.opengroup.org/groups/osdu/platform/domain-data-mgmt-services/seismic/seismic-dms-suite/-/wikis/Seismic-Data-Management-Solution-(SDMS)-)
- TGS Cloud Adoption Roadmap

Key Points:

- **OSDU**: Leverage the Seismic DMS Suite for scalable, cloud-agnostic storage of seismic datasets across CSP environments.
- **TGS**: Utilize Kubernetes-based cloud-native solutions to manage seismic library workloads and support high-performance computations.

3.2 Business Architecture

References:

- OSDU Business Domain Overview (https://community.opengroup.org/groups/osdu/platform/-/wikis/Business-Domain-Overview)
- Seismic DMS Suite Overview (https://community.opengroup.org/groups/osdu/platform/domain-data-mgmt-services/seismic/seismic-dms-suite)

Key Points:

- **OSDU**: Streamline ingestion, retrieval, and indexing processes by integrating seismic data workflows into the Seismic DMS.
- **TGS**: Improve seismic data delivery for Exploration & Production (E&P) by enabling fast and efficient access to indexed MDIO datasets.

3.3 Data Architecture

References:

- Seismic DMS Data Management (https://community.opengroup.org/groups/osdu/platform/domain-data-mgmt-services/seismic/seismic-dms-suite)
- OSDU Storage and Search Services (https://community.opengroup.org/groups/osdu/platform/-/wikis/Storage-Service)
- TGS Data Governance Framework

Key Points:

- **OSDU**: Enable compliant storage and metadata management via the Seismic DMS.
- **TGS**: Optimize seismic data management through the adoption of the MDIO format for large-scale datasets.

3.4 Infrastructure Architecture

References:

- OSDU Infrastructure Guidelines (https://community.opengroup.org/groups/osdu/platform/-/wikis/Deployment)
- Seismic DMS Architecture Overview (https://community.opengroup.org/groups/osdu/platform/domain-data-mgmt-services/seismic/seismic-dms-suite/-/wikis/Seismic-Data-Management-Solution-(SDMS)-)

Key Points:

- **OSDU**: Deploy Seismic DMS services on cloud-managed Kubernetes clusters.
- **TGS**: Implement redundant and autoscaled infrastructure to support ingestion, conversion, and access workflows.

3.5 Application Architecture

References:

- Seismic DMS APIs (https://community.opengroup.org/groups/osdu/platform/domain-data-mgmt-services/seismic)

Key Points:

- **OSDU**: Integrate workflows with Seismic DMS APIs for MDIO ingestion and retrieval.
- **TGS**: Use SDFS, SDFS-UTIL, and Airflow DAGs to enable efficient SEGY-to-MDIO conversion processes.

3.6 Security Architecture

References:

- OSDU Entitlements, Legal, and Policy Services (https://community.opengroup.org/groups/osdu/platform/-/wikis/Core-Services-Overview#entitlements)

Key Points:

- **OSDU**: Implement role-based access control (RBAC) using the OSDU Entitlements Service.
- **TGS**: Encrypt seismic data in transit and at rest. Enforce access controls through policy-driven mechanisms.

3.7 Other Key Areas

References:

- OSDU Compliance Framework
- Seismic DMS Suite Documentation (https://community.opengroup.org/groups/osdu/platform/domain-data-mgmt-services/seismic/seismic-dms-suite)

Key Points:

- **Compliance**: Ensure alignment with industry-specific regulations and retention policies for seismic data.
- **Scalability**: Support large-scale ingestion, transformation, and access to seismic datasets.

4 REQUIREMENTS

4.1 Business Goals

Goal ID	Business Goal	Description
BG-1	Improve seismic data delivery performance	Provide fast and efficient access to seismic datasets.
BG-2	Standardize seismic data workflows	Ensure compatibility with OSDU Seismic DMS and cloud-agnostic deployment.
BG-3	Automate SEGY-to-MDIO conversion	Introduce automated workflows using Airflow DAGs.
BG-4	Enhance operational efficiency	Optimize ingestion, storage, and indexing processes.

4.2 Functional Requirements

FR ID	Functional Requirement	Description
FR-1	Support ingestion of SEGY seismic data	Ingest SEGY files and convert them to MDIO format.
FR-2	Automate SEGY-to-MDIO workflows	Manage conversion processes via Airflow DAGs.
FR-3	Store MDIO datasets in OSDU Seismic DMS	Ensure indexed and compliant storage using OSDU Storage APIs.
FR-4	Enforce RBAC for seismic data	Use OSDU Entitlements Service for user and group policy management.
FR-5	Enable large-scale data transfers	Provide tools for efficient, multi-threaded data transfer operations.

4.3 Non-functional Requirements

4.3.1 Quality Attribute Non-functional Requirements

NFR ID	Quality Attribute	Description	Target Value
NFR-1	Performance	SEGY-to-MDIO conversion speed.	100 MB/min
NFR-2	Scalability	Handle increasing seismic dataset volumes.	Dynamic scaling
NFR-3	Availability	Ensure uptime of ingestion and access services.	99.9% SLA
NFR-4	Security	Encrypt seismic data at rest and in transit.	AES-256 encryption
NFR-5	Observability	Provide logging, monitoring, and tracing.	Full telemetry coverage

4.3.2 Other Non-functional Requirements

NFR ID	Requirement	Description
NFR-6	Compliance	Align workflows with OSDU Seismic DMS compliance policies.
NFR-7	Reliability	Ensure fault tolerance and error recovery in workflows.
NFR-8	Usability	Provide user-friendly CLI tools for seismic data management.

4.4 Constraints

Constraint ID	Constraint	Explanation
C-1	Align with OSDU standards	Follow OSDU API specifications and best practices.
C-2	Cloud infrastructure	Solution must run on cloud-native Kubernetes environments.
C-3	Data format compliance	MDIO datasets must comply with OSDU Seismic DMS standards.
C-4	Open-source policies	All tools and components must adhere to open-source governance rules.

4.5 Assumptions

Assumption ID	Assumption	Explanation
A-1	OSDU core services deployed	Assumes Seismic DMS APIs and Entitlements services are operational.
A-2	Cloud resources available	Sufficient compute and storage resources will be provisioned.
A-3	Network connectivity stable	Reliable connectivity exists between the solution components.
A-4	TGS internal tools available	SEGY datasets and related metadata will be available for ingestion.

5 QUALITY ATTRIBUTES

5.1 Key Quality Attributes

Priority	Quality Attribute	Measurable Metric
High	Performance	- SEGY-to-MDIO conversion throughput: 100 MB/min. - Mean time for data ingestion function call: 500 ms. - Maximum data retrieval latency from Seismic DMS: 1 second.
High	Scalability	- Horizontal scaling supported: yes. - System scaling time (up/down): less than 5 minutes. - Scaling limit for data volume growth: 10 PB/year.
High	Availability	- Service availability (excluding planned downtime): 99.9% SLA. - Planned maintenance downtime: less than 30 minutes per month. - Disaster recovery switch time: 10 seconds.
Medium	Security	- Access control via OSDU Entitlements Service: yes. - Data encryption standard: AES-256. - Audit logging for critical operations: implemented. - Secured communication (TLS): implemented.
Medium	Observability	- Real-time log collection and monitoring: implemented. - Documented troubleshooting tools: available. - Key metrics monitored: CPU, memory usage, data ingestion rate, failure rates.
Medium	Reliability	- Mean time to repair (MTTR): less than 30 minutes. - Mean time between failures (MTBF): 6 months. - Critical failures per year: less than 5.
Low	Testability	- Unit test coverage: 80%. - Integration test coverage: 70%. - Automated functional tests for data ingestion: implemented.

Explanation of Quality Attribute Priorities

1. **Performance**: Ensures efficient ingestion and retrieval of seismic datasets.
2. **Scalability**: Supports growth in seismic data volumes and workloads.
3. **Availability**: Minimizes downtime to maintain continuous seismic data operations.
4. **Security**: Meets industry standards for access control and data protection.
5. **Observability**: Enables real-time monitoring and diagnostic capabilities.
6. **Reliability**: Ensures stable operations with quick recovery from failures.
7. **Testability**: Enhances system robustness through comprehensive testing.

6 BASELINE ARCHITECTURE

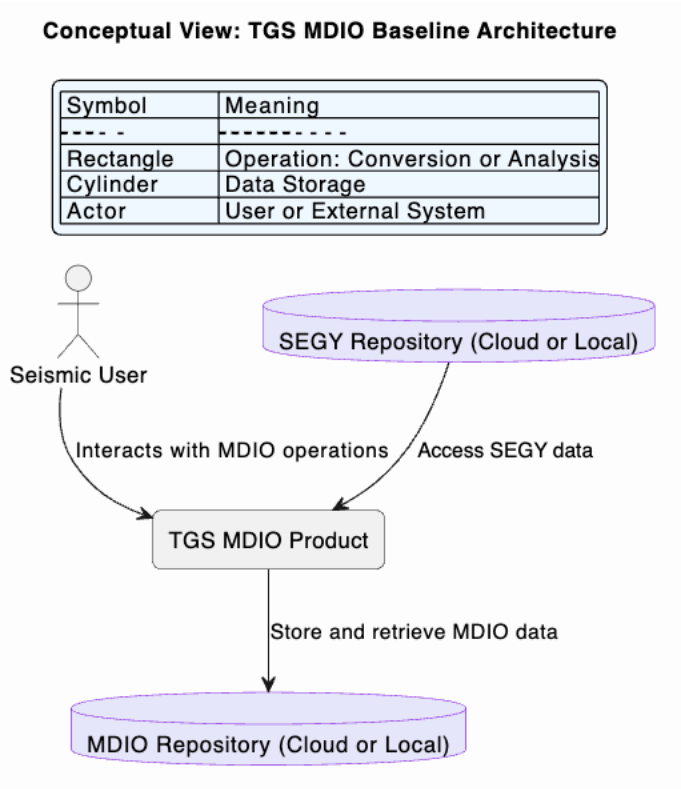
6.1 Conceptual View

The baseline architecture for TGS's MDIO product focuses on its standalone capabilities for managing seismic data. It includes:

- **SEGY-to-MDIO Conversion**:
  Transform SEGY files into MDIO format for efficient access and storage.
- **MDIO-to-SEGY Conversion**:
  Export MDIO collections back to SEGY format for compatibility with legacy systems.
- **Data Operations**:
  Perform partial data slicing, aggregation, and exploration within MDIO collections.

Storage options include cloud storage (e.g., AWS S3, Azure Blob) and local file systems. The system operates independently, without integration with OSDU Seismic DMS or advanced orchestration tools.

Diagram



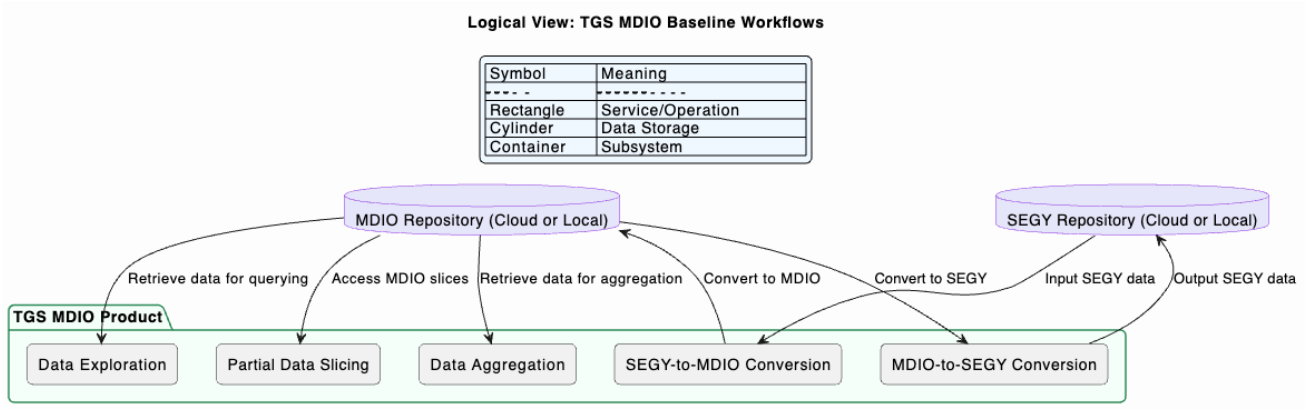
6.2 Logical View

The logical architecture outlines the internal workflows and structure of the TGS MDIO product.

Key components include:

- **SEGY Repository**: Storage for SEGY files in cloud or local environments.
- **MDIO Repository**: Storage for MDIO collections.
- **TGS MDIO Product**:
  - **SEGY-to-MDIO Conversion**: Converts SEGY files into MDIO format.
  - **MDIO-to-SEGY Conversion**: Converts MDIO collections back to SEGY.
  - **Partial Data Slicing**: Enables retrieving specific subsets of seismic data.
  - **Data Aggregation**: Provides combined views of seismic datasets.
  - **Data Exploration**: Supports querying and visualization of seismic data.

Diagram:



6.3 Integration View

The baseline architecture operates in a standalone configuration, focusing on direct interactions with legacy storage systems.

Key Interfaces

- **Legacy Storage APIs**:
  - APIs for accessing SEGY and MDIO datasets stored locally or in plain cloud storage.

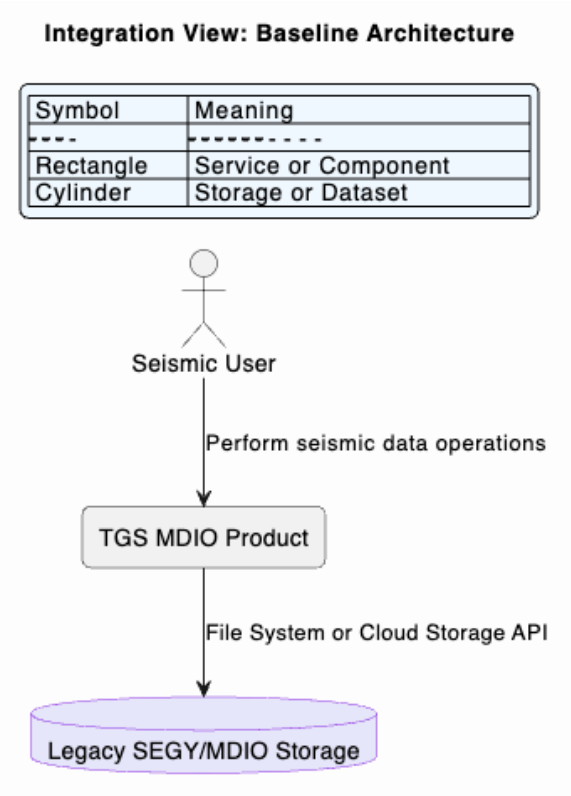
Key Tools and Technologies

- **TGS MDIO Product**:
  - Core application for seismic data operations, including slicing, aggregation, and analysis.
- **Legacy SDUTIL**:
  - Command-line utility for file transfers, directly interacting with storage APIs.

Integration Flow

- **Legacy Dataset Access**:
  - **File System APIs**: MDIO uses POSIX I/O for local storage.
  - **Cloud Storage APIs**: MDIO interacts with AWS S3, Azure Blob for cloud-based storage.
- **Data Operations**:
  - Users interact with MDIO to perform slicing and aggregation on SEGY and MDIO datasets.
- **Legacy SDUTIL**:
  - Facilitates file transfers using storage APIs for movement between storage and local environments.

Diagram:



6.4 Data View

The baseline data architecture handles seismic data in two formats: **SEGY** and **MDIO**.
It includes:

1. **Data Sources**:

- SEGY files uploaded to a centralized SEGY repository.
- MDIO collections created and stored in an MDIO repository.

2. **Data Processing**:

- **SEGY-to-MDIO Conversion**: Transforms SEGY files into MDIO collections.
- **MDIO-to-SEGY Conversion**: Exports MDIO data back to SEGY format.

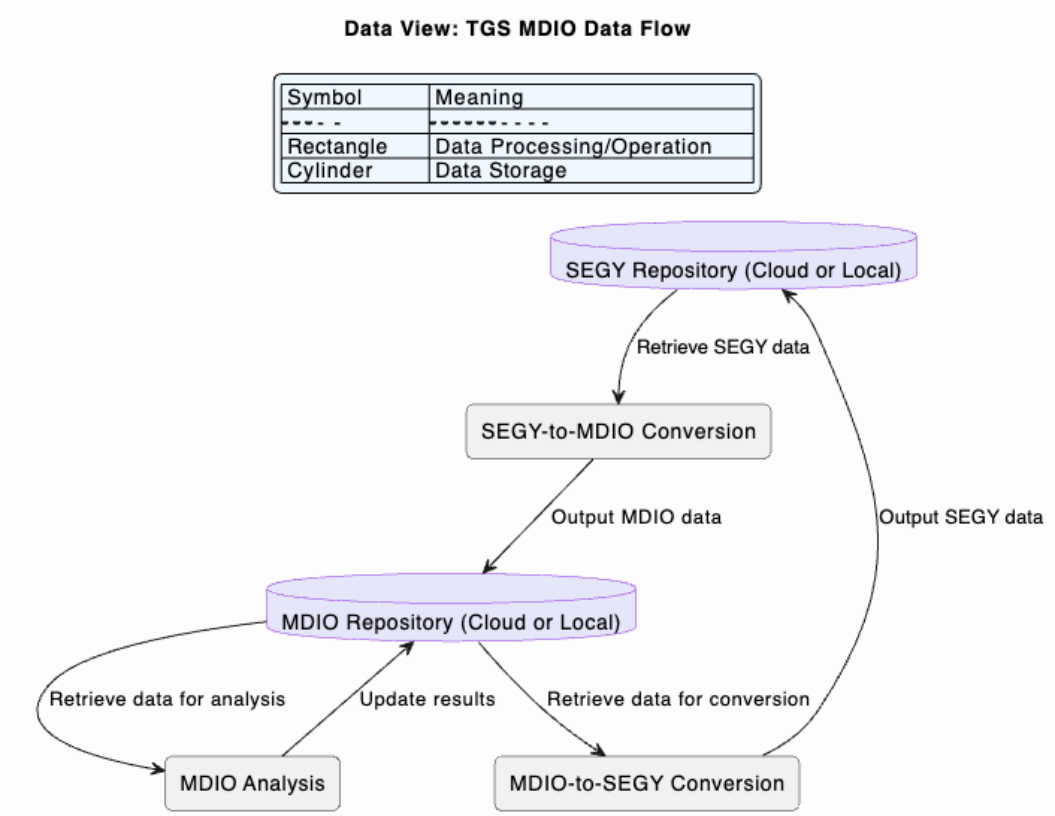
3. **Data Storage**:

- **SEGY Repository**: Stores original SEGY files.
- **MDIO Repository**: Stores MDIO collections for advanced analysis.

4. **Data Flow**:

- Bidirectional flow between SEGY and MDIO repositories for compatibility with legacy systems and advanced analysis.

Diagram:



6.5 Infrastructure / Deployment View

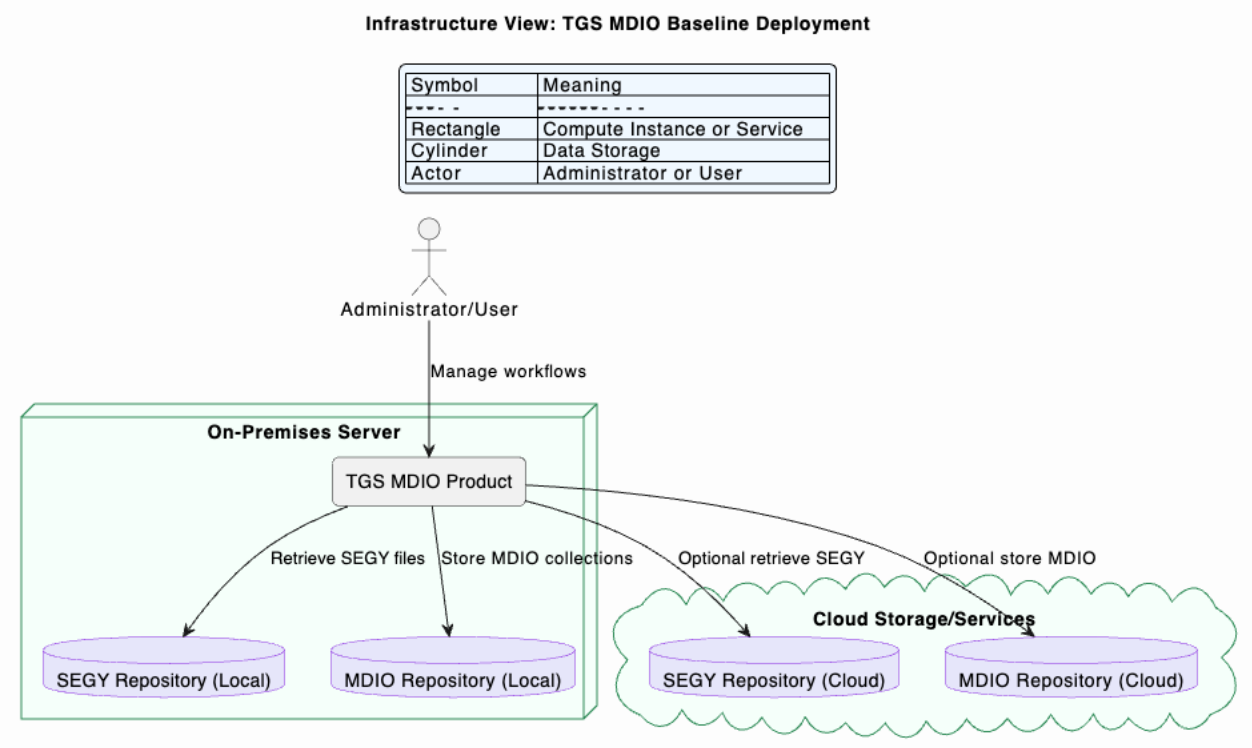
The baseline infrastructure relies on legacy storage systems for seismic data management, without integration with the OSDU Seismic DMS.

Key elements include:

- **Seismic User Workstation**:
  - **Legacy MDIO Product**: Manages seismic data in SEGY or MDIO format.
  - **Local File System Storage**: For local datasets.
  - **Cloud Storage**: For cloud-hosted datasets.

The lack of integration with Seismic DMS introduces inefficiencies in data management workflows.

Diagram:



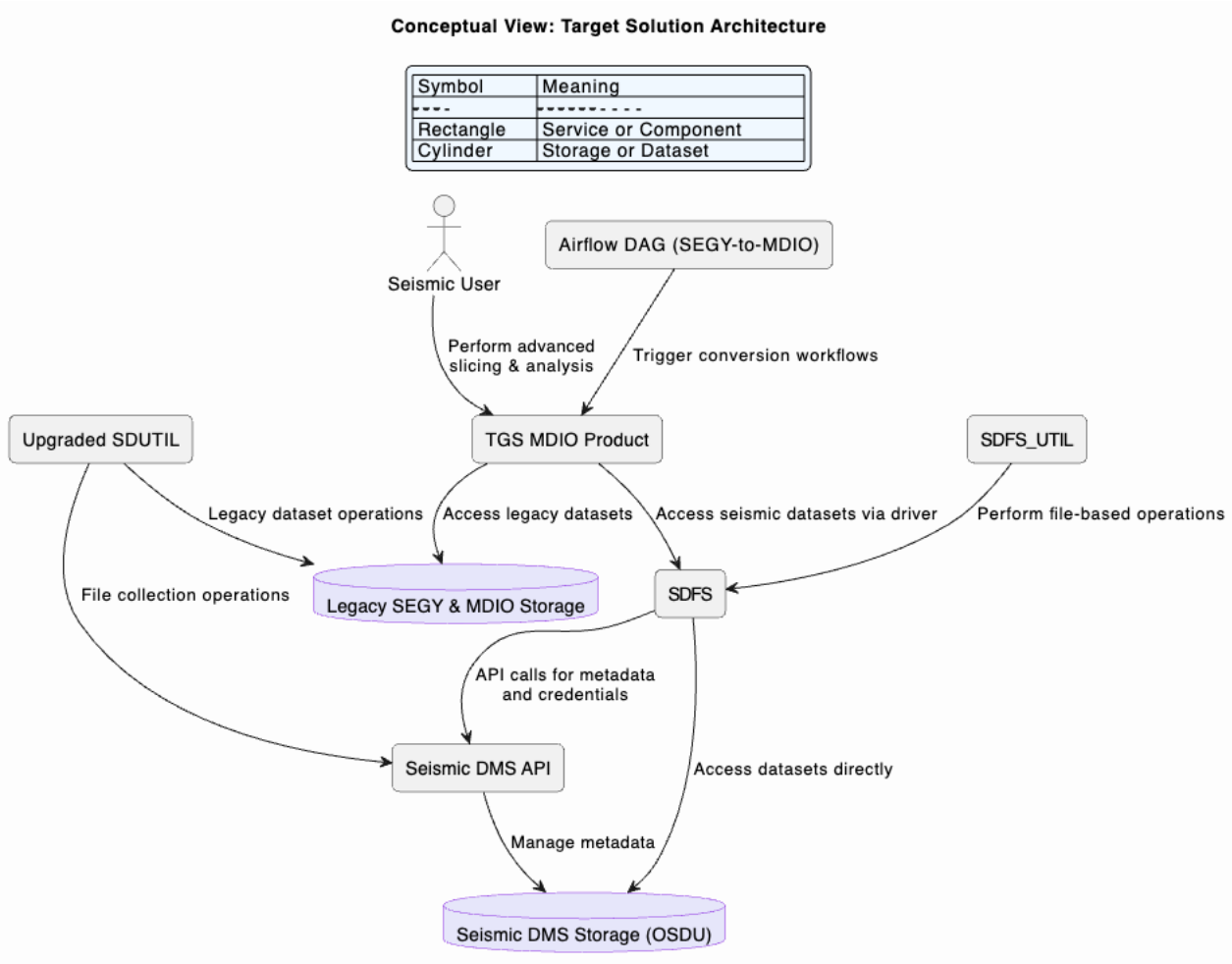
7 TARGET SOLUTION ARCHITECTURE

7.1 Conceptual View

The target solution architecture integrates the TGS MDIO product into the OSDU Seismic DMS ecosystem while maintaining compatibility with legacy storage systems. Key enhancements include:

- **Integration with OSDU Seismic DMS**: Enables seamless interaction with seismic datasets stored in OSDU Seismic DMS.
- **Legacy Storage Support**: Retains the ability to access SEGY and MDIO datasets in legacy local and cloud-based storage systems.
- **Automation with Airflow DAGs**: Automates SEGY-to-MDIO conversion workflows using Airflow, with MDIO and SDFS as internal tools.
- **SDFS**: An fsspec filesystem enabling standardized access to Seismic DMS datasets.
- **SDFS_UTIL**: Facilitates file-based operations on seismic file collections (e.g., MDIO, OVDS) via SDFS.
- **Upgraded SDUTIL**: Enhances legacy OSDU utilities to handle file collections in both Seismic DMS and legacy storage environments.

Diagram:

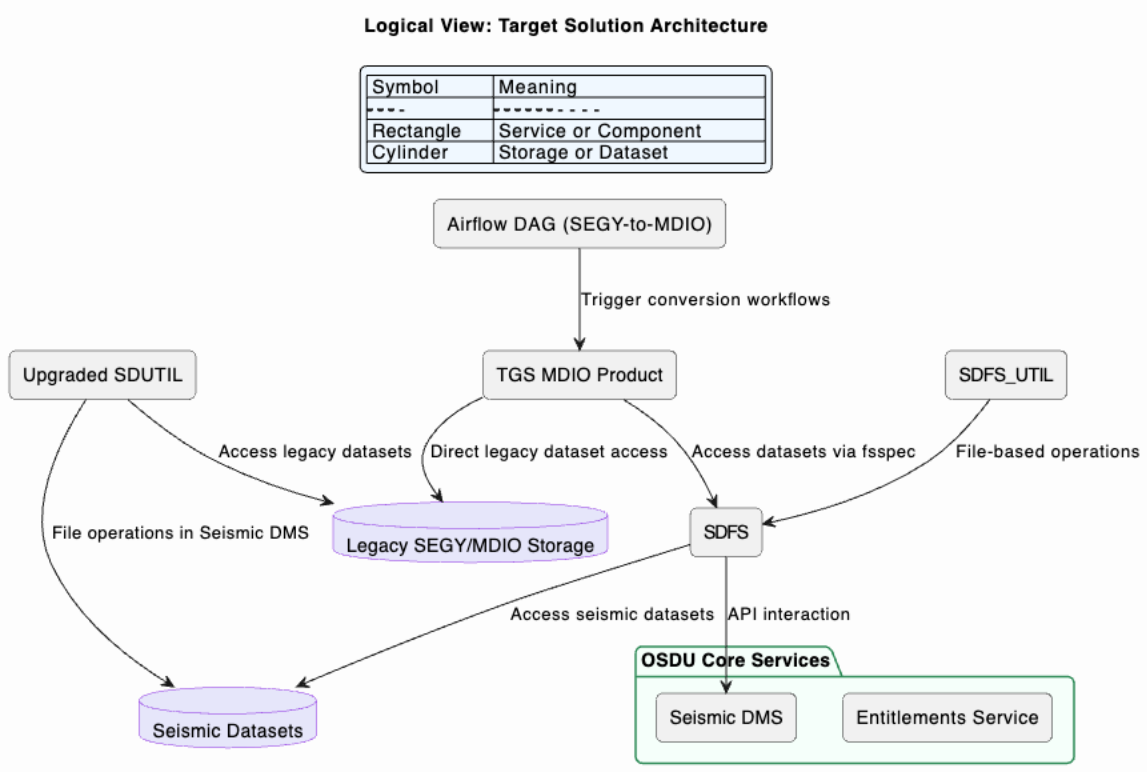


7.2 Logical View

The logical architecture introduces new components and workflows to integrate the TGS MDIO product with OSDU while preserving legacy capabilities. Key components include:

- **OSDU Integration**:
  - **Seismic DMS**: Centralized management of seismic datasets.
  - **Entitlements Service**: Provides role-based access control (RBAC) for seismic data.
- **TGS MDIO Enhancements**:
  - Retains tools for data slicing, aggregation, and analysis.
  - Accesses OSDU Seismic DMS datasets via SDFS, collaborating with Seismic DMS APIs.
  - Preserves direct access to legacy storage for backward compatibility.
- **SEGY-to-MDIO Workflow**:
  - Automates SEGY ingestion and conversion using an Airflow DAG with MDIO tools and SDFS.
- **SDFS_UTIL**:
  - Handles file-based operations on seismic datasets via SDFS.
- **Upgraded SDUTIL**:
  - Enables direct interactions with Seismic DMS datasets and legacy storage for file collection operations.

Diagram:

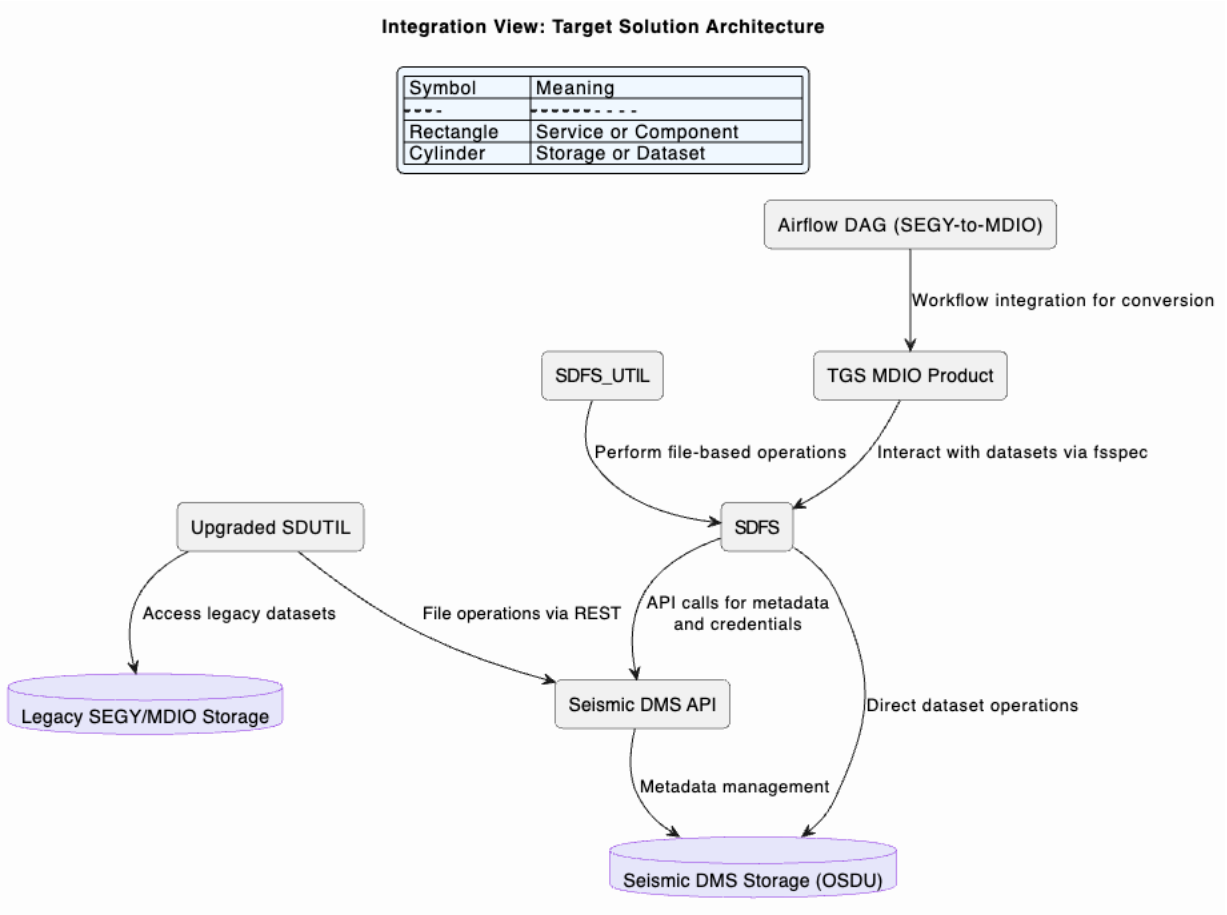


7.3 Integration View

The integration of the TGS MDIO product into the OSDU ecosystem is driven by **SDFS**, which acts as the primary integration layer. Key integration points:

1. **SDFS**:
   - Provides fsspec-based access to seismic datasets in Seismic DMS.
   - Serves as the backbone for workflows and tools like MDIO and SDFS_UTIL.
2. **Seismic DMS Datasets**:
   - Supports storage and management of seismic data formats, including SEGY, MDIO, and OVDS, in Seismic DMS.
3. **TGS MDIO Product**:
   - Performs advanced operations such as slicing, aggregation, and analysis of seismic datasets via SDFS.
4. **SDFS_UTIL and Upgraded SDUTIL**:
   - **SDFS_UTIL**: CLI tool for file-based operations on datasets in Seismic DMS.
   - **Upgraded SDUTIL**: Handles dataset transfers and operations across Seismic DMS and legacy storage.
5. **SEGY-to-MDIO Conversion DAG**:
   - Automates workflows for converting SEGY files to MDIO format using SDFS and MDIO tools.

Diagram:

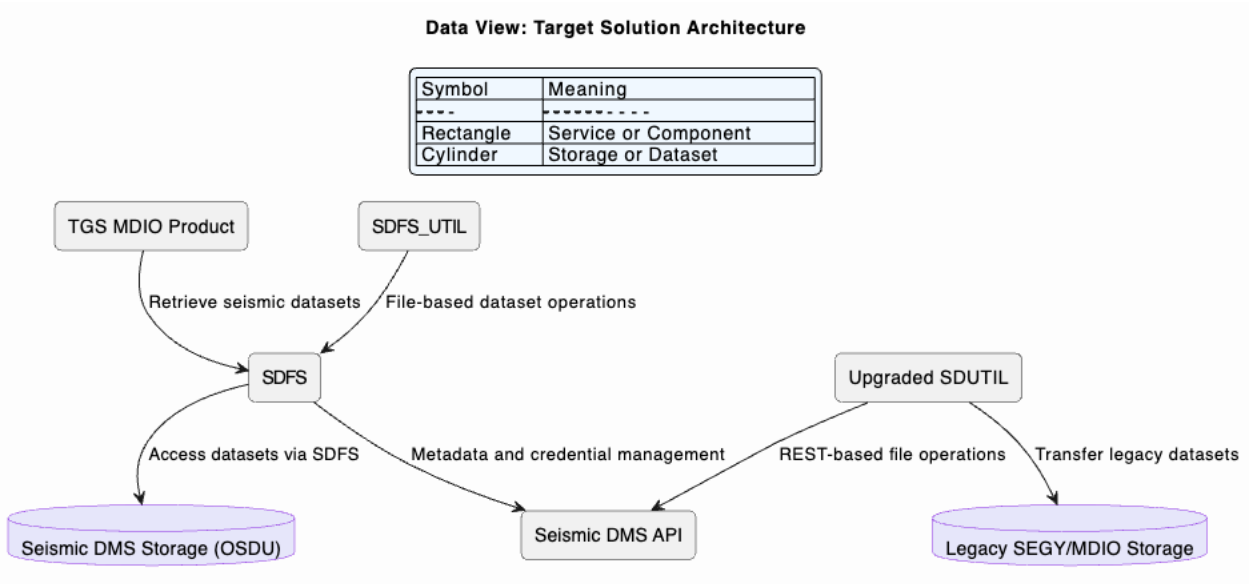


7.4 Data View

The target data architecture enables seamless access and management of seismic data across OSDU and legacy storage systems. Key aspects:

- **Data Sources**:
  - Seismic datasets (SEGY, MDIO, OVDS formats) stored in OSDU Seismic DMS.
  - Legacy datasets stored locally or in cloud-based blob storage.
- **Data Operations**:
  - Automates SEGY-to-MDIO workflows using Airflow.
  - Supports advanced slicing, aggregation, and analysis via the TGS MDIO product.
  - Facilitates file-based operations using SDFS_UTIL and Upgraded SDUTIL.
- **Data Access**:
  - Provides unified access to seismic datasets via SDFS for OSDU Seismic DMS.
  - Retains direct access to legacy storage systems through MDIO and SDUTIL.

Diagram:



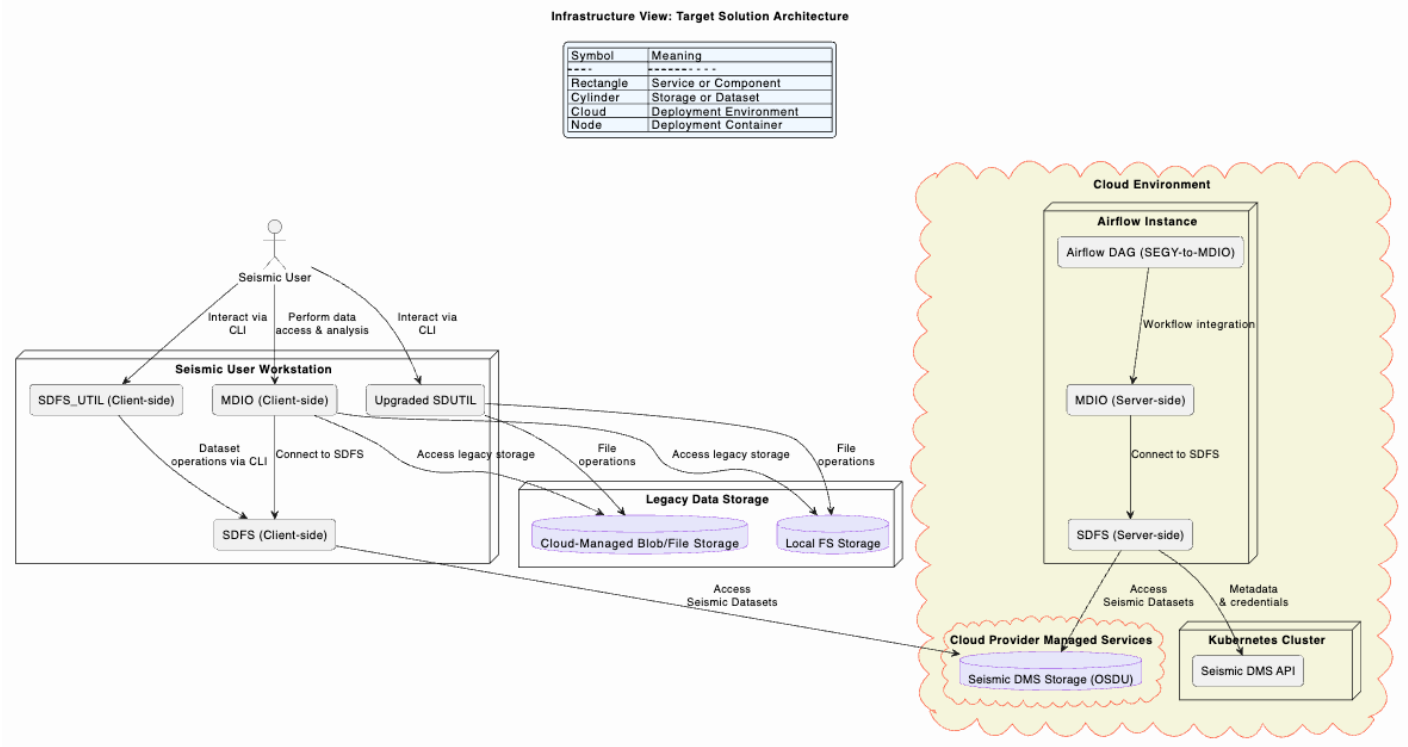
7.5 Infrastructure / Deployment View

The infrastructure supports the integration of the TGS MDIO product with OSDU Seismic DMS while retaining legacy capabilities. Key components:

- **Cloud Environment**:
  - **Kubernetes Cluster**:
    - Hosts Seismic DMS API, SDFS (server-side), and TGS MDIO workflows (e.g., SEGY-to-MDIO).
  - **Airflow Instance**:
    - Executes workflows using Airflow DAGs to process seismic datasets.
  - **Seismic DMS Storage**:
    - Manages seismic datasets in OSDU via cloud storage.
- **Seismic User Workstation**:
  - Provides client-side tools for accessing and analyzing seismic datasets via MDIO and SDFS_UTIL.
  - Retains compatibility with legacy storage systems through Upgraded SDUTIL.
- **Legacy Data Storage**:
  - Supports local and cloud-managed blob/file storage for legacy datasets.

The infrastructure addresses two primary use cases: 1. **SEGY-to-MDIO Workflow**: - Leverages cloud resources to ingest and process SEGY files, storing results in Seismic DMS. 2. **User-Driven Operations**: - Enables users to interact with seismic datasets via MDIO, SDFS_UTIL, and SDUTIL for analysis and data transfer.

Diagram:



8 TRANSITION / MIGRATION

8.1 Migration Approach

Not Applicable:
This project focuses on introducing new functionalities to the OSDU Seismic Domain, including: - SEGY-to-MDIO conversion workflows. - Improved access and analysis of seismic datasets using MDIO and SDFS.

No migration activities are required as the project does not involve re-platforming or transitioning legacy data.

8.2 Migration Roadmap

Not Applicable:
No migration roadmap is required since the project does not include migration efforts.

9 SOLUTION ARCHITECTURE GOVERNANCE

This section outlines governance recommendations to ensure the solution architecture remains consistent and adheres to best practices throughout the software lifecycle. Recommendations are aligned with the phases of the Software Development Lifecycle (SDLC).

9.1 Solution Architecture Design

To maintain architectural consistency and scalability during the design phase, apply the following recommendations:

1. **Key Processes**:
    - Use iterative design practices aligned with OSDU and TGS seismic domain standards.
    - Conduct regular design reviews with cross-functional teams.
    - Document design decisions using UML diagrams and the EPAM SAD template.
2. **Tools**:
    - **UML Diagrams**: Visualize architecture and interactions.
    - **Poetry**: Manage dependencies and package versions consistently.
    - **MyPy**: Enforce strict type checking.
3. **Best Practices**:
    - Leverage **SDFS** for seamless integration with Seismic DMS Storage.
    - Adopt modular design principles for improved maintainability.
    - Use **Airflow DAGs** for orchestrating workflows, including SEGY-to-MDIO conversion.

9.2 Development

To ensure high-quality code adheres to the architecture, apply these recommendations during development:

1. **Key Processes**:
    - Follow Agile methodologies with thorough integration testing.
    - Conduct code reviews to ensure compliance with Pythonic best practices and security standards.
2. **Tools**:
    - **Ruff**: Enforce coding standards and detect bugs.
    - **PyTest**: Perform unit and integration testing.
    - **Bandit**: Conduct security-focused static analysis.
3. **Coding Best Practices**:
    - Maintain strict type annotations and enforce type checks using `mypy`.
    - Target 80%+ code coverage for critical modules using **Coverage.py**.
    - Document public APIs following the Google docstring convention.

9.3 DevOps

For smooth implementation, testing, and deployment, apply the following DevOps recommendations:

1. **Key Processes**:
    - Automate CI/CD pipelines for building, testing, and deploying Python components.
    - Use Terraform and Helm for managing cloud infrastructure and Kubernetes configurations.

2. **Tools**:
    - **Terraform**: Provision cloud environments.
    - **Helm**: Deploy Kubernetes-based components like Airflow.
    - **Nox**: Automate testing across multiple Python versions.
    - **Airflow**: Orchestrate workflows, including SEGY-to-MDIO conversion.
3. **Quality Gates**:
    - Enforce automated static and dynamic analysis during CI using **Ruff** and **Bandit**.
    - Ensure all tests and runtime type checks pass in CI pipelines.

9.4 Quality Assurance

To ensure solution quality and compliance with key attributes, implement the following QA recommendations:

1. **Key Processes**:
    - Conduct regression testing on seismic data workflows.
    - Validate performance metrics for SEGY-to-MDIO conversion and seismic dataset slicing.
2. **Tools**:
    - **Apache JMeter**: Performance testing.
    - **Postman**: API testing and validation.
    - **Xdoctest**: Validate inline code examples.
3. **Quality Gates**:
    - Achieve 80%+ test coverage using **Coverage.py**.
    - Validate compatibility with Python 3.9–3.11 using **Nox**.

9.5 Maintenance

To ensure maintainability and operational continuity, implement the following recommendations:

1. **Key Processes**:
    - Use centralized logging and monitoring with cloud-native services.
    - Conduct periodic audits to review system compliance, security, and performance.
2. **Tools**:
    - **Logging and Monitoring**:
        - **AWS CloudWatch**, **Azure Monitor**, or **Google Cloud Operations Suite**, depending on the deployment platform.
    - **Terraform**: Automate infrastructure updates.
    - **Helm**: Manage Kubernetes deployments.
3. **Best Practices**:
    - Maintain detailed runbooks for deployments and troubleshooting.
    - Implement log retention policies aligned with compliance requirements.
    - Schedule regular backups of Seismic DMS Storage for data integrity.

10 ARCHITECTURE DECISION LOG

The Architecture Decision Log (ADL) documents key architectural decisions, including the rationale, alternatives considered, and decision makers. This ensures transparency and serves as a reference for future changes.

Date	Decision ID	Description	Rationale	Alternatives Considered	Decision Maker(s)
2024-06-20	ADL-001	Adopt **SDFS** as the access driver for Seismic DMS datasets	Ensures seamless integration with OSDU's Seismic DMS API and improves scalability and efficiency	Direct access to Seismic DMS datasets via custom scripts (rejected due to lack of flexibility)	Rostislav Dublin (SA), TGS Architects