FEDERAL AVIATION ADMINISTRATION

# Aircraft Access to SWIM Full Data Exchange Technical Concept Paper

Version 1.0

**7/31/2013**

# EXECUTIVE SUMMARY

This AAtS Full Data Exchange Technical Concept Paper is derived from the draft AAtS Concept of Operations document of June 2013. This paper expands upon the uplink technical concepts described in the Implementation Guidance Document of July 2012 and focuses on developing the complementary downlink technical concepts to enable aircraft to publish aircraft derived data to the FAA's National Airspace System (NAS) System Wide Information Management (SWIM) infrastructure in a globally interoperable manner. Notional interoperability includes not only the FAA SWIM infrastructure, but also the Single European Sky ATM Research (SESAR) SWIM, Japanese Civil Aviation Bureau (JCAB) SWIM, Civil Aviation Authority of China (CAAC) SWIM, and other potential SWIMs.

To validate the downlink concepts, Technical Scenarios (TS) have been derived from the AAtS Initial Concept of Operations. These scenarios are as follows:

- TS1: Continuous Distribution – Demonstrates the distribution of aircraft generated information that is sent at a predetermined update rate (e.g., Publish/Subscribe Service).
- TS2: Event Triggered – Demonstrates the distribution of aircraft generated information that is sent as it is created. This could be through pilot input or automated processes.
- TS3: Request/Reply – Demonstrates the distribution of aircraft generated information once it is requested by the NAS Service.

To achieve the goal of global interoperability and allow aircraft to participate in a Collaborative Air Traffic Management (CATM) solution set, the downlink aspect of the AAtS concepts must address the following:

- Complexity of a Data Management Service (DMS) to manage the interfaces to SWIM-enabled NAS Services.
- Downlinked aircraft data must have boundary protection to only authorized consumers.
- DMSs to multiple SWIM (NAS, Air Navigation Service Providers (ANSPs) and other enterprise data sources) infrastructures and data structures must be interoperable.

In order to realize the downlink concept, various subject matter experts were consulted. Through those discussions, messaging patterns were identified as potential solutions to implement the downlink aspect of the AAtS concepts.  However, these patterns are connections oriented and not data models/formats. Thus, they cannot be used as potential solutions for the data interoperability challenge.

Based on the subsequent analysis performed, the following observations can be made:

- There is no single messaging pattern that can satisfy all the operational / technical scenarios. However, a potential solution that should be considered is an implementation that is a combination of more than one messaging pattern that can satisfy the maximum number of scenarios.
- The DMS needs to leverage the data exchange models used within SWIM in the development and implementation of their publication services. These models are as follows:
    - Aeronautical Information eXchange Model (AIXM)
    - Weather Information eXchange Model (WXXM)
    - Flight Information eXchange Model (FIXM).

| Version | Description of Change | Author | Date |
|---|---|---|---|
| 1.0 | Final Document | F. Aknine / M. De Ris / L. Yee | 07/31/2013 |
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# 1.0 INTRODUCTION

The Next Generation Air Transportation System (NextGen) is a comprehensive overhaul of our National Airspace System (NAS) to make air travel more convenient and dependable, while ensuring flight operations are as safe, secure and efficient as possible [1]. The transformation to NextGen requires capabilities and technologies enabling more efficient operations. The System Wide Information Management (SWIM) program is an integral part of that transformation. SWIM is an information platform that will facilitate simultaneous sharing of information available from the various NAS information systems among flight crews, Air Traffic Management (ATM), airline dispatchers, the military, government agencies, and other users of the NAS, as well as other worldwide information suppliers/consumers.

Currently, there is not an efficient or effective air-ground mechanism for the data management, exchange, and sharing of aircraft data. This reduces the flight crews' scope of planning and ability to collaborate with air traffic management in making dynamic and strategic decisions during all phases of flight. Thus, flight crews rely heavily on voice and other legacy communications for in-flight aviation information which increases pilot workload on the flight deck. ATM personnel and NAS systems do not have real-time access to aircraft data or pilot weather observation data. The aircraft data that may be sent to SWIM includes, but is not limited to, video surveillance, aircraft sensors, and law enforcement data. This data, if made available to NAS users, will establish a common situational awareness environment with aircraft that they do not receive now. The pilot weather observations that may be sent to SWIM includes, but is not limited to, Pilot Reports (PIREPs). Sending PIREPs to SWIM reduces communication over radio frequencies and allows the PIREPs to be available to all SWIM subscribers.

## 1.1 Purpose

The purpose of this document is to complement the uplink technical concept described in the AAtS Implementation Guidance Document [2] and establish the downlink technical concept that will enable the aircraft to deliver aircraft data to the FAA SWIM infrastructure in a globally interoperable manner.

## 1.2 Scope

This technical concept paper describes the concepts, functionality, and behavior of systems necessary to implement an interoperable bi-directional AAtS capability to include:

- Describing how government agencies and commercial entities interact and do business, including rules of engagement, interagency agreements, policies, interconnection and data sharing agreements, and business rules;

- Establishing the network connection, obtaining access, including access policies, controls, and permissions;
- Establishing the service connections, obtaining access, discovering and publishing data to SWIM; and
- Describing the full information exchanges associated with the data, message timeliness, occurrence of lost messages, and statistical information on the occurrence of errors being captured and reported to end users.

The methodology to develop the concepts and functionality include:

- Reviewing the existing AAtS research studies, analysis reports, and discussions with the FAA stakeholders. The source materials, listed in the reference section of this document, provide a good researcher-based perspective of the desired and achievable AAtS functionality; and
- Consulting subject matter experts (SMEs) on topics related to operational and technical concepts, policies, and regulatory guidance that will impact the AAtS concepts.

## 1.3 Background

AAtS is the effort to define connectivity from SWIM Service Oriented Architecture (SOA) shared resources to an aircraft, whether it is on the ground or in the air. AAtS based services will help create a shared common situational awareness among the flight crew, AOCs/FOCs, and ATM (including other global Air Navigation Service Providers (ANSPs)) throughout the entire flight. With AAtS, the flight crew moves from being an isolated operator to an engaged, collaborative decision maker [2]. This connection will provide NAS operational data intended to support uses that affect the efficiency of air traffic management operations up to, but not including, uses that directly affect the trajectory of aircraft. Data delivery uses that do directly affect the trajectory of the aircraft are those that involve Air Traffic Control (ATC) clearances, instructions or information and will leverage higher critical paths such as the FAA's Data Communications system.

The AAtS concepts focus on the following objectives:

- Creating a common situational awareness environment between aircraft and the NAS.
- Providing ground to air and air to ground data exchanges (excluding trajectory negotiations) between aircraft and NAS services.
- Providing aeronautical, weather, and operational flight information to flight crews and operators.
- Providing aircraft derived information to FAA NAS.
- Supporting global interoperability between AAtS users and other ANSPs.

Figure 1-1 describes a logical depiction of the end-to-end system interfaces involved for the aircraft to provide aircraft originated information to NAS Service and Table 1-1 describes the end-to-end system entities.

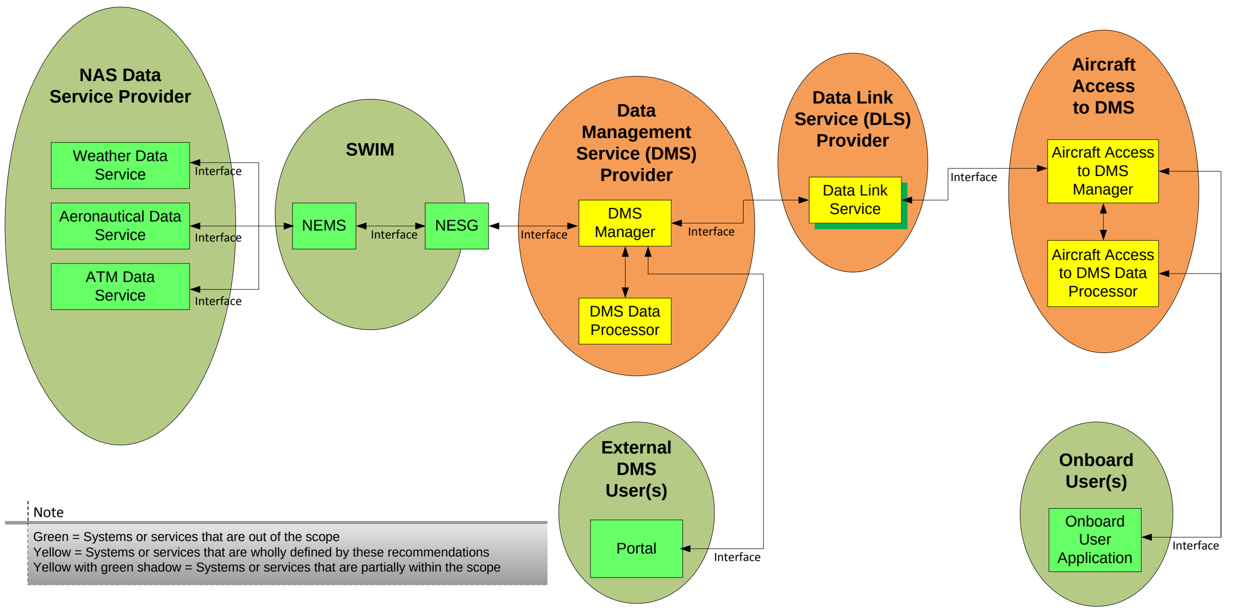


**Figure 1-1 – End-to-End System Interfaces Description**

| Entity | Description |
|---|---|
| Aircraft Access to DMS | The Aircraft Access to DMS is a node that houses the processing and managing services for the AAtS delivery service. |
| Aircraft Access to DMS Data Processor | The Aircraft Access to DMS Data Processor is a node that handles the lower level activities such as retrieving data/information, validating data/information, processing information requests, and preparing information for transmission. Additionally, this node distributes information received to the relevant databases and performs data acquisition activities for data generated by the aircraft. |
| Aircraft Access to DMS Manager | The Aircraft Access to DMS Manager is a node that manages the connections to the related entities and uses appropriate communication protocols, completes necessary message routing, and manages network traffic. |
| Aeronautical Data Service | Provides information such as notices to airmen, flight restrictions, special use airspace, etc. |
| ATM Data Service | Provides information such as traffic flow, playbook, traffic management initiatives, terminal movement, and arrival data. |
| DLS | The DLS provides the wireless connections between the ground and aircraft, including knowing where the aircraft is, and making the connections to achieve the target end-to-end latency and availability. |
| DLS Provider | The DLS Provider is a node that provides the wireless service to connect the aircraft to the ground. |

| Entity | Description |
|---|---|
| DMS Data Processor | The DMS Data Processor is a node that handles the lower level activities such as retrieving data/information, validating data/information, processing information requests, and preparing information for transmission. |
| DMS Manager | The DMS Manager is a node that manages the connections to the related entities and uses appropriate communication protocols, completes necessary message routing, and manages network traffic. |
| DMS Provider | The DMS Provider is a node that houses the processing and managing services for the AAtS delivery service. |
| External DMS User(s) | This system node includes the human operators and systems used to perform business operations for hosting the application programming interface (API) necessary to access the DMS Function for configuration and management purposes. |
| NAS Data Service Provider | The NAS Data Service Provider is a node that provides source information. Additionally, it also represents the end-user(s) of aircraft originated information. |
| SWIM | The SWIM is a node that enables the DMS to connect to NESG, NEMS and further to connect to NAS Service. |
| NEMS | NAS Enterprise Messaging Services include the messaging and management functions needed to support SWIM operations. |
| NESG | The NAS Enterprise Security Gateway (NESG) is a framework for supporting mandated boundary protection services between SWIM and external entities. It provides a standardized scheme for connecting and managing connections to external users. It also enables a layered security scheme to provide defense in depth and provide a buffer between SWIM and external entities. |
| Onboard User(s) | This system node contains the systems used to host the onboard user applications that receive or supply data/information to and from the Aircraft Access to DMS. These include a variety of on-board systems that may include but not be limited to flight management, informational, video surveillance, and sensor systems. |
| Onboard User Application | This is the host application that will store, display, and use the information delivered to the aircraft by the AAtS services. Conversely, it is also considered the system that supplies information to the Aircraft Access to DMS for downlink purposes. |
| Portal | This portal enables external entities (e.g., AOC, FOC) to connect to the DMS and to manage/monitor configurations for functions such as business rules, data filters, and subscriptions. |
| Weather Data Service | Provides information about weather including observations and forecasts. |

**Table 1-1 – End-to-End System Entities Description**

## 1.4 Assumptions

- Aircraft data and weather observation services will be made available from commercial DMS providers via the SWIM infrastructure. AAtS provided information is not intended for command and control purposes.
- AAtS is agnostic of use and can support Category 1 or Category 2 data link delivery services [7].

- A version of the NAS Service Registry/Repository (NSRR) is publically available to enable a prospective DMS Provider to publish services.

## 1.5 Constraints

- FAA has no plans to acquire systems, hardware, or software to directly support AAtS.
- The selected network needs to have sufficient bandwidth to support the desired services.

# 2.0 REFERENCES

[1] *NextGen Implementation Plan*, FAA, March 2011.

[2] *AAtS Implementation Guidance Document*, Version 2.0, February 2013.

[3] *AAtS Concept of Operations Document*, Booz Allen Hamilton, June 2013.

[4] *FAA Telecommunications Infrastructure (FTI) Enterprise Security Gateway User's Guide, Volume II – For Non-NAS Users*, Revision 2c, February 2010.

[5] *SWIM NAS Service Registry/Repository Service Provider User's Manual*, Version 1.0, June 2011.

[6] *SWIM Service Lifecycle Management Process*, Version 2.0, June 2012.

[7] RTCA DO-340, *Concept of Use for AIS and MET Data Link Services* – September 2012.

[8] *FAA Order 1370.104 - Digital Signature Policy*, October 2008.

[9] FAA Aeronautical Information Manual, *Official Guide to Basic Flight Information and ATC Procedures*, February 2012.

[10] *SWIM Governance Policies* Document, Version 2.0, March 2012.

# 3.0 AIRCRAFT DOWNLINK TO SWIM CONCEPT

This section describes the key aspects of the downlink technical concept and includes:

- Providing downlink delivery of aircraft derived information to SWIM-enabled NAS services.
- Creating a shared common situational awareness information environment between air traffic management (ATM) services and the flight deck.
- Encouraging collaborative strategic decision-making by reducing pilot/controller workload, frequency congestion, and the reliance on voice communications.

To realize these key aspects, the following subsections have been developed to describe the concept.

## 3.1 Technical Concept Need

In order to fully realize the benefits of AAtS as described in the AAtS Concept of Operations (ConOps) [3], one must adequately understand what is necessary to transmit aircraft derived information through a connected DMS into SWIM is to create a shared common situational awareness information environment between air traffic management (ATM) services and the aircraft. There is a high likelihood that DMSs will have their own unique manner to exchange information with their customers. Depending on the number of DMSs extant, this could amount to a significantly large number of ways to implement information exchanges. In a commercial environment, these unique information exchanges do not specifically pose a problem as the relationships are usually proprietary and based upon obtaining competitive advantage.

AAtS is inherently a hybrid solution. It is neither completely an FAA infrastructure, nor is it completely a commercial implementation. In an FAA infrastructure the agency can dictate the various methods to exchange information, and has done so through a variety of standards and orders. A commercial system that exchanges information with aircraft must conform to some standards, but depending on the intended use, may not have to conform to any at all. If they do indeed follow standards to exchange information, they are never those employed within the NAS to do the same and are often mutually exclusive.

Due to the nature of SWIM and the concept of AAtS, and in this particular case the bi-directional requirements of the concepts, the commercial method of information exchange poses challenges in complexity and interoperability.

## 3.2 Operational Activities

The AAtS concept describes a functionality and concept to exchange aviation information between the aircraft and FAA's SWIM platform. The individual operational activities that go into that exchange include providing aircraft information and weather observation. These are the operational activities normally conducted in the downlink concept.

Figure 3-1 illustrates the operational activities that will be accomplished with the addition of downlink to the AAtS technical concepts. Table 3-0 describes those operational activities.

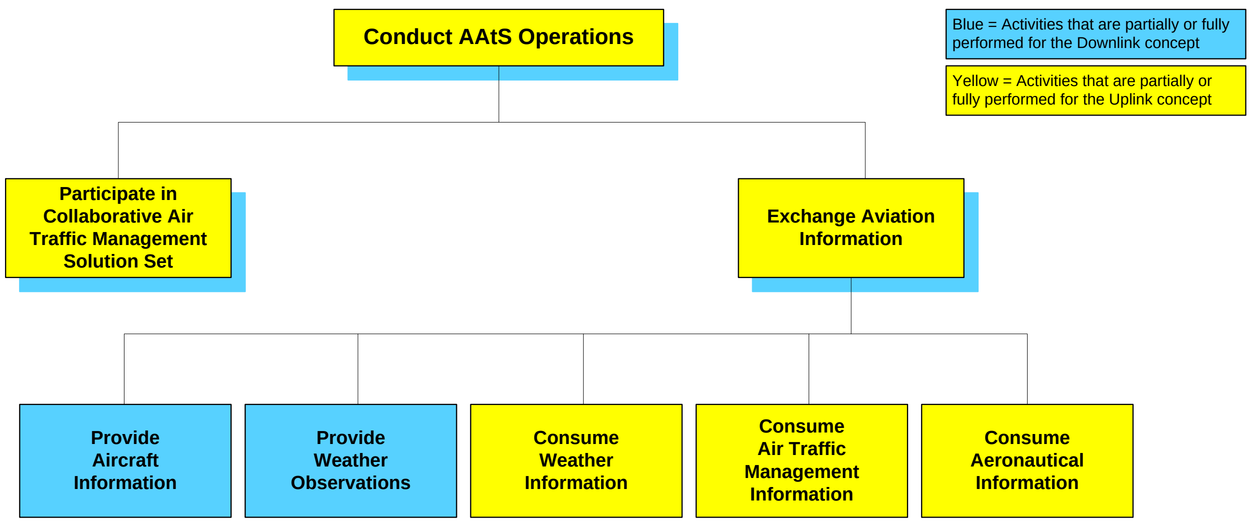


**Figure 3-1 – AAtS Operational Activities**

| Activities | Description |
|---|---|
| Conduct AAtS Operations | This activity includes that set of activities required to provide the full range of capabilities for the bi-directional concept. |
| Exchange Aviation Information | This activity includes the processes for establishing and managing communications, determining the information that will be subscribed to or requested, and managing the actual exchanges. |
| Participate in Collaborative Air Traffic Management Solution Set | The aircraft and air traffic management participate in collaborative information exchanges to develop alternatives for strategic flight planning and management decisions through trajectory information exchange(s) (TIE). |
| Provide Aircraft Information | This function produces data collected by an aircraft, such as sensor, video, decision support data that is transmitted to ground systems via AAtS. |
| Provide Weather Observations | Provide observed weather phenomena and other atmospheric information collected by the aircraft flight crew. |
| Consume Weather Information | The onboard user is the consumer of weather information that includes observations and forecasts |

| Activities | Description |
|---|---|
| Consume Air Traffic Management Information | The onboard user is the consumer of air traffic management information that includes, but is not limited to, flow information, Traffic Management Initiatives (TMI), playbook information, etc. |
| Consume Aeronautical Information | The onboard user is the consumer of the aeronautical information that includes information such as notices to airmen, flight restrictions, special use airspace, etc. |

**Table 3-0 – AAtS Operational Function Descriptions**

## 3.3 System Functions

The system functions were developed by analyzing the scenarios in the AAtS Concept of Operations [3] and the activities described above needed to satisfy these scenarios. Additionally, these functions are intended to describe a fully realized and high functioning implementation which captures most of the intended uses.

The *Perform Data Acquisition* system function is a new function that is added to the downlink AAtS functions to provide aircraft data to SWIM. It provides the collection of data produced by an aircraft, such as sensor, video, decision support data, that is transmitted to ground systems. Sensor data in the AAtS concept includes discrete sensors for the purpose of transmission or those sensors that are part of the aircraft system natively. Decision support data is comprised largely of crew inputted information; however it does also potentially include flight management information.

> **NOTE:** *For previously defined uplink AAtS functions see the AAtS Implementation Guidance Document V2.0*, February 2013 [2].

Figure 3-2 shows the data flow relationships of the *Perform Data Acquisition* system function within the Manage Onboard Communications. This function has a relationship with the *Provide Onboard User Applications* and *Perform Onboard Protocol Translation functions*. Table 3-1 describes the data flow relationships of the *Perform Data Acquisition* function.

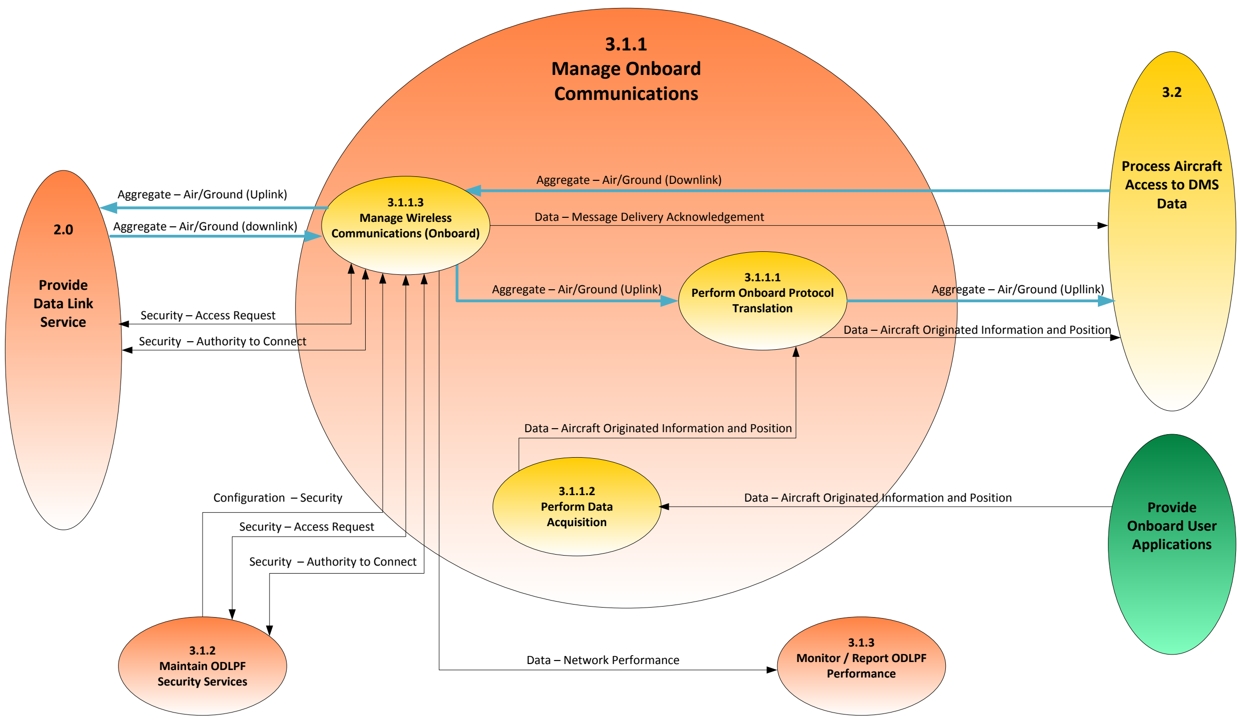


**Figure 3-2 – Manage Onboard Communications**

| Node | Related Node | Data Flow Relationships |
|---|---|---|
| Perform Data Acquisition | Perform Onboard Protocol Translation | The *Perform Data Acquisition* node provides transformed aircraft automation generated information to the *Perform Onboard Protocol Translation* node for conversion to internal Aircraft Access to DMS protocols. |
| | Provide Onboard User Application | The *Perform Data Acquisition* node receives for collection and transformation aircraft automation generated information from the *Perform Onboard User Application* node. Once collected and transformed, this information will be used by the Aircraft Access to DMS for filtering and for transmission off the aircraft. |

**Table 3-1 – Data Flow Relationships of Perform Data Acquisition**

## 3.4 Technical Challenges

The downlink concept needs to address the secure connection of each DMS to multiple services within SWIM and the interoperability of DMSs to multiple sources of information worldwide. To achieve the downlink concept goal of global interoperability and allow aircraft to participate in a Collaborative Air Traffic Management (CATM) solution set, the following challenges should be addressed and resolved:

- ***Challenge #1***: ***Complexity for the DMS to manage the interfaces to SWIM-enabled NAS Services*** – The DMS connects to SWIM services. Each NAS Service provides a Web Service Description Language (WSDL) which defines the interface for that service. In order for the DMS to connect to a NAS Service within SWIM, the DMS needs to conform to the WSDL associated with that NAS Service. Thus, the more SWIM-enabled NAS Services that the DMS will connect to will require the DMS to conform to multiple WSDLs to distribute the same type of data. This can become a challenge to the DMS to manage multiple interfaces to SWIM-enabled NAS Services within the FAA and other data services on a global scale.

- ***Challenge #2: Access Control Protection of Aircraft Data*** – The DMS must ensure that only authorized consumers have access to receive its aircraft data. However, there will be situations where the DMS has to release access control of its data to SWIM so that the data can be routed to the NAS Service endpoints. In this situation, this becomes a challenge to the DMS because it relinquishes visibility of which authorized subscriber has access to its service.

- ***Challenge #3: Interoperability of DMSs to multiple SWIMs (NAS, ANSPs and other enterprise data sources) infrastructures*** – Interoperability can be assured if the messaging patterns between DMS and SWIMs use agnostic technology platforms that leverage global standards prescribed by the World Wide Web Consortium (W3C). This can become a challenge to DMSs when a messaging pattern requires an implementation approach that may not align with W3C standards.

- ***Challenge #4: Interoperability of DMSs to multiple SWIMs (NAS, ANSPs and other enterprise data sources) data structures*** – Data Interoperability can be assured if the data exchanged conforms to a standardized data format. Different SWIMs may use different data exchange models. As a result, this will be a challenge to each DMS to be interoperable and communicate with multiple SWIMs.

## 3.5 Technical Concept

The technical concept of AAtS is evolving to provide aircraft data to the NAS based upon the evolution of the concept of operations. This evolution permits aircraft derived information to be downlinked and shared within the air traffic management system. The process and approach taken to develop and realize the downlink technical concept focused mainly on consulting various subject matter experts (SMEs) to define the path of activities needed. This path includes the following steps:

1. Identify operational scenarios from the *AAtS Concept of Operations* document [3] that describe the downlink concept.

2. Derive technical scenarios from these downlink operational scenarios.
3. Develop potential solutions in the form of "messaging patterns" between DMS and SWIM.
4. Assess and rate these messaging patterns against the technical challenges and scenarios.
5. Recommend the preferred messaging patterns based on their rating per scenario.

The following subsections describe in detail the path that led us to the preferred messaging patterns recommendations.

## 3.5.1 Operational and Technical Scenarios

### 3.5.1.1 Operational Scenarios

The *AAtS Concept of Operations* [3] developed the following Operational Scenarios (OS) to illustrate how the AAtS concept can satisfy the operational need:

- **OS1*: Trajectory Information Exchange*** – Demonstrates how AAtS can provide flight crews the ability to plan in-flight trajectory options. It also demonstrates how AAtS can allow flight crews to update surface movement data to minimize the impact to surface operations.
- **OS2: *Weather Modeling*** – Demonstrates how AAtS can transmit near real-time data on atmospheric conditions to improve weather models used by the FAA which are critical to informing Decision Support Tools (DSTs) and planning NAS system operations.
- **OS3: *Automated Flight Service Station (AFSS)*** – Demonstrates how AAtS can support the future AFSS and the GA flight crews utilizing it by transitioning from a voice-dependent system to a primarily automated and digital exchange.
- **OS4: *Special Activity Airspace (SAA)*** – Demonstrates how AAtS can provide flight crews near real-time awareness in flight of SAA status which creates a more flexible, accessible NAS and allows aircraft operators to make strategic/tactical changes to their flight plan.
- **OS5: *Automated Flight Conditions Report*** – Demonstrates how AAtS can provide flight crews the means to automatically transmit, receive and review near real-time flight conditions reports. This will ensure flight crews access to this type of information and minimize the impact to ATC frequencies.
- **OS6: *Airport Diversion Planning*** – Demonstrates how AAtS can provide GA flight crews with near real-time access to relevant NOTAMs allowing flight crews to have a complete picture of the event and its impact to their flight in order to better inform their decision making.

- **OS7: *Surface Management with Trajectory Based Operations*** – Demonstrate how AAtS allows the flight crew to efficiently exchange information with the full range of NAS entities (e.g., De-ice Control) while providing support to surface management by incorporating future Trajectory Based Operations.
- **OS8: *En-route Strategic Planning*** – Demonstrates how AAtS can provide flight crews with near real-time access to relevant NOTAMs and command center advisories giving them the opportunity to plan their flight, rather than reacting to unplanned events.
- **OS9: *Learning-Capable Decision Support Tool (DST)*** – Demonstrates how AAtS can provide flight crews and the aircraft a means to transmit near real-time information that could be used to help model an accurate picture of the events of a particular day in the NAS, which can ultimately be used to inform a learning-capable DST.

#### 3.5.1.2 Technical Scenarios

An operational scenario analysis was performed by SMEs to determine which ones describe the downlink concept. As a result, scenarios OS1, OS2, OS3, OS5, OS7, and OS9 were identified as relevant downlink OSs. Based on further analysis of these relevant operational scenarios, three technical scenarios (TS) were derived from the operational scenarios:

- **TS1: *Continuous Distribution*** – Demonstrates the distribution of *Aircraft Originated Information* that is sent on predetermined update rate (e.g., Publish/Subscribe Service). Figure 3-3 provides a high level graphical representation depicting continuous distribution of aircraft data to SWIM. Appendix B1 provides a detailed sequence diagram decomposition of system functions that define the DMS and Aircraft Access to DMS functionality involved in fully executing TS1. Table 3-2 describes the data flow relationships between the nodes.

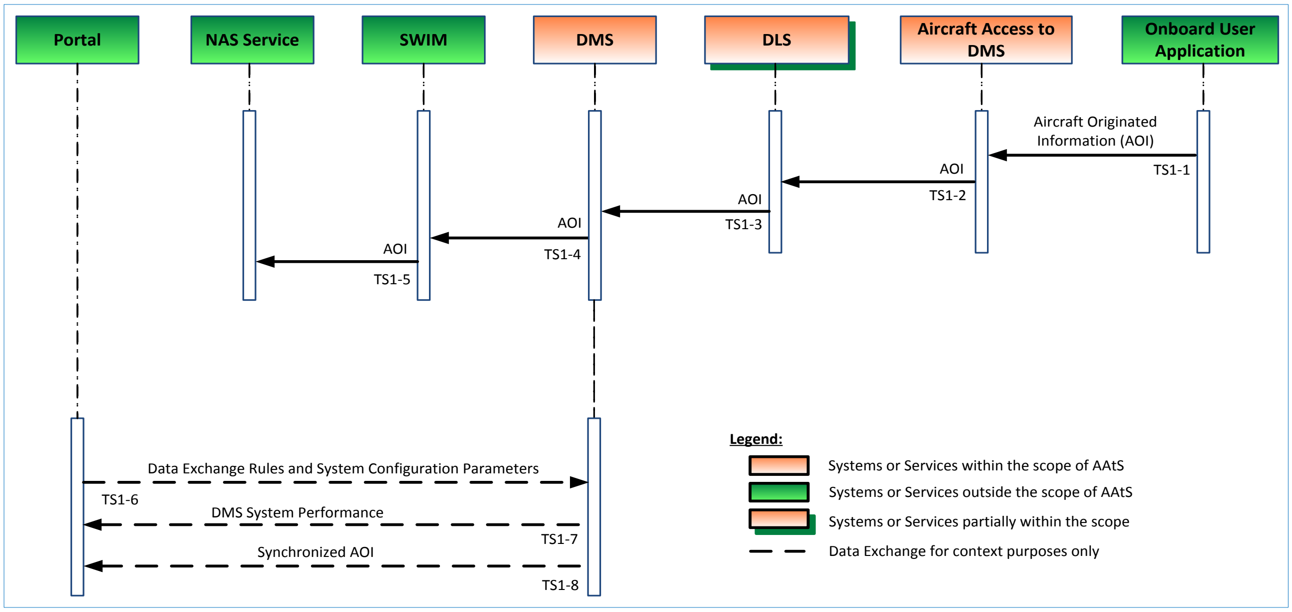


**Figure 3-3 – TS1 Sequence Diagram for Continuous Distribution**

| Number | Data Flow Relationships |
|---|---|
| TS1-1 | The Aircraft Access to DMS receives aircraft generated information for eventual transmission to the DMS via the DLS. |
| TS1-2 | The DMS receives aircraft originated information from the Aircraft Access to DMS via DLS. |
| TS1-3 | The DMS receives aircraft originated information for eventual transmission to the NAS Service via SWIM. |
| TS1-4 | The DMS sends aircraft originated information to the NAS Service via SWIM. |
| TS1-5 | The NAS Service receives aircraft originated information from the DMS via SWIM. |
| TS1-6 | The DMS receives from the Portal rules that contain governance and system rules for data filtering, data provenance, data validation, message prioritization, service security, and synchronization. It also receives configuration parameters from the Portal. |
| TS1-7 | The Portal receives from the DMS service quality information that includes such information as Aircraft Access to DMS, DLS, and DMS service performance and health. |
| TS1-8 | The Portal receives from the DMS synchronized aircraft originated information that is based on synchronization rule. |

**Table 3-2 – TS1 Data Flow Relationships between the nodes**

- **TS2**: ***Event Triggered*** – Demonstrates the distribution of *Automated Flight Conditions Report* that is sent as it is created. This could be through pilot input or automated processes. In this scenario, the established business rules between the provider and consumer determine whether DMS distributes the report or just a notification to the NAS Service on report availability. Figure 3-4 provides a graphical representation depicting aircraft transmitting flight conditions reports to SWIM. Appendix B2 provides a detailed sequence diagram decomposition of system functions that define the DMS and Aircraft Access to DMS functionality involved in fully executing TS2. Table 3-3 describes the data flow relationships between the nodes.

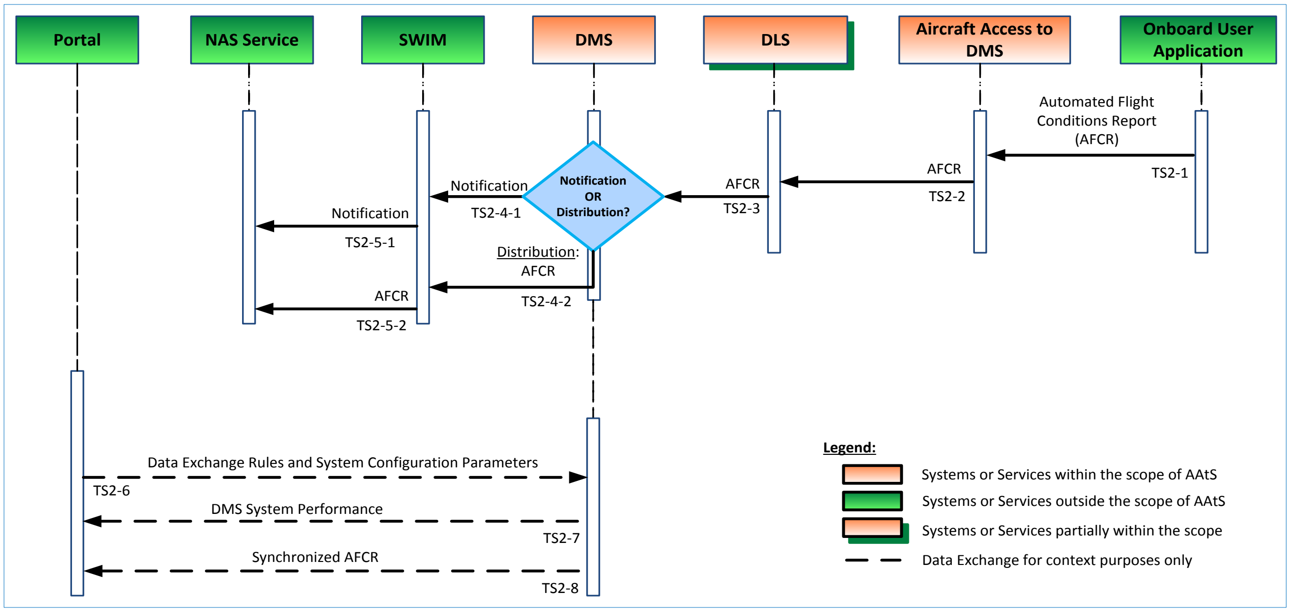


**Figure 3-4 – TS2 Sequence Diagram for Event Triggered**

| Number | Data Flow Relationships |
|---|---|
| TS2-1 | The Aircraft Access to DMS receives AFCR for eventual transmission to the DMS via the DLS. |
| TS2-2 | The DMS receives AFCR from Aircraft Access to DMS via DLS. |
| TS2-3 | The DMS receives AFCR for eventual transmission to the NAS Service via SWIM. |
| TS2-4-1 | The DMS submits notification to the NAS Service via SWIM on report availability. |
| TS2-4-2 | The DMS submits AFCR report to the NAS Service via SWIM based on business rules. |
| TS2-5-1 | The NAS Service receives notification from the DMS via SWIM. |
| TS2-5-2 | The NAS Service receives AFCR from the DMS via SWIM. |
| TS2-6 | The DMS receives from the Portal rules that contain governance and system rules for data filtering, data provenance, data validation, message prioritization, service security, and synchronization. It also receives configuration parameters from the Portal. |
| TS2-7 | The Portal receives from the DMS service quality information that includes such information as Aircraft Access to DMS, DLS, and DMS service performance and health. |
| TS2-8 | The Portal receives from the DMS synchronized aircraft originated information that is based on synchronization rule. |

**Table 3-3 – TS2 Data Flow Relationships between the nodes**

- **TS3:** ***Request/Reply*** – Demonstrates the distribution of *Aircraft Originated Information* once it is requested by the NAS Service. In this scenario, the NAS Service makes a request to DMS to obtain aircraft derived information. The DMS will check to see if the information is available in the DMS data cache. If the information is available, the DMS replies and provides the information directly to the NAS Service. If the information is not available, then the information request will continue to the Onboard User Application where the information will be made available using the *Perform Data Acquisition* system function and subsequently transmitted back to the DMS. Figure 3-5 provides a graphical representation depicting a SWIM-enabled NAS Service making a request to DMS. Appendix B3 provides a detailed sequence diagram decomposition of system functions that define the DMS and Aircraft Access to DMS functionality involved in fully executing TS3. Table 3-4 describes the data flow relationships between the nodes.

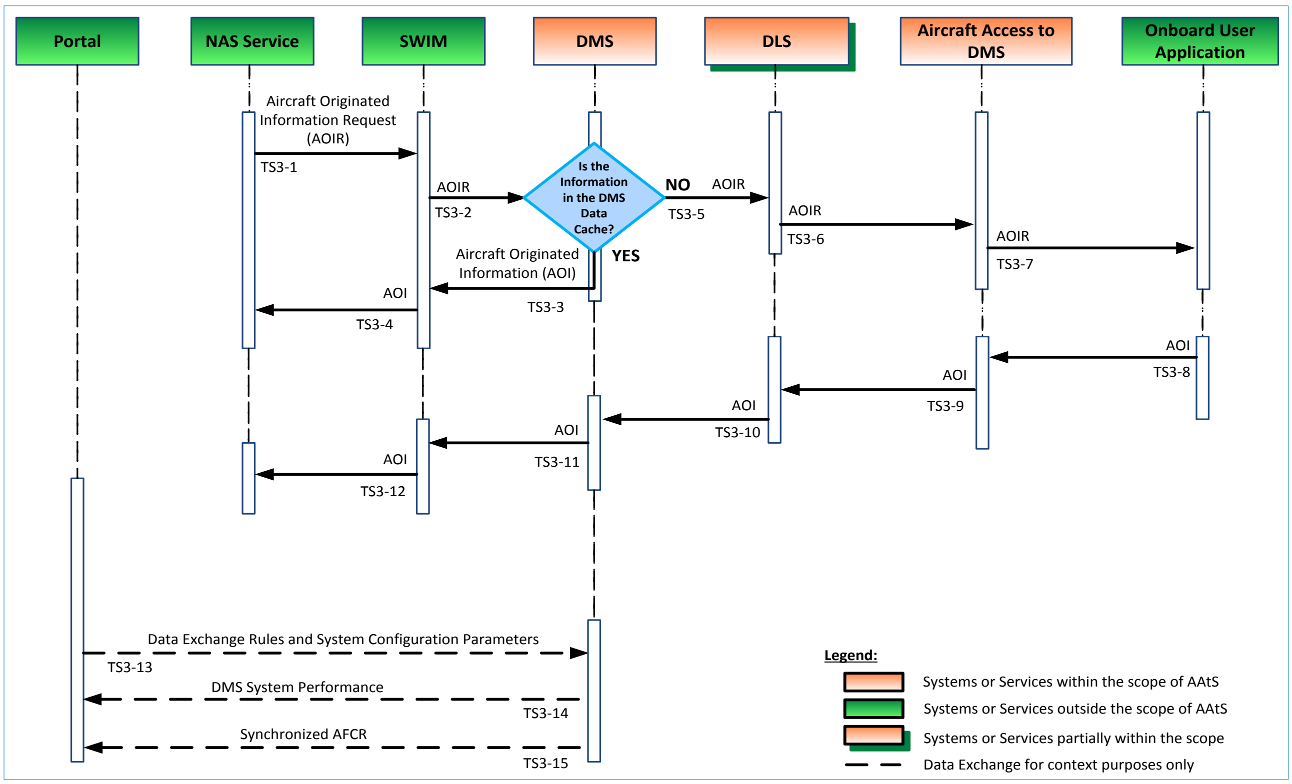


**Figure 3-5 – TS3 Sequence Diagram for Request/Reply**

| Number | Data Flow Relationships |
|---|---|
| TS3-1 | The NAS Service which is the ground-based consumer of aircraft originated information sends a request to the DMS via SWIM. |
| TS3-2 | The DMS receives a request from NAS Service via SWIM. |
| TS3-3 | The DMS checks if the information request is in the data cache. If it is in that location then the DMS provides aircraft originated information to the NAS Service via SWIM. |
| TS3-4 | The NAS Service receives aircraft originated information from DMS via SWIM. |

| Number | Data Flow Relationships |
|---|---|
| TS3-5 | The DMS checks if the information request is in the data cache. If it is not in that location then the DMS continues to the Onboard User Application via DLS and Aircraft Access to DMS. |
| TS3-6 | The Aircraft Access to DMS receives the information request via DLS. |
| TS3-7 | The Aircraft Access to DMS sends the request to the Onboard User Application. |
| TS3-8 | The Onboard User Application provides aircraft originated information to the Aircraft Access to DMS. |
| TS3-9 | The Aircraft Access to DMS provides aircraft originated information to the DMS via DLS. |
| TS3-10 | The DMS receives aircraft originated information from Aircraft Access to DMS via DLS. |
| TS3-11 | The DMS sends aircraft originated information the NAS Service via SWIM based on business rules. |
| TS3-12 | The NAS Service receives aircraft originated information from the DMS via SWIM. |
| TS3-13 | The DMS receives from the Portal rules that contain governance and system rules for data filtering, data provenance, data validation, message prioritization, service security, and synchronization. It also receives configuration parameters from the Portal. |
| TS3-14 | The Portal receives from the DMS service quality information that includes such information as Aircraft Access to DMS, DLS, and DMS service performance and health. |
| TS2-15 | The Portal receives from the DMS synchronized aircraft originated information that is based on synchronization rule. |

**Table 3-4 – TS3 Data Flow Relationships between the nodes**

#### 3.5.1.3 Mapping

The technical scenarios derived in Section 3.4.1.2 were based on analyzing the operational scenarios provided in Section 3.4.1.1.

In order to technically execute OS1, the developing convective weather information received via AAtS has triggered a series of events. This requires the AAtS-equipped aircraft to modify its route of flight resulting in a late arrival at Teterboro Airport (TEB). As such, this is an event triggered activity (i.e., TS2) where AAtS is used to inform air traffic management of the new Earliest Off Block Time for the next leg of the flight. Through the use of AAtS, the current Departure Management Program at TEB is informed of the new departure time which subsequently notifies Air Traffic Control of this change.

In order to technically execute OS2, weather and atmospheric information is needed as input to NOAA’s weather models. This information is available from a number of sources, but more specifically AAtS-equipped aircraft, which can provide the most accurate and real-time weather data. Since the AAtS-equipped aircraft is already collecting such weather data using its onboard aircraft systems, this information can be obtained by the various means described in each technical scenario. Thus, if NOAA, which is already receiving weather data being downlinked from the hundreds of appropriately-equipped aircraft, is a subscriber to the DMS through CSS-

WX or other NAS services, the technical means described in each of the technical scenarios (i.e., TS1, TS2, and TS3) are applicable.

In order to technically execute OS3, a Visual Flight Rules (VFR) flight plan and Pilot Report (PIREP) have been created by a pilot for submission to the AFSS. As such, this is an event triggered activity (i.e., TS2) where AAtS is used to inform AFSS.

In order to technically execute OS5, automated flight conditions reports must be collected and downlinked from the AAtS-equipped aircraft. As such, the onboard aircraft systems will automatically downlink flight conditions reports if and when weather conditions change (i.e., TS1, TS2, and TS3).

In order to technically execute OS7, De-ice Control (i.e., NAS entity) transmits through AAtS a message to the air cargo jet (ACG355) flight crew informing them of their proposed de-ice slot time and asking for receipt and concurrence. At 0036 UTC, ACG355 confirms receipt and concurrence with an AAtS transmitted message back to De-ice Control. As such, this is a Request/Reply event (i.e., TS3). At 0130 UTC, the flight crew receives an alert via AAtS. The captain uses AAtS once again to update ACG355's EOBT and submits a time of 0150 UTC to inform the Departure Management Program (DMP). As such, this is an event triggered activity (e.g., TS2).

In order to technically execute OS9, information is needed from aircraft derived sources to complement the data available from the ground infrastructure to ensure that optimum and efficient usage of the airspace is possible. The data downlinked from AAtS-equipped aircraft is used by a number of decision support tools (DST) to assist both air traffic control and aircraft in flight to optimize the departure, transit, and arrival of aircraft at their destination. AAtS-equipped aircraft will deliver the most real-time information available through any and all of the technical scenarios (i.e., TS1, TS2, and TS3) described and support the creation of a collaborative decision making environment between air traffic control and aircraft during all phases of flight. Thus, such things as flight plan modifications or route changes due to weather, airport status at destination, etc. can be strategically considered to maximize an aircraft's operation and minimize the impact to the NAS.

Table 3-5 is a traceability matrix that summarizes the relationships between the technical and operational scenarios.

| Operational Scenarios (OS) | Technical Scenarios (TS) |
|---|---|

| | TS1: Continuous Distribution | TS2: Event Triggered | TS3: Request/Reply |
|---|---|---|---|
| **OS1:** Trajectory Information Exchange – "*The current P-time for N381's next departure leg is 1910 UTC. Due to the delay, the Captain quickly inputs, using AAtS, a new Earliest Off Block Time (EOBT) of 1930 UTC in order to inform the current Departure Management Program (DMP) at TEB.*" *(AAtS Initial ConOps, 06/19/2013, Section 1.1).* | | **X** | |
| **OS2**: Weather Modeling – "*Meanwhile, National Oceanic and Atmospheric Administration's weather models are continuously being updated based on atmospheric conditions being transmitted via hundreds of AAtS-equipped aircraft, including the B757.*" *(AAtS Initial ConOps, 06/19/2013, Section 1.2).* | **X** | **X** | **X** |
| **OS3**: Automated Flight Service Station – "*The pilot then submits, via AAtS, a VFR flight plan (HEF to RIC) to the AFSS. Using AAtS, the pilot transmits a digital PIREP to the AFSS identifying the severity of turbulence, location, and altitude and aircraft type.*" *(AAtS Initial ConOps, 06/19/2013, Section 1.3).* | | **X** | |
| **OS5**: Automated Flight Conditions Report – "*The B767 automatically generates a Flight Conditions Report which AAtS then transmits to the FAA regarding current atmospheric condition.*" *(AAtS Initial ConOps, 06/19/2013, Section 1.5).* | **X** | **X** | |
| **OS7:** Surface Management with Trajectory Based Operations – "*At 0035 UTC, De-ice Control transmits through AAtS a simultaneous message to the ACG355 flight crew and their FOC informing them of their proposed de-ice slot time and asking for receipt and concurrence. At 0036 UTC, ACG355 confirms receipt and concurrence with an AAtS transmitted message back to De-ice Control. The Captain uses AAtS to once again update ACG355's EOBT.*" *(AAtS Initial ConOps, 06/19/2013, Section 1.7).* | | **X** | **X** |
| **OS9**: Learning-Capable (DST) – "*The flight performance data for the A320 and the rest of its fleet are automatically transmitted, via AAtS, back to the FAA into a database that will inform the same DST that helped traffic managers make decisions today. This prompts the flight crew to use AAtS to investigate route availability.*" *(AAtS Initial ConOps, 04/25/2013, Section 1.9).* | **X** | **X** | **X** |

**Table 3-5 – Traceability Matrix**

### 3.5.2 Types of Messaging Patterns

To address the technical challenges in Section 3.3.2, a number of messaging patterns were evaluated as potential solutions. However, out of the ones that were evaluated, four were identified as potential solutions for NAS Services and DMSs to achieve the downlink concept goal. The following subsections detail the advantages and disadvantages of each messaging pattern solution.

#### 3.5.2.1 Messaging Pattern A: NAS Service Hosting a Web Service Operation

The NAS Service provides a web service function to openly receive aircraft data from the DMS. This approach requires each DMS to continuously push aircraft data to the NAS Service. All the message exchanges between the DMS and NAS Service will be fully based on the web service protocol. The disadvantages and advantages of this messaging pattern are as follows:

**Disadvantages**:

- The data transmitted during the DMS data push will not be received when the NAS Service is offline.
- DMS conforms to the WSDLs of multiple NAS Services for delivering the same data.
- One-way delivery of published data without filtering.

**Advantages**:

- DMS has full access control of its data.
- Technology platform agnostic (i.e., NAS Service is using a web service that can be integrated with various programming languages and there is no requirement to acquire any specific software to be compatible with NAS Service).

#### 3.5.2.2 Messaging Pattern B: DMS Hosting Request-Response Web Service

Each NAS Service makes a request to a DMS to consume aircraft data. In response, the DMS must provide a function that can connect and respond with aircraft data. All the message exchanges between a DMS and NAS Service will be fully based on the web service protocol. The disadvantages and advantages of this messaging pattern are as follows:

**Disadvantages**:

- The data transmitted during the NAS Service request to DMS will not be received when the DMS is offline.

**Advantages**:

- DMS has full access control of its data.

- Technology platform agnostic (i.e., DMS is using a web service that can be integrated with various programming languages and there is no requirement to acquire any specific software to be compatible with DMS).
- Two-way delivery of published data with static filtering pre-conditions.

#### 3.5.2.3 Messaging Pattern C: DMS Hosting Pub-Sub Service using JMS

Each DMS provides a service that publishes aircraft data into SWIM irrespective of whether a consumer is requesting it or not. This service enables the DMS to continuously push data into SWIM. If there is no active consumer, the data will be cleared out by an expiration timer (e.g., time-to-live). The disadvantages and advantages of this messaging pattern are as follows:

**Disadvantages**:

- Technology platform dependent (i.e., The JMS Client of DMS must acquire a specific software to be compatible with NEMS).
- DMS releases its data access control to SWIM.

**Advantages**:

- This messaging pattern uses JMS that is useful for reliable and continuous publishing of data.

#### 3.5.2.4 Messaging Pattern D: DMS Hosting Pub-Sub with Web Service Notification

Each DMS provides a service that can notify consumers of available aircraft data. This service enables a DMS to send notification to its subscribed consumers of new/updated aircraft data by providing the web service parameters to consume the data. Subsequently, the NAS Service makes a request to the DMS to consume aircraft data based on the parameters contained within the notification. All the message exchanges between DMS and NAS service will be fully based on the web service protocol. The disadvantages and advantages of this messaging pattern are as follows:

**Disadvantages**:

- Technology platform dependent (i.e., consuming NAS Service must comply with the specific WSDL defined web service notification specification).

**Advantages**:

- DMS retains access control of its data.
- Two-way delivery of published data with dynamic filtering pre-conditions.

### 3.5.3 Message Pattern Rating

An analysis was conducted by SMEs to evaluate the feasibility of the messaging patterns as potential solutions to the challenges and scenarios. As part of the evaluation process, a rating scale was created ranging from Poor to Very Good. Their individual descriptions are as follows:

- **Poor**: Not viable due to performance issues, technical implementations, or has been determined to be potentially inefficient, costly, and not worth attempting.
- **Fair**: Viable, but may only partially meet the performance or technical requirements and may be technically costly to implement.
- **Good**: Viable and meets most of the performance requirements; is technically feasible with some development cost to implement; and has minimal impact to being integrated with existing configurations.
- **Very Good**: Viable and meets all performance and technical requirements; leverages existing technology with low implementation cost; and has nominal impact to being integrated with existing configurations.

#### 3.5.3.1 Challenge Ratings

A further analysis was performed by SMEs to assess how well the messaging patterns address the challenges. Based upon iterative and detailed SME technical discussions, the rating attributes were applied against the disadvantages and advantages identified in Section 3.3.3. These attributes include, but are not limited to, technology platform, conformance, data access control, and one-way/two-way delivery of published data. As a result, Table 3-6 was created to classify these rating attributes.

| Rating | Attribute |
|---|---|
| **Poor** | DMS continuously pushes full volume of data with no notification while NAS Service is offline. |
| | Technology platform dependent. |
| **Fair** | DMS conformance – DMS conforms to the WSDLs of multiple NAS Services. |
| | DMS releases its data access control to SWIM while maintaining security compliance. |
| | One-way delivery of published data without filtering. |
| **Good** | DMS notification – DMS provides notification to NAS Services of available aircraft data with filtering pre-conditions. |
| | NAS Service responds to notification from DMS – NAS Service consumes aircraft data with filtering pre-conditions |
| | DMS retains access control of its data. |

| Rating | Attribute |
|---|---|
| **Very Good** | Minimal conformance constraints - DMS publishes minimal number of WSDLs. |
| | No conformance to any specific WSDL. |
| | DMS has full access control of its data. |
| | Two-way delivery of published data with filtering pre-conditions. |
| | Technology platform agnostic. |

**Table 3-6 – Challenge Ratings**

The thought process followed to complete Table 3-7 focused on filling the appropriate attribute that exists between the challenges and messaging patterns.

> **NOTE:** *When a cell has multiple rating attributes, an average was taken to be considered as the overall rating for that cell (e.g., "Very Good" with "Fair" will lead to "Good").*

Table 3-7 depicts the summary of the analysis and evaluation effort related to messaging patterns versus technical challenges.

| Technical Challenges vs. Messaging Patterns | Messaging Pattern A<br>NAS Service Hosting a Web Service Operation | Messaging Pattern B<br>DMS Hosting Request-Response Web Service | Messaging Pattern C<br>DMS Hosting Pub-Sub Service using JMS | Messaging Pattern D<br>DMS Hosting Pub-Sub with Web Service Notification |
|---|---|---|---|---|
| **Challenge #1**<br>Complexity for the DMS to manage the interfaces to SWIM-enabled NAS Services and other globally available data services. | **Fair**<br>• DMS conformance | **Very Good**<br>• Minimal conformance constraints | **Very Good**<br>• No conformance to any specific WSDL | **Very Good**<br>• Minimal conformance constraints. |
| **Challenge #2**<br>Access control protection of aircraft data. | **Very Good**<br>• DMS has full access control of its data. | **Very Good**<br>• DMS has full access control of its data. | **Fair**<br>• DMS releases its data access control to SWIM. | **Good**<br>• DMS retains access control of its data while maintaining security compliance. |
| **Challenge #3**<br>Interoperability of DMSs to multiple SWIMs (NAS, ANSPs and other enterprise data sources) infrastructures. | **Good**<br>• Technology platform agnostic – **Very Good**.<br>• One-way delivery of published data without filtering – **Fair**. | **Very Good**<br>• Technology platform agnostic – **Very Good**.<br>• Two-way delivery of published data with filtering pre-conditions – **Very Good**. | **Fair**<br>• Technology platform dependent – Each DMS must use JMS – **Poor**.<br>• One-way delivery of published data without filtering – **Fair**. | **Good**<br>• Technology platform dependent – must comply with the specific WSDL defined Web service notification specification – **Poor**.<br>• Two-way delivery of published data with filtering pre-conditions – **Very** |

**Table 3-7 – Messaging Patterns versus Technical Challenges**

#### 3.5.3.2 Scenario Ratings

A further analysis was performed by SMEs to assess how well the messaging patterns address the scenarios. Based upon iterative and detailed SME technical discussions, the rating attributes were applied against the operational/technical scenarios. These attributes include, but are not limited to, continuous distribution of data, notifications, requests, overloading the online NAS Service, and use of efficient methodologies. As a result, Table 3-8 was created to classify these rating attributes.

| Rating | Attribute |
|---|---|
| **Poor** | DMS continuously pushes volume of data with no notification while NAS Service is offline. |
| | NAS Service provides no notification of its availability. |
| **Fair** | NAS Service makes a request to the DMS based on static filtering parameters. |
| **Good** | NAS Service makes a request to the DMS based on dynamic parameters contained within the notification from DMS. |
| **Very Good** | DMS employs efficient methodologies for the intended use. |
| | NAS Service is able to consume aircraft data effectively within SLA. |
| | Reliable delivery of aircraft data from DMS to NAS Services. |

**Table 3-8 – Scenario Ratings**

Additionally, the results of Table 3-7 were considered, evaluated, and applied where technically appropriate. This provides a multidimensional characterization that depicts the impact of messaging patterns compared to scenarios and how the imposed technical challenges directly affect their relationship. Thus, the ratings are intended to summarize this analysis as follows:

**Technical Scenario #1**

This scenario describes how the four messaging patterns can be applied as a potential solution for the DMS to execute the continuous distribution of aircraft data. The results are as follows:

Pattern A

- When the challenge resolution (Table 3-7) is applied, this results in the following:
    - DMS needs to conform to the WSDLs of multiple NAS Services and is rated as "**Fair**".
    - DMS has full access control of its data and is rated as "**Very Good**".
    - This pattern uses a web service protocol which is technology platform agnostic rated as "**Very Good**" and one-way delivery of published data without filtering rated as "**Fair**".

**The overall rating to satisfy this scenario for pattern A is "Fair".**

Pattern B

- Requires a request-response action. In this scenario, the DMS is continuously pushing aircraft data to SWIM irrespective of any action. Thus, pattern B is not a viable solution for this scenario and was not rated.

Pattern C

- Employs JMS which is an efficient technology for reliable continuous publishing of data. Using the rating attributes established above, this messaging pattern is rated as "**Very Good**". Additionally, Table 3-7 is applied to include:
  - DMS does not need to conform to any specific WSDL and is rated as "**Very Good**".
  - DMS releases its access control to SWIM and is rated as "**Fair**".
  - This pattern is technology platform dependent rated as "**Poor**" and uses one-way delivery of published without filtering rated as "**Fair**".

**The overall rating to satisfy this scenario for pattern C is "Good".**

Pattern D

- Requires the NAS Service to make a request to the DMS to consume aircraft data based on the parameters contained within the notification. Using the rating attributes established above, this messaging pattern is rated as "**Good**". Additionally, Table 3-7 is applied to include:
  - DMS does not need to conform to any specific WSDL and is rated as "**Very Good**".
  - DMS retains access control of its data while maintaining security compliance and is rated as "**Good**".
  - This pattern requires that the NAS service comply with the specific WSDL defined Web service notification specification which is technology platform dependent and is rated as "**Poor**".
  - This pattern uses two-way delivery of published data with filtering pre-conditions and is rated as "**Very Good**".

**The overall rating to satisfy this scenario for pattern D is "Good".**

**Technical Scenario #2**

This scenario describes how the four messaging patterns can be applied as a potential solution for the DMS to execute pilot initiating aircraft data and weather observation data. The results are as follows:

Pattern A

- Will enable NAS Service to consume aircraft data effectively within Service Level Agreement (SLA). Using the rating attributes established above, this messaging pattern is rated as "**Very Good**". However, the NAS Service does not provide notification of its availability and is rated as **Poor**". Additionally, Table 3-7 is applied to include:
  - DMS needs to conform to the WSDLs of multiple NAS Services and is rated as "**Fair**".
  - DMS has full access control of its data and is rated as "**Very Good**".
  - This pattern uses a web service protocol which is technology platform agnostic rated as "**Very Good**" and one-way delivery of published data without filtering and is rated as "**Fair**".

**The overall rating to satisfy this scenario for pattern A is "Good".**

Pattern B

- In this scenario, the pilot initiates a one way action to transmit aircraft data and weather observation data to the DMS. The DMS pushes this data to SWIM irrespective of any action by the NAS Service. However, pattern B requires a request-response action between the DMS and the NAS Service. Thus, pattern B is not a viable solution for this scenario and was not rated.

Pattern C

- Employs JMS which is an efficient technology for reliable continuous publishing of data. Using the rating attributes established above, this messaging pattern is rated as "**Very Good**". Pattern C in this scenario enables NAS Service to consume aircraft data effectively within Service Level Agreement (SLA) and is rated as "**Very Good**". Additionally, Table 3-7 is applied to include:
  - DMS does not need to conform to any specific WSDL and is rated as "**Very Good**".
  - DMS releases its access control to SWIM and is rated as "**Fair**".
  - This pattern is technology platform dependent rated as "**Poor**" and uses one-way delivery of published without filtering and is rated as "**Fair**".

**The overall rating to satisfy this scenario for pattern C is "Good".**

Pattern D

- Requires NAS Service to make a request to DMS to consume aircraft data based on the parameters contained within the notification. Using the rating attributes established above, this messaging pattern is rated as "**Fair**". Thus, DMS provides filtering and is rated as "**Good**". Pattern D in this scenario enables NAS Service to consume aircraft data effectively within Service Level Agreement (SLA) and is rated as "**Very Good**". Additionally, Table 3-7 is applied to include:
    - DMS does not need to conform to any specific WSDL and is rated as "**Very Good**".
    - DMS retains access control of its data while maintaining security compliance and is rated as "**Good**".
    - This pattern requires NAS Service to comply with the specific WSDL defined Web service notification specification which is technology platform dependent and is rated as "**Poor**".
    - This pattern uses two-way delivery of published data with filtering pre-conditions and is rated as "**Very Good**".

**The overall rating to satisfy this scenario for pattern D is "Good".**

**Technical Scenario #3**

This scenario describes how the four messaging patterns can be applied as a potential solution for the DMS to execute the SWIM-enabled NAS Service to DMS request for aircraft data. The results are as follows:

Pattern A

- This scenario requires a request-response action between the DMS and the NAS Service. However, pattern A does not offer this capability. Thus, pattern A is not a viable solution for this scenario and was not rated.

Pattern B

- Requires the NAS Service to make a request to DMS to consume aircraft data based on statically predefined parameters. Using the rating attributes established above, this messaging pattern is rated as "**Good**". Pattern B in this scenario enables NAS Service to consume aircraft data effectively within Service Level Agreement (SLA) and is rated as "**Very Good**". Additionally, Table 3-7 is applied to include:

- DMS has minimal conformance constraints and is rated as "**Very Good**".
- DMS has full access control of its data and is rated as "**Very Good**".
- This pattern uses a web service protocol which is technology platform agnostic rated as "**Very Good**" and two-way delivery of published data with filtering pre-conditions rated as "**Very Good**".

**The overall rating to satisfy this scenario for pattern B is "Very Good".**

Pattern C

- This scenario requires a request-response action between the DMS and the NAS Service. However, pattern C provides a service that publishes aircraft data into SWIM irrespective of whether a consumer is requesting it or not. This pattern does not offer a request-response capability. Thus, pattern C is not a viable solution for this scenario and was not rated.

Pattern D

- Requires the NAS Service to make a request to DMS to consume aircraft data based on the parameters contained within the notification from DMS. Using the rating attributes established above, this messaging pattern is rated as "**Good**". Pattern D in this scenario enables NAS Service to consume aircraft data effectively within Service Level Agreement (SLA) and is rated as "**Very Good**". Additionally, Table 3-7 is applied to include:
  - DMS does not need to conform to any specific WSDL and is rated as "**Very Good**".
  - DMS retains access control of its data while maintaining security compliance and is rated as "**Good**".
  - This pattern requires NAS Service to comply with the specific WSDL defined Web service notification specification which is technology platform dependent and is rated as "**Poor**".
  - This pattern uses two-way delivery of published data with filtering pre-conditions and is rated as "**Very Good**".

**The overall rating to satisfy this scenario for pattern D is "Good".**

#### 3.5.3.3 Messaging Pattern Recommendations

The messaging patterns A, B, and D use web service protocol which is technology platform agnostic. These patterns enable the DMS to retain full access control of its data. Messaging pattern C uses JMS which is efficient for handling reliable continuous publishing of data. This pattern is better suited for the continuous distribution of aircraft data.

Based upon iterative and detailed SME technical discussions related to the analysis above, the following observations can be made:

- ***Observation #1*****:** Messaging pattern A is efficient for TS2 in OS1, OS2, OS3, OS5, OS7, and OS9 due to the random push and low volume of data from DMS. However, this pattern is less efficient for TS1 in OS2, OS5, and OS9 due to the continuous distribution and potential high volume of data being pushed from DMS. Pattern A is technology platform agnostic and DMS has full access control of its data.
- ***Observation #2*****:** Messaging pattern B is very efficient for OS2, OS7, and OS9, but only a subset of their derived technical scenarios (i.e., TS3). This pattern requires NAS Service to establish pre-defined static filtering parameters to consume DMS data. As a result, pattern B uses a full request-response web service operation; enables DMS to retain full access control of its data; and is technology platform agnostic.
- ***Observation #3*****:** Messaging pattern C is efficient for OS2, OS5, and OS9, but only a subset of their derived technical scenarios (i.e., TS1). This pattern requires DMS to provide a service that publishes aircraft data into SWIM using JMS. Pattern C uses JMS which is an efficient methodology for handling reliable continuous publishing of aircraft data.
- ***Observation #4*****:** Messaging pattern D is efficient for all operational/technical scenarios. This pattern requires each DMS to provide a service that can notify consumers of available aircraft data, along with recommended parameters, to efficiently obtain the data. As a result, pattern D uses two-way delivery of published data; allows DMS to keep full access control of its data; and is technology platform neutral. However, the mechanism for handling notifications is available in limited selections of technology platforms (i.e., only certain technology platforms have notification capability).
- ***Observation #5*****:** The *Continuous Distribution of Aircraft Data* (i.e., TS1) can be executed efficiently by messaging pattern C. This pattern uses JMS which is designed to handle continuous distribution of data.
- ***Observation #6*****:** The *Event Triggered* (i.e., TS2) can be executed efficiently by messaging pattern D. This pattern notifies the consumers of available aircraft data.
- ***Observation #7*****:** The *Request/Reply* (i.e., TS3) can be executed efficiently by messaging pattern B. The NAS Service in this pattern makes a request to a DMS to consume aircraft data.

- ***Observation #8*:** Messaging patterns B, C, and D may be combined in a solution set to satisfy the maximum number of operational/technical scenarios.

| **Operational/Technical Scenarios vs. Messaging Patterns** | | **Messaging Pattern A** NAS Service Hosting a Web Service Operation | **Messaging Pattern B** DMS Hosting Request-Response Web Service | **Messaging Pattern C** DMS Hosting Pub-Sub Service using JMS | **Messaging Pattern D** DMS Hosting Pub-Sub with Notification using Web Service |
|---|---|---|---|---|---|
| **OS1:** Trajectory Information Exchange | **TS2:** Event Triggered | | | | |
| **OS2:** Weather Modeling | **TS1:** Continuous Distribution | | | | |
| | **TS2:** Event Triggered | | | | |
| | **TS3:** Request/Reply | | ✓ | | |
| **OS3:** Automated Flight Service Station | **TS2**: Event Triggered | | | | |
| **OS5:** Automated Flight Conditions Report | **TS1:** Continuous Distribution | | | | |
| | **TS2:** Event Triggered | | | | |
| **OS7:** Surface Management with Trajectory Based Operations | **TS2**: Event Triggered | | | | |
| | **TS3:** Request/Reply | | ✓ | | |
| **OS9:** Learning-Capable Decision Support Tool | **TS1:** Continuous Distribution | | | | |
| | **TS2**: Event Triggered | | | | |
| | **TS3:** Request/Reply | | ✓ | | |

**Table 3-9 – Operational/Technical Scenarios versus Messaging Patterns**

Based on the above observations, certain messaging patterns are more suitable to address specific operational/technical scenarios and their implementation will be based on the intended use. Table 3-9 depicts the messaging patterns rated against the operational/technical scenarios. In this table only the viable solutions are shown. If a cell is shown as green, it has been found to be suitably "Good". However, if a cell is shown as green with a check mark, it has been found to be suitably "Very Good". These cells address the operational/technical scenario while adequately resolving the challenges that exist. The cells indicated by amber shading remain a feasible ("Fair") alternative; however, they are not considered to be an optimum solution. As depicted above, there is no one single messaging pattern that can satisfy all the operational/technical scenarios. However, a potential solution that should be considered is an implementation that is a combination of more than one messaging pattern that can satisfy the maximum number of scenarios. The complexity and cost associated with such a solution set will not be evaluated here, but may be a valuable exercise for a future effort.

### 3.5.4 Data Interoperability Recommendations

Data interoperability is the ability to correctly transmit, receive, and interpret data that are exchanged and crosses system boundaries (e.g., DMS and NAS Service, DMS and other SWIMs). As delineated in Section 3.3, Challenge #4 states that each DMS must be able to communicate and exchange data with multiple consumers throughout the globe. Primarily this paper is concerned with data derived from aircraft and pushed into NAS services via SWIM; however, the AAtS concept needs to include the fact that users of AAtS data exchanges will operate on a global scale. This global interoperability is achieved through the DMS' connections and data exchanges with the various consuming entities. These entities could be other commercial systems, value added data processors, and other international SWIMs.

To satisfy the operational scenarios delineated in Section 3.4.1 (i.e., OS1, OS2, OS3, OS5, OS7, and OS9), the DMS must be able to publish data to NAS services via SWIM. Couple these operational scenarios with the challenge resolution above, and the DMS must leverage data exchange models that are accepted on a global level. Since the FAA has mandated the use of several specific exchange models that also happen to be accepted on a global level, these two issues are not mutually exclusive. These models the FAA stipulates for exchange are as follows:

- Aeronautical Information eXchange Model (AIXM)
- Weather Information eXchange Model (WXXM)
- Flight Information eXchange Model (FIXM)

To maintain global interoperability, the DMS needs to use these data models in the creation of their services. This data exchange interoperability is specific only to the ground-to-ground service connections and is not required for the air-to-ground media due to a variety of factors. Examples of these factors that include:

- The verbosity of full XML as compared to the bandwidth available in air-to-ground data link technologies
- Business decisions of implementers pairing the Onboard Client (aircraft) with the DMS
- Compatibility with various Onboard Clients (i.e., each aircraft uses its own Onboard Client).

It is understood that these models are not static creations and are constantly evolving to meet the needs of information exchanged within aviation. It is further understood that there will be situations where the version of the exchange model being published will not match the version established for consumption; such as in situations like:

- The DMS updating to a newer version to capture enhanced capabilities
- The Consuming NAS service updating to a newer version because another ground entity (another DMS or other international SWIM) has updated their service

While there is a certain amount of backwards compatibility built in to the various versions of the standards, there remains the possibility for misalignments of the data formats. If the version of data format used between DMS and the ground entity is not the same, then a data mediation solution implemented based on established business rules. These business rules would be the rules that govern the relationships between the DMS and the various ground entities. This solution would act as a semantic gateway to provide the necessary translation of data exchange models/formats to ensure data interoperability.

# 4.0 CONCEPT COMPLIANCE

In order for the downlink concept to be operationally realized, the DMS must comply with SWIM policies. Compliance will permit the DMS to publish aircraft data and weather observations to SWIM and become a service provider. The following subsections summarize the guidance provided in the *FAA Telecommunications Infrastructure Enterprise Security Gateway User's Guide for Non-NAS Users* [4], *SWIM Governance Policies Document* [10], *SWIM NSRR Service Provider User Manual* [5], and the *SWIM Service Lifecycle Management Process* [6].

## 4.1 Service Compliance

The DMS Providers may provide more than one SWIM compliant service described in the NSRR. In order for DMS to publish services into SWIM, it must comply with SWIM and FAA policies [10]. These policies require that all DMS Providers be registered in the NSRR and that the meta-information describing the service be provided.

The NSRR provides a single place to organize, understand, and manage SOA-related information [5]. In particular, NSRR provides governance features that can be used to verify that services and the meta-information describing those services are registered in accordance with SWIM policies and FAA-STD-064. All services in the NSRR will be assigned a lifecycle stage. Within NSRR, lifecycle advancement from one stage to the next requires approval of the SWIM governance lead [6]. These stages are:

- ***Proposed*** – Indicates that the service has been proposed as a SWIM compliant service.
- ***Definition*** – The service proposal has been approved allowing the provider to proceed with definition of the service contract.
- ***Development*** – The service contract has been approved allowing the provider to proceed to service implementation. The service is under development; may not be under version control; and could be changed without notification.
- ***Verification*** – The service is ready for system-level testing based on the outcome of a Test Readiness Review.
- ***Production*** – The In-Service Decision authority has confirmed that the service is of sufficient quality; is compliant with the set of standards and regulations pertinent to the NAS enterprise; and is therefore approved for use.
- ***Deprecated*** – *The service is scheduled for retirement and may not accept new consumers.*
- ***Retired*** – The service may no longer be used.

Table 4-1 describes the required deliverables and checkpoints for each DMS Provider seeking a service approval for the various lifecycle stages.

| Type | Title | Service Lifecycle Stage | Applicable to New or Updated SWIM Services | Note |
|---|---|---|---|---|
| Deliverable | SOA Suitability Scorecard | Stage 1: Proposed | New and Updated | SOA suitability memo and score is developed as part of the SOA Suitability Assessment. The SOA Suitability Assessment is conducted by the SWIM Program Office, and the required artifacts are created by SWIM and submitted to the DMS Provider. |
| Deliverable | Organizational Unit for Non-NAS Form | Stage 1: Proposed | New | A form completed by the DMS Provider to provide SWIM Program Office with necessary information to create an Organizational Unit (OU) for the DMS Provider within NSRR. |
| Deliverable | Service Description | Stage 1: Proposed | New and Updated | Service Information including Service name, keywords, service description. |
| Deliverable | Concept of Operations for the Capability | Stage 2: Definition | New and Updated | Submit to NSRR the Concept of operations for the service. |
| Checkpoint | Registered Namespaces | Stage 2: Definition | New | DMS Provider submits XML namespace registration to the Federal Data Registry and gets their approval. Subsequently, namespaces are submitted to the NSRR. |
| Deliverable | On-Ramping Form | Stage 3: Development | New | Detailed specifics regarding the service payload, connection end-points, availability requirements, latency specifications, etc. |
| Deliverable | Interface Requirements Document (IRD) or Web Service Requirements Document (WSRD) | Stage 3: Development | New and Updated | Provides a series of requirements for the DMS Provider’s service interface. Refer to FAA-STD-70. |
| Deliverable | Web Service Description Document (WSDD) | Stage 3: Development | New and Updated | Provides technical specification regarding interface specific of the SOA Service. Refer to FAA-STD-65. |

| Type | Title | Service Lifecycle Stage | Applicable to New or Updated SWIM Services | Note |
|---|---|---|---|---|
| Deliverable | XML Schema Definitions for Types | Stage 3: Development | New and Updated | A description of constraint, structure, and content of the data products of the SOA Service. Refer to FAA-STD-063. |
| Deliverable | Service Level Agreement | Stage 3: | New and Updated | Refer to W3C specifications. |
| Deliverable | Web Service Description Language (WSDL) | Stage3 : Development | New and Updated | An XML description for defining the functionality offered by the Web Service. Not applicable to JMS Services. |
| Checkpoint | Security Approval | Stage 4: Verification | New and Updated | Information Systems Security Manager (ISSM) ensures proper security controls have been implemented. |
| Deliverable | Compliance checklist | Stage 4: Verification | New and Updated | To ensure that the design solution has met the system requirements and that the system is ready for use in the operational environment. |
| Checkpoint | Interoperability Test Report | Stage 4: Verification | New and Updated | WS-I Compliance report and ATS Test Report generated by FNTB testing team after successful completion of interoperability testing. |
| Checkpoint | Test Plan/ Producer Review | Stage 4: Verification | New and Updated | SWIM Test and Evaluation Team will review and approve test plans and procedures specifically related to SWIM requirements. |
| Checkpoint | ISD Action Plan | Stage 5: Production | New and Updated | In-Service Definition (ISD) Action Plan describes deployment activities such as product installation and certification for operational use. |
| Deliverable | Deprecation Impact Analysis | Stage 6: Deprecated | New and Updated | The purpose of the Deprecation stage is for operational services to be incrementally removed, either due to the development of new versions, or services that are no longer needed. |
| Deliverable | Retirement Impact Analysis | Stage 7: Retired | New and Updated | During the Service Deprecation process, a retirement |

**Table 4-1 – Required deliverables and checkpoints for DMS Provider**

## 4.2 Security

This section describes the processes and standards involved in satisfying the security requirements for providing aircraft data to SWIM. The following subsections depict the security requirements from the aircraft to DMS and from the DMS to NESG.

### 4.2.1 Security between DMS and NESG

In order to provision data products onto the SWIM messaging infrastructure, the DMS Provider must connect to one of four NESGs located at Atlantic City, Oklahoma City, Atlanta, and Salt Lake City. DMS Providers must utilize a VPN tunnel to connect to the NESG. Incoming connections to the NESG may be established across the Internet or via a Dedicated Transmission Service (DTS). If the connection will utilize the Internet as transport, the connection must be terminated at the FAA Internet Access Point (IAP) at either the Atlantic City or Oklahoma City locations. The DTS connections may be terminated at any of the NESGs based on geographical proximity and convenience [4].

The NESG utilizes the External Demilitarized Zones (DMZ) that house the customer-facing messaging node, also known as the Untrusted Enterprise Service Bus (UESB) node. The UESB node is dedicated solely to interfacing with External Providers. The security requirements for the DMS Provider to NAS communications include:

- DMS Providers must meet NAS Enterprise Boundary Protection (EBP) requirements per FAA Order 1370.104.
- DMS Provider's identity will be established and validated to ascertain authorization level and access rights.
- DMS Provider must digitally sign data payloads to allow for non-repudiation and data integrity validation.

For additional information regarding NAS EBP requirements, please consult the *FTI Enterprise Security Gateway User's Guide for Non-NAS Users* [4] and *FAA Order 1370.104 - Digital Signature Policy* [8].

### 4.2.2 Security between DMS, Aircraft and Portal

The AAtS system (i.e., Aircraft Access to DMS, DLS, DMS, and Portal) maintains secure communications by enforcing service and message security policies, verifying identities and digital signatures, and providing authorization-based access. The following security requirements, among others, must be provided to secure the AAtS environment:

- Each system must provide boundary protection capability. This capability provides a set of security mechanisms that will allow information to be transferred in and out as needed and authorized.
- Each system must provide identification and authentication services. These services allow users and machines to be identified.
- Each system must provide cryptographic key services that support provisioning and validation of digital credentials and keys as well as authentication of those identities. These services make possible other security functions that rely on identities and keys, including confidentiality and integrity, wherever these functions are needed.

**NOTE:**

*Data Confidentiality – Indicates whether encrypting of message data is required for the service or not so that unauthorized entities cannot view the contents of the message.*

*Data Integrity – Refers to the verification that a message has not changed in transit. This property indicates whether data integrity is required for the service as part of the message protection mechanism.*

Another aspect of security for consideration is that data providers, in this case aircraft operators and DMS providers may impose restrictions on the use and redistribution of data. Furthermore, the operational environment may require additional security restriction fields. These fields may be populated by the DMS to accommodate the terms of its data distribution agreements or the need to safeguard company proprietary data.

## 4.3 DMS Performance

The performance of DMS is based on number of errors within DMS and uptime of the data connection with the various aircrafts. This includes the network performance provided by the DLS connecting the aircraft. This DMS is the only node connected to NAS Services via SWIM. As a result, the performance of DMS will be met through a valid Service Level Agreement (SLA) between the DMS Provider and the NAS Service Consumer(s). The SLA is a set of pre-defined and established expectations for levels of performance, usually realistic and measurable, between a Service Consumer(s) and a DMS Provider. An SLA depicts the information about a DMS Provider and the services that it offers. It should be agreed and signed between a DMS Provider and its Service Consumers. The DMS Provider and a Service Consumer(s) will establish an SLA that will include the following:

- *Service Availability* – Expected date and time of service delivery.

- *Service Termination* – Expected date and time of service termination.
- *Hours of Service Operation* – Select the availability of the service from among the following options:
    - Always (24/7): The service is always in operation.
    - Every day: The service is in operation daily between the specified times. Selecting this option provides fields for specifying "from and to" times.
    - Workdays: The service is in operation on workdays between the specified times. Selecting this option provides fields for specifying "from and to" times.
    - Fine grained: The service is in operation on a schedule that may change from day to day. Selecting this option provides fields for specifying "from and to" times for each day of the week.
    - Temporary Offline: The service is temporarily not available.
- *Hours of Provider Operation* – Select the availability of the DMS Provider (e.g., for support) from among the following options:
    - Always (24/7): The DMS Provider is always in operation.
    - Every day: The DMS Provider is in operation daily between the specified times. Selecting this option provides fields for specifying "from and to" times.
    - Workdays: The DMS Provider is in operation on workdays between the specified times. Selecting this option provides fields for specifying "from and to" times.
    - Fine grained: The DMS Provider is in operation on a schedule that may change from day to day. Selecting this option provides fields for specifying "from and to" times for each day of the week.
    - Temporary Offline: The DMS Provider is temporarily not available.
- *Expected Messages per day* – Number of messages processed by the service.
- *Maximum Messages per day* – Number of messages that will be processed by the service.
- *Daily Peak Period* – Select the period of time representing the peak period for the service from among the following options:
    - Always (24/7): The service is always operating at peak.
    - Every day: The service is operating at peak daily between the specified times. Selecting this option provides fields for specifying "from and to" times.
    - Workdays: The service is operating at peak on workdays between the specified times. Selecting this option provides fields for specifying "from and to" times.
    - Temporary Offline: The service is temporarily not available.
- *Throughput* [Msg/min] – The number of calls to the service per minute.
- *Response Time* [Sec)] – The time for the service to respond.
- *Availability* [%] –The availability of the service in its operating hours.
- *Performance* [%] – A measure of the performance of the service.

# A. APPENDIX A – ACRONYMS AND GLOSSARY

| Acronyms/Name | Description |
|---|---|
| Aircraft Access to DMS | The Aircraft Access to DMS is a node that houses the processing and managing services for the AAtS delivery service. |
| Aircraft Access to DMS Data Cache | Collection of data duplicating original values stored in a cache within Aircraft Access to DMS and can be retrieved by repetitive or unique requests. |
| Aircraft Access to DMS Data Processor | The Aircraft Access to DMS Data Processor is a node that handles the lower level activities such as retrieving data/information, validating data/information, processing information requests, and preparing information for transmission. Additionally, this node distributes information received to the relevant databases and performs data acquisition activities for data generated by the aircraft. |
| Aircraft Access to DMS Manager | The Aircraft Access to DMS Manager is a node that manages the connections to the related entities and uses appropriate communication protocols, completes necessary message routing, and manages network traffic. |
| AAtS | Aircraft Access to SWIM will provide aircraft with a means to connect to a common collection of aeronautical services provided from multiple sources including the FAA, DHS, airports, and other information services. |
| Aeronautical Data Service | Provides information such as notices to airmen, flight restrictions, special use airspace, etc. |
| ATM Data Service | Provides information such as traffic flow, playbook, traffic management initiatives, terminal movement, and arrival data. |
| Access Request | A request to connect to a secure system and access data. |
| Aggregate Data Exchange | A collection of system data exchanges that are aggregated into a single systems data exchange line to improve readability. The aggregate line is typically expanded on the child diagram and/or in a table published with the architecture. |
| AIXM | Aeronautical Information eXchange Model |
| ANSP | Air Navigation Service Providers |
| AOC/FOC | Airline Operations Center/Flight Operations Center |
| ATC | Air Traffic Control |
| ATM | Air Traffic Management |
| ATM Data Service | ATM data service provides data such as traffic flow, playbook, traffic management initiatives, terminal movement, and arrival data. |
| Atmospheric Conditions | The state of the atmosphere in terms of temperature, wind, clouds, and precipitation. |
| Authority to Connect | Authority granted to a system to connect and share data with another system. |
| CAAC | Civil Aviation Authority of China |
| CATM | Collaborative Air Traffic Management |
| Conduct AAtS Operations | This activity includes that set of activities required to provide the full range of capabilities for the bi-directional concept. |

| Acronyms/Name | Description |
|---|---|
| Data | A general definition of the information needed by one entity from another that is delivered in machine-readable format. |
| Data Filtering Rule | A rule to filter specific classes of data. For example, if an aircraft requests temperature data for an airport, it generally desires a single aggregate value or a single sensor value versus all the data from multiple sensors. |
| Data Request | A request for information that is both requested and delivered in a machine-readable format. |
| Data Request Configuration Data | Data that configures the business rules that drive data requests in a service-oriented environment. |
| Data Request Rule | A business rule that drives the configuration and frequency of a data request. |
| DLS | The DLS provides the wireless connections between the ground and aircraft, including knowing where the aircraft is, and making the connections to achieve the target end-to-end latency and availability. |
| DMS Data Cache | Collection of data duplicating original values stored in a cache within DMS and can be retrieved by repetitive or unique requests either dynamically while online or by offline consumers when they come back online. |
| DLS Provider | The DLS Provider is a node that provides the wireless service to connect the aircraft to the ground. |
| DMS Data Processor | The DMS Data Processor is a node that handles the lower level activities such as retrieving data/information, validating data/information, processing information requests, and preparing information for transmission. |
| DMS Manager | The DMS Manager is a node that manages the connections to the related entities and uses appropriate communication protocols, completes necessary message routing, and manages network traffic. |
| DMS Provider | The DMS Provider is a node that houses the processing and managing services for the AAtS delivery service. |
| External DMS User(s) | This system node includes the human operators and systems used to perform business operations for hosting the application programming interface (API) necessary to access the DMS Function for configuration and management purposes. |
| DLS | The DLS provides the wireless connections between the ground and aircraft, including knowing where the aircraft is, and making the connections to achieve the target end-to-end latency and availability. |
| DMZ | Demilitarized Zones |
| DST | Decision Support Tool |
| DTS | Dedicated Transmission Service |
| Exchange Aviation Information | This activity includes the processes for establishing and managing communications, determining the information that will be subscribed to or requested, and managing the actual exchanges. |
| EBP | Enterprise Boundary Protection |
| FAA | Federal Aviation Administration |
| FIXM | Flight Information eXchange Model |

| Acronyms/Name | Description |
|---|---|
| FTI | FAA Telecommunications Infrastructure |
| JCAB | Japanese Civil Aviation Bureau |
| Manage Ground Communications Connectivity | This function controls the physical connections to the aircraft including management of transitions and connections among multiple communications media. The level of control is dependent upon knowing the position of aircraft, which data links are available. This is realized by calculating and leveraging using the best route for data exchanges, and making the connections to achieve the target end-to-end latency and availability. Lastly, this function implements requirements for secure communications through methods such as message security policies, verifying identities and digital signatures, and providing authorization-based access. |
| Manage Onboard Communications Connectivity | This function controls the physical connections of the Aircraft Access to DMS. This includes management of session and connection transitions among multiple communication media. This function also maintains and enforces the use of secure communications through message security policies, verifying identities and digital signatures, and providing authorization-based access. |
| Maintain Aircraft Access to DMS Security Services | This functionality implements the security services required to connect to the DMS including, but not limited to, message security policies, verifying identities and digital signatures, and providing authorization-based access. |
| Maintain DMS Security Services | This functionality implements the security services required to connect to the Aircraft Access to DMS including, but not limited to, message security policies, verifying identities and digital signatures, and providing authorization-based access. |
| Maintain / Provide Data Synchronization between Ground and Aircraft Users | This functionality collects aggregates and provides data being exchanged between the Aircraft Access to DMS and DMS. The information maintained by this function is provided as synchronization information to the External Portal based on previously specified rules. This is intended to satisfy a joint safety responsibility between the dispatcher and PIC (14 CFR Part 121). |
| Maintain Secure External Communications | This function manages the connections to SWIM. Additionally, depending on the implementation, this function may host the web interface that allows for the External Portal. Lastly, this function implements requirements for secure communications through methods such as message security policies, verifying identities and digital signatures, and providing authorization-based access. |
| Manage Aircraft Access to SWIM Technical Rules | This function stores and organizes the various rules input by the Provide External DMS Portal and by those that are managed or hardcoded by the DMS provider(s). The rules are subsequently delivered to the relevant peer function as a subset rule specific to the needs of the peer function. |
| MP | Messaging Pattern |
| Monitor / Report Aircraft Access to DMS Performance | This functionality monitors and reports the Aircraft Access to DMS network and general performance as well as collecting the health of each function and sub-function within the Aircraft Access to DMS as well as the network performance of the connection with the DMS and DLS. This is reported to both the DMS via the DLS and the Onboard User Application. Service information reported to the Onboard User Application is used for crew alerting or information request/subscription management. |
| Monitor / Report DMS Performance | This functionality maintains and reports DMS network and general performance, such as number of errors within DMS and up time of the data connection with various “Aircraft Access to DMS” that are clients to the DMS |

| Acronyms/Name | Description |
|---|---|
| | Provider. This reporting is made available to those users having access through the External Portal. |
| NAS | National Airspace System |
| NAS Data Service Provider | The NAS Data Service Provider is a node that provides source information. Additionally, it also represents the end-user(s) of aircraft originated information. |
| NEMS | NAS Enterprise Messaging Services include the messaging and management functions needed to support SWIM operations. |
| NESG | The NAS Enterprise Security Gateway (NESG) is a framework for supporting mandated boundary protection services between SWIM and external entities. It provides a standardized scheme for connecting and managing connections to external users. It also enables a layered security scheme to provide defense in depth and provide a buffer between SWIM and external entities. |
| NSRR | NAS Service Registry/Repository |
| Onboard User(s) | This system node contains the systems used to host the onboard user applications that receive or supply data/information to and from the Aircraft Access to DMS. These include a variety of on-board systems that may include but not be limited to flight management, informational, video surveillance, and sensor systems. |
| Onboard User Application | This is the host application that will store, display, and use the information delivered to the aircraft by the AAtS services. Conversely, it is also considered the system that supplies information to the Aircraft Access to DMS for downlink purposes. |
| OS | Operational Scenario |
| Participate in Collaborative Air Traffic Management Solution Set | The aircraft and air traffic management participate in collaborative information exchanges to develop alternatives for strategic flight planning and management decisions. |
| Perform Data Acquisition | This function includes the collection of data produced by an aircraft, such as sensor, video, decision support data, that is transmitted to ground systems. Sensor data in the AAtS concept includes discrete sensors for the purpose of transmission or those sensors that are part of the aircraft system natively. Decision support data is comprised largely of crew inputted information; however it does also potentially include flight management information. |
| Perform Data Provenance | This function tracks the evolution of data, including the source and authority of data creation, changes to the data along the life history of the data as it passes through the DMS and the functions responsible in creating those changes. It provides a qualitative and quantitative metrics to analyze the quality and the dependability of the data, based on the consumer's trust of the source of creation and the sources that were responsible for modification. |
| Perform Ground Archiving of Information Exchanges | This function performs the archiving of all data being sent and received through the DMS including metadata. One purpose, but not the sole purpose, of archiving data being sent to aircraft is for National Transportation Safety Board (NTSB) use post-accident. See related regulatory documents for archiving data requirements. |
| Perform Ground Data Compression / Uncompression | This function compresses or expands data based on parameters included with the message. |

| Acronyms/Name | Description |
|---|---|
| Perform Ground Data Filtering | This function uses preset filter parameters to determine which data to send to the end-user. This allows the user to limit the amount of information being sent from the DMS to that which is contextually relevant or that which is specified by operational need. |
| Perform Ground Data Validation | This function performs internal validation of the quality of the data to ensure it conforms to the relevant quality requirements. Additionally, this function describes the metadata that is required to communicate that validity to the relevant end-user. |
| Perform Ground Protocol Translation | This functionality performs the translation of the various incoming communication protocol(s) into the protocol used within the DMS. |
| Perform Onboard Archiving of Information Exchanges | This function performs the archiving of all data and metadata that is generated and received by the Aircraft Access to DMS. |
| Perform Onboard Data Compression / Uncompression | This function compresses or expands data based on parameters included with the message. |
| Perform Onboard Data Filtering | This function uses filter parameters that are either preset or established by the Onboard User Application. These parameters are used to determine the depth and breadth of the information to present to a user application. |
| Perform Onboard Data Validation | This function performs internal validation of the quality of the data to ensure it conforms to the relevant quality requirements. This is in part realized through the use of the metadata supplied by the DMS. For information generated onboard the aircraft, this function also describes the metadata that is required to communicate the validity, timeliness, and continuity of data generated by the Aircraft Access to DMS. |
| Perform Onboard Protocol Translation | This functionality performs the translation of the various incoming communication protocols into protocols used within the Aircraft Access to DMS. In some cases, this will not be necessary, as some implementations will have the DMS send the messages in an Aircraft Access to DMS native format. In other cases, the DMS has specifically used a protocol for transmission to suit the needs of a particular data link or to fit within the available throughput of a data link (e.g., ARINC 841). |
| PIREP | Pilot Report |
| Populate Priority and Security Data Fields | This function provides the necessary metadata to outgoing messages that will allow downstream systems to appropriately prioritize or preempt the message topics/queues and network routing. The priority metadata is also used by the Aircraft Access to DMS to flag high priority data/information to the client. Additionally, the protection metadata is used by the Manage Ground Communications Connectivity and the Maintain Secure External Communications nodes to appropriately encrypt message payloads. |
| Portal | This portal enables external entities (e.g., AOC, FOC) to connect to the DMS and to manage/monitor configurations for functions such as business rules, data filters, and subscriptions. |
| Process Ground Subscription / Information Requests | This function processes the information needs of the end-user. This could be in the form of individual information requests or through continued push subscriptions. This includes processing the configuration parameters that are used to establish the structure of the individual user (or onboard user application) informational needs profile. This could include specific standing requests, preferred route filters, and other such things. |

| Acronyms/Name | Description |
| --- | --- |
| Process Onboard Subscription / Information Requests | This function processes the information requests being presented to the Aircraft Access to DMS. These information requests can be generated by the DMS or the user application. The nature of the requests informs this function how to configure the filtering parameters of the Aircraft Access to DMS. |
| Provide Aircraft Information | This function produces data collected by an aircraft, such as sensor, video, decision support data that is transmitted to ground systems via AAtS. |
| Provide Data Integration | This function combines mediated, filtered data into integrated packages for easy messaging and compression by the DMS. |
| Provide Onboard User Applications | This provides the functionality that will store, display, and use the information delivered to the aircraft by the AAtS services. This function also supplies information to the Aircraft Access to DMS for downlink purposes. |
| Provide Data Link Service | The DLS provides the functionality to wirelessly connect the aircraft to the ground. This includes any transceiving functions necessary to resolve connectivity. It should be assumed that downlink data sent by the Aircraft Access to DMS is delivered to the DMS. |
| Provide External DMS Portal | This provides the functionality to connect to the DMS and to manage/monitor configurations for AAtS delivery functions such as business rules, data filters, and subscriptions. Not all implementations will require this function. |
| Provide Weather Observations | Provide collected atmospheric information. |
| SLMP | Service Lifecycle Management Process |
| SOA | Service-Oriented Architecture |
| Subscription Configuration Data | Data that configures the business rules that drive subscriptions in a service-oriented environment. |
| Subscription Configuration Information | The configuration parameters used to establish and modify subscriptions and recurring data requests. |
| Subscription Request | A request for a subscription to data published by a service. |
| Subscription Rule | A business rule that drives the configuration and frequency of a subscription. |
| Synchronization Data | Data that either notifies an aircraft or AOC of data transmitted to the other or copies of the data, in accordance with business rules. |
| Synchronization Rule | A rule that governs how the AOC/FOC will be kept informed of the data that is sent to the aircraft via AAtS. |
| SWIM | The SWIM is a node that enables the DMS to connect to NESG, NEMS and further to connect to NAS Service. |
| Technical Rule | A rule for guiding a decision, e.g. whether the aircrew or the AOC is allowed to negotiate strategic decisions with Air Traffic Management. May be implemented in the decision-support software algorithm in a business system. |
| TS | Technical Scenario |
| TFM | Traffic Flow Management |
| Traffic Flow Management Information | Traffic Flow Management information includes, but is not limited to, traffic flow, playbook, traffic management initiatives, terminal movement, and arrival data. |
| VHF | Very High Frequency |

| Acronyms/Name | Description |
|---|---|
| Video Surveillance Information | This information is captured and provided by the aircraft either through installed equipment or through the use of handheld equipment, e.g. cell phone. |
| Weather Data Service | A SWIM-enabled NAS Program that makes weather data accessible to AAtS. |
| WXXM | Weather Information eXchange Model |
| Wx Data Service | A source of information about weather including observations and forecasts. |

# B. APPENDIX B – SEQUENCE DIAGRAMS

## B.1. TS1 Sequence Diagrams

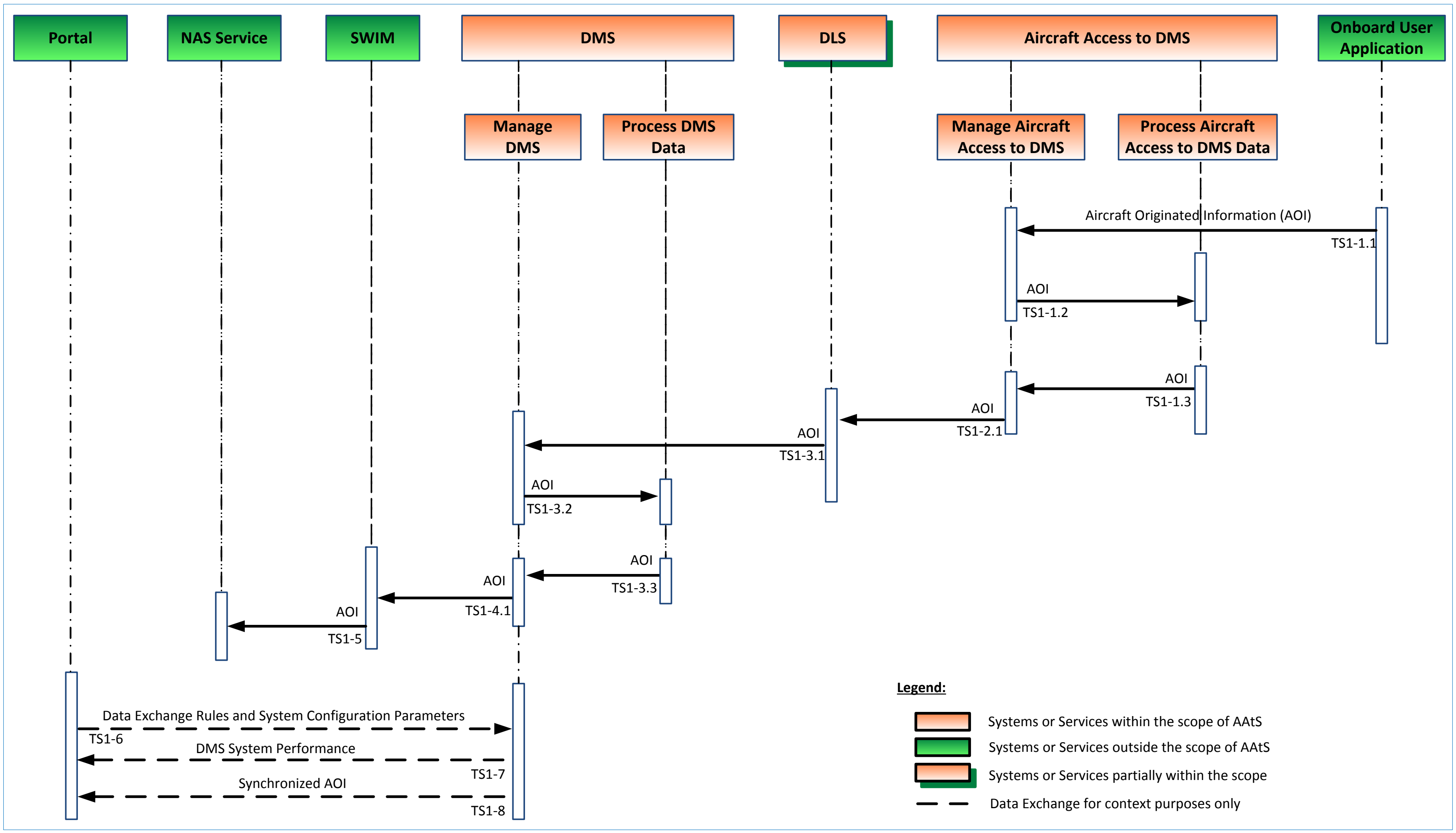


**Figure B1-1 – TS1 Sequence Diagram (Second Level Decomposition)**

| Number | Data Flow Relationships |
|---|---|
| TS1-1.1 | The Manage Aircraft Access to DMS receives aircraft originated information from the Onboard User Application for eventual transmission to the DMS via the DLS. |
| TS1-1.2 | The Process Aircraft Access to DMS receives aircraft originated information from the Manage Aircraft Access to DMS for processing (i.e., compression, filtering, subscription, etc). |
| TS1-1.3 | The Process Aircraft Access to DMS sends processed aircraft originated information to the Manage Aircraft Access to DMS for eventual transmission to the DMS via the DLS. |
| TS1-2 | The DMS receives aircraft originated information from the Aircraft Access to DMS via DLS. |
| TS1-3.1 | The Manage DMS receives aircraft originated information from Aircraft Access to DMS for eventual transmission to the NAS Service via SWIM. |
| TS1-3.2 | The Process DMS Data receives aircraft originated information from the Manage DMS for processing (i.e., compression, filtering, validation, etc.). |
| TS1-3.3 | The Process DMS Data sends processed aircraft originated information to the Manage DMS for eventual transmission to the NAS Service via SWIM. |
| TS1-4.1 | The Manage DMS sends aircraft originated information to the NAS Service via SWIM. |
| TS1-5 | The NAS Service receives aircraft originated information from the DMS via SWIM. |
| TS1-6 | The DMS receives from the Portal rules that contain governance and system rules for data filtering, data provenance, data validation, message prioritization, service security, and synchronization. It also receives configuration parameters from the Portal. |
| TS1-7 | The Portal receives from the DMS service quality information that includes such information as Aircraft Access to DMS, DLS, and DMS service performance and health. |
| TS1-8 | The Portal receives from the DMS synchronized aircraft originated information that is based on synchronization rule. |

**Table B1-1 – TS1 Data Flow Relationships between the nodes**

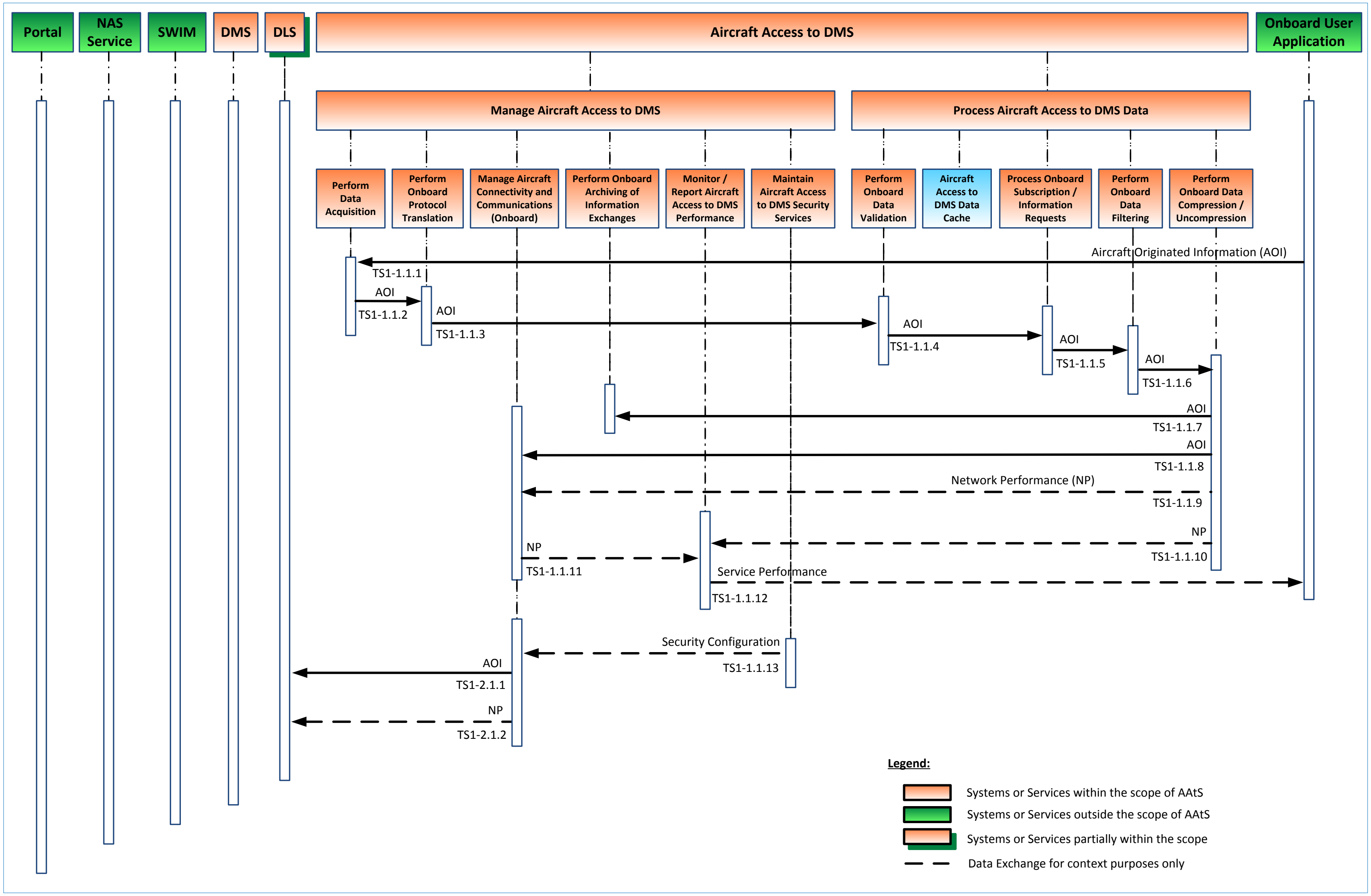


**Figure B1-2 – TS1 Sequence Diagram Decomposition of Aircraft Access to DMS**

| Number | Data Flow Relationships |
|---|---|
| TS1-1.1.1 | The *Perform Data Acquisition* node receives for collection and transformation aircraft automation originated information from the *Perform Onboard User Application* node. Once collected and transformed, this information will be used by the Aircraft Access to DMS for filtering and for transmission off the aircraft. |
| TS1-1.1.2 | The *Perform Onboard Protocol Translation* node receives transformed aircraft automation originated information from the *Perform Data Acquisition* node. |
| TS1-1.1.3 | The *Perform Onboard Data Validation* node receives from the *Perform Onboard Protocol Translation* node aircraft originated information for validation. |
| TS1-1.1.4 | The *Process Onboard Subscription / Information Requests* node receives validated aircraft originated information from the *Perform Onboard Data Validation* node for processing. |
| TS1-1.1.5 | The *Perform Onboard Data Filtering* node receives processed aircraft originated information from the *Process Onboard Subscription / Information Requests* node |
| TS1-1.1.6 | The *Perform Onboard Data Filtering* node provides filtered aircraft generated information to the *Perform Onboard Data Compression / Uncompression* node for compression and inclusion in the downlink aggregate. |
| TS1-1.1.7 | The *Perform Onboard Archiving of Information Exchanges* node receives all data and metadata exchanged between the DMS and Aircraft Access to DMS from the *Perform Onboard Data Compression / Uncompression* node for archiving purposes. |
| TS1-1.1.8 | The *Manage Aircraft Connectivity and Communications (Onboard)* receives from the *Provide Onboard Data Compression / Uncompression* node the post-compression downlink aggregate is provided for transmission off the aircraft. |
| TS1-1.1.9 | The *Manage Aircraft Connectivity and Communications (Onboard)* receives performance information from the *Provide Onboard Data Compression / Uncompression* node. |
| TS1-1.1.10 | The *Monitor / Report Aircraft Access to DMS Performance* node receives performance information from the *Provide Onboard Data Compression / Uncompression* node. |
| TS1-1.1.11 | The *Monitor / Report Aircraft Access to DMS Performance* node receives performance information from the *Manage Aircraft Connectivity and Communications (Onboard)* node. |
| TS1-1.1.12 | The *Monitor / Report Aircraft Access to DMS Performance* node provides the *Provide Onboard User Application* node with Aircraft Access to DMS service performance information. |
| TS1-1.1.13 | The *Maintain Aircraft Access to DMS Security Services* node provides to the *Manage Aircraft Connectivity and Communications (Onboard)* node security configurations. The connections that the Aircraft Access to DMS maintains may have varying security controls and configurations. These are managed by the Maintain Aircraft Access to DMS Security Services node but realized by the Manage Onboard Communications node. |
| TS1-2.1.1/ TS1-2.1.2 | The *Manage Aircraft Connectivity and Communications (Onboard)* provides to the DMS aircraft originated information and Aircraft Access to DMS performance information via DLS. |

**Table B1-2 – TS1 Data Flow Relationships between the nodes**

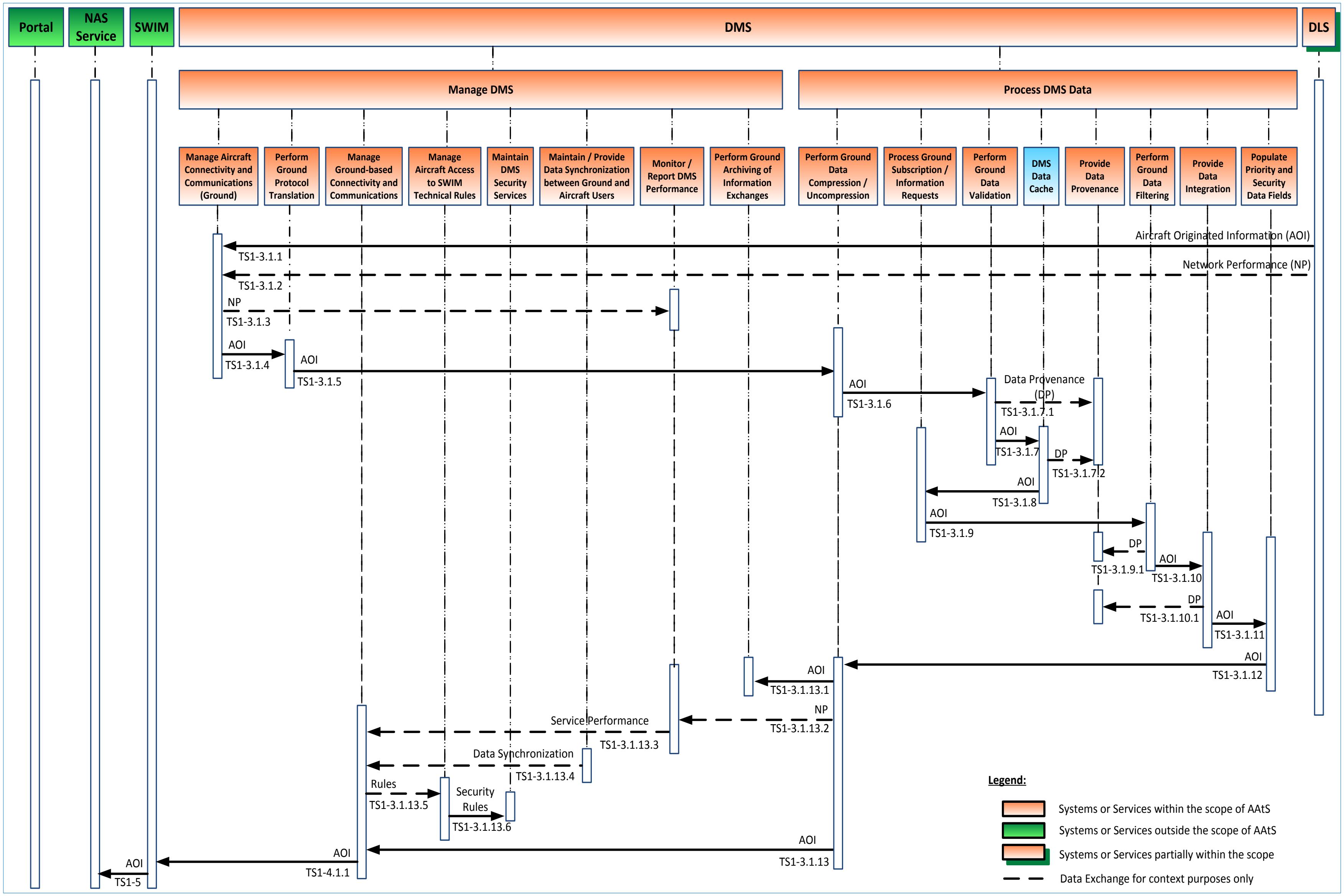


**Figure B1-3 – TS1 Sequence Diagram Decomposition of DMS**

| Number | Data Flow Relationships |
|---|---|
| TS1-3.1.1/ TS1-3.1.2 | The *Manage Aircraft Connectivity and Communications (Ground)* receives from the Aircraft Access to DMS aircraft originated information and Aircraft Access to DMS performance information via DLS. |
| TS1-3.1.3 | The *Manage Aircraft Connectivity and Communications (Ground)* provides to the *Monitor/Report DMS Performance* node the Aircraft Access to DMS and DLS performance information. |
| TS1-3.1.4 | The *Manage Aircraft Connectivity and Communications (Ground)* provides all communications coming into the DMS from the Aircraft Access to DMS for any necessary protocol communication translation. |
| TS1-3.1.5 | The *Perform Ground Protocol Translation* node supplies the Perform *Ground Data Compression / Uncompression* node all data incoming to the DMS once communication protocol translation has been performed. |
| TS1-3.1.6 | The *Perform Ground Data Compression / Uncompression* node receives and provides uncompressed down linked information to the *Perform Ground Data Validation* node for validation and eventual storage within the *DMS Data Cache*. |
| TS1-3.1.7 | The *Perform Ground Data Compression / Uncompression* node receives and provides uncompressed down linked information to the *DMS Data Cache for* storage. |
| TS1-3.1.7.1 | The *Perform Ground Data Validation* node provides to the *Provide Data Provenance* node the provenance information that is defined previously in provenance rule. |
| TS1-3.1.7.2 | The *DMS Data Cache* node provides the *Perform Data Provenance* node the provenance information that is defined previously in the provenance rule. |
| TS1-3.1.8 | The *DMS Data Cache* node responds to the relevant queries that the *Process Ground Subscription / Information Requests* node makes in order to satisfy the needs of individual requests or subscription parameters. The requesting entity could be a client Aircraft Access to DMS or a ground Information Service Provider. |
| TS1-3.1.9 | The *Perform Ground Data Filtering* node receives the requested/subscribed aircraft originated information from the *Perform Ground Subscriptions / Information Requests* node. |
| TS1-3.1.9 | The *Perform Ground Data Filtering* node provides to the *Provide Data Provenance* node the provenance information that is defined previously in provenance rule. |
| TS1-3.1.10 | The *Perform Ground Data Filtering* node provides conflated and filtered semantically rich information to the *Provide Data Integration* node for integration with other data types. |
| TS1-3.1.10.1 | The *Provide Data Integration* node provides to the *Provide Data Provenance* node the provenance information that is defined previously in provenance rule. |
| TS1-3.1.11 | The primary output of the *Provide Data Integration* node is the data/information that has been prepared for transmission to the end-user. The aggregated, combined, conflated, filtered semantically rich information is provided to the *Populate Priority and Security Data Fields* node to populate the appropriate metadata to establish its priority and protection prior to transmission. |
| TS1-3.1.12 | The *Populate Priority and Security Data Fields* node provides the prioritized, classified, aggregated, combined, conflated, filtered semantically rich information to the *Perform Ground Data Compression / Uncompression* node for transmission to the end-user. |

| Number | Data Flow Relationships |
|---|---|
| TS1-3.1.13 | The *Perform Ground Data Compression / Uncompression* node provides uncompressed down linked information to the *Manage ground-based Connectivity and Communications for transmission to the NAS Service.* |
| TS1-3.1.13.1 | The *Perform Ground Data Compression / Uncompression* node provides to the *Perform Ground Information Exchange Archiving* node the aircraft originated information data for archiving. |
| TS1-3.1.13.2 | The *Perform Ground Data Compression / Uncompression* node provides to the *Monitor/Report DMS Performance* node performance information. |
| TS1-3.1.13.3 | The *Monitor / Report DMS Performance* node provides to the *Manage Ground-based Connectivity and Communications* node the DMS performance. This information is intended for the External DMS Portal. |
| TS1-3.1.13.4 | The *Maintain / Provide Data Synchronization Between Ground and Aircraft Users* node provides the *Manage Ground-based Connectivity and Communications* node the synchronization information in a format/structure specified by previously specified rules. This information is ultimately intended for the External Portal. |
| TS1-3.1.13.5 | The *Manage Ground-based Connectivity and Communications* node provides to the *Manage Aircraft Access to SWIM Technical Rules* node the rules that will dictate the behavior of the DMS. |
| TS1-3.1.13.6 | The *Manage Aircraft Access to SWIM Technical Rules* node provides security rule to the *Maintain DMS Security Services* node. This business rule promulgates how the DMS Security Services maintain and configure the security of the AAtS. |
| TS1-4.1.1 | The *Manage Ground-based Connectivity and Communications* node provides aircraft originated information to NAS Service via SWIM |
| TS1-5 | The NAS Service receives aircraft originated information from the DMS via SWIM. |

**Table B1-3 – TS1 Data Flow Relationships between the nodes**

# B.2. TS2 Sequence Diagrams

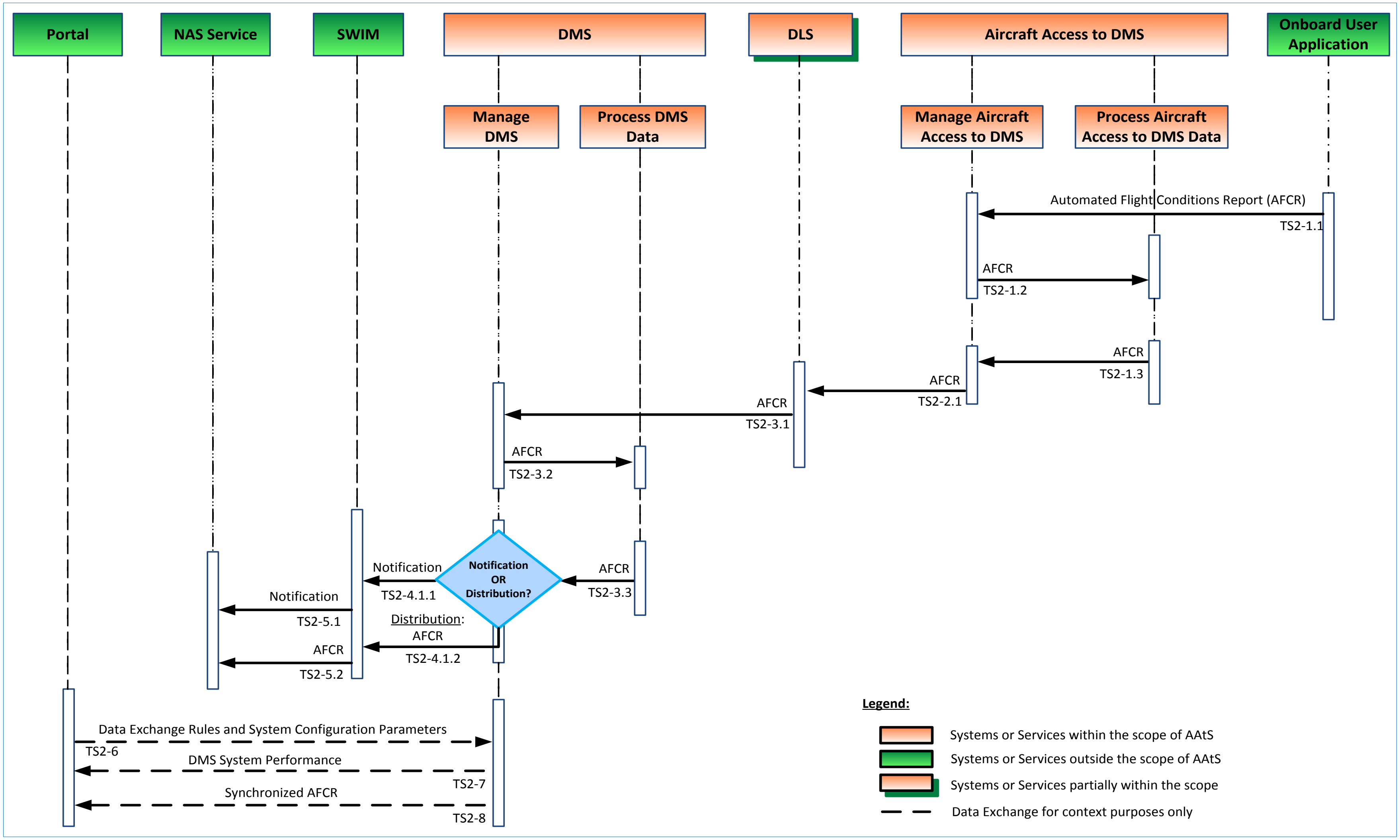


**Figure B2-1 – TS2 Sequence Diagram (Second Level Decomposition)**

| Number | Data Flow Relationships |
|---|---|
| TS2-1.1 | The Manage Aircraft Access to DMS receives AFCR from the Onboard User Application for eventual transmission to the DMS via the DLS. |
| TS2-1.2 | The Process Aircraft Access to DMS receives AFCR from the Manage Aircraft Access to DMS for processing (i.e., compression, filtering, subscription, etc.). |
| TS2-1.3 | The Process Aircraft Access to DMS sends processed AFCR to the Manage Aircraft Access to DMS for eventual transmission to the DMS via the DLS. |
| TS2-2 | The DMS receives AFCR from the Aircraft Access to DMS via DLS. |
| TS2-3.1 | The Manage DMS receives AFCR from Aircraft Access to DMS for eventual transmission to the NAS Service via SWIM. |
| TS2-3.2 | The Process DMS Data receives AFCR from the Manage DMS for processing (i.e., compression, filtering, validation, etc.). |
| TS2-3.3 | The Process DMS Data sends processed AFCR to the Manage DMS for eventual transmission to the NAS Service via SWIM. |
| TS2-4.1.1 | The Manage DMS submits notification to the NAS Service via SWIM on report availability. |
| TS2-4.1.2 | The Manage DMS submits AFCR report to the NAS Service via SWIM based on business rules. |
| TS2-5.1 | The NAS Service receives notification from the DMS via SWIM. |
| TS2-5.2 | The NAS Service receives AFCR from the DMS via SWIM. |
| TS2-6 | The DMS receives from the Portal rules that contain governance and system rules for data filtering, data provenance, data validation, message prioritization, service security, and synchronization. It also receives configuration parameters from the Portal. |
| TS2-7 | The Portal receives from the DMS service quality information that includes such information as Aircraft Access to DMS, DLS, and DMS service performance and health. |
| TS2-8 | The Portal receives from the DMS synchronized AFCR that is based on synchronization rule. |

**Table B2-1 – TS2 Data Flow Relationships between the nodes**

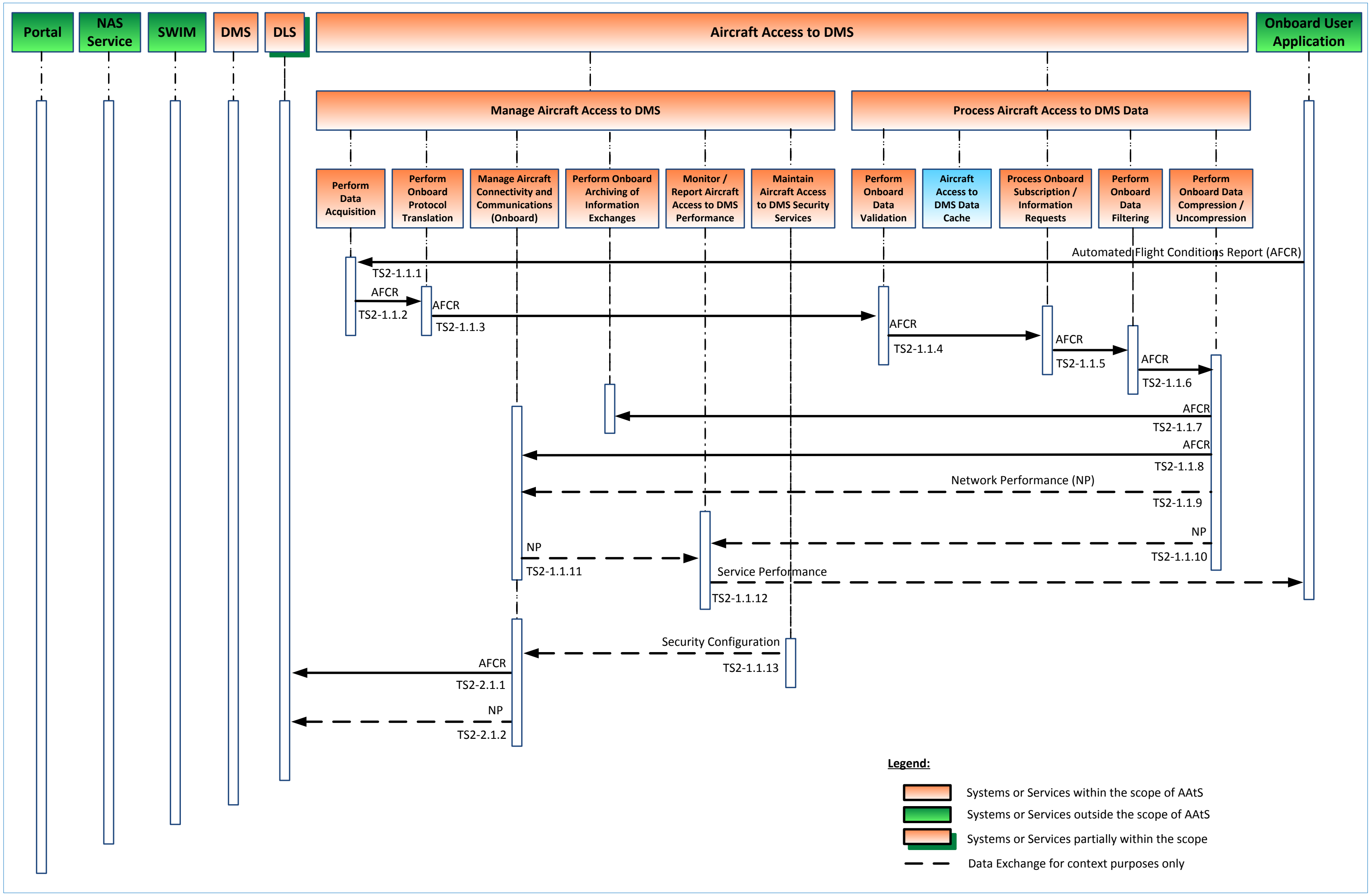


**Figure B2-2 – TS2 Sequence Diagram Decomposition of Aircraft Access to DMS**

| Number | Data Flow Relationships |
|---|---|
| TS2-1.1.1 | The *Perform Data Acquisition* node receives for collection and transformation AFCR from the *Perform Onboard User Application* node. Once collected and transformed, this information will be used by the Aircraft Access to DMS for filtering and for transmission off the aircraft. |
| TS2-1.1.2 | The *Perform Onboard Protocol Translation* node receives transformed AFCR from the *Perform Data Acquisition* node. |
| TS2-1.1.3 | The *Perform Onboard Data Validation* node receives from the *Perform Onboard Protocol Translation* node AFCR for validation. |
| TS2-1.1.4 | The *Process Onboard Subscription / Information Requests* node receives validated AFCR from the *Perform Onboard Data Validation* node for processing. |
| TS2-1.1.5 | The *Perform Onboard Data Filtering* node receives processed AFCR from the *Process Onboard Subscription / Information Requests* node |
| TS2-1.1.6 | The *Perform Onboard Data Filtering* node provides filtered AFCR to the *Perform Onboard Data Compression / Uncompression* node for compression and inclusion in the downlink aggregate. |
| TS2-1.1.7 | The *Perform Onboard Archiving of Information Exchanges* node receives all data and metadata exchanged between the DMS and Aircraft Access to DMS from the *Perform Onboard Data Compression / Uncompression* node for archiving purposes. |
| TS2-1.1.8 | The *Manage Aircraft Connectivity and Communications (Onboard)* receives from the *Provide Onboard Data Compression / Uncompression* node the post-compression downlink aggregate is provided for transmission off the aircraft. |
| TS2-1.1.9 | The *Manage Aircraft Connectivity and Communications (Onboard)* receives performance information from the *Provide Onboard Data Compression / Uncompression* node. |
| TS2-1.1.10 | The *Monitor / Report Aircraft Access to DMS Performance* node receives performance information from the *Provide Onboard Data Compression / Uncompression* node. |
| TS2-1.1.11 | The *Monitor / Report Aircraft Access to DMS Performance* node receives performance information from the *Manage Aircraft Connectivity and Communications (Onboard)* node. |
| TS2-1.1.12 | The *Monitor / Report Aircraft Access to DMS Performance* node provides the *Provide Onboard User Application* node with Aircraft Access to DMS service performance information. |
| TS2-1.1.13 | The *Maintain Aircraft Access to DMS Security Services* node provides to the *Manage Aircraft Connectivity and Communications (Onboard)* node security configurations. The connections that the Aircraft Access to DMS maintains may have varying security controls and configurations. These are managed by the Maintain Aircraft Access to DMS Security Services node but realized by the Manage Onboard Communications node. |
| TS2-2.1.1/<br>TS2-2.1.2 | The *Manage Aircraft Connectivity and Communications (Onboard)* provides to the DMS AFCR and Aircraft Access to DMS performance information via DLS. |

**Table B2-2 – TS2 Data Flow Relationships between the nodes**

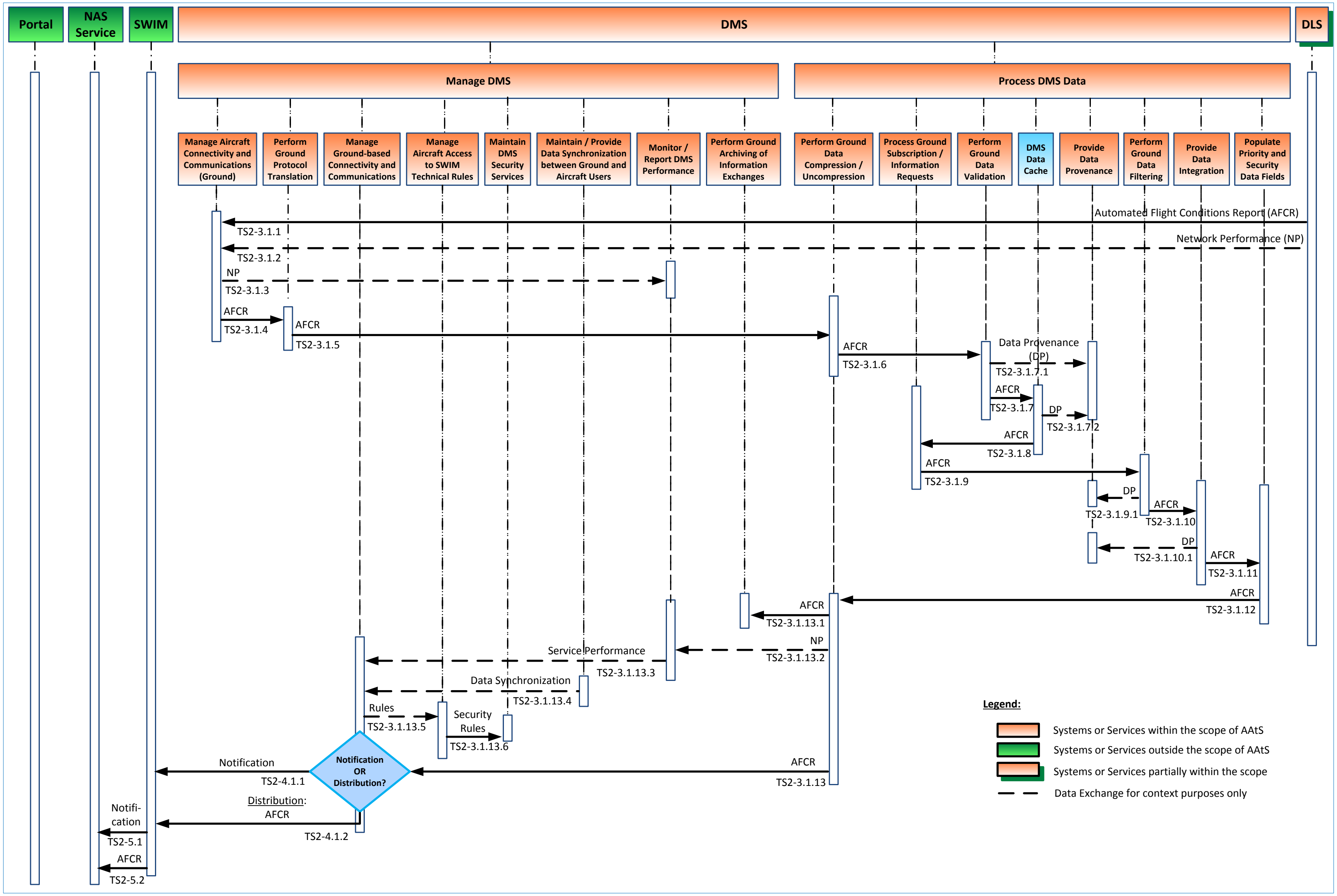


**Figure B2-3 – TS2 Sequence Diagram Decomposition of DMS**

| Number | Data Flow Relationships |
|---|---|
| TS2-3.1.1/<br>TS2-3.1.2 | The *Manage Aircraft Connectivity and Communications (Ground)* receives from the Aircraft Access to DMS AFCR and Aircraft Access to DMS performance information via DLS. |
| TS2-3.1.3 | The *Manage Aircraft Connectivity and Communications (Ground)* provides to the *Monitor/Report DMS Performance* node the Aircraft Access to DMS and DLS performance information. |
| TS2-3.1.4 | The *Manage Aircraft Connectivity and Communications (Ground)* provides all communications coming into the DMS from the Aircraft Access to DMS for any necessary protocol communication translation. |
| TS2-3.1.5 | The *Perform Ground Protocol Translation* node supplies the Perform *Ground Data Compression / Uncompression* node all data incoming to the DMS once communication protocol translation has been performed. |
| TS2-3.1.6 | The *Perform Ground Data Compression / Uncompression* node receives and provides uncompressed down linked information to the *Perform Ground Data Validation* node for validation and eventual storage within the *DMS Data Cache*. |
| TS2-3.1.7 | The *Perform Ground Data Compression / Uncompression* node receives and provides uncompressed down linked information to the *DMS Data Cache for* storage. |
| TS2-3.1.7.1 | The *Perform Ground Data Validation* node provides to the *Provide Data Provenance* node the provenance information that is defined previously in provenance rule. |
| TS2-3.1.7.2 | The *DMS Data Cache* node provides the *Perform Data Provenance* node the provenance information that is defined previously in the provenance rule. |
| TS2-3.1.8 | The *DMS Data Cache* node responds to the relevant queries that the *Process Ground Subscription / Information Requests* node makes in order to satisfy the needs of individual requests or subscription parameters. The requesting entity could be a client Aircraft Access to DMS or a ground Information Service Provider. |
| TS2-3.1.9 | The *Perform Ground Data Filtering* node receives the requested/subscribed AFCR from the *Perform Ground Subscriptions / Information Requests* node. |
| TS2-3.1.9 | The *Perform Ground Data Filtering* node provides to the *Provide Data Provenance* node the provenance information that is defined previously in provenance rule. |
| TS2-3.1.10 | The *Perform Ground Data Filtering* node provides conflated and filtered semantically rich information to the *Provide Data Integration* node for integration with other data types. |
| TS2-3.1.10.1 | The *Provide Data Integration* node provides to the *Provide Data Provenance* node the provenance information that is defined previously in provenance rule. |
| TS2-3.1.11 | The primary output of the *Provide Data Integration* node is the data/information that has been prepared for transmission to the end-user. The aggregated, combined, conflated, filtered semantically rich information is provided to the *Populate Priority and Security Data Fields* node to populate the appropriate metadata to establish its priority and protection prior to transmission. |
| TS2-3.1.12 | The *Populate Priority and Security Data Fields* node provides the prioritized, classified, aggregated, combined, conflated, filtered semantically rich information to the *Perform Ground Data Compression / Uncompression* node for transmission to the end-user. |

| Number | Data Flow Relationships |
| --- | --- |
| TS2-3.1.13 | The *Perform Ground Data Compression / Uncompression* node provides uncompressed down linked information to the *Manage ground-based Connectivity and Communications for transmission to the NAS Service.* |
| TS2-3.1.13.1 | The *Perform Ground Data Compression / Uncompression* node provides to the *Perform Ground Information Exchange Archiving* node the AFCR data for archiving. |
| TS2-3.1.13.2 | The *Perform Ground Data Compression / Uncompression* node provides to the *Monitor/Report DMS Performance* node performance information. |
| TS2-3.1.13.3 | The *Monitor / Report DMS Performance* node provides to the *Manage Ground-based Connectivity and Communications* node the DMS performance. This information is intended for the External DMS Portal. |
| TS2-3.1.13.4 | The *Maintain / Provide Data Synchronization Between Ground and Aircraft Users* node provides the *Manage Ground-based Connectivity and Communications* node the synchronization information in a format/structure specified by previously specified rules. This information is ultimately intended for the External Portal. |
| TS2-3.1.13.5 | The *Manage Ground-based Connectivity and Communications* node provides to the *Manage Aircraft Access to SWIM Technical Rules* node the rules that will dictate the behavior of the DMS. |
| TS2-3.1.13.6 | The *Manage Aircraft Access to SWIM Technical Rules* node provides security rule to the *Maintain DMS Security Services* node. This business rule promulgates how the DMS Security Services maintain and configure the security of the AAtS. |
| TS2-4.1.1 | The *Manage Ground-based Connectivity and Communications* node provides notification of AFCR availability to NAS Service via SWIM |
| TS2-4.1.2 | The *Manage Ground-based Connectivity and Communications* node provides AFCR to NAS Service via SWIM |
| TS2-5.1 | The NAS Service receives notification from the DMS via SWIM. |
| TS2-5.1 | The NAS Service receives AFCR from the DMS via SWIM. |

**Table B2-3 – TS2 Data Flow Relationships between the nodes**

# B.3. TS3 Sequence Diagrams

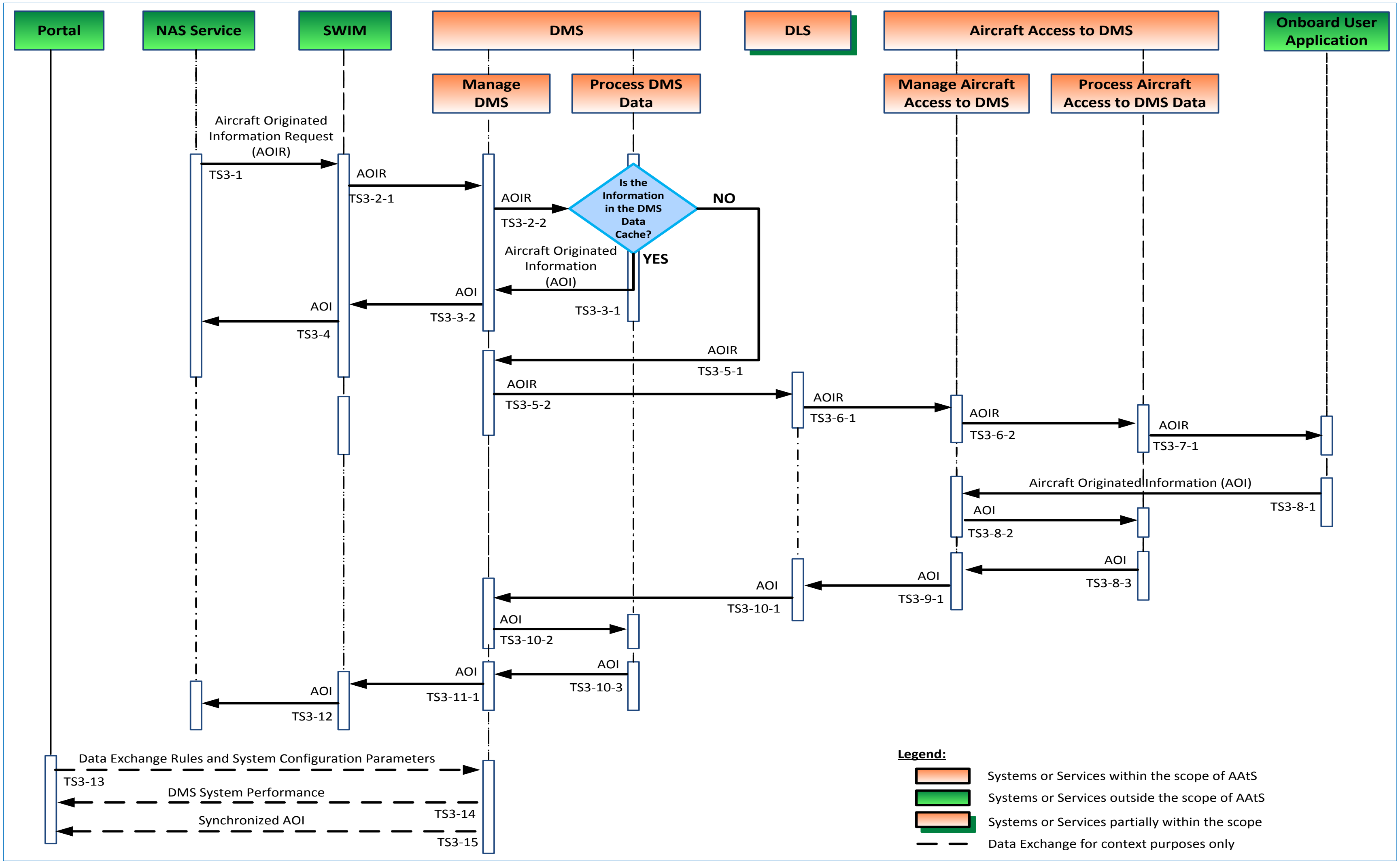


**Figure B3-1 – TS3 Sequence Diagram (Second Level Decomposition)**

| Number | Data Flow Relationships |
|---|---|
| TS3-1 | The NAS Service which is the ground-based consumer of aircraft originated information sends a request to the DMS via SWIM. |
| TS3-2-1 | The Manage DMS receives a request from the NAS Service via SWIM. |
| TS3-2-2 | The Manage DMS sends a request to the Process DMS Data for processing (i.e., compression, validation, filtering, etc.). |
| TS3-3-1 | The Process DMS Data checks if the information request is in the data cache. If it is in that location then the Manage DMS provides aircraft originated information to the NAS Service via SWIM. |
| TS3-3-2 | The Manage DMS provides aircraft originated information to the NAS Service via SWIM. |
| TS3-4 | The NAS Service receives aircraft originated information from the Manage DMS via SWIM. |
| TS3-5-1 | The DMS checks if the information request is in the data cache. If it is not in that location then the Process DMS Data sends back the request to the Manage DMS. |
| TS3-5-2 | The Manage DMS sends the request to the Onboard User Application via DLS and Aircraft Access to DMS. |
| TS3-6-1 | The Manage Aircraft Access to DMS receives the information request via DLS. |
| TS3-6-2 | The Manage Aircraft Access to DMS sends a request to the Process Aircraft Access to DMS Data for processing (i.e., compression, validation, filtering, etc.). |
| TS3-7-1 | The Process Aircraft Access to DMS sends the request to the Onboard User Application. |
| TS3-8-1 | The Manage Aircraft Access to DMS receives aircraft originated information from the Onboard User Application for eventual transmission to the DMS via the DLS. |
| TS3-8-2 | The Process Aircraft Access to DMS receives aircraft originated information from the Manage Aircraft Access to DMS for processing (i.e., compression, filtering, subscription, etc). |
| TS3-8-3 | The Process Aircraft Access to DMS sends processed aircraft originated information to the Manage Aircraft Access to DMS for eventual transmission to the DMS via the DLS. |
| TS3-9-1 | The Manage Aircraft Access to DMS provides aircraft originated information to the DMS via DLS. |
| TS3-10-1 | The Manage DMS receives aircraft originated information from the Manage Aircraft Access to DMS via DLS. |
| TS3-10-2 | The Process DMS Data receives aircraft originated information from the Manage DMS for processing (i.e., compression, filtering, validation, etc.). |
| TS3-10-3 | The Manage DMS receives the processed aircraft originated information from Process DMS Data for eventual transmission to the NAS Service via SWIM. |
| TS3-11-1 | The Manage DMS sends aircraft originated information the NAS Service via SWIM based on business rules. |
| TS3-12 | The NAS Service receives aircraft originated information from the DMS via SWIM. |
| TS3-13 | The DMS receives from the Portal rules that contain governance and system rules for data filtering, data provenance, data validation, message prioritization, service security, and synchronization. It also receives configuration parameters from the Portal. |
| TS3-14 | The Portal receives from the DMS service quality information that includes such information as Aircraft Access to DMS, DLS, and DMS service performance and health. |

| Number | Data Flow Relationships |
|---|---|
| TS2-15 | The Portal receives from the DMS synchronized aircraft originated information that is based on synchronization rule. |

**Table B3-1 – TS3 Data Flow Relationships between the nodes**

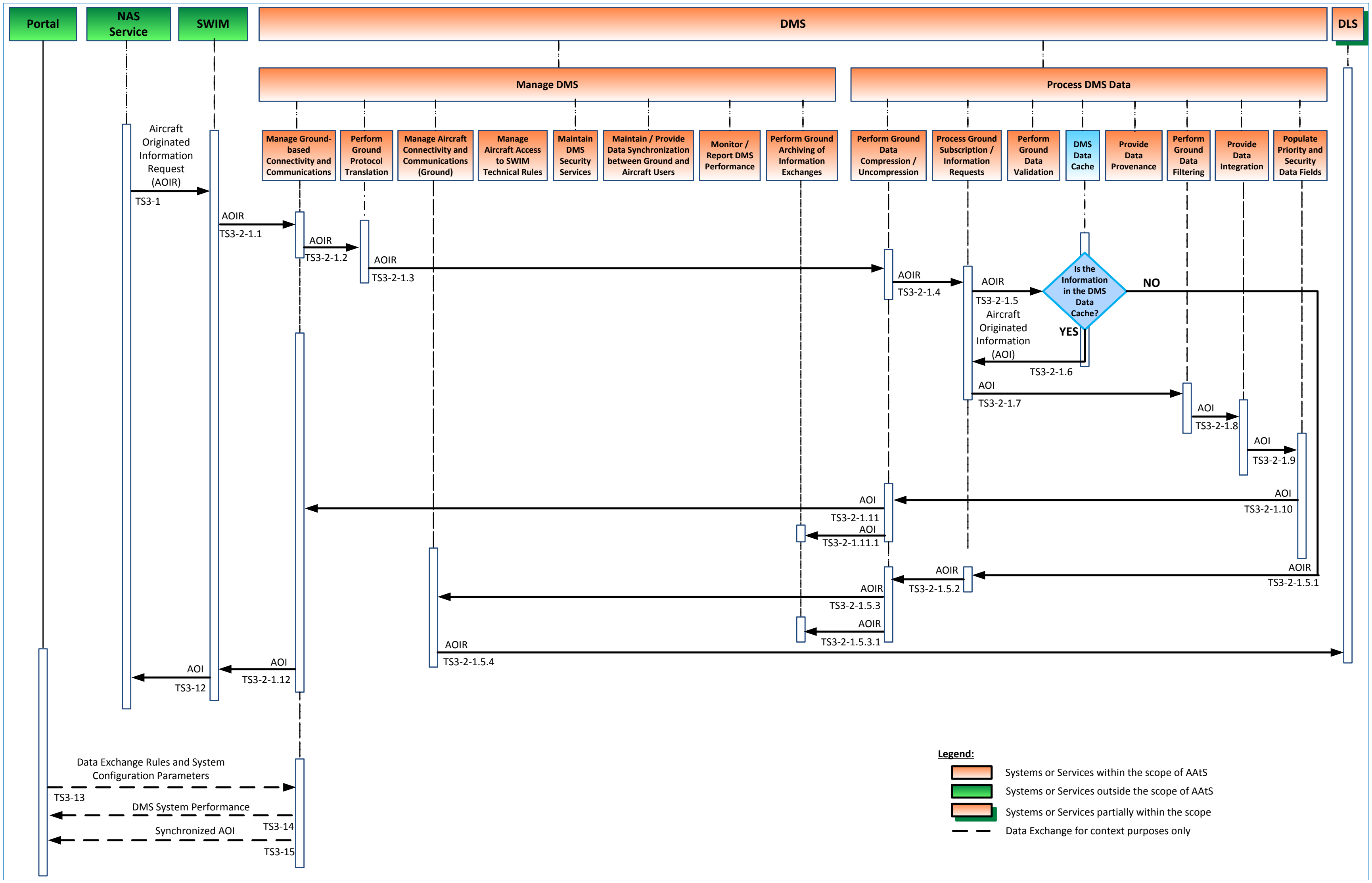


**Figure B3-2 – TS3 Sequence Diagram Decomposition of DMS**

| Number | Data Flow Relationships |
|---|---|
| TS3-1 | The NAS Service which is the ground-based consumer of aircraft originated information sends a request to the DMS via SWIM. |
| TS3-2-1.1 | The *Manage Ground-based Connectivity and Communications* receives a request from the NAS Service via SWIM. |
| TS3-2-1.2 | The *Manage Ground-based Connectivity and Communications* node provides all communications coming into the DMS from the NAS Service for any necessary communication protocol translation. |
| TS3-2-1.3 | The *Perform Ground Protocol Translation* node supplies the *Perform Ground Data Compression / Uncompression* node all data incoming to the DMS once communication protocol translation has been performed. |
| TS3-2-1.4 | The *Perform Ground Data Compression / Uncompression* node provides to the *Provide Ground Subscription / Information Requests* node information request for processing. |
| TS3-2-1.5 | The *Process Ground Subscription / Information Requests* node provides to the *DMS Data Cache* node processed information request. |
| TS3-2-1.6 | If the information request is the DMS data cache node then this node responds to the relevant queries that the *Process Ground Subscription / Information Requests* node makes in order to satisfy the needs of individual requests or subscription parameters. |
| TS3-2-1.7 | The *Perform Ground Data Filtering* node receives the requested/subscribed aircraft originated information from the *Perform Ground Subscriptions / Information Requests* node. |
| TS3-2-1.8 | The *Perform Ground Data Filtering* node provides conflated and filtered semantically rich information to the *Provide Data Integration* node for integration with other data types. |
| TS3-2-1.9 | The primary output of the *Provide Data Integration* node is the data/information that has been prepared for transmission to the end-user. The aggregated, combined, conflated, filtered semantically rich information is provided to the *Populate Priority and Security Data Fields* node to populate the appropriate metadata to establish its priority and protection prior to transmission. |
| TS3-2-1.10 | The *Populate Priority and Security Data Fields* node provides the prioritized, classified, aggregated, combined, conflated, filtered semantically rich information to the *Perform Ground Data Compression / Uncompression* node for transmission to the end-user. |
| TS3-2-1.11 | The *Perform Ground Data Compression / Uncompression* node provides to the *Manage Ground-based Connectivity and Communications* node compressed DMS data. |
| TS3-2-1.11.1 | The *Perform Ground Data Compression / Uncompression* node provides to the *Perform Ground Archiving of Information Exchange* node compressed DMS data for archiving. |
| TS3-2-1.12 | The NAS Service receives from the *Manage Ground-based Connectivity and Communications* node DMS data via SWIM. |
| TS3-2-1.5.1 | If the information request is not the DMS data cache node then this node responds to the relevant queries that the *Process Ground Subscription / Information Requests* node makes in order to satisfy the needs of individual requests or subscription parameters. |

| Number | Data Flow Relationships |
|---|---|
| TS3-2-1.5.2 | The *Perform Ground Data Compression / Uncompression* node receives from the *Process Ground Subscription / Information Requests* node the requests, subscriptions, and configurations being fielded by the relevant consumers. |
| TS3-2-1.5.3 | The *Perform Ground Data Compression / Uncompression* node provides to the *Manage Ground-based Connectivity and Communications* node compressed information request. |
| TS3-2-1.5.3.1 | The *Perform Ground Data Compression / Uncompression* node provides to the *Perform Ground Archiving of Information Exchanges* node compressed information request for archiving. |
| TS3-2-1.5.4 | The *Manage Ground-based Connectivity and Communications* node provides to the Aircraft Access to DMS information request via DLS. |
| TS3-12 | The NAS Services receives DMS data via SWIM. |
| TS3-13 | The DMS receives from the Portal rules that contain governance and system rules for data filtering, data provenance, data validation, message prioritization, service security, and synchronization. It also receives configuration parameters from the Portal. |
| TS3-14 | The Portal receives from the DMS service quality information that includes such information as Aircraft Access to DMS, DLS, and DMS service performance and health. |
| TS2-15 | The Portal receives from the DMS synchronized aircraft originated information that is based on synchronization rule. |

**Table B3-2 – TS3 Data Flow Relationships between the nodes**

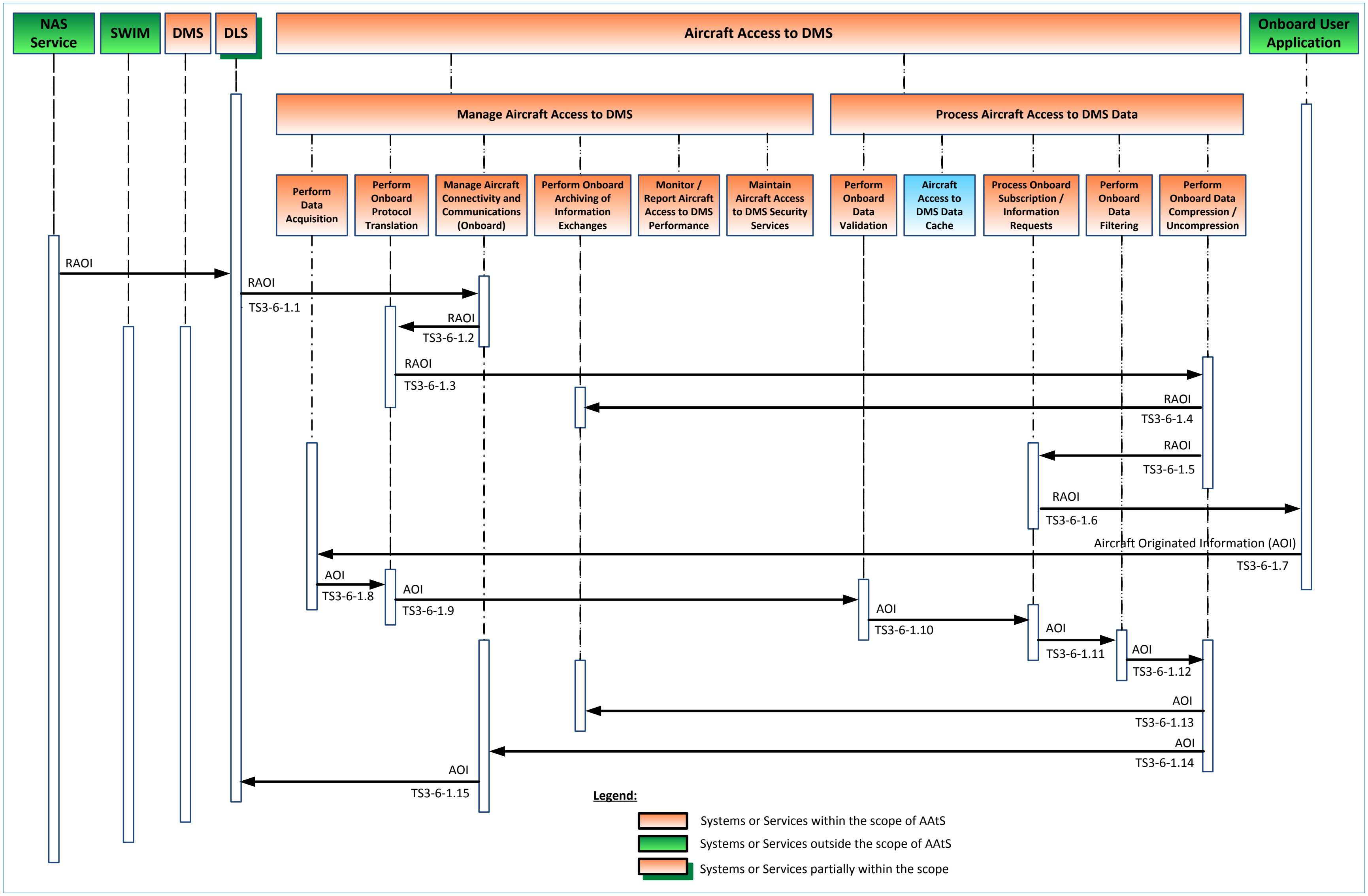


**Figure B3-3 – TS3 Sequence Diagram Decomposition of Aircraft Access to DMS**

| Number | Data Flow Relationships |
|---|---|
| TS3-6-1.1 | The *Manage Aircraft Connectivity and Communications (Onboard)* node receives the information request from DMS via DLS. |
| TS3-6-1.2 | The *Perform Onboard Protocol Translation* node receives the information request provided by the DMS via the DLS from the *Manage Aircraft Connectivity and Communications (Onboard)* node. |
| TS3-6-1.3 | The *Perform Onboard Protocol Translation* node provides to the *Perform Onboard Data Compression / Uncompression* node translated information request to protocols used by the Aircraft Access to DMS for further uncompression and processing. |
| TS3-6-1.4 | The *Perform Onboard Data Compression / Uncompression* node provides to the *Perform Onboard Archiving of Information Exchanges node uncompressed information request for archiving.* |
| TS3-6-1.5 | The *Perform Onboard Data Compression / Uncompression* node provides to the *Process Onboard Subscription / Information Requests* node information request for processing. |
| TS3-6-1.6 | The *Process Onboard Subscription / Information Requests* node gets the required information from the Onboard User Application. |
| TS3-6-1.7 | The *Perform Data Acquisition* node receives for collection and transformation aircraft automation originated information from the *Perform Onboard User Application* node. Once collected and transformed, this information will be used by the Aircraft Access to DMS for filtering and for transmission off the aircraft. |
| TS3-6-1.8 | The *Perform Onboard Protocol Translation* node receives transformed aircraft automation originated information from the *Perform Data Acquisition* node. |
| TS3-6-1.9 | The *Perform Onboard Data Validation* node receives from the *Perform Onboard Protocol Translation* node aircraft originated information for validation. |
| TS3-6-1.10 | The *Process Onboard Subscription / Information Requests* node receives validated aircraft originated information from the *Perform Onboard Data Validation* node for processing. |
| TS3-6-1.11 | The *Perform Onboard Data Filtering* node receives processed aircraft originated information from the *Process Onboard Subscription / Information Requests* node |
| TS3-6-1.12 | The *Perform Onboard Data Filtering* node provides filtered aircraft generated information to the *Perform Onboard Data Compression / Uncompression* node for compression and inclusion in the downlink aggregate. |
| TS3-6-1.13 | The *Perform Onboard Archiving of Information Exchanges* node receives all data and metadata exchanged between the DMS and Aircraft Access to DMS from the *Perform Onboard Data Compression / Uncompression* node for archiving purposes. |
| TS3-6-1.14 | The *Manage Aircraft Connectivity and Communications (Onboard)* receives from the *Provide Onboard Data Compression / Uncompression* node the post-compression downlink aggregate is provided for transmission off the aircraft. |

| Number | Data Flow Relationships |
|---|---|
| TS3-6-1.15 | The *Manage Aircraft Connectivity and Communications (Onboard)* provides to the DMS aircraft originated information via DLS. |

**Table B3-3 – TS3 Data Flow Relationships between the nodes**