A Study on Processing Method of SWIM Data

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Summary
SWIM (System Wide Information Management), which is an on-going research project of advanced aviation countries such as the United States, Europe, etc., has been proposed as a measure to solve several problems. These problems exist due to the absence of standard data format to be owned and operated by the aeronautical communication network. On this account, SWIM has been developed based on the specification of AXIM, FIXM and WXXM in order to convert the voice and simple text centric data into a standard of data exchange model that is scalable to a variety of formats. This paper states each data to be handled by SWIM and also proposes the requirements of data domains, which are the system to process data at SWIM local server and the consequent data domain using WSDL (Web Service Description Language)

Key words:
SWIM, ASBU, AXIM, FIXM, WXXM

1. Introduction

The conventional aeronautical communication network is configured based on the point-to-point method by aviation professionals and their system is used independently[1]. Thus, their databases are inconsistent due to the absence of standard data format. Moreover, there are several serious problems such as inefficient information, limited use of information, limitation of flexible measures for exceptional cases, difficulty of applying new services, etc. On that account, both of the United States and Europe are developing SWIM (System Wide Information Management) technology that provides data used in air traffic, airport, etc. promptly and accurately through integrating the aeronautical communication networks [2, 3, 4].
The essence of SWIM technology is to convert the voice and simple text centric data into a standard of data exchange model that is scalable to a variety of formats. In addition, SWIM is operated by the message transfer system that unifies the point-to-point based conventional aeronautical communications. Thus, data providers or users should exchange data using a new form of standard data exchange model[5, 6, 7].
The current international standard data exchange models handled by SWIM include AIXM (Aeronautical Information Exchange Model) that is the data exchange model related to the air intelligence out of aviation related information, FIXM (Flight Information Exchange Model) that is the data exchange model to provide the common definitions and structures as to aviation and WXXM(Weather eXchange Domain), and the data exchange model for weather [2, 8].
This paper is organized as follows. Chapter 2 describes the data covered at SWIM and Chapter 3 describes the requirements of each data domain. Chapter 4 describes the configuration and procedure of each data domain. Lastly, the conclusions are summarized in Chapter 5.

2. Data Exchange Models for SWIM

Fig. 1 represents the data covered by SWIM. Currently, the air intelligence, flight information and weather information are being considered as data to be covered by SWIM at this initial phase of development[2, 8].

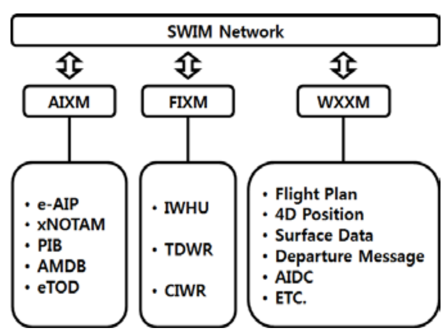

Fig. 1 Data covered at SWIM

2.1 AIXM (Aeronautical Information Exchange Model)

AIXM is the standard data exchange model that includes the air intelligence among the aviation related information; the current version is 5.1. In 2007, the establishment roadmap of e-AIM (e-Aeronautical Information Manual) to convert paper-based air intelligence into digital information was confirmed at the 36th general meeting of ICAO (International Civil Aviation Organization) and

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SARPs (Standards and Recommended Practices). The guideline were created and presented in Annex 15 of ICAO Doc. 8126. Meanwhile, ASBU (Aviation System Block Upgrade) defined AXIM as the task for service improvement through e-AIM and is currently proceeding accordingly[9].

The information contained in AIXM includes e-AIP (e-Aeronautical information Publication), xNOTAM (Notice to Airmen), PIB (Pre-Flight Notice Bulletin), AMDB (Aerodrome Map Data Base), eTOD (e-Terrain and Obstacle Data), etc. e-AIP is the publication that contains the air intelligence which is essential and permanent for flight. It was digitized in Korea in 2010. xNOTAM is the notice that contains the information on aeronautical facilities, tasks, procedures, failures, status, etc., which aviation professionals should be aware. It has been operated since 2011. PIB is the information as to important effective notifications for operation, which are written before flight. It has been operated as pilot test since 2012. AMDB is the airfield map database and eTOD contains the information as to topography and obstacles[2, 5, 6, 9].

The step-by-step model of AIXM is classified into AICM (Conceptual Data Model) and AIXM. AICM is represented by the diagram that uses UML (Unified Modeling Language) as shown in Fig. 2. The diagram is divided into several conceptional areas and is represented as a package in UML model structure. It consists in the feature to represent the major aeronautical entities, the attribute to define the characteristics of features, and the relationship to represent the link between the features and the business rules that are the check points for the relationship and data.

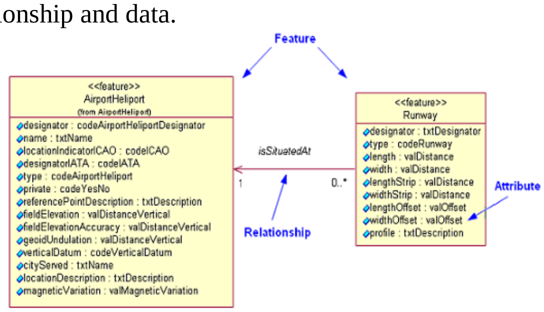

Fig. 2 AICM diagram

AIXM consists in XML Schema encoded as shown in Fig. 3 for the exchange of air intelligence. Schema is created by mapping the features, attributes and business rules of AICM with XML. The diagram in Fig. 3 shows how the runway is represented by AIXM XML Schema. The features are wrapped by RunwayTimeSlice and the inside is made up of the attributes. AIXM XML is used in NOTAMs that unifies AIP automatic issuance, aeronautical chart automatic production and publishing system, and also AMDBs related applications[2, 5, 6].

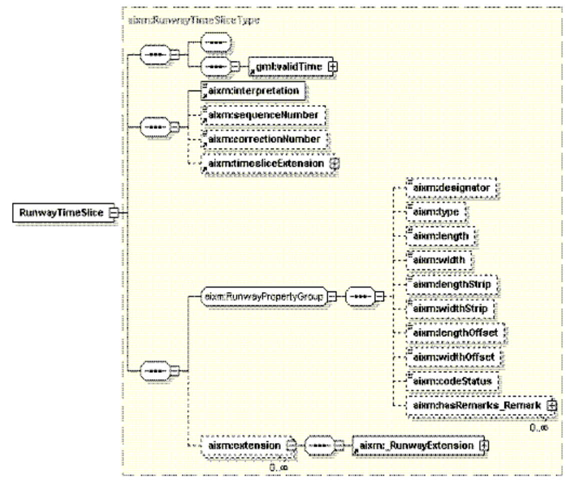

Fig. 3 Example of XML schema

2.2 FIXM (Flight Information Exchange Model)

FIXM is the data exchange format to provide the common definitions and structures as to flight; thus, it has the following characteristics: mutual operation between aviation systems of different countries, being independent of the platform, compliance with the international standards, geographical and temporal information, and continuous evolution[10].

The information contained in FIXM is classified into FIXM Core and FIXM Extension as shown in Table 1. FIXM Core contains ICAO information for flight or the information that needs to be shared. FIXM Extension contains the information that is selectively applied to some flights[2, 5, 6, 10].

Table 1 : Information contained in FIXM

Classification	Information
FIXM Core	Flight Recognizor : GUFI, Airplane Recognizor, etc.
	Flight Operator: Airline, Gear, Government, etc.
	Characteristics of Airplane during Flight
	Flight Plan and Plan Modifications
	Flight Status and Location
	Flight Delay and Cancellation
	Flight Emergency Situation
FIXM Extension	ASDE-X surveillance is used only for airspace management and surface movement and it is not used for flight planning or flight track.
	Surface movement information (runway assignment and taxi routing) is used only for the prediction or improvement of airport operation.
	Information used only for certain areas
	Specific vendor information that supports specific applications or systems
	Information that considers including FIXM Code

FIXM's model class consists in FICM (Conceptual Data Model), FIXM (Logical Data Model) and FIXS (Physical Data Model). FICM represents the concept of flight data and the relationship between the concepts. Thereby, providing the view of upper level, it represents the data element located in the flight data dictionary using UML. It is marked as an exchange model of the actual physical application and the independent abstract form based on the current models and standards at FIXM. Lastly, FIXS represents the logical data model physically, thus, it is marked using XML Schema and is independent of implementation. The class structure of FIXM Schema model is organized as shown in Fig. 4[2, 5, 6].

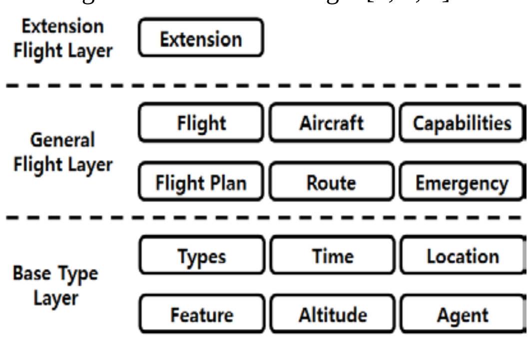

Fig. 4 Flight Data Schema Model Layer

2.3 WXXM (Weather Exchange Model)

WXXM is the data standard for weather. ICAO is planning on converting the weather information such as METAR (METeorological Aviation Report), TAF (Terminal Aerodrome Forecast), etc. into XML format[11].

The information contained in WXXM includes IWHU (Integrated Weather Handling Unit), TDWR (Terminal Doppler Weather Radar) and CIWS (Corridor Integrated Weather System). IWHU means the weather information provided by AMOS (Aerodrome Meteorological Observation System), the airport meteorological equipment (no verbs, something wrong here but I don't understand the meaning). TDWR is the weather radar device at airport, which detects and provides the information about dangerous climate phenomena (microburst, wind shear, etc.) early to airplanes that take off and land[2, 5, 6, 11].

WXXM's model class consists in WXCM (Conceptual Data Model), WXXM (Logical Data Model) and WXXS (Physical Data Model) as shown in Fig. 5. WXCM is the concept of virtual conceptional model and the definition of packages; thus, it is composed of plain text and UML package diagram, and it complies with ISO 19100 for defining concepts and applying geographical information. WXXM is the modified version of WXCM for data exchange and it mainly consists in the common information. WXXS represents WXXM physically; thus, it is marked using XML Schema and it uses GIS standard in the area of aviation by accepting GML standard[2, 5, 6, 11].

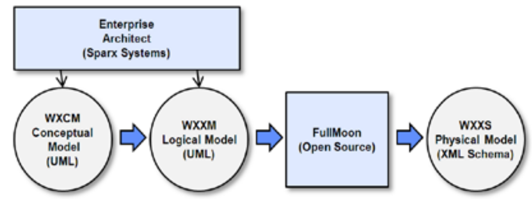

Fig. 5 Weather Model tool chain

WXCM out of WXXM's model classes is classified into base layers, the general weather layer and the aviation-specific weather layer as shown in Fig. 6. The base layer is the building block to be combined at the upper level to represent weather data; thus, it is composed of ISO concept, O&M (observation and consortium) and unit. ISO concepts include ISO 19103 (basic type: decimal, vector, real, integer, character and boolean), ISO 19107 (special schema: GM_point, GM_curve, GM_surface and GM_polygon), ISO 19108 (temporal: TM_position, TM_instant and TM_period) and ISO 19123 (coverages: CV_coverage, CV_discrete coverage and CV_continuous coverage). O&M indicates result values by the observation sensor, the observer, and the analytical procedure simulation in accordance with OGC (Open geospatial Consortium). Unit expresses the measurement unit such as temperature, luminous intensity, pressure, distance, angle, etc[2, 5, 6].

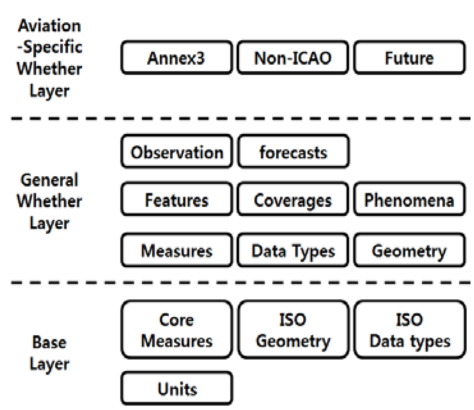

Fig. 6 Weather Data Schema Model Layer

General weather layer is consisted of weather-specific data type, weather-specific measure, observation & forecast, and coverage. Weather-specific data type is the data type used restrictively in weather; thus, it determines data type used in cloud type, obscuration, precipitation, hydrometer, etc. Weather-specific measure is classified into the area to be used commonly for weather measurement (bearing, depth, horizontal distance and vertical distance) and the area used for specific areas (air temperature, cloud height, horizontal visible distance, vertical visible distance, wind direction and wind speed). The mark for observation and forecast is classified in accordance with weather observation, actual time of weather forecast, and forecast analysis time. The coverage is defined in ISO 19123 and performs the role of mapping the spatiotemporal domain and attributes values. Spatiotemporal consists in a set of direct positions of coordinate space[2, 5, 6].

3. Requirement of SWIM Data Domain

Chapter 3 describes the requirements of data domains that handle aviation related data which is explained in Chapter 2.

3.1 Requirement of AID (Aeronautical Information Data Domain)

The requirements of AID that covers aeronautical data are as follows. First, it is imperative to implement the functions of registering and deregistering air intelligence service providers. Second, air intelligence service providers should implement the function of modifying information. Third, air intelligence service providers should register the latest service information at registry. Fourth, air intelligence service providers should implement the function of inquiring services by searching registries.

3.2 Requirement of FDD (Flight Data Domain)

The requirements of FDD that covers flight data are as shown in Table 2.

Table 2 : Requirements of FDD

No.	Requirement
1	Data to be inputted to FDD should be based on the international standard. If not formatted in accordance with the standard, then it should be converted to the international standard format at the adapter.
2	The adapter should distribute only those modified clusters when modifying FO (Flight Object).
3	PO creation function of FDD should be operated automatically when FO is created at legacy.
4	It is imperative to recognize the relevant transferee and operate FO transfer function of FDD when the legacy system requests for FO transfer.
5	The adapter should be able to receive the notice of modification results through FO modification notice interface of FDD.
6	FDD should implement an interface for participant confirmation, transfer approval, FO service application, etc. in order to proceed with requirements when receiving participants' requests, FO transfer and FO application through the adapter.
7	The adapter should decide and notify its decision on approval for application when receiving an application for participant request service from legacy.

3.3 Requirement of WXD (Weather eXchange Domain)

The requirements of WXD that cover weather data are as follows. First, publishers should implement the function of publishing for consumers of service. Second, it is imperative to implement the functions of subscribing and unsubscribing for the subscribers who use push method. Third, it is imperative to implement the functions of selectively registering and renewing for the subscribers who use push method. Fourth, it is imperative to implement the functions of subscribing, unsubscribing, and message reception for the subscribers who use push method. Fifth, it is imperative to implement the function of selectively registering and renewing for the subscribers who use pull method.

4. Suggested SWIM Data Domain

The proposed interface of SWIM data domain is defined by WSDL (Web Service Description Language).

4.1 Suggested AID

The data to be covered at AID is shown in Table 3.

Table 3 : Data to be covered at AID

Data	Type
Airfield	Structure, Geography, Connection, Lighting, Supporting Surface, Configuration (Plan), Capacity (Plan)
Helicopter Port	Structure, Geography, Connection, Lighting, Sign, Surface, Configuration (Plan), Capacity (Plan)
Topography and Obstacles	Topography and Obstacles
Airplane	Model, Technology, Equipment, Performance, Symbol, Environment Proof
Airspace	Airway, Airspace Capacity (Plan), Definition of Airspace, Airspace Sectors (Plan), Available Capacity of Airspace (Plan) and Airway (Plan)
Flight Safety Facilities	Designation/Reference Point, Approach Lighting System, DME, Landing System, TACAN, NDB, VOR, Marker, Configuration Plan, Monitoring Plan and Navigation System

The participants of AID are classified into service providers and service callers. Service providers implement the information of AID as a whole or in parts. They return fault messages when services are not supported. In addition, they register services at the registry subsystem. Service callers implement the service calls of AID as a whole or in parts and invoke call messages at the local SWIM middleware.
The services within AID include SDO service, WFS (web feature service), and reporting management. SDO services

are used for searching the information as to the private or public slots of AIM or the data entity information saved in the two slots. Fig. 7 represents the procedure of SDO service. SDO service should be registered at the server using UDDI and clients should be able to verify the registration. First, the legacy system at the client side requests for SDO operation to AID of SLS (SWIM Local Server) through an adapter using UDDI. (Clients may request directly to SLS when they support web service call since they do not need to request to the adapter.) AID at the client side requests for SLS SDO at the server side using the registry service of SLS. SLS at the server side receives SDO request and then sends it to the legacy system at the server side. The legacy system at the server side searches for relevant data and sends the result hereof to SLS at the client side through SLS. This process is terminated when SLS at the client side sends the received results to the legacy system at the client side.

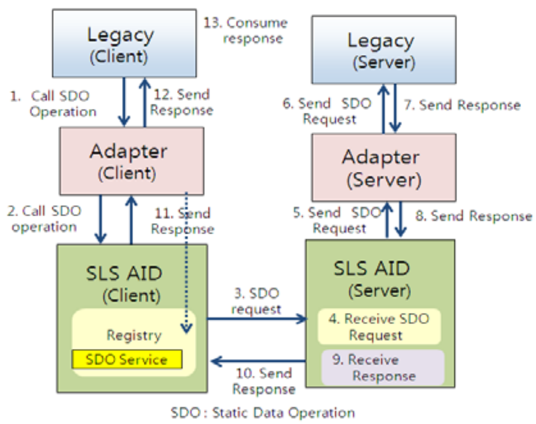

Fig. 7 Procedure of SDO service

The procedure of WFS is shown in Fig. 8. WFS should be able to register the server using UDDI just like SDO service and clients should be able to verify the registrations. First the legacy system at the client side request for WFS operation to AID of SLS through the adapter using UDDI. (Clients may request directly to SLS when they support web service call since they do not need to request to the adapter.) SLS at the client side calls GetCapablities, GetFeature, DescribeFeatureType, etc. sequentially in order to upload geospatial data when receiving a request for WFS operation. Then, it requests to the registry of SLS at the server side using the three services. SLS at the server side receives the request for WFS and then sends it to the legacy system at the server side. The legacy system at the server side searches relevant data and then sends the result hereof to SLS at the client side through SLS. This process is terminated when SLS at the client side sends the received results to the legacy system at the client side.

4.2 Suggested FDD

The data managed at FDD is represented by FO (Flight Object) and is the most important element that can be shared between ATM domains. FO contains the information about the flight structure (aircraft, city pair, etc.), taxi plan, trajectory detail, etc. It is classified into static data, which has low update frequency such as airplane data, and dynamic data, which has high update frequency such as trajectory detail.

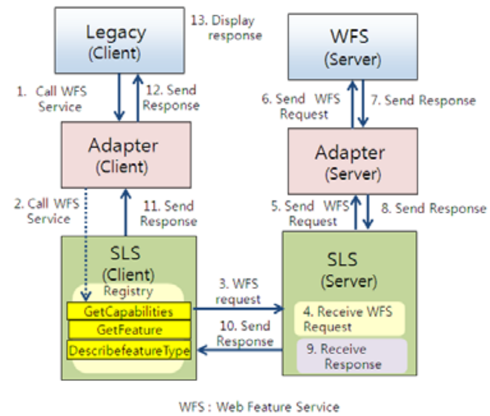

Fig. 8 Procedure of WFS

FO consists in several clusters. It groups data with cluster or related data in order to proceed with data distribution efficiently. If it is related to data contained in other clusters or modified simultaneously, (weird "then" because of previous "if") it sends more than one cluster to one event. Thus, a FO related event usually sends several clusters. Regionally corrected FO should exchange relevant details between the stake-holders; the corrected data will be notified to those stake-holders who requested for reception based on publication method in advance.

Fig. 9 schematized the clusters forming FO. The clusters are aircraft, departure, arrival, coordination, constraint/script, departure clearance, and flight plan information. In particular, flight plan data includes IOP Interoperability) information, SSR code, and trajectory information. Also, ATSU distribution list, release ID, etc. are added.

The participants at FDD can be sub-divided into the following three types. First, the manager collects a part of modified information from the contributor in order to calculate the corresponding Data D and then distributes it to the stake-holders. Second, the contributor set some values of information forming Data D, then transfers the modified topic value to the manager and consumes the modified Data D. Third, the user registers the published Data D as a whole or in parts.

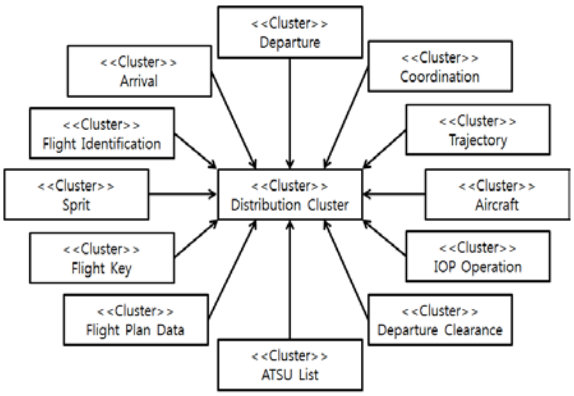

Fig. 9 FO cluster

Fig. 10 represents the creation, modification, and consumption process of FO inside FDD. The legacy system that performs the role of manager produces LFI (Legacy Flight Information) and sends it to its own adapter. The adapter at the manager side converts the flight information in the form of legacy into the international standard based FO information in accordance with FIXM. Then, this adapter calls for Create FO service or update service of FDD within SLS. After then, it transmits FO to Remote SLS that performs the role of consumer at SLS. FDD of SLS at the consumer side notifies the receipt of FO to its own adapter and sends FO. The adapter at the consumer side converts the received FO into its own LFI information and transmits it to the legacy system at the consumer side. The legacy system at the consumer side uses the received LFI data for the purpose of their own system.

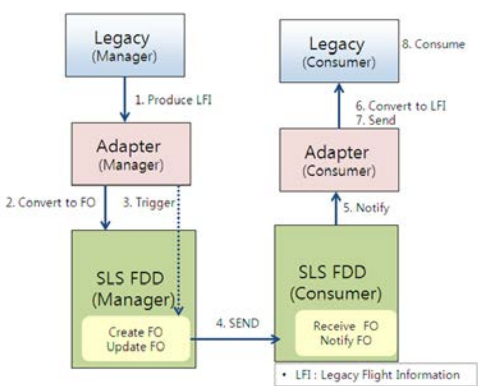

Fig. 10 Creation, modification and consumption process of FO

Fig. 11 represents the transfer process of FO inside FDD. The legacy system that performs the role of manager produces LFI and sends the data hereof to its own adapter. The adapter at the manager side converts LFI into the international standard based on FO information in accordance with FIXM and then this adapter calls for handover FO service of FDD within SLS. After then, it transmits the handover request to FDD of Remote SLS that performs the role of contributor at SLS. FDD of SLS at the contributor side notifies the handover request to the adapter and the adapter at the contributor side receives the handover request. The adapter at the contributor side converts the handover request into its own LFI information and transmits it to the legacy system at the contributor side. The legacy system at the consumer side renews the received LFI data at its own system.

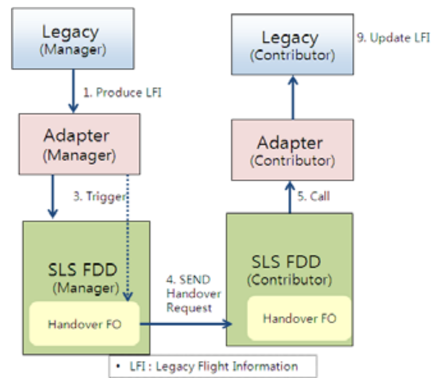

Fig. 11 Transfer process of FO

4.3 Suggested WXD

WXD exchanges and distributes data based on WXXM data model developed by Eurocontrol and FAA (Federal Aviation Administration). It is notified to the stake-holders who are interested in the information through weather information method. It supports for lattice data and external data in addition to the aviation weather observation data.

The data managed at WXD is classified into the airport weather, the regional weather, and the weather risk. Airport weather provides the unified weather information and the view on risks as to the airfields and the region hereof. These information are provided from several sources (the other weather information providers such as airplane, ground weather radar, satellite and ground based profile, global weather forecast system, etc.). It also includes RVR (Runway Visual Range), QNE/QNH, temperature, precipitation, wind, etc. In case of local weather, it is not required to state a period for the future as the weather data for specific period and airspace volume. The weather risk data refers to the meteorological risk as to specific flights and the information is obtained from weather radar or the received weather reports.

The participants, the service, and the processing procedure of WXD have the same configuration and details as AID described in Section 1 of Chapter 3.

5. Conclusion

This paper described data exchange models such as AXIM, FIXM and WXXM, which are covered at SWIM, this is proposed to solve the problems resulting from the inconsistency of data formats of the existing aeronautical communication networks. Furthermore, it proposed the requirements of data domains for processing each data and the data domains to satisfy the requirements thereof.

The proposed data domains are the system to process data at SWIM that is currently under development; thus, they are expected to be applied in practical applications. One will be able to use a variety of information at an inexpensive information service fee, this is made possible by the proposed data domains. Also, the capability of exchanging information with other countries will be raised. Furthermore, they will contribute to promote the improvement of jointly perceived operations. In addition, it will be possible to develop new services and also to reduce the development cost through using an open-type based data exchange model and a standardized interface.

Acknowledgment

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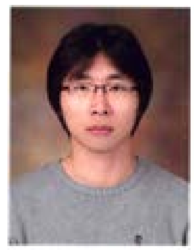

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