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Chapter 1 - Introduction

(1) This Early Project Report summarises the results of the OGC-OWS 6 test bed. It is based on the OGC-OWS 6 Engineering Report, which describes the process and means developed for demonstrating and evaluating within the context of the Aviation thread of Open Geo-spatial Consortium (OGC) Interoperability Program (IP) initiative Open Web Services, Phase 6 (OWS-6), the use of models such as Aeronautical Information Exchange Model (AIXM) and Weather Information Exchange Model (WXXM) in a Web Services Environment. The OGC Report also provides the main findings and proposes further work area to be explored which could be the foundation for a next OWS iteration – OWS-7.

(2) The ‘Aviation Thread’ of the OWS-6 test bed was a jointly sponsored EUROCONTROL/FAA activity, carried out by OGC industrial partners on a equal cost sharing basis.

1.1 Context

(3) The Aeronautical Information Management (AIM) subtask was a new thread within OWS, with the aim to develop and demonstrate the use of the Aeronautical Information Exchange Model (AIXM) and Weather Information Exchange Model (WXXM) in an Open Geospatial Consortium (OGC) Web Services environment. The AIM subtask focused on evaluating and advancing various AIXM features in a realistic trans-Atlantic Aviation scenario setting by devising and prototyping a Web Services Architecture for providing aeronautical and weather information directly to flight decks. Simulated Electronic Flight Bags (EFB) and hand-held devices (such as PDAs and Blackberries) were used, while the airplane was assumed to be at the gate or en-route to its destination.

(4) AIXM version 5 was developed by the Federal Aviation Administration (FAA) and EUROCONTROL as a global standard for the representation and exchange of aeronautical information, as a continuation of earlier AIXM versions developed by EUROCONTROL for the needs of the European AIS Database (EAD). AIXM 5 is designed as a basis for digital aeronautical information exchange and for enabling the transition to a net-centric, global aeronautical management capability. Both agencies were interested to evaluate the potential of OGC Web Services and other information

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1 See [www.aixm.aero](http://www.aixm.aero) for more information about AIXM version 5.
sharing technologies in conjunction with the net-centric System Wide Information Management (SWIM) concept by demonstrating and enhancing the use of models such as AIXM and WXXM in a Web Services Environment.

(5) It is envisioned that the core principles of OGC Web Services and standards may be included in the overall logic of future interoperable Air Traffic Management (ATM) information sharing on the local, regional and global levels. The OGC Standards and the related ISO19100 series of standards for geographic information are considered relevant in the context of the SESAR Programme SWIM thread activities as dealt with by WP8 – Information Management and WP14 – SWIM. Indeed, it is envisaged that aspects of the ATM Information Model – AIRM, will be built upon OGC and ISO19100 related specifications. This will allow standard data exchange of spatial and temporal data, hence supporting interoperable means of information coding and filtering applicable in the context of the services oriented and 4D trajectory based SESAR concept. Furthermore, at the interface level, specifications such as the Web Feature Service are a potential candidate for global interoperable access to geo-temporal aeronautical content and could therefore become valid means to share information on the future SWIM infrastructure.

1.2 Definition, abbreviations and acronyms

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<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AIXM</td>
<td>Aeronautical Information Exchange Model</td>
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<td>ATC</td>
<td>Air Traffic Control</td>
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<td>ATM</td>
<td>Air Traffic management</td>
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<td>EFB</td>
<td>Electronic Flight Bags</td>
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<td>FAA</td>
<td>Federal Aviation Administration</td>
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<td>FE</td>
<td>Filter Encoding</td>
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<td>FES</td>
<td>Filter Encoding Specification</td>
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<td>METAR</td>
<td>Aviation Routine Weather Report</td>
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<td>NOTAM</td>
<td>Notification to airmen</td>
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<tr>
<td>OASIS</td>
<td>Advancing open standards for the global information society</td>
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<td>OGC</td>
<td>Open Geo-spatial Consortium</td>
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<td>OWS-6</td>
<td>Open Web Services, Phase 6</td>
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<td>RDBMS</td>
<td>Relational Data Base Management System</td>
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<td>RFQ</td>
<td>Request For Quotation</td>
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<td>SES</td>
<td>Sensor Event Service</td>
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<td>TAF</td>
<td>Terminal Aerodrome Forecast</td>
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<td>W3C</td>
<td>World Wide Web Consortium</td>
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<td>WFS</td>
<td>Web Feature Service</td>
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<td>WXXM</td>
<td>Weather Information Exchange Model</td>
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Chapter 2 - Scope of Work

(6) The OCG-OWS-6 initiative was to establish a baseline for the technical architecture, its alternatives and issues for implementing the use cases as specified in the OWS-6 AIM thread RFQ including the temporal WFS supporting the temporal FE 2.0 operators, the Event Service Notification architecture and the client EFBs.

(7) The AIM thread focused on providing up-to-date aeronautical and weather information to pilots and aircraft while at the airport gate or en-route to its destination by:
   - Providing access to integrated, rich and distributed aeronautical and weather information in a standard way, both on demand and automatically,
   - Maximizing amount of useful information delivered to aircraft avionics, EFB or hand-held electronic display devices while at the gate or en-route to destination,
   - Filtering information using spatial and temporal criteria based on intended flight plan and current conditions.

(8) To support these goals, the scope of the OWS-6 AIM thread was defined by the following areas of work:
   - Use and enhancement of Web Feature Service (WFS) and Filter Encoding (FE) specifications in support of AIXM features and 4-dimensional flight trajectory queries,
   - Architecture of standards-based mechanism to alert/notify users of changes to user-selected aeronautical and weather information,
   - Prototype of Aviation client for retrieval, integration and visualization of aeronautical, weather and other aviation-related data, emphasizing time and spatial filtering specified by the user. Automatic notification of changes to aeronautical information that may be relevant to the plane along its intended route of flight, as specified by the user. In-flight update notifications related to spatial-temporal events are sent as AIXM 5.0 based Digital NOTAM messages.

(9) In general the architecture combined existing standards from OGC and other standards organizations like OASIS and W3C and it implemented new components as required. The system components were based on existing OGC and other standards for distributed processing environments and web services. This report describes the use of these standards and also notes alternatives that are available to address specific issues detected during the interoperability test experiments.
Chapter 3 - OWS-6-AIM
Scenario & Architecture and Technology Platform

(10) The AIM thread of the OWS-6 initiative was intended to provide implementation best practice know how and feedback on viable standards and technologies used to implement a solution that meets the requirements and use cases of an automated near real-time information management for the aviation community. This will integrate AIXM encoded data for aviation relevant permanent and temporary information and other data sources such as weather data in a spatial – temporal context for pre-flight and in-flight information via web services.

3.1 OWS-6 Scenario for Aviation Information Management (AIM) Thread

(11) This scenario provided a fictitious, but realistic context for a demonstration of the functionality developed in the Aviation thread of OWS-6, including interaction with other OWS components. The scenario was intended to prompt the exercising of interfaces and the use of encodings that were developed, tested or enhanced within OWS-6.

(12) One major objective was to demonstrate the ability of Web Feature Service (WFS) and the Filter Encoding Specification (FES) to provide access to aeronautical information in AIXM 5.0 format in response to direct user queries or in response to alerts generated when specific aeronautical information - as defined by that user- is updated. The scenario also included a demonstration of retrieval of pertinent weather data and delivering it to the aircraft.

(13) The participants in this scenario were the flight crew, Air Traffic Control (ATC), ground controllers, the custodians/providers of aeronautical information (and information updates), and the custodians/providers of the weather information. The scenario was built around a fictitious flight from an airport located in United States, over the Atlantic and landing at an airport in Sweden, after a diversion decision is taken in flight due to the closure of the initial destination airport. The flight trajectory is indicated in Fig 1.
3.2 Aviation Thread System Architecture Overview

(14) The main Aviation Thread Architecture components that supported the scenario were:

- **Temporal WFS** that serves the AIXM data mapped from a RDBMS and supports FES2.0 filter expressions to retrieve AIXM baseline data, AIXM “deltas” and Digital NOTAMs
- An **Event Service** that acts as an information broker between the data producers of Digital NOTAMs and subscribing clients (EFB) of the Digital NOTAMs. Digital NOTAM events are pushed to all clients that have provided a matching filter when subscribing
- **Client EFB** installed on mobile devices or as part of the Avionics system that query the temporal WFS to get the latest information from the AIXM WFS service related to their flight plan and then subscribe to the Event Service to receive related Digital NOTAMs while in the air
- **Weather Service WFS’s** that provide weather information for weather stations (METARs) as GML features and forecasts (TAFs) as WXXM encoded features

(15) The main components are shown in figure below.

![Architecture Overview and Main Components](image)

Figure 2 – Architecture Overview and Main Components

2 More information about the AIXM Temporality model, which uses concepts such as “baseline” and “Tempdelta” is available on the [www.aixm.aero](http://www.aixm.aero) Web site, in the "Temporality" document (see the "Downloads" section)
Chapter 4 - OWS-6 results and recommendations

4.1 OWS-6 AIM accomplishments and lessons learned

(16) OWS-6 prototyping and experimentations demonstrated 5 main added values for the next ATM developments:

- that a standards-based web-services architecture delivering AIXM 5 encoded data can meet the Aviation requirements for aeronautical information provision;
- feasibility of using WFS 2.0 and FE 2.0 to provide on-demand access to AIXM 5;
- integration of weather data affecting route of flight within given interval of time;
- ability of quick prototyping and implementation of Aviation client functionality based on standard web service interfaces and exchange formats;
- standards-based architecture for event alert notifications

(17) OWS-6 demonstrated that a standards-based web-services architecture revolving around AIXM 5.0 can meet the Aviation requirements for timely on-demand aeronautical data access, integration, notification and visualization

- Except for minor changes/glitches, the underlying OGC and ISO standards (GML, WFS, FE) fully supported the Aviation requirements
- By enabling access to subsets of information (rather than full downloads of data), the web-services architecture opens up issues related to data integrity and consistency at the client
- AIS data bases using AIXM5 need data validation and QA at load time or update time to avoid data inconsistencies e.g. missing identifiers, tangling references etc.
- The need for frequent client-server communications in this architecture (for updates and events) highlights issues related to reliability, security and bandwidth of underlying messaging channels

(18) OWS-6 demonstrated feasibility of using WFS and FE to provide on-demand access to AIXM 5.0 baseline information as well as temporary and permanent deltas

- Demonstrated practicality of starting with existing Shapefile source data and serving it as AIXM 5.0 via WFS
• Successfully implemented accurate and timely retrieval of relevant subsets of AIXM 5.0 data based on spatio-temporal FE filters
  o Identified changes to GML and FE to accommodate for the uncertainty in the end time periods of aviation data changes. This has been addressed in a GML change request
  o Identified need to query data based on time of upload/update of data/changes
    ▪ Achieved by adding appropriate metadata to features in the database (and the events) using ISO GML metadata
    ▪ Increased the size of the data significantly making it harder for Aviation clients to efficiently parse and interpret the data
  o Uncovered issues with time indeterminate position “Unknown”, which have been addressed through a change request for the FE specification.

(19) OWS-6 demonstrated integration of weather data affecting route of flight within given interval of time
  • Demonstrated successful access and retrieval of relevant WXXM and other GML-based weather data via WFS. Using the same standard interface (WFS) and exchange format (GML) for both weather and aeronautical information lowers the learning curve and implementation barrier for Aviation clients.
  • Uncovered issues related to textual nature of aeronautical weather data and consistent portrayal/symbology options.

(20) OWS-6 demonstrated ability of quick prototyping and implementation of Aviation client functionality based on standard web service interfaces and exchange formats for filtering, accessing, integrating and visualizing AIXM and weather data
  • Three different Aviation client prototypes have been developed
  • Client prototyping experiences highlight overhead associated with web-services architecture and AIXM 5.0 including
    o Inherent complexity of GML schemas and impacts on parsing and processing efficiencies given the hierarchical sub-classing from GML abstract data types and substitution groups
    o Difficulty in mapping of AIXM data model to existing (binary) data models in operational software (e.g. PCAvionics’ MountainScope)
    o Critical responsibility of data integration at the client (baseline, deltas, events, etc) to continuously maintain an accurate and up-to-date representation of the data
    o Critical responsibility of resolving and maintaining feature and property inter-dependencies in AIXM 5.0
    o Reliable messaging and connection issues in support of push-based event alert mechanism
    o Issues of pushing notifications to clients that have dynamic IP addresses
    o Issues of pushing notifications to clients behind a firewall

(21) OWS-6 demonstrated standards-based architecture for event alert notifications
  • Demonstrated the feasibility of subscription based data updates
  • Demonstrated feasibility of incorporating the OASIS WSN mechanism in the architecture
  • Demonstrated feasibility and reliability of mechanism for matching subscription requests (based on time and space) to various events
  • Experience to-date uncovered issues related to latency of events and reliability of messaging
• WSN SOAP-based approach creates a considerable overhead for Aviation clients (open connection issues, firewall issues, etc)

A video has been also provided by OGC at the end of the test bed, demonstrating the AIM Thread scenario, as played by the different participants. This video is available on the OGC Web site: http://www.opengeospatial.org/pub/www/ows6/index.html

Detailed video/slideshows are also available from each of the companies that have participated in the execution of the OWS-6 scenario, highlighting the developments and findings in their area of interest. The complete material can be browsed in less than one hour using the link: http://www.opengeospatial.org/pub/www/ows6/web_files/aim.html.
4.2 Recommendations for further development

Even if the OWS-6 experimentation demonstrated promising results in terms of the using models such as Aeronautical Information Exchange Model (AIXM) and Weather Information Exchange Model (WXXM) and WXXM in a Web Services Environment, several issues (both technical and standardisation) still are to be addressed/explored such as:

- **Further improving/adapting underlying standards**, e.g.
  - Overcoming/addressing GML ISO metadata complexity and size issues
  - Optimising WFS FE spatio-temporal filters
  - Simplifying/decoupling of AIXM schemas (through modularisation)

- **Understanding/improving metrics** for them, e.g.
  - Performance of spatio-temporal queries
  - Trigger changes in the WFS-T rather than database
  - Simplify subscription matching
  - Support multiple data sources at the Event Service
  - Latency of events and updates
  - Data integrity strategies

- **Investing in further client development**, e.g.
  - Investing in reusable components (e.g. open source for parsing AIXM, WXXM, etc)
  - Exploring efficient ways for visualizing the data (e.g. 3D, Google Earth, etc)
  - Capturing steps for easy transition/evolution of current EFB software providers

- **Improving the Event Alert architecture**, e.g.
  - Supporting weather events
  - Addressing intermittent access issues
  - Exploring other Event standards such as WS-Eventing (W3C Draft spec)
  - Explore usage of CAP (Common Alerting Protocol)
  - Investigate using a REST architecture style for Digital NOTAM delivery to remove the SOAP overhead from the clients
  - Implement Transport and Message Level Reliability and Security (TLS, MLS)
  - Persists Subscriptions and Registrations (Subscription and Registration Lifecycle management)
  - Explore Pluggable ES Architecture to use different (Domain Specific) filter encodings
  - Resolve Alerts in the Event Service via a WFS request with the subscription filter
  - firewall issues, ...
  - Define an OGC standard for eventing / event services (even SAS is not an OGC)

- **Building on the OWS-6 AIM architecture**, e.g.
  - Updating of feature base via WFS-T for events
  - Implement WFS2.0 with full FES2.0 support
- Addressing intermittent access issues
- Incorporating elements of existing infrastructure (e.g. SWIM)

These were proposed as the foundation for the next OWS iteration – OWS-7, which is currently in final preparation and expected to start in January 2010.

Finally the test bed activities have demonstrated the OGC standards to allow for a quick and good return on investment. They are therefore to be considered as one of the potential and serious candidates for some of the SJU SWIM Thread activities.