OGC® OWS-9 Web Feature Service Temporality Extension
Engineering Report

Copyright © 2013 Open Geospatial Consortium.
To obtain additional rights of use, visit http://www.opengeospatial.org/legal/.

Warning

This document is not an OGC Standard. This document is an OGC Public Engineering Report created as a deliverable in an OGC Interoperability Initiative and is not an official position of the OGC membership. It is distributed for review and comment. It is subject to change without notice and may not be referred to as an OGC Standard. Further, any OGC Engineering Report should not be referenced as required or mandatory technology in procurements.
Abstract

This document is a deliverable of the OGC Web Services (OWS) Initiative - Phase 9 (OWS-9). This Engineering Report summarizes the OWS-9 activity regarding the extension of the Web Feature Service (WFS) and Filter Encoding (FE) standards to support dynamic feature data.

Specifically this document describes the result work performed in OWS-9 on the WFS Temporality Extension. The technical specification including background is discussed and defined in the OGC Discussion Paper 12-027r1. This document gives a summary about issues, lessons learned, recommendations, accomplishments and benefits for the Aviation Architecture. It also gives an outlook on future work items and change requests.

Keywords

ogcdoc, ows9, ows-9, wfs, fe, aviation, temporality

What is OGC Web Services 9 (OWS-9)?

OWS-9 builds on the outcomes of prior OGC interoperability initiatives and is organized around the following threads:

- **Aviation**: Develop and demonstrate the use of the Aeronautical Information Exchange Model (AIXM) and the Weather Exchange Model (WXXM) in an OGC Web Services environment, focusing on support for several Single European Sky ATM Research (SESAR) project requirements as well as FAA (US Federal Aviation Administration) Aeronautical Information Management (AIM) and Aircraft Access to SWIM (System Wide Information Management) (AAtS) requirements.

- **Cross-Community Interoperability (CCI)**: Build on the CCI work accomplished in OWS–8 by increasing interoperability within communities sharing geospatial data, focusing on semantic mediation, query results delivery, data provenance and quality and Single Point of Entry Global Gazetteer.


- **OWS Innovations**: Explore topics that represent either new areas of work for the Consortium (such as GPS and Mobile Applications), a desire for new approaches to
existing technologies to solve new challenges (such as the OGC Web Coverage Service (WCS) work), or some combination of the two.

- **Compliance & Interoperability Testing & Evaluation (CITE):** Develop a suite of compliance test scripts for testing and validation of products with interfaces implementing the following OGC standards: Web Map Service (WMS) 1.3 Interface Standard, Web Feature Service (WFS) 2.0 Interface Standard, Geography Markup Language (GML) 3.2.1 Encoding Standard, OWS Context 1.0 (candidate encoding standard), Sensor Web Enablement (SWE) standards, Web Coverage Service for Earth Observation (WCS-EO) 1.0 Interface Standard, and TEAM (Test, Evaluation, And Measurement) Engine Capabilities.

**The OWS-9 sponsors are:** AGC (Army Geospatial Center, US Army Corps of Engineers), CCREA-GeoVIQUA-EC, EUROCONTROL, FAA (US Federal Aviation Administration), GeoConnections - Natural Resources Canada, Lockheed Martin Corporation, NASA (US National Aeronautics and Space Administration), NGA (US National Geospatial-Intelligence Agency), USGS (US Geological Survey), UK DSTL (UK MoD Defence Science and Technology Laboratory).
License Agreement

Permission is hereby granted by the Open Geospatial Consortium, ("Licensor"), free of charge and subject to the terms set forth below, to any person obtaining a copy of this Intellectual Property and any associated documentation, to deal in the Intellectual Property without restriction (except as set forth below), including without limitation the rights to implement, use, copy, modify, merge, publish, distribute, and/or sublicense copies of the Intellectual Property, and to permit persons to whom the Intellectual Property is furnished to do so, provided that all copyright notices on the intellectual property are retained intact and that each person to whom the Intellectual Property is furnished agrees to the terms of this Agreement.

If you modify the Intellectual Property, all copies of the modified Intellectual Property must include, in addition to the above copyright notice, a notice that the Intellectual Property includes modifications that have not been approved or adopted by LICENSOR.

THIS LICENSE IS A COPYRIGHT LICENSE ONLY, AND DOES NOT CONVEY ANY RIGHTS UNDER ANY PATENTS THAT MAY BE IN FORCE ANYWHERE IN THE WORLD.

THE INTELLECTUAL PROPERTY IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NONINFRINGEMENT OF THIRD PARTY RIGHTS. THE COPYRIGHT HOLDER OR HOLDERS INCLUDED IN THIS NOTICE DO NOT WARRANT THAT THE FUNCTIONS CONTAINED IN THE INTELLECTUAL PROPERTY WILL MEET YOUR REQUIREMENTS OR THAT THE OPERATION OF THE INTELLECTUAL PROPERTY WILL BE UNINTERRUPTED OR ERROR FREE. ANY USE OF THE INTELLECTUAL PROPERTY SHALL BE MADE ENTIRELY AT THE USER’S OWN RISK. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR ANY CONTRIBUTOR OF INTELLECTUAL PROPERTY RIGHTS TO THE INTELLECTUAL PROPERTY BE LIABLE FOR ANY CLAIM, OR ANY DIRECT, SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES, OR ANY DAMAGES WHATSOEVER RESULTING FROM ANY ALLEGED INFRINGEMENT OR ANY LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR UNDER ANY OTHER LEGAL THEORY, ARISING OUT OF OR IN CONNECTION WITH THE IMPLEMENTATION, USE, COMMERCIALIZATION OR PERFORMANCE OF THIS INTELLECTUAL PROPERTY.

This license is effective until terminated. You may terminate it at any time by destroying the Intellectual Property together with all copies in any form. The license will also terminate if you fail to comply with any term or condition of this Agreement. Except as provided in the following sentence, no such termination of this license shall require the termination of any third party end-user sublicense to the Intellectual Property which is in force as of the date of notice of such termination. In addition, should the Intellectual Property, or the operation of the Intellectual Property, infringe, or in LICENSOR’s sole opinion be likely to infringe, any patent, copyright, trademark or other right of a third party, you agree that LICENSOR, in its sole discretion, may terminate this license without any compensation or liability to you, your licensees or any other party. You agree upon termination of any kind to destroy or cause to be destroyed the Intellectual Property together with all copies in any form, whether held by you or by any third party.

Except as contained in this notice, the name of LICENSOR or of any other holder of a copyright in all or part of the Intellectual Property shall not be used in advertising or otherwise to promote the sale, use or other dealings in this Intellectual Property without prior written authorization of LICENSOR or such copyright holder. LICENSOR is and shall at all times be the sole entity that may authorize you or any third party to use certification marks, trademarks or other special designations to indicate compliance with any LICENSOR standards or specifications.

This Agreement is governed by the laws of the Commonwealth of Massachusetts. The application to this Agreement of the United Nations Convention on Contracts for the International Sale of Goods is hereby expressly excluded. In the event any provision of this Agreement shall be deemed unenforceable, void or invalid, such provision shall be modified so as to make it valid and enforceable, and as so modified the entire Agreement shall remain in full force and effect. No decision, action or inaction by LICENSOR shall be construed to be a waiver of any rights or remedies available to it.

None of the Intellectual Property or underlying information or technology may be downloaded or otherwise exported or reexported in violation of U.S. export laws and regulations. In addition, you are responsible for complying with any local laws in your jurisdiction which may impact your right to import, export or use the Intellectual Property, and you represent that you have complied with any regulations or registration procedures required by applicable law to make this license enforceable.
## Contents

<table>
<thead>
<tr>
<th></th>
<th>Introduction</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>1.1</td>
<td>Scope</td>
<td>1</td>
</tr>
<tr>
<td>1.2</td>
<td>Document contributor contact points</td>
<td>1</td>
</tr>
<tr>
<td>1.3</td>
<td>Revision history</td>
<td>1</td>
</tr>
<tr>
<td>1.4</td>
<td>Foreword</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>References</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Conventions and abbreviated terms</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Executive Summary</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Accomplishments</td>
<td>3</td>
</tr>
<tr>
<td>5.1</td>
<td>Identification of use cases for aviation</td>
<td>3</td>
</tr>
<tr>
<td>5.2</td>
<td>Mapping of use cases to WFS operations and FES filters</td>
<td>4</td>
</tr>
<tr>
<td>5.3</td>
<td>Problem analysis, categorization and generalization</td>
<td>4</td>
</tr>
<tr>
<td>5.4</td>
<td>Identification of AIXM TM specifics compared to the general GML</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Dynamic Feature Model</td>
<td>4</td>
</tr>
<tr>
<td>5.5</td>
<td>Conceptual design of the extension</td>
<td>4</td>
</tr>
<tr>
<td>5.6</td>
<td>Model creation and generation of a physical representation</td>
<td>4</td>
</tr>
<tr>
<td>5.7</td>
<td>Documentation</td>
<td>4</td>
</tr>
<tr>
<td>5.8</td>
<td>Proof that all use cases are covered and example creation</td>
<td>4</td>
</tr>
<tr>
<td>5.9</td>
<td>Implementation</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Demo scenarios and tested Temporality Extension use cases</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>Implementation results</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>Future work items</td>
<td>5</td>
</tr>
<tr>
<td>8.1</td>
<td>Implementation and tests</td>
<td>5</td>
</tr>
<tr>
<td>8.2</td>
<td>Handling of long-term data</td>
<td>5</td>
</tr>
<tr>
<td>8.3</td>
<td>Compatibility</td>
<td>5</td>
</tr>
<tr>
<td>8.4</td>
<td>Property exclusion</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>Benefits for the Aviation Architecture</td>
<td>6</td>
</tr>
</tbody>
</table>
OGC® OWS-9 WFS Temporality Extension Engineering Report

1 Introduction

1.1 Scope

This OGC™ document describes the result work performed in OWS-9 on the WFS Temporality Extension. The technical specification including background is discussed and defined in the OGC Discussion Paper 12-027r1. This document gives a summary about issues, lessons learned, recommendations, accomplishments and benefits for the Aviation Architecture. It also gives an outlook on future work items and change requests.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The Open Geospatial Consortium shall not be held responsible for identifying any or all such patent rights.

Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.

1.2 Document contributor contact points

All questions regarding this document should be directed to the editor or the contributors:

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timo Thomas</td>
<td>COMSOFT GmbH, Germany</td>
</tr>
</tbody>
</table>

1.3 Revision history

<table>
<thead>
<tr>
<th>Date</th>
<th>Release</th>
<th>Editor</th>
<th>Primary clauses modified</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-11-23</td>
<td>Draft</td>
<td>Timo Thomas</td>
<td>all</td>
<td>First initial draft of the report.</td>
</tr>
</tbody>
</table>
1.4 Foreword

This document is a deliverable of the OGC Web Services (OWS) Initiative - Phase 9 (OWS-9). Its contents cover the summary of the work carried out regarding the Web Feature Service Temporality Extension, which resulted in OGC Discussion Paper 12-027r1.

2 References

The following documents are referenced in this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

OWS-9 Engineering Reports:

- OGC 12-147, OWS-9 Aviation Architecture Engineering Report
- OGC 11-093r2, OGC® OWS-8 Aviation Architecture ER (2011-09-30)
- OGC 11-073r2, OGC® OWS-8 Aviation: Guidance for Retrieving AIXM 5.1 data via an OGC WFS 2.0 (2011-11-04)
- OGC 10-131r1, OGC® OWS-7 Aviation – AIXM Assessment Report (2010-08-18)

Other OGC Documents:

- OGC 12-027r2, WFS Temporality Extension
- ISO/DIS 19142 and OGC 04-094, OpenGIS® Web Feature Service 2.0 Interface Standard (2010-11-02)
- ISO/DIS 19143 and OGC 09-026r1, OpenGIS® Filter Encoding 2.0 Encoding Standard (2010-11-22)

Aviation specific documents:

- AIXM 5 Temporality Model 1.0 (2010-09-15)

3 Conventions and abbreviated terms

AIXM Aeronautical Information Exchange Model
DNOTAM Digital NOTAM
ES Event Service
Executive Summary

The Aeronautical Information Exchange Model (AIXM) is designed to enable the management and distribution of Aeronautical Information Services (AIS) data in digital format. The newest version of this model, AIXM 5.1, is based on GML 3.2 and features an exhaustive temporality model loosely based on the GML Dynamic Feature Model.

Various interoperability test-beds at OGC, in particular OWS-7 and OWS-8, have applied OGC’s WFS 2.0 and FES 2.0 standards on AIXM 5 data. Though it could be demonstrated that a basic interoperability is possible, it turned out that some key requirements could not be fulfilled.

After OWS-8, work on an extension to the WFS specification started to overcome these shortcomings. This work was continued and intensified in OWS-9, resulting in the WFS Temporality Extension Discussion Paper, OGC document 12-027r2. It summarized the observations made and showed that these requirements are not specific to AIXM 5, but more generally apply to any data model featuring temporality.

Accomplishments

By creating the WFS TE Discussion Paper, the following accomplishments were made.

Identification of use cases for aviation

A total of 8 use cases where identified out of different areas of application, including but not limited to visualization, decision support, AIP publication, NOTAM communication and data replication.
5.2 Mapping of use cases to WFS operations and FES filters

Where possible, the identified use cases were mapped to WFS operations and FES filters.

5.3 Problem analysis, categorization and generalization

A problem analysis revealed two key unfulfilled requirements:

1. The ability to filter time slices using FES filters
2. The ability to generate SNAPSHOT time slices

5.4 Identification of AIXM TM specifics compared to the general GML Dynamic Feature Model

AIXM 5.1 temporality model is loosely based on the GML Dynamic Feature Model. A detailed comparison of both models was undertaken.

5.5 Conceptual design of the extension

An extension of WFS/FES was designed. This process included discussion with interested parties from other perspectives (e.g. clients) and performance considerations like required bandwidth and minimum latency.

5.6 Model creation and generation of a physical representation

A model of the extension was created and embedded in the existing UML model of WFS/FES. A physical model (XML Schema) was then generated out of the UML model using existing transformation tools.

5.7 Documentation

A detailed documentation of all introduced elements and the overall concept was created.

5.8 Proof that all use cases are covered and example creation

For each of the identified use cases mentioned above it was tested whether it is covered by the created extension. For each, an example query was created.

5.9 Implementation

Parts of the extension were implemented on server side in the Web Feature Service of CADAS-AIMDB, COMSOFT’s AIXM 5.1 database. These were in particular:

- SNAPSHOT generation
PropertyExclusion projection clause

6 Demo scenarios and tested Temporality Extension use cases

Two scenarios where created and demonstrated:

- Retrieve the state of a runway at a specific point in time (SNAPSHOT generation)
- Retrieve all airports fulfilling specific constraints at a point in time in the future (BASELINE filtering)

As there were no client implementations available, COMSOFT created a thin client for the purposes of the demo.

7 Implementation results

No specific observations were made during the implementation of the Temporality Extension. The implemented parts are ready to be used in future test beds.

8 Future work items

Future work items directly related to the work on the specification can be found in the discussion paper. Items relevant for future test beds are listed below.

8.1 Implementation and tests

A more complete implementation should be provided to allow further testing. It should especially include a client and advanced functionality such as the evaluation of properties with schedules.

8.2 Handling of long-term data

Future test beds should include long-term aspects of handling of AIXM 5.1 data, including long histories of permanent and temporary changes. This would more reflect real-world scenarios and would emphasis the importance of the Temporality Extension.

8.3 Compatibility

In the course of maturation of the extension, further effort should be invested in the compatibility of the extension with the existing WFS standard, e.g. regarding join queries.

Regarding the compatibility with AIXM, future test beds should include transactional operations in their focus covering the complete life time of features (commissioning, permanent changes, temporary changes, corrections, cancelations, decommissioning).
8.4 Property exclusion

The test bed revealed that the introduced projection clause for excluding properties is also useful for other domains and areas of application, like event services [see OWS-9 Architecture Engineering Report]. As it isn’t directly related to the temporality issues, the PropertyExclusion projection clause should be separated from the Temporality Extension and given its own namespace.

9 Benefits for the Aviation Architecture

Existing test beds for the Aviation domain focused on the general processing of AIXM data so far. The history of features played only a minor role. Sample data mainly consisted of one time slice per feature (the commissioning) and temporary changes (DNOTAMs). Permanent changes were barely used, as were corrections and cancelations of data. In these simple scenarios, exchanging features with the full history of time slices was not a problem.

A key design element of the AIXM TM is that it never forgets. For long-running productive systems, the amount of time slices of a feature can grow to great numbers. Efficient retrieval of a set of time slices of interest will then become a key requirement. The WFS Temporality Extension paves the way for these use cases in an efficient and convenient manner.

Another key functionality developed is the generation of SNAPSHOT time slices, which represent the complete state of a feature at a given point in time. This relieves clients from implementing the complex AIXM TM algorithm and also saves bandwidth. It enables “thin” clients, which do not need to have a full understanding of the AIXM Temporality Model to successfully interact with an AIXM 5.1 data store through the WFS. Support for recurring changes of data on a regular basis, called “properties with schedules” in AIXM TM terminology, is also included, as are constraints based on the value of a property in the future, which are important for decision support applications.