Open Geospatial Consortium

OGC® Testbed 10 Summary Engineering Report

Warning

What is the OGC Testbed 10?

The Open Geospatial Consortium (OGC) is the only international organization that brings industry players together to help organizations manage risks and difficulties that relate to communication about real-world location and mobility. The OGC combines rapid prototyping, standards development, coordination with other standards organizations, and aggressive standards marketing to address users' challenging geospatial integration problems.

Over the last 18 years, the OGC's Member organizations have developed a unique and proven interoperability testbed process that saves invested time and money while creating new business opportunities and driving innovation. The OGC Interoperability Program plans and conducts plugfests, pilots and the annual OGC Testbed.

This report summarizes the results of OGC Testbed 10. Testbed 10 sponsorship totaled $1.2 million USD and attracted in-kind contributions by participants of approximately $1.6 million USD for a 2.3x return on investment. Testbed requirements were provided by eleven (11) sponsors from the US, Canada and Europe. Requirements ranged from environmental management and civil government mapping to maintaining common operating pictures in disaster zones and battlefields. Twenty-nine (29) participating organizations, working on specific interoperability problems detailed in the sponsors' use cases and scenarios, delivered extraordinary value in the following areas:

☐ **Cross-Community Interoperability (CCI):** Increase Geospatial community interoperability by building on Testbed 9 CCI work in semantic mediation, volunteer geographic information (VGI), provenance and data quality, and the Global Gazetteer. Explore the potential of interoperability in the hydrology domain utilizing semantic mediation and ontologies to more easily share and visualize geospatial data.

☐ **Open Mobility:** Explore the geospatial standards requirements needed to support the growing mobile environment where client applications are mobile and information services are mobile and increasingly distributed across cloud infrastructures. The Open Mobility thread addressed these requirements while leveraging on the work achieved in Testbed 9 in the areas of OGC GeoPackage and GeoPackaging services and new OWS Context encodings.

☐ **Aviation:** Demonstrate use of the Aeronautical Information Exchange Model (AIXM), the Flight Information Exchange Model (FIXM), and Weather Information Exchange Model (WXXM) to build on the work accomplished in prior OGC testbeds to advance the applications of OGC Web Services standards in next generation air traffic management systems to support European and US aviation modernization programs.

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Summary OGC Testbed 10

1 Overview

The OGC Testbed 10 was an initiative of OGC's Interoperability Program to collaboratively extend and demonstrate OGC's baseline for geospatial interoperability. The majority of work for Testbed 10 was conducted between October 2013 and April 2014. Key outcomes are:

- 40 Software Components (servers, clients, tools and other applications) were implemented and used in interoperability testing.

- 19 Engineering Reports (ERs) were written. Testbed 10 ERs were either technical specifications or reports regarding testing and analysis. Several Change Requests were also developed as recommendations for changes to existing standards. These CRs were entered into the OGC's change request tracker: http://www.opengeospatial.org/standards/cr

- Testbed 10 ERs were posted to the OGC Standards Program Pending Documents archive and have either been approved for public release or are being reviewed by OGC TC members for public release. Engineering reports approved for public release are accessible on the web here: http://www.opengeospatial.org/standards/per

- 11 Sponsoring organizations defined requirements for Testbed 10. The sponsors' requirements were captured in the Request For Quotations/Call For Participation (RFQ/CFP) document that was released by OGC 15 July 2013 seeking organizations that wished to participate in the Testbed.

- 40 organizations in total participated in some aspect of Testbed 10. Roles for organizations in Testbed 10 included sponsors, participants and architects. Additionally there were many organizations that were observers of Testbed 10.

    o A presentation and demonstration of the results of Testbed 10 was performed during the OGC's Technical Committee meeting in Washington, DC in March 2014. In addition, two public webinars were conducted: one for the Aviation Thread; and one for the Cross-

Community/Open Mobility Thread. Proceedings of these demonstrations were recorded and are available online here:

- Testbed 10 Presentation and Demonstration:
  Part 1: https://www.youtube.com/watch?v=l3TJRini5XQ
  Part 2: https://www.youtube.com/watch?v=0vXsq9nj7Cg

- Testbed 10 Aviation Thread Webinar:
  https://www.youtube.com/watch?v=UXDCRkMVSa4

- Testbed 10 Cross-Community and Open Mobility Threads Webinar:
  https://www.youtube.com/watch?v=3WwaLyZeSug

1.1   Document contributor contact points

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

Name	Organization
Lew Leinenweber	Initiative Director, OGC

2 Sponsoring Organizations

OGC Testbed 10 was sponsored by the following 11 organizations:

- AGC (Army Geospatial Center, US Army Corps of Engineers)
- ESA (European Space Agency)
- EUROCONTROL
- FAA (US Federal Aviation Administration)
- GeoConnections - Natural Resources Canada
- Harris Corporation
- Lockheed Martin Corporation
- NGA (US National Geospatial-Intelligence Agency)
- NOAA National Weather Service (NWS)
- USGS (US Geological Survey)
- UK DSTL (UK Defence Science and Technology Lab)

3 OGC Testbed 10 Interoperability Program (IP) Team

The IP Team is an engineering and management team to oversee and coordinate OGC Interoperability Initiatives. The IP Team facilitates architectural discussions, synopsizes technology threads, and supports the candidate standard editorial process. The IP Team is comprised of OGC staff and representatives from member organizations. The Testbed 10 IP Team was:

- Interoperability Program Executive Director: Dr. Nadine Alameh, OGC
- Initiative Director: Lew Leinenweber, OGC
- Thread Architects
  - o Aviation: Johannes Echterhoff, interactive instruments
  - o Cross-Community Interoperability, Dr. Luis Bermudez, OGC
  - o Open Mobility, Dr. Raj Singh, OGC
- IT and Demonstration Support: Greg Buehler, Mark Buehler, OGC

4 List of Participating Organizations

The following OGC member organizations played one or more roles in OGC Testbed 10 as participants (responded to the RFQ/CFP and provided in-kind contributions).

- 52North
- Arizona State University
- Atmosphere
- Augmented Technologies
- The Carbon Project
- CSIRO
- Cloudant
- Compusult
- Comsoft
- CubeWerx
- EADS Astrium/CNES
- Envitia
- Frequentis
- Galdos
- GeoMatys
- Global Runoff Data Center (GRDC)
- GIS.FCU
- George Mason Univ
- Harris Corporation
- iGSI
- ImageMatters
- Interactive Instruments
- Jacobs University
- Luciad
- m-click
- the PYXIS Innovation
- Snowflake
- Terradue
- UAB-CREAF
- Univ of Southern California
- WiSC

5 Schedule

The OGC Testbed 10 was conducted according to the following key milestone schedule.

Table 1, OGC Testbed 10 Milestone Schedule

Milestone	Date
Concept Development	Jan 2013 – May 2013
RFQ Release	July 15, 2013
Q&A Webinar	Aug 6, 2013
RFQ Due	Aug 26, 2013
Kickoff (Aviation)	Sep 27, 2013 (Frascati Italy)
Kickoff (CCI, Open Mobility)	Oct 7-9, 2013 (GMU Fairfax)
TC Presentation and Demo	Mar 27, 2014
Final Deliverables	April 30, 2014
Testbed 10 Testbed Webinars	27 May (Aviation), 28 May (CCI-OM)

After the Kickoff Meeting, design, development and testing of Testbed 10 components was conducted in a distributed fashion. Collaboration was supported using telecoms, a web portal, twiki, web collaboration tools, and e-mail.

The Statement of Work milestones defined various deliverables specific to each participant. A number of ERs were completed beyond the Final Deliverables date. This was a result of inputs needed for the work not being available as anticipated. See ER table for more information.

6 Development Threads

Testbed 10 was organized around the following threads:

1) Aviation
2) Cross-Community Interoperability
3) Open Mobility

An introduction to each of these threads is provided. A list of ERs developed in each thread is also provided.

6.1 Aviation

The Aviation Thread focused on advancing the interoperable management and dissemination of aeronautical and flight information. To this end, the Aviation thread addressed the following main tasks:

- **Advance interoperable management of aeronautical and flight information**
  - Test, validate and demonstrate the use of FIXM, AIXM, WXXM, and Digital NOTAM[1] in a service-oriented architecture including Web Feature Service (WFS), Web Coverage Service (WCS), and Event Service.
- **Develop recommendations for exchange of terrain data**
  - Assess and investigate suitable formats and approaches for the interoperable exchange of terrain data that satisfy Aviation domain requirements.
- **Advance human factor based portrayal of Digital NOTAMs**
  - Improve the way that aeronautical information, especially NOTAMs, is visualized.
- **Advance compliance**
  - Advance the capability to test the conformance of geometry types contained in AIXM datasets and improve the documentation of the WFS extension to handle dynamic feature data.
- **Advance support of AIXM in development tools (J2EE, .NET)**
  - Investigate and test ways to improve AIXM software development.

Sponsors: FAA, EUROCONTROL, NOAA NWS, Harris Corporation

Participants: 11 organizations

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[1] Notice to Airmen

6.2   Key Accomplishments

The key accomplishments of the Aviation thread activities are:

☐ **Designed and implemented a GML 3.2 based encoding for FIXM 2.0** – a GML 3.2 Application Schema for FIXM 2.0 was developed and tested. This work is fundamental to serving FIXM data using an OGC WFS 2.0 compliant implementation.

☐ **Developed application patterns for disseminating updates FIXM 2.0 features** – Since FIXM 2.0 does not provide a temporal concept equivalent to the one defined for AIXM 5.1, an alternative approach for the publish/subscribe based dissemination of FIXM features was developed in order to enable the integration of FIXM data into the Aviation service architecture.

☐ **Integration of Weather Data** – Access to NOAA's weather data was made available using an OGC Web Coverage Service. For the first time within an OGC Testbed, the returned weather data were then integrated into the Aviation scenarios. Backed by NOAA's Web-gridded Document Service and encoded as WXXM, the WCS instance provided forecast weather data demonstrating new uses while applied in interesting use cases and scenarios.

☐ **Terrain Data Exchange** – A set of recommendations on exchange formats to meet International Civil Aviation Organization (ICAO) Annex 15 and ADQ requirements; strategies to overcome cross-border differences in terrain data due to differences in national geodetic systems and provision of seamless terrain data; and demonstrated approaches to provide web-based access to eTOD data in an INSPIRE compliant way.

☐ **Binding AIXM to Development tools** – Demonstrated automated creation of generated AIXM data bindings for established programming languages; documented issues observed while creating these bindings, integration into development tools (IDEs, application servers) and an evaluation in terms of language integration and performance.

The following Engineering Reports were prepared to document the results in each of these task areas.

Table 2, Aviation Thread ERs

OGC Doc #	Title
12-027r3	OGC Testbed 10 WFS Temporality Extension Discussion Paper Revision
14-000	OGC Testbed 10 GML for Aviation Conformance Testing ER
14-006	OGC Testbed 10 Aviation Recommendations for the Exchange of Terrain Data ER
14-007	OGC Testbed 10 Aviation Binding AIXM to Development Tools ER
14-008	OGC Testbed 10 Aviation Architecture ER
14-037	OGC Testbed 10 Aviation FIXM GML Schema ER
14-038r1	OGC Testbed 10 Aviation Dissemination of Weather Data ER
14-039	OGC Testbed 10 Aviation Human Factor Based Portrayal of Digital NOTAMs ER

The following software components were developed, deployed and used to test and demonstrate the results achieved in this thread.

Table 3, Aviation Thread Software Components

Component	Implementer
Web Feature Service - Transactional	m-click
Web Feature Service - Transactional	Snowflake
Event Service	52 North
Aviation Client	Luciad
AIXM Binding Tool	52 North
GML Conformance Test Scripts	Galdos
AIXM Validation Service	m-click
WCS Adapter for WGDS	GMU

6.3 Cross-Community Interoperability (CCI)

The Cross-Community Interoperability (CCI) thread was focused on tasks to build on interoperability within and between communities sharing geospatial data and to advance semantic mediation approaches for data discovery, access and use of heterogeneous data models and heterogeneous metadata models. The CCI Thread investigated the creation of domain ontologies and tools to create, assemble, and disseminate geographic data provided voluntarily by individuals. In addition, the CCI Thread demonstrated integration across all OGC web services with the intent to provide a better understanding of service content and the relationships or associations that exist between OGC services and resources/content. To this end, the thread addressed the following main tasks:

☐ **Ontology** – Created an ontology that renders shared vocabulary and taxonomy, which models a domain with the definition of objects/concepts, as well as their properties and relations.

☐ **Volunteered Geographic Information (VGI) –** The VGI effort continued on the work of Testbed 9 to expand the use of OGC services and standards for VGI access, data linking, and rule-based conflation based on results from attribute and spatial queries of gazetteer data.

☐ **Gazetteer -** The Virtual Global Gazetteer effort extended the Single Point of Entry Global Gazetteer (SPEGG) work from Testbed 9, building on the framework established in that testbedand expanding gazetteer functionality to include gazetteer conflation and semantic gazetteer linking.

☐ **WPS conflation and provenance –** Advanced data and service discovery. Investigated new and/or existing services using the benefit of semantic mediation approaches to support discovery of pertinent services or data collections.

☐ **Linked WPS and Decision Rules –** Developed a framework for WPS to investigate diverse data sets and build relational linkages and, when appropriate, invoke other services (e.g. WPS Conflation).

☐ **Profiles –** Developed and tested implementations based on the latest versions of the Defence Geospatial Information Working Group (DGIWG) and the National System for Geospatial Intelligence (NSG) profiles of OGC Web Services.

☐ **Hydro Model Interoperability –** Demonstrated interoperability among hydrographic and hydrologic data sources by linking model concepts across different hydrologic models to facilitate retrieval and delivery of data in a selected model format.

Sponsors: NGA, AGC, USGS, Natural Resources Canada (NRCan), UK DSTL, Lockheed Martin

Participants: 14 organizations

The following Engineering Reports were prepared to document the results in these task areas.

Table 4, CCI Thread ERs

OGC Doc #	Title
14-001	OGC Testbed 10 Provenance ER
14-016	OGC Testbed 10 Volunteered Geographic Information (VGI) ER
14-021r2	OGC Testbed 10 CCI Profile Interoperability ER
14-029r2	OGC Testbed 10 Virtual Global Gazetteer ER
14-048	OGC Testbed 10 Hydro Model Interoperability ER
14-049	OGC Testbed 10 Ontology ER

The following software components were developed, deployed and used to test and demonstrate the results achieved in this thread.

Table 5, CCI Thread Software Components

Component	Implementer
CCI OGC Client App	Pyxis
CCI OGC Web Service: DGIWG WFS TDS Locking	interactive instruments
CCI OGC Web Service: NSG WMS Profile Service	interactive instruments
CCI OGC Web Service: Catalog	Compusult
CCI OGC Web Service: National Map	Compusult
CCI OGC Web Service: DGIWG WMS	Envitia
CCI WPS 2.0 Conflation Service	52North
CCI WPS 2.0 Conflation Service	Arizona
Hydro Mediation Service	GIS.FCU; CSIRO, GRDC (in-kind advisory support)
Hydro Model Service	GIS.FCU
Local WFS	Compusult
NGA WFS-G	interactive instruments
Ontology Mapping Component	CSIRO
Ontology Mapping Component	Imagematters
Semantic Mediation Service	Imagematters
Semantic Mediation Service (virtual gazetteer service)	Envitia
USGS WFS-G	Compusult
Virtual Global Gazetteer Client	Pyxis
Virtual Global Gazetteer Service	CSIRO
WFS/WPS for VGI	52North

6.4   Open Mobility

The Open Mobility thread explored geospatial standards requirements to implement mobile applications, information service concepts and Cloud computing. Client applications used in this testbed are mobile. Clients can also be found in enterprise desktop environments, workhorse tablets, or phone platforms. Data sets may be available via information services for mobile applications. They are distributed across clouds, internal servers and even individual users. And they consist of raw data and just-in-time processing capabilities. To this end, the thread addressed the following main tasks:

- **Cloud Computing**: Exploitation and service performance enhancement

- **Mobile Data**: OGC GeoPackages and GeoPackaging services

- **OWS Context**: JSON encoding and OGC KML annotations

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☐ **Linked OWS**: Augmenting the OGC architecture to facilitate linking related data across services

Sponsors: NGA, ESA, and UK DSTL

Participants: 12 organizations.

The following Engineering Reports were prepared to document the results in these task areas.

Table 6, Open Mobility Thread ERs

OGC Doc #	Title
14-002	OGC Testbed 10 OWS Context Annotations ER
14-009r1	OGC Testbed 10 OWS Context JSON Interoperability ER
14-013r1	OGC Testbed 10 Service Integration ER
14-017	OGC Testbed 10 OWS Context in NIEM ER
14-028r1	OGC Testbed 10 Performance of OGC Services in the Cloud ER
14-058r1	OGC Testbed 10 GeoPackaging ER

The following software components were developed, deployed and used to test and demonstrate the results achieved in this thread.

Table 7, Open Mobility Software Components

Component	Participants
GeoPackage creator	CarbonProject, Cloudant, Compusult, Envitia, Luciad
GeoPackage client	Augmented Technology, Compusult, Envitia, Luciad
GeoPackage client with OWS Context	Augmented Technology, Envitia, Luciad
OWS Context Client	UAB CREAF
GeoPackaging WPS	Cloudant, Compusult, Envitia, Luciad
Cloud-based OGC service	Cubewerx, Geomatys/CNES, Terradue
Cloud infrastructure service	Amazon, GMU, Terradue