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Project Report

Innovation in OGC: The Interoperability Program

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Abstract: The OGC Interoperability Program is a source of innovation in the development of open standards. The approach to innovation is based on hands-on; collaborative engineering leading to more mature standards and implementations. The process of the Interoperability Program engages a community of sponsors and participants based on an economic model that benefits all involved. Each initiative begins with an innovative approach to identify interoperability needs followed by agile software development to advance the state of technology to the benefit of society. Over eighty initiatives have been conducted in the Interoperability Program since the breakthrough Web Mapping Testbed began the program in 1999. OGC standards that were initiated in Interoperability Program are the basis of two thirds of the certified compliant products.

Keywords: Open Geospatial Consortium (OGC); interoperability; standards; innovation; geospatial

1. Introduction

This paper describes the Open Geospatial Consortium (OGC) Interoperability Program (IP) [1]. OGC-IP is a unique process for creating innovative implementations and specifications that feed into the OGC consensus Standards Program [2,3]. OGC-IP combines innovation based on prototyping with more traditional standards-setting organizational activities. This paper provides data on the results of the approach that hands-on prototyping has had on the effectiveness of the consensus standards development process.

The paper is organized in the following sections:

- Innovation through collaborative prototyping:

Section 2 presents software and standards development concepts and practices that underlie the OGC-IP approach.

- OGC Interoperability Program Process:

Section 3 describes the policies and procedures defined for OGC-IP to link collaborative prototyping with standards development.

- History of OGC-IP Initiatives:

Section 4 presents data on the 85 OGC-IP initiatives that have been conducted beginning with the Web Mapping Testbed in 1999 and the OGC Testbed series.

- Assessing the Results of OGC-IP:

Section 5 assesses the result of OGC-IP activities from several perspectives including the effect on OGC Standards, maturing implementations in various communities, and assessing the results based on the approaches identified in Section 2.

- Continuing to innovate the process:

Section 6 describes how, based on the results to date, the OGC-IP process is being refined for future progress.

2. Innovation through Collaborative Prototyping

In 1999 the World Wide Web was changing how people worked, entertained themselves, and shared ideas. The OGC recognized it was vital to integrate maps and geospatial information with the emerging Web. The OGC also realized that creating a new generation of open standards to share maps and other information in the fast-paced environment of the Web would require more than traditional standards meetings and document writing. To rapidly deliver new candidate standards, the consortium considered several approaches in software development as the basis for OGC-IP.

Standard-setting organizations (SSO) typically play three roles: (1) identify alternatives to solve technological challenges; (2) motivate convergence when there are multiple perhaps conflicting solutions; and (3) regulate the behavior of members, e.g., ensuring that firms disclose relevant patents. The second role regarding convergence to consensus often determines the effectiveness of an SSO. [4].

To motivate the convergence of options, the Internet Engineering Task Force (IETF) emphasizes the value of running code. To reach the status of Draft Standard, IETF requires evidence of running code, with at least two independent and interoperable implementations. To become an Internet Standard, the IETF must determine that a specification has achieved “significant implementation and successful operational experience”. While the IETF occasionally organized “connect-a-thons” for interoperability testing, it does not provide any formal development support [5].

To motivate convergence based on multiple solutions, OGC-IP adopted the IETF emphasis on running code and, furthermore, established formal support for interoperability testing. The development approach was based on fostering multiple prototypes as an effective approach for innovation and the convergence of technology solutions. The efficacy of innovation through experimentation and prototyping is well known. "As a rule, the more prototypes and prototyping cycles per unit of time, the more technically polished the final product." [6]. Iterative software development processes (Figure 1) emphasize the need for multiple prototypes and extensive communications with the stakeholders. Iterative and independently developed prototypes are the core development concept of OGC-IP. A mantra that began in first OGC Web Mapping Testbed is "build a little, test a little, build a little more".

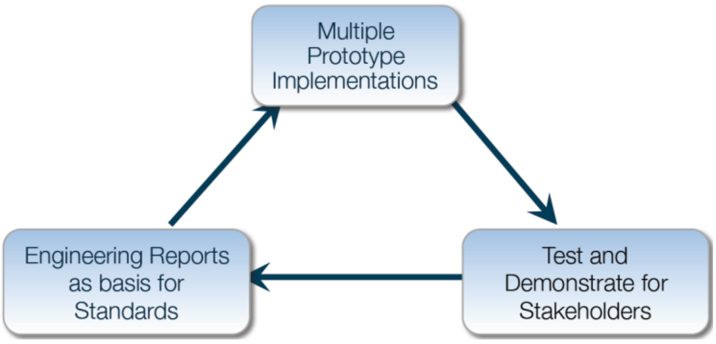

Figure 1. Iterative software development processes driving standards.

While agile development processes produce significant efficiencies [6], the role of documenting the approaches in specifications must also be considered. Boehm *et al.*, studied seven software teams working on the same problem. Four teams used a specification-driven approach and three used a prototyping approach. The main results of the experiment were (1) prototyping yielded products with roughly equivalent performance, but with about 40% less code and 45% less effort; (2) the prototyped products rated somewhat lower on functionality and robustness, but higher on ease of use and ease of learning; and (3) specifying produced more coherent designs and software that were easier to integrate [7]. In keeping with this study, the role of documentation while prototyping was embedded in the OGC-IP approach.

The last key consideration in the definition of OGC-IP was the bold economic step of engaging "sponsors" to provide small, but important, reimbursements to software developers to cover some of the costs of standing up live map and data servers around the world, documenting and demonstrating how they could work together in real-time. As the developers were already developing solutions the sponsor funding needed only to cover the costs of the collaborative project. This innovative "cost-sharing" approach was begun in the first Web Mapping Testbed (WMT) and brought a new level of agility to developing geospatial standards. Within a year, WMT evolved into OGC-IP, a hands-on engineering effort designed to change the way open standards were developed.

In summary, the themes introduced above regarding software development that underlay the concept of OGC-IP are:

- Innovation by convergence of alternatives is key to establishing standards.
- Innovation in software development is best achieved through rapid prototyping.

- A mix of prototyping and specifying is needed for evolution of standards.
- Collaborative development can be stimulated by linking sponsor requirements and cost share funding to software and specification development.

3. The OGC Interoperability Program Process

3.1. Standards Setting Organizations Run on Defined Processes

In order to perform the roles of an SSO, the founders of consortia must create a firm foundation intended to support robust development, consensus building, and eventual standards adoption by a wide community. Such a foundation must be tailored to the technology, the market, the participants, and all other important factors peculiar to the challenge at hand [8]. OGC-IP was defined through a set of defined policies and procedures that implemented the approaches described in the previous section. This section describes how OGC-IP was defined to unite users and industry in accelerating interface development and validation, and the delivery of interoperability to the market.

Prior to creating the OGC-IP, the OGC Standards Program produced standards based on a process focused on specification documents and little evidence of implementation. OGC-IP augmented the Standards Program with:

- A way to test interoperability concepts in working software, and gain consensus on key points of new standards by documenting what works.
- An iterative development environment to develop, test, and validate standards under real-world conditions.
- A setting that allows technology users and providers to work hands-on and collaboratively.
- Identification of new areas of development needed to meet market and policy requirements.
- An effective way to share the costs of developing well-crafted standards that provide concrete foundations for future enterprise architectures.
- A repeatable process for building & exercising private-public partnerships to
    - Accelerate development of emerging concepts.
    - Rapidly demonstrate new mission capabilities.
    - Drive global trends in technology and interoperability.

3.2. OGC-IP Policies and Procedures

The primary purpose of OGC-IP is to bring sponsors and participants together in rapid, hands-on, collaborative engineering efforts to achieve one or more of the following objectives:

- Produce and test candidate standards to advance geoprocessing interoperability.
- Perform research on the use of information technology regarding relevance and ability of standards to help solve geospatial interoperability problems.
- Develop and test prototype interoperable infrastructures based on OGC and related standards.
- Advance and demonstrate the maturity of interoperable implementations sufficient for organizations to base procurement decisions.

The policies and procedure of OGC-IP exist to provide guidelines for the successful completion of these objectives [9]. The policies and procedures use several strategies to identify emerging requirements and promote collaborative engineering. Figure 2 shows the process within an OGC-IP initiative. The steps in Figure 2 include overlapping activities and are completed within a time frame of several months.

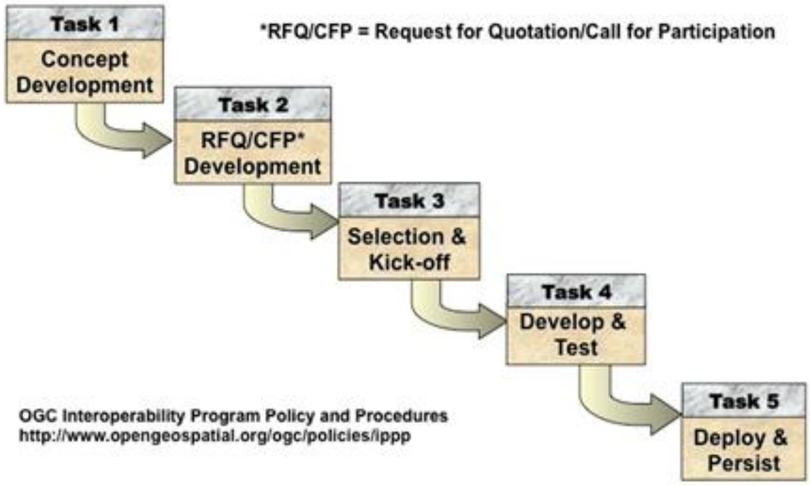

Figure 2. Developments within an OGC-IP Initiative (Source [9]).

The concept development process in Figure 2 is a critical to "finding" ideas that are explored in initiatives. OGC gets input from its own members via the standards program, from OGC members at the strategic levels, and from many liaisons with other organizations. This provides a rich balance between current/potential technology users and current/potential technology providers. Essentially, the process is a community-brainstorming event. The result is a set of requirements from sponsoring organizations—both government and commercial—that are used to develop a Request for Quotation/Call for Participation (RFQ/CFP) for the initiative.

Once emerging needs are identified, an RFQ/CFP is prepared and released to the public for the broadest opportunity for community engagement. The RFQ/CFP strategy emphasizes an inclusive approach when selecting participants.

The three development steps of Figure 2—kKickoff; Develop and Test; and Deploy and Persist—are the heart of the innovation process. Competitively-selected initiative participants are geospatial software developers who engage in rapid design/development cycles guided by the requirements of the sponsors. Depending on the technical maturity level of the initiative, the requirements may range from conducting experiments to define new standards to refining existing standards and implementation to the highest level of maturity. In general, the outcomes of these development steps are of three types:

1. Engineering reports, which may be draft standards intended to become standards or reports of testing results and conclusions. The reports also document ideas for further exploration. Change requests to existing standards are also created and entered in the OGC CR database.
2. Software implementations of OGC standards or draft standards to be used in debates that are settled using the approach of "interoperable running code wins."

3. Demonstrations of the software and standards in real world examples to show why the technology matters to end-users.

The OGC-IP development process (Figure 2) has been influenced by agile development processes but differs in several critical ways. The agile development manifesto emphasizes responding to change over following a plan: to plan in advance but when the plan goes out of date the plan should be disregarded [10]. The OGC-IP process emphasizes experimentation within the development sprint of a testbed followed by an updating of the technical specifications based on results of the testbed—a process labeled "evolutionary development" [11]. The results of each OGC testbed affect the OGC standards baseline as well as the plans for the next OGC-IP Testbed. (For more details see the evolutionary development process defined by OGC in the GEOSS Architecture Implementation Pilot [12].)

3.3. Technology Maturation Framework

In addition to a direct effect on the Standards Program, OGC-IP has extended its processes to promote the maturity of the implementation of OGC standards. In order to achieve this, OGC-IP came to define several types of initiatives focused on technology maturity levels: testbeds, experiments, pilots, plugfests, and OGC Network. The technology maturation approach of the Interoperability Program is shown in Figure 3. OGC conducts the various initiatives to move from experimentation with draft specifications in a testbed or interoperability experiment toward focused testing of adopted OGC standards by the community in a plugfest and the refinement of the specifications in near-operational environments in a pilot or in operational activities of the OGC Network. Testbeds typically address development at a technology readiness level of TRL 4 while pilots address TRL 7 [13].

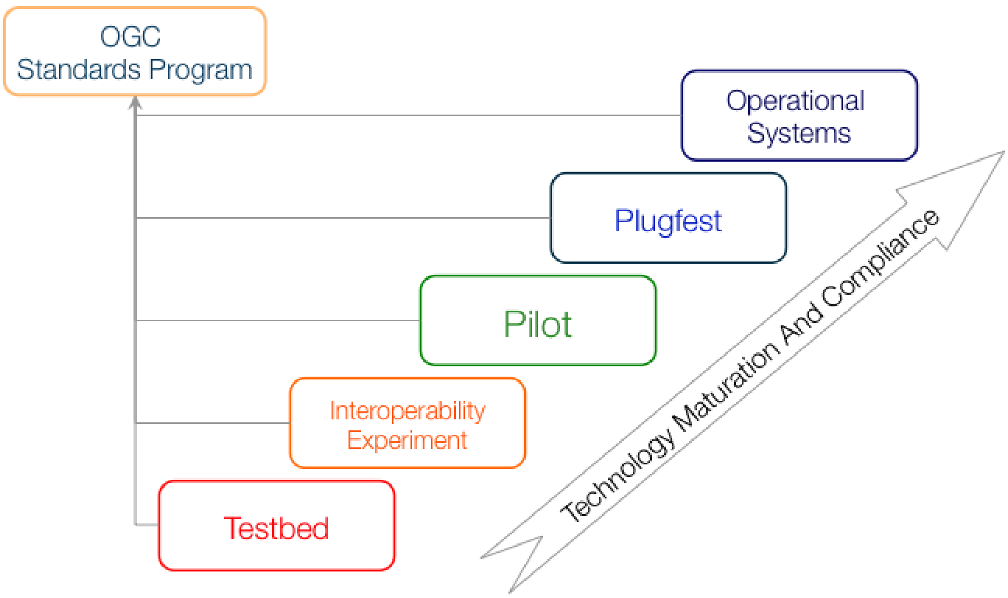

Figure 3. Increasing Technology Readiness in OGC-IP Initiatives.

Table 1 provides a definition for each type of initiative listed in Figure 3.

Table 1. OGC Interoperability Program Initiatives.

Initiative Type	Description of Initiative
Testbeds	A Testbed Initiative is a collaborative research and development effort to develop, architect, test, and demonstrate candidate standards for interoperability. A testbed can have a single sponsor, but ideally multiple sponsors will collaborate on a joint initiative that represents a set of their requirements and interests.
Interoperability Experiments	An Interoperability Experiment is managed and operated mostly by OGC member organizations focused on a specific area of refining the OGC technical baseline. The process is facilitated—not led—by an OGC staff person.
Pilots	A Pilot is a collaborative effort that applies technology elements from the OGC Technical Baseline and other (non-OGC) technologies to Sponsor scenarios. In practice, a Pilot is where an OGC standard—or set of OGC standards—can be "stress tested" based on real-world application and experience.
Plugfests	A Plugfest is an event where vendors cooperatively test (and possibly refine) their OGC-based products in a hands-on engineering setting. Plugfests are used to (1) assess the degree to which different products in the marketplace interoperate together based on their implementation of OGC standards; and (2) advance the interoperability of geospatial products and services based on OGC standards in general or within specific communities.
OGC Network™	The OGC Network is an online infrastructure of Internet-accessible, configuration-controlled components that implement OGC Standards. The OGC Network supports multiple communities of interest for research in geospatial interoperability and provides a persistent demonstration capability. OGC Network is a network of networks.

4. History of OGC-IP Initiatives

4.1. The First Web Mapping Testbed, September 1999—A Breakthrough Event

The first OGC-IP initiative in September 1999 was the "Web Mapping Testbed (WMT)". This first WMT was the source of what became the OGC/ISO Web Map Service (WMS) International Standard. WMS was a breakthrough in mapping for the early web. Another breakthrough was the testbed process itself. It yielded results in four months in comparison to prior typical timeframe of years to develop a standard. Uptake of WMS in the OGC SP was quick due to the process results. WMT became the basis for OGC-IP. The success of the WMT can be judged by understanding its role as a prototype for OGC-IP process with the community still referencing it 16 years later. Table 2 lists the number of each initiatives type conducted in OGC-IP since 1999.

Table 2. OGC Interoperability Program Initiatives: 1999 to 2014.

Interoperability Program Initiative Type	Instances of Initiative Type
Plugfests	4
Pilots	26
Interoperability Experiments	18
Testbeds	18
Concept Development	13
Support Services	6
Total number of OGC-IP Initiatives:	85

4.2. OGC Web Services Testbed Series

Driven by the WMT success, OGC has been annually conducting a major (virtual) testbed. These have been known as OGC Web Services (OWS) Testbeds. In 2014 the name was simplified to "OGC Testbed". Table 3 provides a summary of the history of OGC Testbeds. Details of the contents of each Testbed Thread can be found by examining the summary reports for each testbed posted as OGC engineering reports [14]. Note the breadth of the ideas and concepts explored and their diversity and how the testbeds build on the results of the previous Testbeds. Later it will be shown how pilots spin out the results of testbeds into communities.

Table 3. OGC Testbed Series.

Testbed	Comp Leted	Threads
OWS-1.1	2002	Common Architecture, Web Mapping, Sensor Web Enablement (SWE)
OWS-1.2	2003	Common Architecture, SWE, Image Handling, Feature Handling
OWS-2	2004	Common Architecture, Information Interoperability, Image Handling for Decision Support, OpenLS, Compliance Testing
OWS-3	2005	Common Architecture, SWE, Decision Support Services (DSS), Digital Rights Management (DRM), OpenLS
OWS-4	2007	SWE, Geospatial Processing Workflow (GPW), DSS, DRM, GIS/BIM, OpenLS
OWS-5	2008	SWE, GPW, Agile Geo, Compliance Testing
OWS-6	2009	SWE, GPW, DSS, Aviation, Compliance Testing
OWS-7	2010	Sensor Fusion Enablement (SFE), Feature and Decision Fusion (FDF), Aviation
OWS-8	2011	Observation Fusion, Feature Fusion, Aviation
OWS-9	2012	Aviation, Cross-Community Interoperability (CCI), Security and Services Interoperability (SSI), OWS Innovations, Compliance Testing
OGC Testbed 10	2014	Aviation, Open Mobility, Compliance Testing
OGC Testbed 11	2015	Urban Climate Resilience (UCR), Aviation, Geospatial extensions to NIEM, Compliance Testing
OGC Testbed 12		(Being planned as of July 2015)

The typical magnitude of recent Testbeds is indicated by these statistics from OGC Testbed 10:

- Forty software components (servers, clients, tools and other applications) were implemented and participated in interoperability testing.
- Nineteen engineering reports (ERs) were written. Testbed 10 ERs were either technical specifications or reports regarding testing and analysis.
    - Testbed 10 ERs were reviewed in the OGC Standards Program and have been posted for public release.
    - Change Requests were also identified and have been entered into OGC's public process for reporting such requests.
- Eleven Sponsoring organizations defined requirements for Testbed 10. The sponsors' requirements were captured in the RFQ/CFP document that was released by OGC seeking organizations that wished to participate in the Testbed.

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

Figure 4 provides a picture of the participants present at the kickoff event of the OWS-9 Testbed, May 2012. The picture includes many but not all of the individuals involved in the testbed.

Figure 4. OWS-9 Testbed Kickoff.

5. Assessing the Results of the OGC-IP

5.1. OGC Standards and OGC-IP Activity

So how can we assess the effectiveness of the OGC-IP? Has OGC-IP made a difference in the quantity and quality of standards adopted by the OGC consensus process? Were the approaches underlying the creation of OGC-IP (Section 2) demonstrated to be effective as anticipated? This section provides data from the multiple OGC-IP initiatives to assess these questions. Subsequent sections summarize in a more qualitative fashion the role of OGC-IP in maturing the implementations in two domains.

As of July 2015, OGC had approved 42 standards (not including extensions as separate standards) [15]. Of the 42 OGC standards, 32 have been analyzed, implemented, and tested as part of an OGC-IP Initiative. Of the 42 OGC standards, 14 originated in an OGC-IP initiative, meaning the first draft of the OGC standard was written as a report in an OGC-IP Initiative.

The 14 OGC Standards initiated in OGC-IP are

- Web Map Service (WMS)
- Web Map Tile Service (WMTS)
- Web Feature Service (WFS)
- Web Coverage Service (WCS)
- Web Coverage Processing Service (WCPS)
- Geography Markup Language (GML)
- Sensor Model Language (SensorML)
- Sensor Observation Service (SOS)
- Sensor Planning Service (SPS)

- OWS Context
- Styled Layer Descriptor (SLD) Profile of the WMS
- Symbology Encoding (SE)
- Filter Encoding
- GeoPackage

It is then useful to consider the implementation of OGC standards initiated in OGC-IP. Organizations can self-declare they have implemented an OGC standard and they can go further to certify their implementation as OGC® Compliant. Table 4 lists the number of self-declared implementations of OGC standards and the number of implementations certified as compliant.

Table 4. OGC Self-Claimed Implementations and Compliant Implementations.

	Implementing	Compliant
All OGC Standards	6653	784
14 OGC Standards Initiated in OGC-IP	5292	521
Percentage of all Implementations	80%	67%

Table 4 shows that the 14 OGC standards initiated in OGC-IP were the basis for 80% of the implementations and 67% of the compliant implementations of all OGC standards, or making this into a rough statement: one-third of OGC standards—those initiated in OGC-IP—account for two-thirds of the compliant products. These statistics indicate the additive value of the OGC-IP process towards implementations of OGC standards.

5.2. Maturing Technology: Sensor Web Enablement

Working with the OGC Standards Program, OGC-IP has contributed to the development and deployment of geospatial standards in general and their application to domains. Two specific examples are provided: Sensor Web Enablement (SWE) in this section and aviation in the next section. These examples show the how the maturation of technology from testbeds into pilots benefited the communities using the standards.

The OGC SWE suite of standards were developed and approved based on implementation and testing in OWS Testbeds one, three, and four. (Figure 5) OGC members adopted Version 1 of the SWE Standards in 2007 [16].

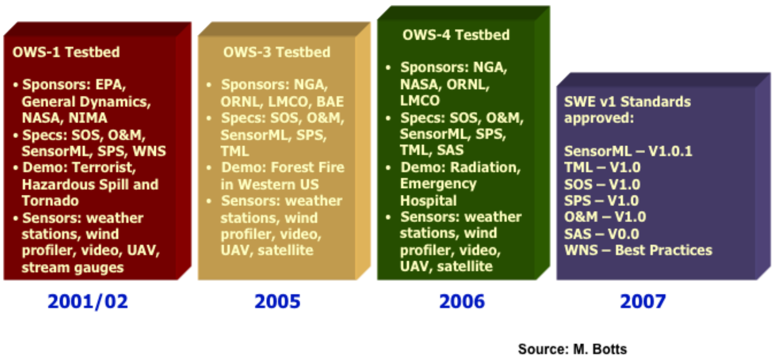

Figure 5. Development of Sensor Web Enablement in OGC Testbeds.

After SWE Version 1.0 was adopted as OGC Standards, the OGC-IP continued to aid the development and deployment in several domains: DoD, NOAA, and NASA (Figure 6). Each of the initiatives in the three domains matured the standards and provided best practices for the domain. For example, the Sensor Observation Service (SOS)—one of the SWE standards developed in earlier testbeds—became the main focus in the Ocean Science Interoperability Experiments (IE). As a result of the Ocean IEs NOAA deployed operational versions for SOS for the Integrated Ocean Observing System (IOOS). Similar developments of SWE for the Department of Defense/Intelligence Community and for NASA's EO-1 Satellite are described in a recent report that summarizes the technology maturation of SWE [7].

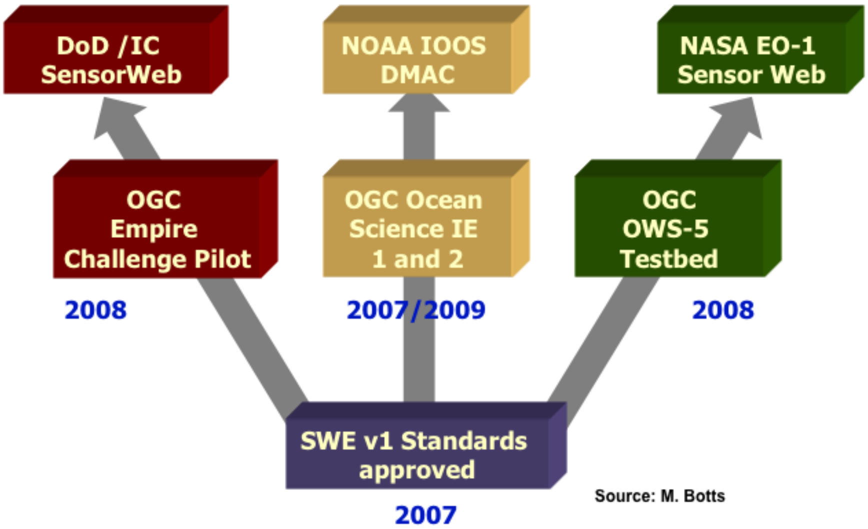

Figure 6. OGC-IP influence on SWE Deployments.

5.3. Maturing Technology: Aviation

The interoperability program delivered both innovation and quality at a critical transformational time in the aviation industry.

The modernization movement in the aviation information management domain has significantly benefited from OGC-IP activities. A transition to a net-centric, global interoperability management capability is at the core of this modernization, as defined in high profile initiatives such as the US NextGen and the European Union's Single European Sky ATM Research (SESAR) programs. To enable this transition, the US Federal Aviation Administration (FAA) and EUROCONTROL have introduced new global information exchange models for Aviation Weather and Flight information based on mature OGC standards.

The OGC standards application to aviation began with in 2009 with the OWS-6 Testbed and continued in each testbed following, as well as two additional initiatives as shown in Figure 7. For example the FAA's Special Access Airspace (SAA) Pilot deployed the architecture and standards used in OWS-6 and OWS-7 on FAA testing environment with the result being best practices for specific FAA needs.

The FAA and EUROCONTROL selected OGC-IP specifically as a venue to bring innovation into their conservative industry by actively engaging the wider geospatial industry (beyond just aviation) to support the operational use and validation of the emerging information exchange models. The OGC-IP has proved quite successful in accelerating the uptake of these models, and more specifically in demonstrating that standards-compliant commercial-off-the-shelf products can be quickly applied and adapted to meet the aviation domain requirements.

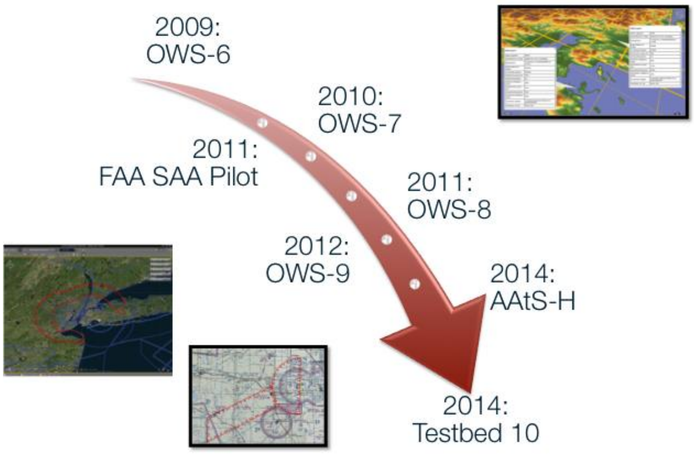

Figure 7. Aviation in OGC-IP.

On a more measurable level, the recommendations of each initiative shown in Figure 7 have been directly incorporated into newer versions of the aviation/weather/flight information models, and have been submitted for broader consideration to both the NextGen and SESAR System Wide Information Management (SWIM) modernization frameworks.

5.4. Benefits to Sponsors

The benefits to sponsors and participants from direct engagement in OGC-IP Initiatives are listed Figure 8. Sponsors realize a direct economic benefit as activity in an OGC initiative is ~2.5 times the sponsors funding.

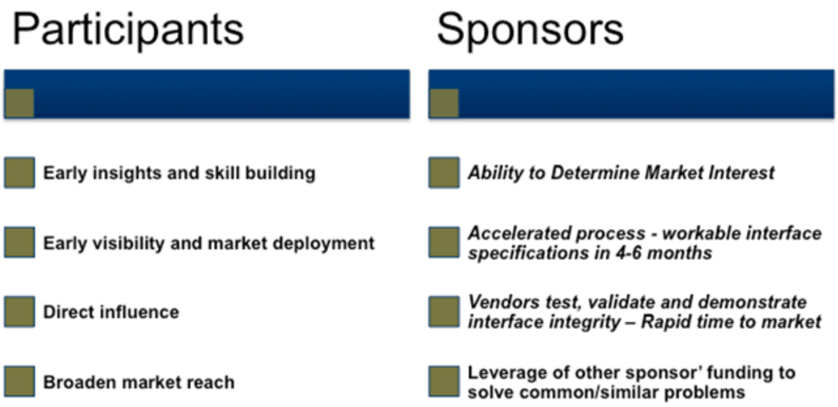

Figure 8. Roles within an OGC-IP Initiative.

The benefits of OGC-IP extend to the entire OGC membership and public through connection to the OGC Standards Program (Figure 9). The results of OGC-IP as shown in Figure 9 are prototype implementations and engineering reports (ERs). The OGC-IP ERs are considered in the OGC Standards Programs as input to existing standards or as the basis of new standards development. The OGC Standards Program has made the ERs public documents. The ERs are also the basis for new specification development or extensions in the Standards Program. Select ERs become the basis of a Standards Working Group in the OGC Standards Program.

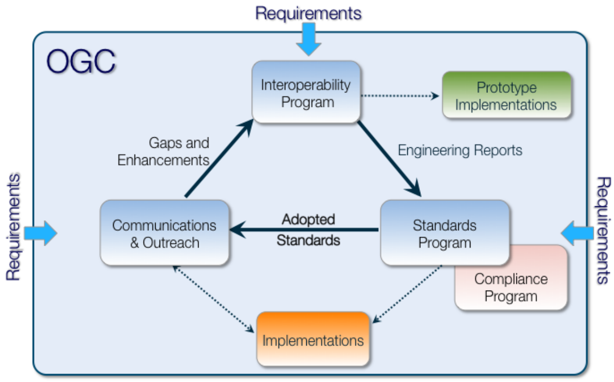

Figure 9. Interactions with OGC Programs.

5.5. Assessing OGC-IP Development Approaches

Section 2 concluded with a set of development approaches that underlie OGC-IP. Considering the earlier parts of this section, Table 5 addresses the outcomes of those approaches.

Table 5. Assessing OGC-IP Development Approaches.

Development Approach	Assessment
Innovation by convergence of alternatives is key to establishing standards	• Prior to OGC-IP OGC was adopting implementation standards at a rate of less than one per year. After the initiation of OGC-IP, 35 standards have been adopted in 15 years. • This leap in adoption rate was due to the convergence to consensus observed in the OGC standards program based on OGC-IP implementation.
Innovation in software development is best achieved through rapid prototyping	• With an emphasis on running code, OGC-IP achieved more rapid convergence to consensus around innovative solutions that the previous specification-only approach to standards adoption. • Standards-based implementation in the marketplace increased substantially after OGC-IP was operating. Implementation was stimulated by initial implementations and successful interoperability in OGC-IP. • One-third of OGC standards - those initiated in OGC-IP—account for 80% of the implementations and 67% of the compliant products.

Table 5. *Cont.*

Development Approach	Assessment
A mix of prototyping and specifying is needed for evolution of standards	• Specifications are the essential knowledge basis for open standards adoption. • Specifications are essential for independent development of interoperable implementations. • Specifying produced more coherent designs and software that was easier to integrate based on continued development in subsequent initiatives, e.g., Pilot initiatives
Collaborative development can be stimulated by linking sponsor requirements and cost share funding to prototype development.	• OGC-IP has maintained a 2.5-to-1 ratio of value of effort to sponsorship, due to the in-kind contributions of the participants. • OGC-IP is an effective economic model for collaborative development based on prototyping and open standards.

6. Continuing to Innovate the Process

As an innovation platform, OGC-IP will continue to innovate the process, in part by connecting with other revolutionary approaches that bring industry providers together to collaborate on solutions to problems.

The OGC-IP is working closer with other domain leaders on joint initiatives to share and cross-pollinate geospatial expertise with other traditional areas. For example, the OGC-IP is working closely with justice domain on several projects closely related to public safety and homeland security.

Just as OGC continues to mature OGC-IP also continues to seek new ways to better adapt to a changing world. First and foremost, OGC-IP has become more agile, and is evolving with the maturity of agile development. Interoperability experiments, pilots and plugfests allow for rapid sharing of technologies and ideas to forward the development of geospatial standards.

An OGC-IP pilot is where an OGC standard—or set of OGC standards—can be “stress tested” and perfected based on real-world application and experience. As a pilot is performed in the span of a few months, this method provides extremely quick feedback to the standards community of the maturity of the standards, and reveals any issues with standards.

The expanding use of plugfests is critical with the quickly changing application community. The plugfest quickly allows developers to assess the degree to which different products in the marketplace interoperate together based on their implementation of OGC standards. The United Kingdom Interoperability Assessment Plugfest in 2014 [17] is an excellent example of how quickly a plugfest can demonstrate the maturity of certain standards in use by the geospatial community, as well as what standards can use further refinement.

Interoperability experiments lend themselves to an agile development. As defined the in the OGC-IP Policies, “the IE must be ‘lightweight’ and must focus on a single interoperability issue”. This single focus lends itself to rapid, concentrated analysis of specific themes. As interoperability experiments are performed by members with no sponsor funding, there is no need to generate financial contracts to run the program. It is anticipated that interoperability experiments will become used more in the OGC to help facilitate and advance specific focus areas.

As the both the geospatial community and agile technologies change and mature over time, the interoperability program will continue to adapt and expand the types of interoperability initiatives.

7. Summary

Through fast-paced initiatives, OGC's Interoperability Program promotes rapid prototyping, testing and validation of standards. The OGC approach recognizes that development and management of prototypes provides for communications and progress in the development and evolution of OGC standards.

Global, innovative, hands-on rapid prototyping and testing program designed to unite users and industry in accelerating interface development and validation, and the delivery of interoperability to the market.

Initiatives are driven by geospatial interoperability requirements expressed as real-world scenarios, business cases, and applied research topics. This approach not only encourages rapid standards development, but also broadly involves technology providers to aid in determining the ability of emerging standards and industry technologies to meet these requirements.

OGC-IP initiatives have helped to shorten the timelines for standards development while reducing the overall risk that a standard will not meet the needs of the community (Figures 10 and 11). By applying proven, repeatable policies and procedures, the OGC has successfully conducted over 80 international testbed and pilot initiatives since 1999.

It is worth repeating the point about the participants' benefits here: they have been subsidized to do some research and development on new ideas and with the backing of the standards program, as well as the obvious interest from the sponsors, they have positioned themselves to go full speed after the testbed to move their components from prototypes to operational.

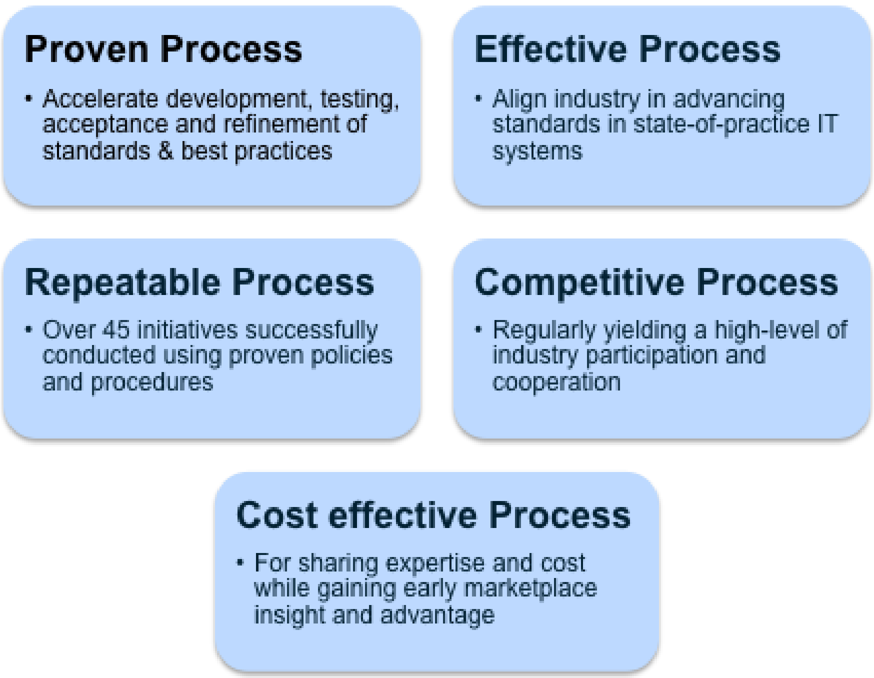

Figure 10. OGC-IP Advantages.

Figure 11. Ingredients for Success in OGC-IP.

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The OGC-IP would not have been possible without the sponsorship of over 30 organizations. Sponsors for each initiative are listed with the initiative summaries [1].

Countless numbers of organizations have been Participants in the Interoperability Program. Without the contributions made by Participating Organizations, the Testbeds would not have been possible.

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Author Contributions

George Percivall was the primary author of this article. Each of the co-authors—Terry Idol, Nadine Alameh and Jeff Harrison—contributed to the article on a roughly equal basis. All authors reviewed the final version of the article.

Conflicts of Interest

The authors declare no conflict of interest.

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