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► **To cite this version:**

Arne Berre, Sven Schade, Dumitru Roman. Environmental Infrastructures and Platforms with Citizens Observatories and Linked Open Data. Jiří Hřebíček; Gerald Schimak; Miroslav Kubásek; Andrea E. Rizzoli. 10th International Symposium on Environmental Software Systems (ISESS), Oct 2013, Neusiedl am See, Austria. Springer, IFIP Advances in Information and Communication Technology, AICT-413, pp.688-696, 2013, Environmental Software Systems. Fostering Information Sharing. <10.1007/978-3-642-41151-9\_65>. <hal-01457500>

**HAL Id: hal-01457500**

**<https://hal.inria.fr/hal-01457500>**

Submitted on 6 Feb 2017

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# Environmental Infrastructures and Platforms with Citizens Observatories and Linked Open Data

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**Abstract.** A number of past and current research and development projects aim to improve the sharing and use of environmental information. In 2010, the Environmental Infrastructures and Platforms (ENVIP) initiative was introduced as a means to identify the European potentials and specify common building blocks ('services and enablers') related to these projects. Work began with a set of projects supporting the Shared Environmental Information System (SEIS). This paper briefly summarizes the ongoing result collection and introduces the next wave of activities, which will follow two newly emerging trends: Citizens Observatories and Linked Open Data. We invite interested parties and project consortia to provide their contributions for future analysis and synergies through the CEN/TC287 TR 15449-2 Best practices registry and the ENVIP initiative.

**Keywords:** Environmental, Infrastructure, Platform, Architecture

## 1 Introduction

In the context of environmental systems, Information and Communication Technologies (ICT) have an essential role to play as they provide the necessary support in terms of tools, systems and protocols to establish a dynamic environmental space of collaboration in a more and more sophisticated digital world. Core challenges are not only related to providing seamless environmental data access to public authorities, businesses and the public at large, but also to allowing for interoperable environmental services based on Web technologies, and stimulating innovation and growth.

The Shared Environmental Information System (SEIS) [1] is one of three major initiatives along with the INSPIRE Directive [2] and the Global Monitoring for Environment and Security (Copernicus) [3] undertaken by Europe to collect and share environmental information for the benefit of the global society. Different efforts emerged towards the creation of infrastructures and platforms for Environmental Information Systems and Services – including a rich set of European research and development projects. Spatial data infrastructure (SDI) is a general term for the computerised environment for handling data that relates to a position on or near the surface of the earth. It may be defined in a range of ways, in different circumstances, from the local up to the global level.

In this context, the Environmental Infrastructures and Platforms (ENVIP) initiative [4-7] was introduced as a means to identify the European potentials, specify

common services and building blocks ('enablers') and their relations, and provide a framework to sustain the results of research and development projects that are usually funded for up to four years.

This position paper summarizes initial findings (Section 2), shows the recent structure of CEN/TC287 TR 15449-2 (Section 3), and points to upcoming areas with a new set of projects (Section 4). We conclude with an open invitation for further contributions (Section 5).

## 2 ENVIP Analysis of Past Research and Development Projects

A number of SEIS contributing projects have recently been completed. Some of the SEIS related projects under the environment topic have been investigated in previous ENVIP events, in particular at ENVIP'2010 [5-6] and at the ENVIP session during ISESS'2011 [7]. Table 1 shows the results from ENVIP'2010.

**Table 1.** ENVIP reference architecture contributions from ENVIP'2010

Project	Ontologies/domain models	(Service) discovery	(Service) Composition	Sensors access / streams	(Web) visualisation	Multilingualism	Transformation/mapping	Standards contributions	Security
TATOO	X	X			X	X			
PESCADO		X	X		X				
UncertWeb		X	X					X	
SUDPLAN			X		X				
HYDROSYS				X	X				
NETMAR	X	X	X		X	X	X		
OEPI	X	X	X				X		
GENESI-DEC	X	X	X		X				X
LARKC				X				X	
ENVISION	X	X	X	X	X	X	X	X	
DIADEM	X		X		X		X		

The ENVIP'2010 workshop analysed a number of projects that were presented (Tatoo [8], PESCADO [9], UncertWeb [10], SUDPLAN [11], HYDROSYS [12], NETMAR [13], OEPI [14], GENESI-DEC [15], LARKC [16], ENVISION [17] and DIADEM

[18], with respect to the their use and contributions of technologies to the areas of ontology models, service discovery and composition, sensor usage, visualisation, multi language support, transformation/mapping technologies, planned standards contributions and security.

**Table 2.** ENVIP reference architecture contributions from ISESS'2011

Project	Reference Architectures	Semantic Annotation, Ontologies & Publication	Resource discovery	(Data, Service and Model ) Composition	Sensors and Observation Web	(Web) visualization and Portals	Context and Multilingualism	Security, Trust, Privacy
TATOO	X	X	X			X		
PESCADO	X		X	X		X		
SUDPLAN	X			X		X		
data.reglee. Info	X	X	X					
SA-DEM	X							
GENESIS	X	X	X	X		X		X
GS-SOIL	X	X					X	
ENVISION	X	X	X	X	X	X	X	
DIADEM	X	X		X		X		
CryoLand	X			X				
RBIS	X			X				
ENVIROFI	X		X	X	X	X	X	X

The ENVIP session at ISESS'2011 [7] adopted some of the analysis structure from ENVIP'2010 by starting the creation of a reference architecture, extending to broader resource discovery, and composition. At ISESS'2011 some of the projects from ENVIP'2010 presented their further progress, and in addition a number of new projects were presented, in particular data.reglee [19], SA-DEM [20], GENESIS [21], GS-SOIL [22], CryoLand [23], RBIS [24] and ENVIROFI [25-26].

The ENVIROFI project has also extended work on the reference model and on the further identification of specific environmental enablers and generic enablers as reported in the paper [27] at ISESS'2013.

A next step is now the more detailed analysis of the actual results from the various projects, where the CEN/TC287 TR 154449-2 Best practices foundation for this is presented in the next section.

### **3 A structure for SDI best practices – CEN/TC287 TR 15449-2**

A recent activity in CEN/TC287 [33] has aimed at creating a foundation for the development of SDIs, including a collection of best practices and results from recent SDI related projects and activities, through the creation of the technical report TR 15449 Spatial Data Infrastructures, with five different parts.

The intended readership of this Technical Report are those people who are responsible for creating frameworks for SDIs, experts contributing to INSPIRE, experts in information and communication technologies and e-government that need to familiarize themselves with geographic information and SDI concepts, and standards developers and writers.

The CEN/TR 15449 parts on Geographic Information – Spatial data infrastructures consists of five parts: part 1: Reference model – providing a foundation for SDI and the other parts, part 2: Best practices – collecting results from recent European projects, part 3: Data centric view – providing guidelines on data specifications for an SDI, part 4: Service centric view – providing guidelines on service specifications for an SDI, and part 5: Validation and Testing – supporting validation and testing for the data and services of an SDI.

The part 2 “Best practices” is aimed at collection of best practices results from recent and ongoing projects in particular for projects in the frame of the European Union funding programmes. Experiences from ENVIP were used as input to the creation of the TR 15449-1 Reference model, and the corresponding best practices structure in TR 15449-2. This part of the technical report provides best practices regarding Spatial Data Infrastructures (SDIs), referencing to the outcomes of the projects in the frame of the European Union funding programmes. It summarizes the deliverables of projects, structured according to the reference model defined in part 1, to be made available in an on-line repository where the relevant outcomes are collected and classified in order to provide a structured sets of recommendations for implementing SDIs at the European, national and sub-national level. The outcomes delivered by these relevant practices are collected into a document registry available through the CEN/TC287 web site.

The following table shows the structure for capturing various elements of project results related to various dimensions, such as the provisioning of SDI reference model components, the support for the various phases of an SDI, and the services from the architectural service reference model, (derived from the ISO/TC211 ISO 19119 service taxonomy).

**Table 3.** TR 15449-2 template for recording best practices project results

<i>Project</i>	<i>Name</i>	
<i>Relevant classification</i>	<i>SDI reference model components</i>	<input type="checkbox"/> Data <input type="checkbox"/> Register <input type="checkbox"/> Discovery <input type="checkbox"/> View <input type="checkbox"/> Invoke <input type="checkbox"/> Download <input type="checkbox"/> GeoRM <input type="checkbox"/> Orchestration and Composition
	<i>Phases of an SDI</i>	<input type="checkbox"/> Concept and design <input type="checkbox"/> Implementation <input type="checkbox"/> Validation
	<i>Architectural reference model services</i>	<input type="checkbox"/> Human Interaction Services <input type="checkbox"/> Model Management Services <input type="checkbox"/> Workflow/Task Services <input type="checkbox"/> System Management Services <input type="checkbox"/> Processing Services <input type="checkbox"/> Communication Services
	<i>Project document type</i>	<input type="checkbox"/> Standards <input type="checkbox"/> Specifications <input type="checkbox"/> Technical reports <input type="checkbox"/> Guidelines
	<i>Free Keywords</i>	
<i>Relevant outcomes</i>		

Finalised and ongoing projects and activities are now encouraged to make their relevant deliverables and results available through the CEN/TC287 Best practices project registry. Information about how to do this can be found on the CEN/TC287 website [33].

#### 4 ENVIP Evolution

A number of the initial projects and activities that contributed to ENVIP have now finished, while new projects are emerging, and the next step is to analyse which of the results that should be captured as best practices to be used by other projects and activities in the future, and potentially also fed into future standardisation activities. We are now encouraging these projects to provide their best practices input to the CEN/TC287 best practices collection activity and to support further elaboration of the usability of results through the ENVIP community.

There are two major trends that also will influence the future evolution of ENVIP. Firstly, user contributed content and citizen science with crowd sourcing and volunteered geographic information (VGI) has gained major attention over the last few years. Secondly, the request for ‘raw data now’ and for the combination of data from various sources, has resulted in an immense interest and activity in Linked Open Data.

The remainder of this section describes these areas and identify some on-going projects of interest. It is the intention to update and complement the services and ena-

blers that now are being collected from the last four years of SEIS related projects, in order to complete the picture of emerging Environmental Infrastructures and Platforms and to make diverse research results better accessible and comparable.

#### **4.1 The raise of Citizens' Observatories**

The European Commission recently funded a total of five Citizens' Observatories Projects under the topic "Developing community-based environmental monitoring and information systems, using innovative and novel earth observation applications". All are tasked to develop highly innovative technologies, while each project addresses a particular domain and selected locations in and beyond Europe and connections with international standardization organizations, such as CEN/TC287, ISO/TC211, OGC, INSPIRE and GEOSS are foreseen.

The following five projects received funding by the European FP7 for Research, under the Environment theme of the Cooperation Specific Programme CITI-SENSE Development of Sensor-based Citizens' Observatory Community for Improving Quality of Life in Cities [34], WeSenseIt Citizen Observatory of Water [35], COBWEB Citizen Observatory Web [36], Citclops Citizens' Observatory for Coast and Ocean Optical Monitoring [37], OMNISCIENTIS Odour Monitoring and Information System based on Citizen and Technology Innovative Sensors [38]. These activities are complemented by two COST actions. "Mapping and the citizen sensor" [39]: Which focuses on the rise of citizen sensors e.g. volunteers contributing information from remote devices, and its potential to radically change mapping, and "ENERGIC" [40] a European Network Exploring Research into Geospatial Information Crowdsourcing: software and methodologies for harnessing geographic information from the crowd.

The five projects of the environment topic, together with the two COST actions, will design, develop and test a new environmental information system founded on the concept of the citizens' observatories that will help to empower citizens allowing them to influence in the environmental governance processes, as well provide models for decision-makers that facilitate connections between environmental governance, global policy objectives and citizens' needs.

It is assumed that these projects can take advantage of previous developed environmental infrastructures and platforms, as well as provide further input to these, in particular related to the areas of mobile computing, offline support and user interaction.

#### **4.2 The Use of Linked Open Data**

The European Commission recently funded a number of projects related to the use of Linked Open data in combination with geospatial and environmental information, and also a set of upcoming projects focused on publication and consumption of open data. Linked Open Data is becoming a source of unprecedented visibility for environmental data that is expected to enable the generation of new businesses as well as a significant advance for research in the environmental area.

The following projects has received funding by the European FP7 for Research, under the Environment theme of the Cooperation Specific Programme: GeoKnow - Geospatial Data and the Semantic Web [41], Linked Geo Data [42] and SmartOpenData

[43]. Such projects will provide advances in publication and consumption of existing environmental data, with a focus on how Linked Open Data technologies can be applied generally to spatial data resource and specifically to public open data portals, GEOSS Data-CORE, GMES, INSPIRE and voluntary data (OpenStreetMap, GEP-WIKI, etc.), and how it can impact on the economic and sustainability progress in environment research.

Addressing environmental geospatial data management based on LOD will require harmonization of geospatial metadata (ISO19115/19119 based) with principles of Semantic Web, provisioning of spatial data fusion introducing principles of Open Linked Data, improvement of spatial data visualisation of Geospatial Open Linked Data and publication of the resulting information according to user requirements and Linked Open Data principles to provide new opportunities for research and business.

Wide applicability of LOD in the environmental geospatial domain will have to be complemented by adoption of new standards covering alignment and compatibility of semantic technologies, geospatial data interoperability, new RDF-based vocabularies for integrated location description and Open Data Quality, Certification and Reputation. This work will require semantic harmonisation of different datasets of INSPIRE -INSPIRE compliance doesn't guarantee harmonisation-, GEOSS and GMES and should be consistent with the ISO/TC 211 standards.

## 5 Conclusions and Outlook

A broader initiative has been started for the further identification of services and architectural components through the ENVIP community [6] and the CEN/TC287 TR 15449-2 SDI Best practices [12].

The objective is that recently finished and ongoing projects and initiatives around SDI can contribute with their results and best practices to the various architectural elements of an SDI, including the experiences from the use of various geospatial and IT based standards. With an expansion in new projects for citizen observatories and Linked Open Data it is seen that these projects can benefit from the best practices of the recent activities, as well as contribute with new potentially shared services. This will also serve as a foundation for change requests for existing standards and for potentially new standard through the collaboration with CEN/TC287, OGC, ISO/TC211, GEOSS and INSPIRE.

For an optimal evolution from past to present projects we encourage project consortia for these projects, as well as other organizations working on related topics, to contribute their relevant results to the CEN/TC287 TR 15449-2 Best practices registry and to join the ENVIP initiative at [www.envip.eu](http://www.envip.eu) for the further analysis and synergies of the results. The ENVIP'2013 workshop session during ISESS'2013 has aimed at a further refinement of the ENVIP reference architecture and also continued the reporting and analysis of emerging project results, including reports from emerging projects in the areas of Citizens observatories and Linked Open Environmental data.

**Acknowledgments.** We thank the initial contributors to the ENVIP community for their foundation for the work, and for the partners in the supporting projects ENVISION (FP7- 249120), ENVIROFI (FP7 – 284898) and CITI-SENSE (FP7-



308524) for their further input. This position paper is based on the ENVIP community activities, extended from previous work in various European research projects and also from standardisation work in the context of ISO/TC211, CEN/TC287, OGC and OMG.

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