3.1 Publishable summary

Project context and objectives

Lots of Earth Observation (EO) data has become available at no charge in Europe and the US recently and there is a strong push for **more open EO data**. For example, a recent paper on Landsat data use and charges by the US National Geospatial Advisory Committee – Landsat Advisory Group starts with the following overarching recommendation: "Landsat data must continue to be distributed at no cost". Similarly, the five ESA Sentinel satellites that would soon go into orbit, starting with Sentinel-1 that has already been launched on 3 April, 2014, have already adopted a fully open and free data access policy. In the same spirit, the Autumn 2012 edition of the newsletter of the European Association of Remote Sensing Companies makes the case for a free and open data policy for GMES, arguing that this will fuel the development of the geo-information services industry, and as a result, bring maximum economic benefit to Europe.

Open EO data that are currently made available by space agencies such as ESA and NASA are **not following the linked data paradigm**. Therefore, from the perspective of a user, the EO data and other kinds of geospatial data necessary to satisfy his or her information need can only be found in **different data silos**, where each silo may contain only part of the needed data. **Opening up these silos** by publishing their contents as RDF and **interlinking them with semantic connections** will allow the **development of data analytics applications** with great environmental and financial value.

The ICT STREP project TELEIOS (http://www.earthobservatory.eu/), coordinated by the University of Athens, is the first project internationally that has introduced the linked data paradigm to the EO domain, and developed prototype applications that are based on transforming EO products into RDF, and combining them with linked geospatial data. Examples of such applications include wildfire monitoring and burnt scar mapping, semantic catalogues for EO archives, and rapid mapping. The wildfire monitoring application is available on the Web (http://papos.space.noa.gr/fend_static/) and has been used operationally by government agencies in Greece in the summer fires of 2012. Recently, it has also been awarded 3rd place in the Semantic Web Challenge.

TELEIOS concentrates on developing data models, query languages, scalable query evaluation techniques, and efficient data management systems that can be used to prototype applications of linked EO data. However, developing a methodology and related software tools that support the whole lifecycle of linked open EO data (e.g., publishing, interlinking, quality assuring etc.) has **not** been tackled by TELEIOS.

Concept, main objective and partners of LEO
The main objective of LEO is to go beyond TELEIOS by **designing and implementing software supporting the whole life cycle of linked open EO data and its combination with linked geospatial data**, and by **developing a precision farming application** that heavily utilizes such data. To help **European enterprises acquire the competences and resources needed** to develop innovative data analytics services based on linked open EO data, LEO brings together the two core academic partners of TELEIOS (UoA and CWI), two SMEs and one industrial partner with lots of experience with EO data and their applications (SA, VISTA and PCA).

The **detailed scientific and technical objectives** of LEO are the following:

1. To develop **publishing tools** that transform open EO data and metadata, made available by space agencies such as ESA and NASA, from their standard formats into RDF and make it available on the Web of data.
2. To develop **publishing tools** that transform open geospatial data and metadata from their standard formats into RDF and make it available on the Web of data. Open geospatial data (e.g., digital maps, administrative data, environmental data, etc.) are typically used together with EO data in applications such as precision farming and are made available by public agencies as well (e.g., the Bavarian Topographical Survey for our precision farming application).

3. To develop **tools that interlink open EO data sources and geospatial data sources** published as RDF on the Web.
4. To develop **tools for cross-platform searching, browsing and visualization** of linked EO data and linked geospatial data.
5. To demonstrate the value of the developed tools by:
    a. Performing **large-scale publication and linking of open EO data** from the GMES data warehouse managed by ESA, and relevant geospatial datasets made available by other public bodies in Europe.
    b. Developing a **precision farming application** that shows how geo-information services based on linked open EO data, linked geospatial data and specialized algorithms can contribute to an environmentally friendly increase in the efficiency of agricultural production.

The above objectives are fully in line with the topics addressed by **Theme (c) "Software components and intuitive end user applications based on reuse of open data"** of Objective ICT-2013.4.3.

Measures of success
We will measure the success of LEO technologies in two ways: (i) by carrying out **large-scale** publication, interlinking and deployment of linked open EO data and geospatial data and (ii) by **having the precision farming application evaluated** by selected user groups to ascertain its economic and environmental value.

Expected final results

The expected scientific and technological results of LEO are the following:

1. A detailed specification of the linked EO data life cycle
2. Publication of various EO and geospatial data as linked data (e.g., OpenStreetMap data and Natura 2000 of Bavaria-Germany available in http://datahub.io/organization/leo, etc.)
3. The publishing tool GeoTriples that takes as input vector or raster EO data and geospatial data available in some well-known formats and transform it into RDF
4. An extension of the tool Silk for interlinking open EO data and geospatial data
5. The tools LEO Data Search Engine and LEODroid for searching and browsing linked EO data and geospatial data
6. The tool Sextant for browsing and visualization of linked EO data and geospatial data
7. The LEO software stack integrating the above tools and others produced by the partners in earlier projects (e.g., TELEIOS)
8. The precision farming application LEOpatra

Impact of final results

We expect that the open source LEO software stack to be delivered will be undertaken by many developers in Europe, since no such tools for linked open EO data exist at the moment, and related tools for linked geospatial data are very rudimentary. The activities of WP1, WP5 and WP7 have helped disseminate these tools to stakeholders from EO organizations, government agencies with open data responsibilities, SMEs and e-agriculture software providers.

The WP1 collaboration with ESA through the 2014 workshop "Linked Open EO data and Open Search" and the development of the FedEO demo for ESA using LEO technologies, have disseminated these technologies to ESA and the Copernicus programme of the European Commission.

The open EO and geospatial data that have been made available as linked open data in WP5 are targeted to the precision farming application, but they can also be reused by other relevant applications such as land management. The linked data that we published is available in the datahub portal (http://datahub.io/organization/leo). The datasets published are OpenStreetMap data on waterbodies in Germany, the Administrative Units of Germany, the Natura 2000 of Bavaria-Germany and the Sentinel-2 metadata.. To aid reuse, the generated linked data are also available for querying via a SPARQL endpoint at http://data.linkedeodata.eu/LEO/

Finally, LEO has developed the mobile precision farming application LEOpatra which concentrates on fertilization and makes use of satellite images and linked open geospatial data. E-agriculture and especially the use of remote sensing, GPS, geospatial and mobile technologies in agriculture, is an important area of research and development internationally and has been supported actively by ESA, Copernicus, FAO and other relevant agencies. In Europe, the current reform proposals for the Common Agricultural Policy towards 2020 have set specific objectives such as viable food production, sustainable management of natural resources and climate action, and balanced territorial development. These objectives are addressed by the precision farming application of WP5.

LEO also contributes indirectly to the GEO work program as articulated in "GEO 2012-2015 WORK PLAN". We mention especially the tasks:

- Advances in Life-cycle Data Management. The work on linked Earth Observation data as presented in the IIM 2014 paper by Manolis Koubarakis
- Advancing GEOSS Data Sharing Principles
- Global Agricultural Monitoring and Early Warning

Project public website

The public website of LEO can be found at http://www.linkedeodata.eu/. The website reflects the public image of the project through a clean functional design, and provides up-to-date information about the progress of the project.