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Preparations for Sentinel-2 in Europe: workshop summary

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Invitation

EuroSDR, Norway Digital and Norwegian Space Centre invites you to the workshop "Preparations for Sentinel 2 in Europe". The workshop will take place in Oslo 25th and 26th November at the premises of the Norwegian Space Centre.

Objectives and background

The main objective is to initiate contact and collaboration among national agencies (or project groups) in Europe responsible for preparing or providing support and services to national users of satellite images, with special focus on Sentinel-2 and Landsat.

ESA plans to launch Sentinel 2A in 2015 and 2B in 2016/17. When the two planned Sentinel-2 satellites (optical satellites with 10, 20 and 60 m res.) are both operational, areas in Europe will be covered every 5 days. Due to increasing overlap with latitude, actual frequency of coverage will be even greater.

The high frequency of image acquisition and the free of charge data policy for Sentinel-2 will probably change how satellite data are used. Today's single scene oriented use will probably shift more and more to use of satellite image time series (i.e. image stacks or data cubes). Correspondingly, focus will shift from analysis of spatial structures based on single date datasets to analysis of spatio-temporal structures in dynamic scenes based on image stacks. This development will put high demands on data processing capacity as data volumes will increase greatly. Time series of images require that high standards are met in the pre-processing steps.

In Norway, a working group within Norway Digital has conducted a survey to identify preparations that are needed to support operational services based on data from Sentinel-2. The report is available on their website.

We assume similar preparations are being made throughout Europe, and we think it is a good idea to arrange a workshop to discuss common challenges. That is the main reason why we invite to the workshop.

The workshop will be free of charge, coffee breaks and lunch both days included.

Deadline for registration: 1. November 2014

Maximum number of participants: 40

Program committee

Arnt Kristian Gjertsen, Norwegian Forest and Landscape Institute

Clement Mallet, IGN France

Guro Dahle Strøm, Norwegian Space Centre

Jon Arne Trollvik, Norwegian Mapping Authority, Chair EuroSDR Commission 3, Production systems and processes

Agenda

Title	Preparations for Sentinel-2 in Europe
Objective	Initiate contact and collaboration among national agencies (or project groups) in Europe responsible for either preparing and providing satellite data, or preparing support and services to national users of satellite images, with special focus on Sentinel-2 and Landsat 8.
Goal	Share experiences and knowledge gained in the preparations for Sentinel-2 in each country; identify common challenges and discuss possible solutions; identify fields of possible cooperation.
Preparation	How are the preparations for Sentinel-2 organized in your country and what is the current status? How is the production flow designed, from data input to user products?
Venue	Premises of the Norwegian Space Centre, Oslo, Norway 6th floor, Drammensveien 165, 0277 Oslo (http://www.romsenter.no/eng).
Dates	November 25 and 26, 2014
	Day 1
11:30 – 12:30	Registration and lunch
12:30 – 12:45	Welcome address by programme committee.
12:45 – 13:15	<i>Invited speaker 1 (Bianca Hoersch, ESA):</i> ESA's current plans for the Sentinel-2 mission: products, global DEM, collaborative ground segments, toolbox development, cooperation with USGS, inter-calibration of Sentinel-2 MSI and Landsat 8 OLI sensors, etc.
13:15 – 13:35	<i>Invited speaker 2 (Tobias Storch, EOC, DLR):</i> An example of an operational national satellite centre in Germany. What is critical for a successful service?
13:35 – 13:50	Coffee break
13:50 – 14:10	<i>Invited speaker 3 (Marc Leroy, CNES):</i> An example of an operational national satellite centre in France (THEIA). What is critical for a successful service?
14:10 – 14:30	<i>Invited speaker 4 (Norbert Pfeifer, TU Vienna):</i> Earth Observation Data Centre (EODC), a solution for collaborative exploitation of Sentinel data. What is needed to provide flexibility of services to the users?
14:30 – 14:45	Presenting headlines to be discussed by the participants during the break-out session. Participants are split into working groups. Facilitator and referent for each group are selected by the groups. <ul style="list-style-type: none"> 1. How are the preparations for Sentinel-2 organized in the different countries and what is the current status? How is the production flow designed, from data input to user products? Cooperation among countries to put up services? 2. Requirements on functionality of the system and services provided to the users (temporal composites (every 4 weeks, 2 weeks, etc.), spatial mosaics, support for time series and change detection, cloud/shadow detection, support for user defined/developed processing algorithms, subscription of export jobs, etc.), how fast should products be ready?, interoperability with Landsat 8 and other optical sensors?; 3. Requirements on a data archive. What data should be archived in addition to ESAs archive? All acquisitions, all with cloud cover < X%, the whole year or a limited season, all levels produced or only level 1B, metadata; country by country archive?
14:30 – 16:30	Break-out session 1. All headlines 1 to 3 are discussed in each group. The groups

	<p>minute the discussions on posters to be presented by one member during the following wrap-up session. The content of the posters are included in the minutes of the workshop.</p> <p>Keynotes move between groups to aid in the discussions.</p>
16:30 – 17:30	Wrap-up session 1 where the posters are presented. Followed by round-the-table discussion.
20:00	Get-together dinner (no host). Address: Café Skansen, Rådhusgata 32, 0151 Oslo (http://www.cafeskansen.no/)
	Day 2
08:30 – 08:45	Coffee
08:45 – 08:50	Welcome address for the second day
08:50 – 09:35	Invited speaker 5 (<i>Ferran Gascon, ESA</i>): Methods and tools for automatic ortho-rectification and automatic atmospheric correction at ESA's processing centre. What is available for the users and how will ESA process from level 1B to 1C?
09:35 – 10:20	Invited speaker 6 (<i>Marc Leroy, CNES</i>): Methods and tools for automatic ortho-rectification and automatic atmospheric correction (MACCS) at THEIA processing centre. What is available for the users and collaborative ground segments (CGSs)? How will THEIA process from level 1B to 1C?
10:20 – 10:50	Invited speaker 7 (<i>Kai Sørensen, NIVA and Carsten Brockmann, Brockmann Consults</i>): Pre-processing requirements for coastal and water applications.
10:50 – 11:05	Coffee
11:05 – 11:20	<p>Presenting headlines to be discussed by the participants during the break-out session. Participants are split into working groups. Facilitator and referent for each group are selected by the groups.</p> <ol style="list-style-type: none"> 4. Requirements on a data management system (data store and management, data organization, tiling of images according to a national grid, e.g. 100 x 100 km tiles, etc.); 5. Requirements on ortho-rectification. How can an automated ortho-rectification using a national DEM best be performed? Is the global DEM ESA will use of sufficient quality or do we need to use a national DEM?; and 6. Requirements on atmospheric correction. How can an automated atmospheric correction of Sentinel-2 and Landsat 8 datasets best be performed? How to address possible needs for cross calibration of sensors?
11:20 – 12:15	<p>Break-out session 2. All headlines 4 to 6 are discussed in each group. The groups minute the discussions on posters to be presented by one member during the following wrap-up session. The content of the posters are included in the minutes of the workshop.</p> <p>Keynotes move between groups to aid in the discussions.</p>
12:15 – 13:00	Lunch in the canteen
13:15 – 13:45	Break-out session 2 continues
13:45 – 14:45	Wrap-up session 2 where the posters are presented. Followed by round-the-table discussion.
14:45 – 15:00	Closing session with summary of all the sessions of the workshop and finally recommendations of the workshop. Future collaboration between participating countries? Do we need follow-up workshops?

List of participants

Last_name	First_name	Company	Country
Brockmann	Carsten	Brockmann Consult	Germany
Broge	Niels	Danish Geodata Agency	Denmark
Bruton	Ciaran	Ordnance Survey Ireland	Ireland
Bye	Bente Lilja	BLB	Norway
Cantou	Jean-Philippe	IGN France	France
Cerdeira	Cecilia	Plan- og bygninsetaten - Oslo kommune	Norway
Danielsen	Johan	Norwegian Environment Agency	Norway
Dehls	John	Geological Survey of Norway	Norway
Dick	Øystein	Geomatics section, IMT - NMBU	Norway
Edgardh	Lars	Spacemetric AB	Sweden
Ferbar	Michaela	Plan- og bygningsetaten	Norway
Gascon	Ferran	ESA	Italy
Gjertsen	Arnt Kristian	Norwegian Forest and Landscape Institute	Norway
Groesz	Floris	Blom Geomatics	Norway
Grud	Kristoffer	Norsk Romsenter	Norway
Hanssen	Frank	NINA	Norway
Heilimo	Jyri	Finnish Meteorological Institute	Finland
Heisig	Holger	swisstopo - Swiss Federal Institute for Topography	Switzerland
Herland	Einar-Arne	Norwegian Space Centre	Norway
Hoersch	Bianca	ESA	Italy
Hovenbitzer	Michael	Federal Agency for Cartography and Geodesy	Germany
Iwanoczko	Andrew	Exelis VIS	United Kingdom
Jökulsson	Guðmundur	KSAT	Norway
Karlsen	Thomas	Lantmäteriet	Sweden
Kastdalen	Leif	Environmental Analysis	Norway
Korsnes	Andreas	Norwegian Mapping Authority	Norway
Ledang	Anna Birgitta	Norwegian Institute for Water Research (NIVA)	Norway
Leroy	Marc	CNES	France
Lonar Barth	Vigdis	Norwegian Space Centre	Norway
Mallet	Clement	IGN	France
Moldestad	Dag Anders	Norwegian Space Centre	Norway
Nesje	Øystein	Ministry of Climate and Environment	Norway
Nilsson	Mats	Swedish University of Agricultural Sciences	Sweden
Persson	Anders	Swedish Forest Agency	Sweden
Pfeifer	Norbert	Vienna University of Technology, Department of Geodesy and Geoinformation	Austria
Rosengren	Mats	Metria	Sweden
Storch	Tobias	DLR (German Aerospace Center), EOC (Earth Observation Center)	Germany
Strøm	Guro Dahle	Norwegian Space Centre	Norway
Støver	Stein H.	KSAT	Norway

Last_name	First_name	Company	Country
Sørensen	Kai	NIVA	Norway
Trollvik	Jon Arne	Norwegian Mapping Authority	Norway
Wenneberg	Sandra	Swedish Environmental Protection Agency	Sweden
Åswärn	Dag	Spacemetric	Sweden

Photos



Participants of the workshop. Photo: Jon Arne Trollvik



Ferran Gascon, ESA during his presentation. Photo: Arnt Kr Gjertsen



Marc Leroy, CNES during his presentation. Photo: Arnt Kr Gjertsen



Kai Sørensen, NIVA during his presentation. Photo: Arnt Kr Gjertsen



Carsten Brockmann, Brockmann Consult during his presentation. Photo: Arnt Kr Gjertsen

Workshop summary

The summary is partly based on the presentations and on the outcomes of discussions in the working groups.

Q1: Preparations for S2 organised in the different countries

France – has an operational national satellite data centre called THEIA. THEIA is the national collaborative ground segment (CGS) for Sentinel-2 (S-2) data. Plateforme d'Exploitation des Produits Sentinelles (PEPS) will be the mirror site for S-2 data and will also store global data for France. THEIA produces land cover maps every year, up to now based on Landsat and SPOT data. There is a strong interest from scientist for S-2 data.

Germany – DLR contains a processing centre for earth observation (EO) data. A CGS for S-1, S-2, and S-3 is currently under establishing. Ideally this will contain a global archive (including processing capabilities) and with near real time (NRT) services for marine applications. There will be a tender including a national rolling archive for S-1, S-2, and S-3 for Germany soon. Germany is funding for a national program for environmental and security services based on EO data. Federal agencies are encouraged to use EO data. PlanetDEM, based on SRTM, is considered as sufficient for German areas.

Sweden – is currently investigation the user needs and discussions are ongoing on how to finance a CGS and national processing centre. The set-up of a mirror site for Sentinel data coordinated by the Swedish Space Board is one likely option. Use of best available digital elevation model (DEM) is seen to be critical, and the needs are probably similar to that of Norway.

Denmark – has established a user group aimed to advice the Copernicus user forum. Key questions are need for a mirror site, funding of the infrastructure, who are the stakeholders. How far will the ESA hub provide for the identified user needs? The potential is large regarding Greenland, but we are aware of possible problems with inaccurate DEM for ortho-rectified products. Several national institutions are potential users of S-2 data.

Finland – has established a CGS for S-1 data and covers Finland and the whole Baltic basin. Real time (RT) sea-ice monitoring was the driving force. Procurement is ongoing and a system shall be in place in May 2015. A CGS for S-1, S-2, S-3, and 5P is planned and will be hosted by the Finnish Meteorological institute (FMI).

UK – the Satellite Applications Catapult is an independent innovation and technology company to foster growth across the economy through the exploitation of space. Based in Oxford, England, it was established in May 2013, by Innovate UK (former Technology Strategy Board) as one of seven centres of excellence (<https://www.catapult.org.uk/#>) to accelerate the take-up of emerging technologies and drive economic growth.

The Satellite Applications Catapult shall be a Data Hub carrying a rolling holding of S-1, S-2 and S-3 data. There is a commercial-grade ESA-funded long-term archive storage facility in place – based in Farnborough, UK. It is anticipated that the Farnborough Archive facility shall principally be accessed

by commercial users, but this does not preclude access for government, research and academic applications.

Ireland – awareness is high among current users of satellite images. The Ordnance Survey uses airborne data but is investigating future use of S-2 and Landsat data to complement airborne data.

Switzerland – is not a member of Copernicus and has at the moment no plans for a CGS. There is a lack of demand for products based on EO data. Switzerland has a full coverage with aerial photographs every 3 years with 25 and 50 cm resolution. A user survey has been conducted. The Swiss Space Office the coordinator of EO activities.

Austria – has made an initiative for a new model on cooperation in earth observation with the Earth Observation Data Centre (EODC). EODC is in development and is a solution for collaborative exploitation of Sentinel data. It is basically a bottom-up initiative with top-down guidance. EODC was first proposed by an Austrian EO expert and supported by ESA and Austrian Aeronautics and Space Agency. EODC will act as a community facilitator and will work together with its partners from science, the public and the private sectors in order to foster the use of EO data for monitoring of water and land.

Norway – has established a CGS for S-1 data and work is ongoing to establish a CGS for S-2. Norway Digital (NSDI) has working group to explore the national user needs. Two reports have been published (in 2012 and 2014). Norway is a member of Copernicus. It is still unclear how S-2 CGS will be funded. Norway has signed an agreement with ESA for a mirror site for Sentinel data. Testing of interfaces for near real time (NRT) use of S-1 data will start soon, with marine applications and landslides. An optical satellite data centre is planned to enable easy user access to S-2 data. Products to be archived are still to be defined. Cooperation with other Nordic countries to establish services can be a good idea. Norwegian Mapping Authority is aiming to take a central role regarding archiving and distribution of Copernicus data.

Q2: Requirements on functionalities

The data volume from S-2 will be very large and much larger than users are used to handle. One 100 km x 100 km tile of level 1C data will weigh ~500 MB and data transfer will require large data bandwidth. Transfer of several gigabytes of data over Internet will be slow. It is therefore recommended to bring software and algorithms to the data, as it will be much easier to transfer the final products to the users because data volume will be much smaller. The data centers should provide an API for the users to develop their applications on the server side and to take advantage of on-the fly processing.

The baseline for a CGS service is a mirror of ESA products. The mirror archives should have a rolling archive that store data on-line longer than ESA is planning (ESA's data hub has a rolling archive with two months of data) and store all older data in an off-line archive. Online accessibility of data is critical. Availability of data within one day is probably sufficient for most users, but for disaster management faster access will be need.

Temporal composites are demanded with a service that gives monthly composites. Also time series data are demanded. However, most users lack competence to preprocess and use time-series data

and needs expert support. Cloud and cloud shadow detection are crucial for these services and need to be part of the pre-processing.

Ideally, level 2A (atmospheric correction) and time composites (level 3) should be Copernicus services, but the national CGSs must provide these product levels if ESA is not providing them.

Interoperability with Landsat 8 raises a question on the DEMs used by USGS and ESA. Currently, they plan to use different DEMs and this will cause some alignment problems, especially in rough terrain. It would be an advantage that all data are ortho-rectified with the same DEM.

The functionality should allow users to define batch jobs, e.g. advance export jobs for future acquisitions.

Q3: Requirements on archive

Is it sufficient to store level 1B? If there is a reprocessing of level 1B by ESA, how will the data be distributed to replace existing archives of level 1B data? Or would it be better to distribute level 1A/level 0 plus software and auxiliary data to the national CGSs? Then, when ESA provides updated algorithms the CGSs can reprocess the archived data.

National processing centres should concentrate on the products generated by them and archive these data. Archiving encompass not only physical storage, but also the scientific expertise (stewardship). Temporal composites should be archived because the demand for such data is likely to be high.

It should be a mechanism to get large volume of data from ESAs long term archive. This will be important when a user needs data from an area not covered by the national data archive.

Important questions are how one can repatriate global data from a national mirror site and how to grab data not in my national portal? There is a concern about becoming of data outside of Europe.

Several participants commented that national mirror sites are contradictory to the idea behind Inspire.

Q4: Data management

Should the production be systematic (robust, every day) or only made on user demand? A systematic approach puts less demand on the data store, i.e. file system vs. data cube. An example of a data cube approach is the Australian Data Cube.

Storage organized in tiles of 100 km x 100 km in a national grid seems to be a good solution. The internal data format may be different from the user product format (e.g. GeoTIFF, netCDF). It is a good idea to complement with other sensors, e.g. Landsat 8, on the same grid and store image data together with metadata. This is essential for e.g. geographic search to find the data subset the user asks for. This requires an indexed system to find pixels inside a user defined AOI, and is the basis for advanced uses such as time series and change detection.

Q5: Orthorectification

ESA is planning to use PlanetDEM 90 for orthorectification from level 1B to level 1C. PlanetDEM 90 is based on SRTM 90m (3-arc second international dataset) and is an enhanced version where voids

have been eliminated. For higher latitudes north of 60° N, outside the coverage of SRTM, the dataset has been complemented with other sources. Instead of GTOPO30, with the very coarse 30-arc second resolution, PlanetDEM 90 has used Russian maps at 1:100,000 and 1:200,000 scales for high latitudes in North Scandinavia and Danish 1:250,000–1:500,000 geological maps for Greenland. In addition to orthorectification, PlanetDEM 90 will be used for slope correction in atmospheric corrections.

The orthorectification to level 1C will do a good job for many countries, but not for all. The target geometric accuracy is 12.5 m for geo location and 0.3 pixels for multi-temporal registration, which makes the product very good for many applications. However, in rugged terrain it is expected that the resolution and accuracy of PlanetDEM 90 will be insufficient. It is therefore recommended that an effort is undertaken to identify more suitable elevation data for these areas. A question was raised on how to guarantee international compatibility if national DEMs are used and how to deal with international border areas?

A coordinated approach from the Nordic countries is encouraged. This will require clearly expressed needs from the users and technical and management aspects need to be resolved. One possibility is that the Nordic countries produce a 30 m DEM and allow PlanetDEM to incorporate it. The Nordic countries may write a joint letter to ESA that expresses a demand for equal quality for high latitudes areas above 60° N as for the rest of Europe.

EuroDEM, owned by EuroGeographic, is a possible generic solution. EuroDEM is a pan-European height dataset consisting of regularly distributed terrain points at 2-arc second resolution (approx. 60 m). It was produced using the existing official national height databases in a cooperation with the mapping and cadastral agencies in Europe. For areas where no DEM could be delivered, SRTM 90m was used to complement the dataset.

Landsat 8 data should ideally be orthorectified using the same DEM as for S-2. This will make data fusion easier. It will then be necessary to acquire Landsat 8 data in sensor geometry, i.e. in a product level similar to S-2 1B.

Q6: Atmospheric correction

Atmospheric correction (AC) is a support activity for deriving the final products, and is especially important for change detection, time series, and temporal composites. ESA will provide a toolbox for the users that can produce level 2A from level 1C. The tool will be called SEN2COR and is based on ATCOR, software developed by DLR. The French satellite data centre, Theia, is using a different approach based on MACCS, software developed by CNES. MACCS and ATCOR differ in that MACCS has a multi-temporal approach using several acquisitions taken within short time intervals to determine the aerosol content in the atmosphere. The basic idea is that surface reflectance changes slowly while aerosol properties changes quickly with time. ATCOR uses a mono-temporal approach and use the dense dark vegetation method to estimate aerosol content. Both approaches have their merits. CNES and DLR are discussing possibilities to merge the two methods into a single unified approach. MACCS works for Landsat 8 with 16-day time interval and would work even better with S-2 data with 3- to 5-day time interval.

Over land and water AC methods have different requirements, strengths and weaknesses. Over water AC is more difficult and needs special treatment. Thus, it should be possible to apply two different approaches, one for land and one for coastal areas and inland waters, or maybe both in an ensemble approach. AC in northern latitudes also requires special treatment because of aerosols, topographic, and adjacency effects. If a DLR/CNES solution is adopted, it should address the issues of land/water and high latitudes.

Cross-calibration of Landsat 8 and S-2 is a science topic. We need to test S-2 data to see whether vicarious system calibration with in-situ instrumentation is necessary.

It will be difficult for non-experts to use the toolbox and tune the processes, and it will be necessary to have default parameters for all areas world-wide.

Workshop recommendations

1. Orthorectification with PlanetDEM 90 will do a good job for most of Europe but not for all areas. Areas with rough topography and high latitudes need a DEM with better quality. Nordic countries with high latitudes north of 60 degrees have common interest in an improved DEM for these areas. A common initiative towards ESA to solve this issue is recommended.
2. It is recommended that Landsat 8 data is orthorectified using the same DEM as for S-2 in order to fuse the datasets.
3. Atmospheric correction over land and water and high latitudes has different requirements. The solution adopted by ESA should address this issue and allow for special treatments according to area and user demands.
4. The mirror sites are recommended to archive level 1B and process level 1C and 2A, either systematic or on-demand. However, it should be considered to archive level 1A instead of 1B. If there is a reprocessing of level 1B by ESA, it might be more efficient that the mirror sites reprocess from 1A to 1B instead of downloading 1B again.
5. International collaboration to build up data centres should be considered. It would possibly be more cost efficient and give higher quality and a common standard of services. We must identify similarities in needs between countries and areas for possible collaboration. EODC is an example of an initiative to foster international cooperation.
6. Data volume from S-2 will be very large. It is recommended to bring algorithms and SW to the data (server side) instead of data to the SW (user side). On the fly-processing will demand more from the data store than systematic processing (i.e. data cube vs. file system). The French Theia is an example of a national data centre that has taken a systematic approach to processing.
7. A workshop at this level was welcomed and several participants proposed a follow-up workshop in one year time to report national status, progress, and discuss common challenges.