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Analysis of a common satellite data infrastructure

The Agency for Data Supply and Efficiency & The Danish Meteorological Institute

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Front page photo: Photo of Denmark, May 27th 2017, recorded by the OLCI-instrument on board the Sentinel-3A satellite. The photo has been downloaded from the Copernicus Open Access Hub [scihub.copernicus.eu]. Copyrights: European Space Agency – ESA.

Management summary

Background and purpose of the analysis

Implementation of the EU's earth observation programme, Copernicus, and the growing range of satellite-based observations of the earth offered by organisations such as ESA[1], EUMETSAT[2], national space agencies, e.g. NASA [3] and JAXA[4] and a number of commercial data providers open up new opportunities for growth in the Danish space sector in the years to come. Satellite-based earth observations are used to monitor and examine changes in the ground surface, e.g. the Defence Command Denmark's handling of coastal and border control, studies of growth conditions for agricultural crops or research projects on the dynamics of the inland ice.

Previous studies show how the use of satellite data in new areas may lead to quality improvements and innovation in the public sector, research institutions and private sector companies. In the study "The Danish Space Economy 2016"[5], Rambøll estimates the total socioeconomic potential in Denmark of the Copernicus satellites to be DKK 7.5 billion towards 2030. The potential covers a variety of categories that can be divided into three groups: Streamlining national politics, European and national policy development, and global policy development.

However, no studies have yet been conducted on the socioeconomic potential of improved access to and use of satellite data-based earth observations by Danish users. At the same time, it remains unknown which barriers that currently prevent existing and potential users from increasing or commencing their use of satellite-based earth observations.

We expect that by coordinating the collection and processing of data as well as providing easier access and deliver data in useful formats, the duplication of work among public authorities and research institutions may be reduced and the potential of utilizing satellite data spread out to multiple potential users. We even expect that increased access to data will lead to efficiency and quality improvements in the public sector and may result in lower product development prices for private companies, enabling them to allocate resources to the development of new products and services.

The assumed gain potential forms the basis of this study, which uses Denmark's national space strategy from June 2016 as a starting point. Annual revenue for space activities in Denmark is estimated at DKK 4.4 billion in 2016, of which 90% of the space sector revenue is attributed to the downstream area[6], expecting

1 European Space Agency

2 European Organisation for the Exploitation of Meteorological Satellites

3 National Aeronautics & Space Administration

4 Japan Aerospace eXploration Agency

5 https://ufm.dk/en/publications/2016/the-danish-space-economy-2016

6 Denmark's national space strategy, 2016, p. 8, the Danish Government

continued growth within this area[7]. Thus, taking the above into account, it is relevant to investigate growth opportunities in the area[8] of satellite-based earth observations categorised as being downstream.

The purpose of this analysis is to provide an overview of what value easier *access* to satellite data will have to users. Easy and targeted access to relevant satellite data is an important precondition of realising the above mentioned large socio-economic gain potential.

The valuation of easier access to satellite data is based on the users' current known needs. This is a rather conservative approach given that the use of satellite data is still a specialised niche area. It is expected that satellite data will be used in more areas and in more processes in the future.

Although the approach is conservative, the analysis shows that the value of easier access to satellite data – taking the users' current known needs into consideration – is positive. The underlying assumption for this positive business case is that, the opportunities of the European Commission's coming initiative for setting up a future European satellite data infrastructure will be utilised – referring to the so-called DIAS centres. These centres will make it significantly easier to access Copernicus data. The initiative is called the Copernicus Data and Information Access Services (DIAS) and is, according to plan, to be established in the first six months of 2018. In combination with the utilisation of the possibilities related to DIAS, the possibility of a Danish access point could entail a so-called "hybrid solution" – which broadly supports Danish users' needs and which forms the basis of the positive business case.

The hybrid solution is based on DIAS with a Danish front-end solution and possible reuse of parts from existing infrastructure of other member countries. Denmark may reuse a number of existing solutions, which in combination will take Danish users' needs into account without requiring extensive resources for a complex and time-consuming establishment project. A front-end solution will also ensure the development of skills in terms of providing guidelines on access to and knowledge of satellite data as well as the ability to analyse new cross-organisational needs. A hybrid solution can be put into service within a relatively short time frame and, at the same time, the establishment and operating costs can be kept at a relatively low level.

It is still too early to conclude whether DIAS will be able to replace existing national solutions and become the future infrastructure in Denmark, covering the needs of all Danish users for other satellite data than the Copernicus data (Sentinel data). Thus, Danish authorities are encouraged to stay updated on the deliveries of the DIAS centres and on this basis consider establishing the hybrid solution.

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7 The Rambøll report "Analyse- og evidensgrundlag for rumområdet i Danmark" ("Analysis and evidence base for the area of space in Denmark"), May 2016 - Ramboll, contains a relatively detailed description of what Danish users use satellite-based earth observations for today. "Rummet kalder Jorden" ("Space is calling earth"), the Technical University of Denmark (DTU) and CenSec, 2014, describe the potential for Danish public authorities of using satellite data.

8 The downstream area of the space sector consists of processes, services and data that use the information collected in space by satellites. There are three satellite types relevant to the downstream area: Earth observations, navigation and satellite communication. This analysis only concerns the downstream area and is limited to processing earth observation data. 'Earth observation data' means data taken from earth observation satellites, and information and services resulting from satellite data, for example the six Copernicus services used for understanding changes to the earth's surface over time. Other forms of satellite data from the navigation and communication area are therefore not covered by our study.

Experience from neighbouring countries as well as international and commercial solutions

When the potential gain of the Danish space sector is to be analysed, it is essential to consider the current development of satellite data distribution taking place in neighbouring countries, international organisations and in the commercial market.

Denmark has no common satellite data infrastructure, and Danish users retrieve data according to ability and need through different providers, including ESA's Sci-Hub, international organisations and/or commercial providers. Several neighbouring countries already have common satellite data infrastructures in operation that were established as Collaborative Ground Segments (CollGS) in cooperation with ESA. ESA is a separate data infrastructure that distributes satellite data and services from Copernicus and ensuring the archiving and processing of data.

Through the analysis, experience and recommendations were gained from European countries which today have CollGS solutions. Through interviews with authorities in Germany, Finland, Sweden and Greece, it became clear that all countries are ready to cooperate with the Danish authorities and recommend the reuse of existing data infrastructure solutions and that user needs are mapped in depth before a solution is found. In addition, all CollGS countries mention that training of users is crucial and more important than the establishment of a common data infrastructure, according to the German space authorities. Moreover, Danish authorities are encouraged to keep up with what the DIAS centres will deliver, and then consider constructing a front-end for DIAS which will satisfy and support the needs of Danish users.

It is still too early to conclude whether DIAS will be able to replace existing national solutions and become the future infrastructure in Denmark, fulfilling the need of all Danish users for other satellite data than the Copernicus data (sentinel data). The reason for the uncertainty is among other things that it remains unknown what other types of free data from e.g. USGS and NASA that will be released on DIAS, in what format, and to what extent. When it comes to the development of services and use of processor power, DIAS will become available on commercial conditions. Another commercial market is that for satellite data infrastructure in which in particular Amazon, Airbus and Digital Globe are strong players.

Analysis approach and methodology

The purpose of the analysis is to:

1. Map current and potential use of satellite data
2. Map current resource consumption and market size
3. Map technical needs and barriers, including analysis of national and international infrastructure solutions
4. Determine the socioeconomic potential of improved data access, governance considerations and business case for the establishment of a data infrastructure.

Through steps 1-3, it will be possible to identify which features and contents a data infrastructure solution must have, in order to be able to realize the potential of improved access for Danish users. On the basis of the identified needs and a number of score criteria, the most appropriate type of satellite data infrastruc-

ture will be selected. A business case will subsequently be prepared with the purpose of identifying the socioeconomic potential and costs associated with the establishment of the selected satellite data infrastructure. The study involves Danish users who for analysis purposes have been divided into three user types - companies, public authorities and research institutions.

The analysis is conducted through;

- Interviews with Danish key users at public authorities, private companies and research institutions
- A questionnaire-based survey among current and potential users
- Interviews with representatives from countries that have already established a data infrastructure solution
- User statistics on downloads via Sentinel Sci-Hub; similarly, the Copernicus committee has been interviewed.

The current use of satellite data among Danish users

The results of the analysis show that the current use of satellite data is in particular within agriculture, fisheries, forestry, as well as the environment, air and pollution. Research institutes, for instance, use satellite data for mapping the inland ice and climate change and for research into the desertification of the Sahara. Public authority use has primarily been centred around a few governmental authorities, which, however, all use satellite data to a large extent. The use of satellite data among regions and municipalities remains relatively limited, although there are examples of municipalities that use satellite data to identify invasive species, map urban environments and adapt to climate change. Private companies, use satellite data for example, for monitoring and planning of activities in the field, and consulting engineer companies use high-resolution data from satellites for topographic mapping in connection with construction work.

For all three user groups, satellite data on Denmark constitute the greatest geographical scope, followed by Greenland and the Faroe Islands, and the other Nordic countries. Research institutions and private companies, however, also use satellite data across the rest of the world - for example, a consulting engineering company uses satellite data on parts of Africa in connection with the construction of railways on behalf of the World Bank.

All three user groups use satellite data for research, monitoring, visualisation and thematic mapping, and the majority of respondents will have access to data via international public sector organisations as well as to a lesser extent through commercial data providers. In addition, private companies also use international cloud service providers such as Amazon and Google.

The satellite data most used by all three groups is freely accessible optical satellite images with a level of detail which is better than 30 metres, e.g. Sentinel 2, Landsat and freely accessible radar satellite images, e.g. Sentinel 1.

The majority of the companies and research institutions surveyed either handle all satellite data tasks or receive pre-processed data (where clouds and elements disturbing the atmosphere have been removed)

from a supplier and subsequently perform analyses and interpretation of data. The public authorities have generally been divided into two groups: one group that processes data or asks an external supplier to process data, but performs analyses and interpretation of data, and one group that receives interpreted and analysed data from a supplier.

Use potential of facilitating easy access to satellite data

The respondents were presented with a scenario of a future data infrastructure which will facilitate access to satellite data. On the basis of this, they were asked to consider a number of potential areas as a result of easier access to the data infrastructure. Respondents among private companies in particular see a potential in using satellite data within water supply, sewerage and waste handling as well as the sea and the Arctic. Most of the private companies see the potential in developing existing and new 0products and adding value to existing products. Public authorities see a potential in using satellite data for the environment, air and pollution as well as water supply, construction and transport. The majority of the public authorities see the potential in using satellite data for new work areas, increasing quality in their performance of existing tasks and solving their tasks more effectively. Research institutes see a potential in improving the quality of education and in being able to launch research projects more easily.

Mapping of the current time spent on satellite data-related tasks

To examine the amount of time spent by current users on satellite data tasks, respondents were asked to state how large a share of total time spent by employees in their organisation was spent on satellite data-related tasks. Subsequently, they were asked to indicate how the time spent by their employees may be divided into the following sub-processes:

- Data collection
- Data processing
- Analysis
- Development of algorithms
- Administration in relation to data purchasing
- Operation and maintenance of own IT infrastructure for satellite data
- Other tasks related to satellite data

These data made it possible to calculate time spent by the employees in question on satellite data-related tasks on an annual basis, and the resource consumption in the form of payroll costs, assuming an average annual salary of DKK 800,000, and a 37-hour working week, corresponding to 1,600 annual hours of work.

The results showed that public authorities are spending approximately DKK 173 million annually on satellite data-related tasks; private companies use approx. DKK 22 million, and research institutions are spending approximately DKK 193 million. The total time related to the use of satellite data across the three user groups corresponds to approx. DKK 388 million a year which equals 485 full-time equivalents.

Results of the mapping of existing barriers

All three user groups indicate a barrier in the form of lack of access to technical solutions that ease access to satellite data and facilitate the use of data. Most public authorities responding to the survey indicate that the lack of knowledge about potential application and how to gain access to satellite data constitutes a barrier to the use of satellite data to support their tasks. A large part of the private companies currently not using satellite data also state that lack of knowledge about access to data is a barrier. In general, research institutes find that they face few barriers, but do, however, indicate that the lack of employees with the right skills is a barrier to increasing the use of satellite data.

Results of the mapping of technical needs and barriers

Research institutions are looking for an infrastructure that can deliver raw satellite data. In addition, they want a data infrastructure that also posts historical data, pre-processed data and services. This is also demanded by public authorities for whom access to raw satellite data is a requirement. Private companies express different needs for a future infrastructure, but they predominantly express a need for an infrastructure with raw and pre-processed satellite data. All three user groups indicate a need for an infrastructure which guarantees a high service reliability as well as data-coverage over Greenland.

The results indicate that a Danish satellite data infrastructure could be established as a hybrid solution based on DIAS

On the basis of the analyses conducted, the results indicate that establishment of a hybrid solution meet Danish user needs better than the development of a unique Danish infrastructure. The hybrid solution is based on DIAS with a Danish front-end solution and possible reuse of parts of another member country's existing infrastructure. The motive for the scenario is that Denmark may reuse a number of existing solutions, which in combination will take into account Danish users' needs without requiring extensive resources for a complex and time-consuming establishment project. A hybrid solution could be put into service within a relatively short time frame and, at the same time, the establishment and operating costs could be kept at a relatively low level.

According to plan, DIAS is expected to be ready for commissioning in the first half of 2018 and will presumably cover most of the requirements of Danish users in terms of access to free satellite data, including Copernicus data - and probably EUMESAT/ECWMF data. This is the reason why the hybrid solution uses DIAS as the foundation for a Danish infrastructure. In order to meet the need of Danish users for knowledge and information about satellite data, for technical and application purposes it could be an option to re-use one of Denmark's existing public data infrastructures as a front-end towards users.

A positive business case, but uncertainties do exist

The business case analyses the direct gain opportunities in relation to the processes of working with satellite data. Calculated by applying the Danish state's business case method; the business case shows that the establishment of the hybrid solution involves a gain potential. Overall, the total gain potential for 2022 - when the full potential has been realized - is estimated at DKK 40.5 million or 50.6 full-time equivalents for the current users per year. This corresponds to a 10.4% reduction of the operating costs for the current users. Operating costs for the actual hybrid solution are expected to be DKK 3 million in 2022. Overall, the

potential gain amounts to approx. DKK 37.5 million (see table 1). In addition, project costs total DKK 14 million, distributed as DKK 0.13 million for the idea phase, DKK 3.6 million for the analysis phase, DKK 6.2 million for the procurement phase and DKK 4.1 million for the implementation phase. The full potential contains the potential of each of the three user types: public authorities, research institutions and private companies.

Table 1:Potential gain, full-time equivalent and the potential gain percentage (the difference in percentage terms between the operating costs in scenarios 0 and 1 in 2022)

	Potential gain (mio. DKK)	Full-time equivalents (number of FTEs)	Potential gain (%)
Private companies	2.4	3.0	11.1
Public authorities	5.7	7,1	3.3
Research institutions	32.4	40.5	16.8
Total	**40.5**	**50.6**	**10.4**
Operating costs for hybrid solution	-3		
Potential gain less operating expenses	**37.5**	**46.9**	**9.7**

The potential gain should be seen as a range of possible outcomes where DKK 40.5 million is the full gain potential, provided that users are not able to reduce their current expenses associated with satellite data-related tasks in the years to come. The reason is primarily the assumption that scenario 0 is maintained at a flat level throughout the entire time perspective of the business case. Since the potential gain is subject to uncertainty, the business case model features an uncertainty spread of +/- 25% on operating costs. Thus, users may - even without the hybrid solution - be able to achieve part of the gain potential themselves. In such case, the potential hybrid solution gain may be less as the difference between operating costs in scenario 0 and scenario 1 will be smaller. If users without the hybrid solution are able to reduce their current costs (e.g. as a result of the future DIAS), the potential gain of DKK 40.5 million will decrease, depending on how large savings they themselves are able to make. Table 1 shows the potential gain of implementing the hybrid solution in DKK, number of full-time equivalents and the potential gain percentage, respectively, for private companies, public authorities and research institutions.

The gain potential expresses the amount of time freed by implementing the hybrid solution which can be realised in different ways, for instance:

- For private companies, the gain potential may lead to increased productivity and thereby free up resources for more value-adding activities, to improve existing products and services or contribute to the development of new products and services.
- For public authorities and research institutions, the gain potential could free up funds and time for more value-adding work