DECOVER –
GEOINFORMATION SERVICES TO UPDATE AND SUPPLEMENT LAND COVER DATA FOR GERMAN DECISION MAKERS

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ABSTRACT:

There is a growing need for consistent and up to date land cover data at various scales by regional, national and European authorities. Main drivers are recent or upcoming European directives and initiatives, which contain increasingly spatially differentiated monitoring and reporting obligations in agriculture, environmental protection, water management, soil protection or spatial planning.

DeCOVER is a national research project to develop and demonstrate innovative and cost-efficient geo-information services to address this growing need in Germany. The DeCOVER consortium consists of eleven partners and is co-funded by the Federal Ministry of Economics and Technology (BMWI) via the German Aerospace Center (DLR).

The expected services will support the implementation of European directives at various scales and are developed in close cooperation with key decision makers and in exchange with European developments within the framework of the Global Monitoring for Environment and Security (GMES) initiative. DeCOVER also acts as a SDIC (Spatial Data Interest Community) within the INSPIRE process to take into account these recent infrastructure developments.

In summary the main objectives of DeCOVER are to:

- develop a service concept of core services and additional services to provide land cover information based on user needs at various scales
- employ latest ontology-based semantic interoperability techniques to define interoperability potential between different land cover data bases
- improve existing land cover data sets by use of change detection methods
- increase information depth using optical and radar satellite data (data fusion)

KURZFASSUNG:

Die Nachfrage an konsistenten und aktuellen Landbedeckungsdatensätzen auf verschiedenen Maßstabsebenen durch regionale, nationale und europäische Institutionen wächst stetig vor dem Hintergrund europäische Direktiven und Initiativen. Diese beinhalten vermehrt räumlich differenzierte Berichtspflichten innerhalb unterschiedlichster Ressorts wie Landwirtschaft, Umwelt-, Wasser- und Bodenschutz oder Raumplanung.

Das nationale deutsche Forschungs- und Entwicklungsprojekt DeCOVER wird innovative und kosteneffiziente Geoinformationsdienste konzipieren und demonstrieren, um diesen wachsenden Bedarf in Deutschland zu begegnen. Das DeCOVER-Konsortium besteht aus elf Mitgliedern und wird gefördert mit Mitteln des Bundesministeriums für Wirtschaft und Technologie durch das Deutsche Zentrum für Luft- und Raumfahrt e.V. (DLR).

Die angestrebten Dienste werden die Umsetzung der europäischen Direktiven auf verschiedenen Ebenen unterstützen. Sie werden in enger Zusammenarbeit mit Entscheidungsträgern und unter Berücksichtigung europäischer Entwicklungen innerhalb der europäischen GMES-Initiative entwickelt. DeCOVER wird sich als SDIC in die INSPIRE-Initiative einbringen, bzw. INSPIRE-Vorgaben berücksichtigen.

Die Kernaspekte des DeCOVER-Projektes sind:

- Entwicklung eines Dienste Konzeptes mit Ausgangs- und Ergänzungsdiensten entsprechend der Nutzeranforderungen auf verschiedenen Maßstabsebenen
- die Anwendung semantischer Ontologien zur Beschreibung des Interoperabilitätspotenzials verschiedener Landbedeckungsdatensätze
- die Entwicklung und Anwendung von Change Detektion Methoden zur Unterstützung der Fortführung bestehender Datenkataloge
- die gemeinsame Nutzung von Radar und optischen Fernerkundungsdaten zur Steigerung der Informationstiefe

1. BACKGROUND AND EUROPEAN CONTEXT

Up to date land cover data are an important information source for lots of public authorities. The need for such land cover / land use data is constantly growing. Currently in Germany available data, such as the European CORINE LAND COVER (CLC), the German ATKIS® (Authoritative Topographic and Cartographic Information System) and several BNTK data (Biotope and Land Use Type Mapping Schemes by the Federal States) can be improved in terms of quality and whether the data is up to date (Backhaus et al 2004, Bach et al 2005, Bareth 2001, Mohaupt-Jahr 2004, Seiler et al 2004, Zölitz-Möller 2001). It can be said, that

- the European CLC is neither sufficient in its thematic and geometric resolution.
- the German ATKIS data, mapped by the German federal states and supplied by the Federal Agency of Cartography and Geodesy, not always provides the needed information depth and timeliness.
- the BNTK data sets provide high-detailed environmental information but do not cover whole Germany and their updates can not be guaranteed.

In the context of GMES (Global Monitoring for Environment and Security), a joint initiative of European Commission and European Space Agency, several services are developed to provide spatial information to support the monitoring and reporting obligations of European directives (Overview at www.gmes.info, Example Water Framework Directive Dworak et al 2005). These implementations take place with strong participation of German authorities, researchers and service providers. Current developments at the European level support a new European-wide land cover data set (Core Service Land Monitoring). This data set must be seen as a European consensus and will solely contain thematic land cover data information supporting European reporting obligations. Its geometric and thematic resolution will only partly support national and regional needs. DeCOVER will complement and extend these developments at the national and regional level for German users.

To support and take into account recent and future service infrastructure developments DeCOVER has registered as a SDIC (Spatial Data Interest Community) within the INSPIRE process. This participation shall assure the integration of DeCOVER results into the INSPIRE process as well as taking the upcoming INSPIRE specifications on board the DeCOVER developments.

2. SERVICE CONCEPT

2.1 DeCOVER Core Service

A set of geo-information services has been designed to support national and regional users in their monitoring and reporting obligations. The DeCOVER service concept is divided in core and additional services. The DeCOVER Core Service has two main focal points

- Provide national harmonized land cover data and thus support the German spatial data infrastructure (GDI-DE) in providing selected and validated geo-information.

- Employ change detection and interoperability methods to support existing data bases (namely ATKIS, CLC and BNTK), increase efficiency and reduce costs to promote long-term service continuation

The DeCOVER Core Service Object catalogue is based upon harmonized user requirements, interoperability potential to update CLC, BNTK and AKTIS and results of a cost-benefit analysis. The Core Service can provide a nation-wide data set, which can de directly used to support end-users in their monitoring and reporting obligations. In providing interoperability to CLC and other upcoming potential harmonized European data sets it will be consistent with European standards on EO based land cover data bases. Change detection methodologies are applied to identify areas of land cover change and thus provide a targeted indication for an update of existing land cover catalogues.

2.2 Additional DeCOVER Services

A further portfolio of geo-information services are designed to meet user requirements, which can not be served by the DeCOVER Core Service. These services will address specific user needs in several thematic fields at regional scales (e.g. Water Quality management, Soil protection, Nature protection, Forest Monitoring, Spatial planning). These services will be implemented by demand on user designated areas, providing more detailed information on specific land cover aspects (e.g. NATURA 2000 Monitoring, Forest Monitoring, Cross Compliance Monitoring).

3. CORE SERVICE OBJECT CATALOGUE

3.1 Design

The content of the DeCOVER CORE Service Object Catalogue (i.e. the specific land cover classes and their definitions) are based on three different aspects: user requirements, interoperability potential and the results of a cost-benefit analysis.

The acceptance and success of DeCOVER depends on the service usability for end users and the expected costs for using these services. DeCOVER follows a strongly user orientated approach to meet the real existing user needs and to direct method development for maximum cost-benefit-efficiency. A comprehensive user requirement analysis has served as a base for the DeCOVER object catalogue, a compilation of required land cover classes/information for specific purposes. End user information needs from different administrative levels and within relevant application areas (e.g. water management, environmental protection, cartography, spatial planning) has been analyzed and compiled (Buck 2006). Selected core users are also involved in validation cycles to ensure target-oriented project development.

This initial user requirement analysis has shown real synergies between (thematically) different user needs. It showed that different users require similar land cover information. Bringing together these synergies in one DeCOVER Service provides a potential to minimize future costs to guarantee a long term service continuation. Parallel to the user requirement analysis, interoperability potential between the identified land cover classes has been analyzed, to optimize synergies between existing data sets and newly collected information.

The currently tested core-service object catalogue includes 39 service land cover/use classes arranged in hierarchical order (Table 1).

Table 1. The currently listed 39 core service object classes

V	Vegetationsflächen			
	VN	Naturnahe Vegetation	VNf	Vegetation auf Feuchtflächen
			VNg	Vegetation mit Gezeiteneinfluß
			VNk	Kraut- und Staudenvegetation
			VNs	Strauchvegetation, Wald-Strauch Übergangsstadien, Gehölzstrukturen
	VV	Wald	VVn	Nadelwald
			VVm	Mischwald
			VVl	Laubwald
			VVu	Unbestockte Waldflächen
	VL	Landwirtschaft _jährliche Nutzungsfolgen	VLg	Wirtschaftsgrünland
			VLa	Ackerbau
	VD	Landwirtschaft _Dauerkulturen	VLw	Weinbau
			VLo	Obstbestand
			VLh	Hopfenanbau
			VLs	Dauerkultur-Sonstige
	VK	Komplexe Landwirtschaftliche Strukturen		
G	Gewässer			
	GB	Gewässer im Binnenland	GBl	Gewässerläufe
			GBf	Gewässerflächen
	GG	Gewässer mit Gezeiteneinfluss		
	GM	Meer		
F	Vegetationsfreie/-arme Fläche			
	FN	Natürlich vegetationsfreie/-arme Flächen	FNw	Watt
			FNd	Strände, Dünen, Sandflächen
			FNf	Felsflächen ohne/mit wenig Vegetation
			FNg	Gletscher/ Dauerschneegebiet
			FNs	Sonst. natürlich vegetationsfreie Fläche
	FA	Anthropogen vegetationsfreie/-arme Fläche	FAa	Abbauflächen
			FAd	Deponien, Abraumhalden
			FAb	Baustellen
B	Bebaute Bereiche			
	BS	Siedlungsbereich	BSs	starker Überprägung
			BSm	mittlerer Überprägung
			BSg	geringer Überprägung
			BSw	mit wenig Überprägung
			BSa	Sport/Freizeit- anlagen
			BSf	Städtische Grünflächen
	BI	Industrie/ Gewerbe-flächen	BId	Dichte Industrie-/Gewerbeflächen unter Nutzung
			BIl	Lockere Industrie-/Gewerbeflächen unter Nutzung
			BIb	Industriebrachen, Militärbrachen
	BV	Verkehr	BVs	Straßen/Eisen- bahnnetze, funktional Flächen
			BVh	Hafengebiete
			BVf	Flughäfen

For this object catalogue a detailed mapping guide has been designed containing themes like object class descriptions or recommendations concerning the data model. The first verification and optimization of the mapping guide will be accomplished during the first test demonstration.

3.2 Core Service Demonstration

The designed Core Service and its underlying process chain are currently tested and demonstrated on two selected test areas (Figure 1). These test are expected to conclude in May 2007.
The Core Service employs a novel sequential process chain. This means, that the data production is progressing stepwise from one specific thematic object group (TOG) to the next, namely from urban areas to water bodies to forest areas to agricultural areas to natural areas. Within these specific TOGs specially adapted classification algorithms are applied to map the relevant thematic object classes.
This sequential process chain has two main merits. It integrates available thematic expert knowledge (because every TOG will be processed by a specialist partner) and flexible processing conditions. In difference to standard processing tiles (e.g. by dividing satellite images into regular quadrates), the DeCOVER processing units are patches of about 225 km^2 using significant natural or anthropogenic boundaries (e.g. rivers or streets). This enables a flexible patch by patch operation depending on processed data from the previous TOG as well as provided satellite data. By using natural or significant anthropogenic

boundaries the necessary but labour intensive (mostly manual) thematic and geometric border adjustments are minimized.

Figure 1. DeCOVER Test Sites

4. INNOVATIVE METHODS

The following chapter will provide an overview of the relevant core technical and scientific approaches and methods within the DeCOVER project, without going into too much detail. The following three areas are of major concern within DeCOVER:

- Semantic interoperability - Method to compare and visualize interoperability potential of geoinformation (object types) within and in-between different data sources (object catalogues CLC, ATKIS®, BNTK and others)
- Change detection - cost-efficient and timely continuation of land cover data through the automatic detection of changes
- Data Fusion – Co-Registration and joint analysis of optical and radar data

4.1 Semantic interoperability

To support the update of the existing data bases such as the European Corine Land Cover as well as the German topographic reference data set (ATKIS) the potential synergies between the different data base objects (land cover classes) of these catalogues have been assessed. All object classes of the relevant object catalogues were described and formalized using ontologies and brought into a knowledge base. Based on their semantic description, objects can then be compared between different catalogues using a similarity index. Objects showing a

high interoperability potential are included in the DeCOVER core service, as previously described.. The semantic interoperability results can also serve as a component for further research into object transfer between different land cover object catalogues.
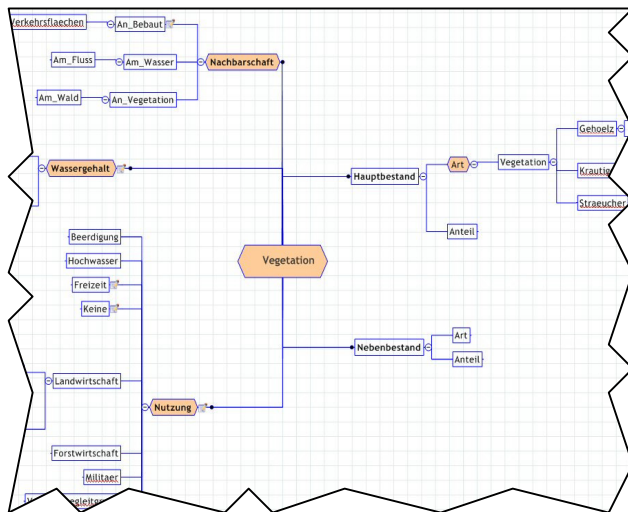

Figure 2. Part of a Sample Ontology

4.2 Change Detection

The DeCOVER concept foresees to integrate change detection methods to enable automatic detection of areas containing land cover changes. Based on this information, targeted manual updates of existing land cover objects within ATKIS, BNTK, CLC can be performed to improve efficiency and reduce costs. The developed Change Detection Methods should enable to:

- Identify areas of land cover change and probabilities of land cover change
- Indicate the type/ direction of change

The following change detections methodological aspects will be assessed within the DeCOVER project:

- Statistical satellite sensor independent change detection attempts using change probabilities and expert knowledge for thematic and structural change behaviour using optical data
- Change detection relative sensor to sensor, to assess the degree of method and process adaptation between different optical satellite sensors (e.g. IRS to SPOT, Quickbird, Rapid Eye), using object-orientated classification methods and tools
- Change detection using user data sets (geometrical and thematic aspects)

4.3 Data Fusion

Data fusion methods will be developed to increase automation of DeCOVER object classification to use the higher information depth of combined optical and radar data. This includes the design of a preprocessing chain (geometric and radiometric correction) and the adaptation of existing co-registration methods to co-register optical and radar data. Methods will be tested for combining textural, structural and spectral information from optical and SAR data in order to achieve highest information contents.

5. PROJECT STATUS

5.1 Summary findings

Up to now the most important project milestones are, as described above, the initial user requirements analysis, the transformation of its results into the design of the DeCOVER Object Catalogue and the ontological description of all relevant land cover data sets (BNTK, ATKIS, CLC, GSE Land). Additionally a corresponding draft mapping guide was written and the sequential processing chain was developed based on the patch processing unit.

The Core Service demonstration is currently on its way and will be finished by May 2007 for internal and external validation. A quality assurance concept has been designed and will also be tested during the Core Service demonstration, to guarantee mandatory quality standards.

5.2 Next steps

The results of the first Core Service demonstration will feed back into the development cycle and lead to further improvements concerning aspects like quality management and standards, data model or mapping guide definitions. The demonstration results will then undergo internal and external (user) validation. Demonstration experiences will also provide valuable input for a detailed cost-benefit-analysis. The demonstration outcomes and cost-benefit aspects will be discussed in details within selected key user consultations and presented and discussed during the next DeCOVER user workshop planned for September 2007.

Further methodological work in 2007 will concentrate on the development of efficient change detection algorithms to update land cover information and how the information depth about environmental systems can be increased by fusing state-of-the-art optical and radar satellite data. Upon the availability of RapidEYE and Terra-SAR-X data these will be integrated into a second demonstration phase. For this the processing chain has to be adapted to incorporate data fusion methods for combined optical and radar data use in order to increase automatic classification parts within the DeCOVER process chain.

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