EO-PLAN-GIS

Operational earth observation applications involving user communities on national and European level

Jürgen WEICHSELBAUM, Christian HOFFMANN, Klaus STEINNOCHER, Franz-Stefan WEIGL

Jürgen WEICHSELBAUM, GeoVille Information Systems GmbH, Museumstr. 9-11, 6020 Innsbruck, Austria, weichselbaum@geoville.com
Christian HOFFMANN, GeoVille Information Systems GmbH, Museumstr. 9-11, 6020 Innsbruck, Austria, hoffmann@geoville.com
Klaus STEINNOCHER, ARC Seibersdorf research GmbH, Systems Research Division, Environmental Planning Dept., 2444 Seibersdorf, Austria, klaus.steinnocher@arcs.ac.at
Franz-Stefan WEIGL, Tele Atlas GmbH, Database Operation Management, Bösendorferstr. 2/17-18, 1010 Wien, Austria, franz-stefan.weigl@teleatlas.com

1 INTRODUCTION

The joint GeoVille/ARC Seibersdorf project EO-Plan-GIS has the objective of deriving Earth Observation (EO)/Geographic Information System (GIS) products for public and private customers (i.e. Austrian state governments and digital mapping industry). Representatives of three state administrations (i.e. Carynthia, Upper Austria and Vorarlberg) and of Tele Atlas (a commercial enterprise in the production of digital road databases) have been actively involved in the project activities.

The major focus of the project is on the automated differentiation of built-up areas and the derivation of land use/cover data for both the state governments and Tele Atlas, as well as on the update and upgrade of the Tele Atlas road network. Using GIS methods, the EO-derived base data will be adapted to serve the individual user needs (i.e. Geographic State Information Systems and Tele Atlas MultiNet).

EO-Plan-GIS was initiated by the Austrian Ministry of Transport, Innovation and Technology as a national initiative within the framework of the current GMES (Global Monitoring for Environment and Security) activities of ESA and the EU. It delivers inputs into the following GMES domains:

- European Regional Monitoring, Subtopic A: Land cover change in Europe, characterisation of land cover changes (1950 – 2000) in the EU with particular emphasis on landscapes and urban areas.
- Horizontal Support Action – Information Management Tools & the Development of a European Spatial Data "Infostructure".

2 USER REQUIREMENTS

2.1 Regional governments

At the customer segment state governments there is a general lack of detailed spatial information characterising settlement structures and their development in geographical terms. Instead, existing information is usually limited to statistical socio-economic data referring to administrative units. In temporal terms, data availability is basically restricted to the census taking place every 10 years. These data are not an adequate basis for the spatial/temporal assessment of urban development and for urban planning in the spatial context of infrastructure systems, hydrology, ecology, etc.

2.2 Tele Atlas

Tele Atlas as an actor in the digital mapping industry produces and sells vector data of road networks and its attributes for navigation purposes, including some land cover/use information. The potential task of EO in this case is updating and upgrading of these products with the major concern being the improvement of the positional accuracy ('upgrade') and the expansion of the existing road network database ('update'). The 'Tele Atlas Multinet Guide' defines the positional accuracy requirements for roads within urban areas with a 5m treshold and for non-metroploitan areas with 10m.

3 PROPOSED PRODUCTS AND METHODOLOGY

3.1 State governments – Information products on settlement for regional planners

The settlement products are designed in a hierarchical manner, i.e. each product builds upon the former product:

- The **Base product** is a GIS vector layer, representing built-up areas for two points of time (current and historic). It is derived from geocoded panchromatic satellite imagery applying a texture based classification algorithm *(Steinnocher, 1997)*.
- The **Thematic product** is a refined vector layer, representing different land use entities within built-up areas. It is derived from the image data and the base base product by visual image interpretation. The nomenclature refers to European standards (CORINE land cover/MOLAND) including the classes residential areas, industrial/commercial areas, transport units, green urban areas.
- The **Analysis products** are derived from intersection of the thematic products with socio-economic data sets and allow for the derivation of different statistical analysis products *(Steinnocher & Köstl, 2002)*:

- development of residential areas over time
- development of industrial/commercial areas over time
- development of population over time
- population density per settlement
- development of population density per settlement

3.2 Tele Atlas – Upgrade and update of digital database

- **EO product for upgrade of the Tele Atlas street network in dense urban areas**

The analysis of the Tele Atlas street network in dense urban areas is carried out through a 'non-road' database derived by means of object-oriented image classification of VHR airborne and/or spaceborne EO data as well as 3-dimensional building models *(Hoffmann et al. 2002, Petrini-Monteferri et al. 2001)*. The product consists of a GIS data layer representing all locational deviating road segments having an overlap with non-road features, an alphanumerical list containing the Tele Atlas attributes and a classification of the road segments by a 5 m threshold to the respective road centre line *(c.f. Tele Atlas MultiNet accuracy standards for dense urban areas)*.

- **EO product for update and upgrade of the Tele Atlas street network in non-metropolitan areas**

Based on automated road extraction from VHR satellite data, this product provides a GIS data layer of "hot-spots" and an alphanumerical list indicating both possibly missing road segments (missing geometry) and possibly deviating road segments larger 10m (i.e. positional deviation) outside of dense urban areas *(c.f. Tele Atlas MultiNet accuracy standards for non-metropolitan areas)*.

- **EO product for the derivation of land cover and land use data**

This product supplies refined GIS data layers for the Tele Atlas themes "Woodland" and "Built-Up Area" derived by automated image classification of multispectral satellite imagery *(Weichselbaum et al. 2002)*.

4 FIRST RESULTS

For the Carynthian testsite covering the area between Klagenfurt and Villach the thematic products for 1967 and 2001 have been derived. Fig. 1 shows a subset of the area, the development of residential areas in and around Velden. The background image has been acquired by IRS-1C on August 12, 2001. The white areas represent the residential areas in 1967, the striped areas indicate the increase of built-up areas between 1967 and 2001. Light grey areas represent park or leisure areas within the settlements.

EO product for monitoring the development of settlement areas

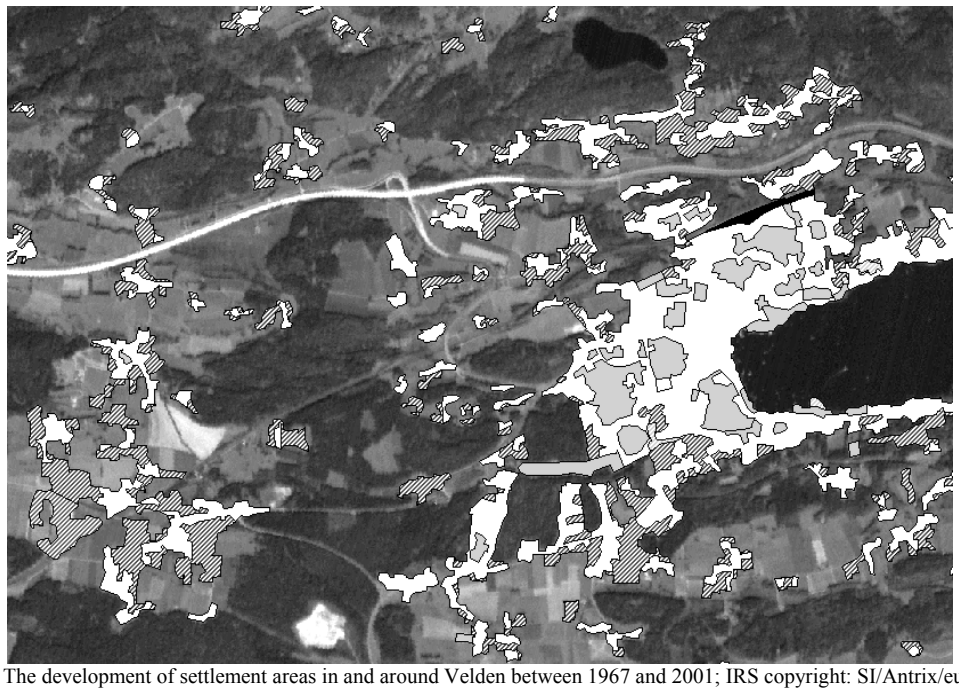
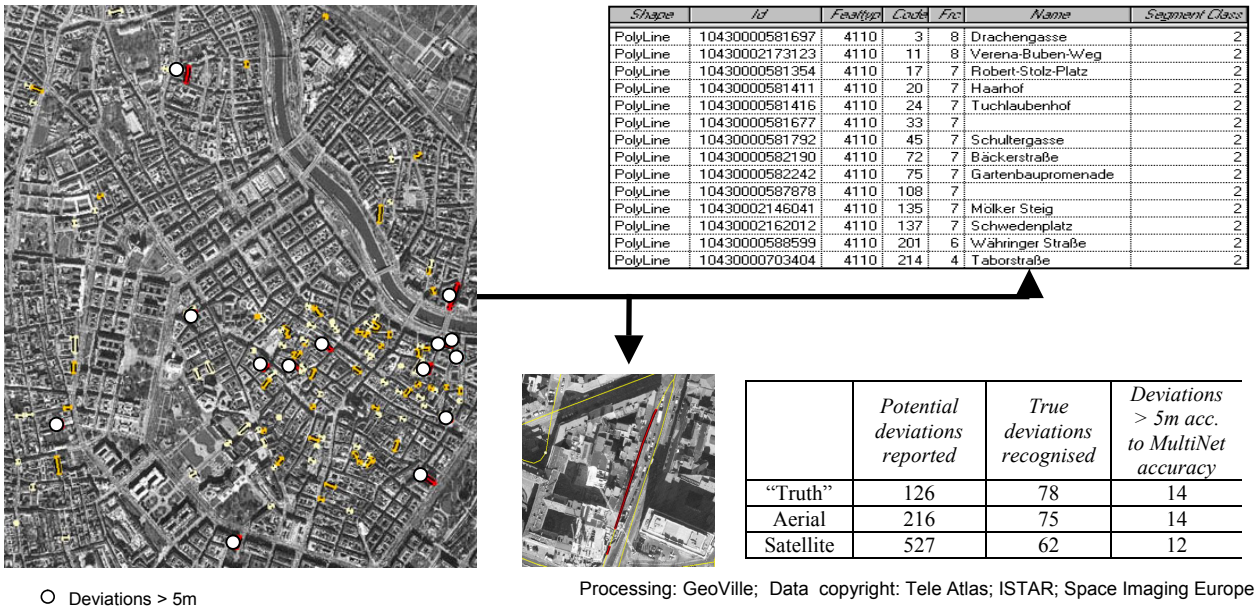


Fig. 1: The development of settlement areas in and around Velden between 1967 and 2001; IRS copyright: SI/Antrix/euromap

Project work regarding the Tele Atlas road network has been carried out for the inner city of Vienna (local approach for approx. 9 sqkm) and for the surroundings of Klagenfurt (non-metropolitan approach).

EO product for upgrade of street network in dense urban areas



	Potential deviations reported	*True deviations recognised*	*Deviations > 5m acc. to MultiNet accuracy*
"Truth"	126	78	14
Aerial	216	75	14
Satellite	527	62	12

Fig. 2: Positional deviations within the Tele Atlas road network in the city of Vienna

The results in fig. 2 show locations of positional deviations of the road network in the inner city of Vienna and have been derived based on non-road databases automatically extracted from very high resolution aerial photographs combined with additional elevation information and Ikonos satellite data. For validation a manually digitized non-road database and a cadastre was used. These automatically derived non-road databases separate roads from buildings and green urban areas and are subsequently intersected by the Tele Atlas road network, which finally leads to different layers of road segments overlapping with non-road features. The road segments reported are visually classified in 'potential deviations reported' (all segments reported automatically), 'true deviations recognized' (all segments representing having an overlap with non-road features) and 'deviations larger 5 m' (all segments having a positional error of larger 5 m to the virtual road centerline). According to MultiNet accuracy standards for urban areas the deviations larger 5m only are of relevance.

Both the manually digitized non-road database ('truth') and the automatically produced non-road database based on aerial photography recognize 14 deviations larger 5 meters, whereas the satellite-based model leads to 12 deviations, showing a relatively large number of potential deviations compared to the other non-road databases. In fact, not all 'deviating' segments really represent true errors – some segments are reported because of the large number of over- and underpaths especially in the old part of the city of Vienna.

The approach outside dense urban areas considers an update and upgrade of the Tele Atlas road network satisfying a positional accuracy of 10 meters minimally. For this purpose automated road extraction based on SPOT-5 satellite data (with a geometric resolution of 2.5 m in panchromatic mode and an aerial coverage of 60x60km) is performed in order to derive 'hot-spots' of missing geometry or positional deviations within the Tele Atlas road network.

5 SYNERGIES

Addressing two different user groups is supposed to bear synergies, both with regard to the exchange of reference data and through the utilisation of a common EO-derived base product (i.e. land use/cover data). This is particularly true since Tele Atlas data are more and more in use by public administrations and authorities responsible for spatial planning (e.g. road database linked with adress information). In turn, Tele Atlas is also increasingly using information content a-priori collected and utilized by public organizations (e.g. Points of Interest).

6 OUTLOOK

State Governments

In the next step the project will concentrate on the operationalization of the workflow for establishing the defined EO products. In case of the state governments, existing image analysis methods will be adapted and configured, and data processing chains will be developed, that meet the product definitions. The general work pattern for the products designed will comprise two basic steps:

- Derivation of primary EO based land cover/use data sets applying texture analysis methods, and

- Production of secondary products based on the GIS analysis of different primary EO products (change detection) and the common analysis of EO land cover/use data sets and additional GIS layers, such as demographic development.

The land cover/use data will be derived by means of automated classification techniques, supplemented by visual refinement and correction. The visual analysis is necessary in addition to automated image classification, because this method does not satisfy the required classification accuracy and does not allow for deriving all land cover/use classes of interest. Automated techniques are nevertheless applied because they highly rationalize the overall procedure.

Tele Atlas

In case of Tele Atlas, some further refinement of the technical procedure will be necessary, before the techniques can be turned into operational tools. These comprise the following steps/goals:

- Integration of additional data sets such as multispectral EO data for improved extraction of roads in open areas (e.g. improved separation of roads and agriculture by means of vegetation indices);
- Improving the separation of roads and building complexes within built-up areas;
- General increase of classification accuracy both in built-up areas and open spaces.

It can be concluded that the developed applications have the technical potential to fulfil key user needs. In the next project steps it will be of key importance to turn the technical developments into commercially viable products. This task will be carried out in one dedicated Working Package and will serve to define cost benefit ratios, etc. and ultimately to generate a sustainable service portfolio via the project EO-Plan-GIS.

7 REFERENCES

Hoffmann, C.; Steinnocher, K.; Kasanko, M.; Grubisic, R. (2002): The Role of GIS and very high Resolution Image Data as Planning Support Tools-Case Study of Belgrade. In: Manfred Schrenk (Hg./Ed.), MULTIMEDIAPLAN.AT & IEMAR, CORP2002 Proceedings, ISBN 3-901673-07-5, Band 2, Vol. 2, S. 375-378, TU Wien, 27. Feb.- 1. März 2002

Petrini-Monteferri, F; Steinnocher, K.; Hoffmann, C.; Engelhardt, K.; Koren, G. (2001): IKONOS-Satellitendaten für Stadtinformationssysteme – Fallbeispiel Klagenfurt. In J. Strobl, T. Blaschke, G. Griesebner (Hrsg.): Angewandte Geographische Informationsverarbeitung XIII, Wichmann Verlag, Heidelberg, 2001, pp. 356-361.

Steinnocher K. (1997): Texturanalyse zur Detektion von Siedlungsgebieten in hochauflösenden panchromatischen Satellitenbilddaten. In (F. Dollinger, J. Strobl Hrsg.): AGIT IX, Salzburger Geographische Materialien, Heft 26, pp. 143-152.

Steinnocher K., Köstl M. (2002): Verdichtung oder Zersiedelung? Eine Analyse des Flächenverbrauchs im Umland von Wien. In (Manfred Schrenk Hrsg.): CORP2002: Beiträge zum 7. Symposion zur Rolle der Informationstechnologie in der und für die Raumplanung, pp. 193-200.

Weichselbaum, J; Steinnocher, K.; Petrini-Monteferri, F. (2002): Das aktuelle Landsat-7 Satellitenbildmosaik von Österreich – Erstellung und Anwendungsperspektiven. In J. Strobl, T. Blaschke, G. Griesebner (Hrsg.): Angewandte Geographische Informationsverarbeitung XIV, Wichmann Verlag, Heidelberg, 2002, pp. 601-606.