

Urban Land Use Data for the Telecommunications Industry

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Abstract

Universal Mobile Telecommunications System (UMTS) is the new third generation telecommunication standard. UMTS stands mainly for a fast data transfer and complex multimedia applications. In order to offer specific UMTS services for special user groups and localities, such as trade fairs, the telecommunications industry uses high resolution urban land use (clutter) data that provides information about urban density as well as a variety of utilization categories. The urban clutter data set covers the whole of Germany and provides 24 urban density and urban use classes, with a minimum object size of 0.5-2 ha, depending on the object class.

The data was produced on the basis of "EuroMaps", a high resolution satellite image mosaic of Germany. The natural colour mosaic is based on up-to-date IRS-1C/D data; the high resolution (5-m on the ground) as well as the high positional accuracy (RMSE 90 % < 12 m) of the image data, in combination with their homogeneity, make EuroMaps well suited for large area mapping in the field of urban development.

Visual interpretation techniques supported by special mapping software, designed for streamlining the production, were applied to map the urban areas in detail. The whole production took one year.

Generally, the urban geometries can be used for several applications. For example, statistics about municipal or regional population density, as well as construction and industrial sites, can be derived from the data. The regional reference of the information and manifold regional statistics and analysis can easily be derived by overlay with ancillary information.

Introduction

With the recent unequalled success story of mobile telecommunications technology, service network operators have been undertaken enormous investment for the network infrastructure in order to improve the quality and availability of telecommunication services in general and also to provide specific services.

The high costs and the lack of available radio frequencies require an effective planning and modelling of radio propagation, especially when considering the rapid growth of network size and number of users. The number of services in the third generation Universal Mobile Telecommunication System – UMTS - is substantially higher than with GSM. Increased system complexity and others parameters actually reinforce the demand for effective network planning. For instance, one of the fundamental characteristics of UMTS is that the coverage range is intrinsically linked to the capacity of the system: more traffic carried by a cell results in a smaller the coverage area for the cell.

Background

E-Plus Mobilfunk GmbH & Co. KG, a German mobile network operator, runs an area-wide digital, mobile network for the whole of Germany. Generally, digital, spatially-oriented land cover/land use data (Clutter data) and radiowave propagation models are the basis for its macrocellular radio network planning, which ensures an area-wide supply with accompanying good quality by optimizing the available frequencies as well as antenna positions and characteristics.

Besides physical parameters, strategic ones also play a major role in the planning of mobile networks. While an optimal network quality has to be ensured in those places where demand is high, inevitable interferences have to be placed in areas where they influence the telecommunication services as little as possible or not at all. Also, sparsely populated and unpopulated areas have to be served with lower network capacities than dense populated areas.

For that reason E-Plus Mobilfunk GmbH & Co. KG was interested in a country-wide urban clutter data set of the whole of Germany outlining different settlement geometries and densities, as well as special urban zones such as trade fairs or industrial areas.

Beside this data set, population data as well as housing and infrastructure data are also necessary for computerized microcellular radio network planning in order to realize an effective microcellular network modelling and to offer specific UMTS services for special user groups and localities.

Base Data

Satellite Data

The requirements concerning data actuality and a minimum object size of 0.5-2 ha, depending on the object class, required the use of high resolution satellite data for the classification of urban areas. This applies especially to urban density classes which are assigned mainly on the basis of textural context.

With "EuroMaps", a common product development of GAF AG and Euromap GmbH, a high resolution natural colour satellite image mosaic from Germany is available based on up-to-date IRS-1C/D data. The high resolution (5-m on the ground) and the high positional accuracy (RMSE 90 % < 12 m) of the image data, in combination with their homogeneity, make Euro-Maps very well suited for large area mapping in general and particularly in the field of urban development.

Ancillary Data

- **Municipal Data:** Generally statistical data (e.g. population data) are based on municipal data. These data were therefore merged with the derived built-up areas to ensure compatibility/consistency of clutter data with ancillary data.
- In order to delineate industry, trade and service classes, geographically linked company data and addresses were included in the classification. The data comprised information about location, number of employees and the trade branch.
- For refining operations, topographic maps with a scale of 1 : 25.000 and city plans were included in the data interpretation. Both sets of ancillary data were

essential for the delineation of the classes “large” and “small scale industry”, “trade and service enterprises”.

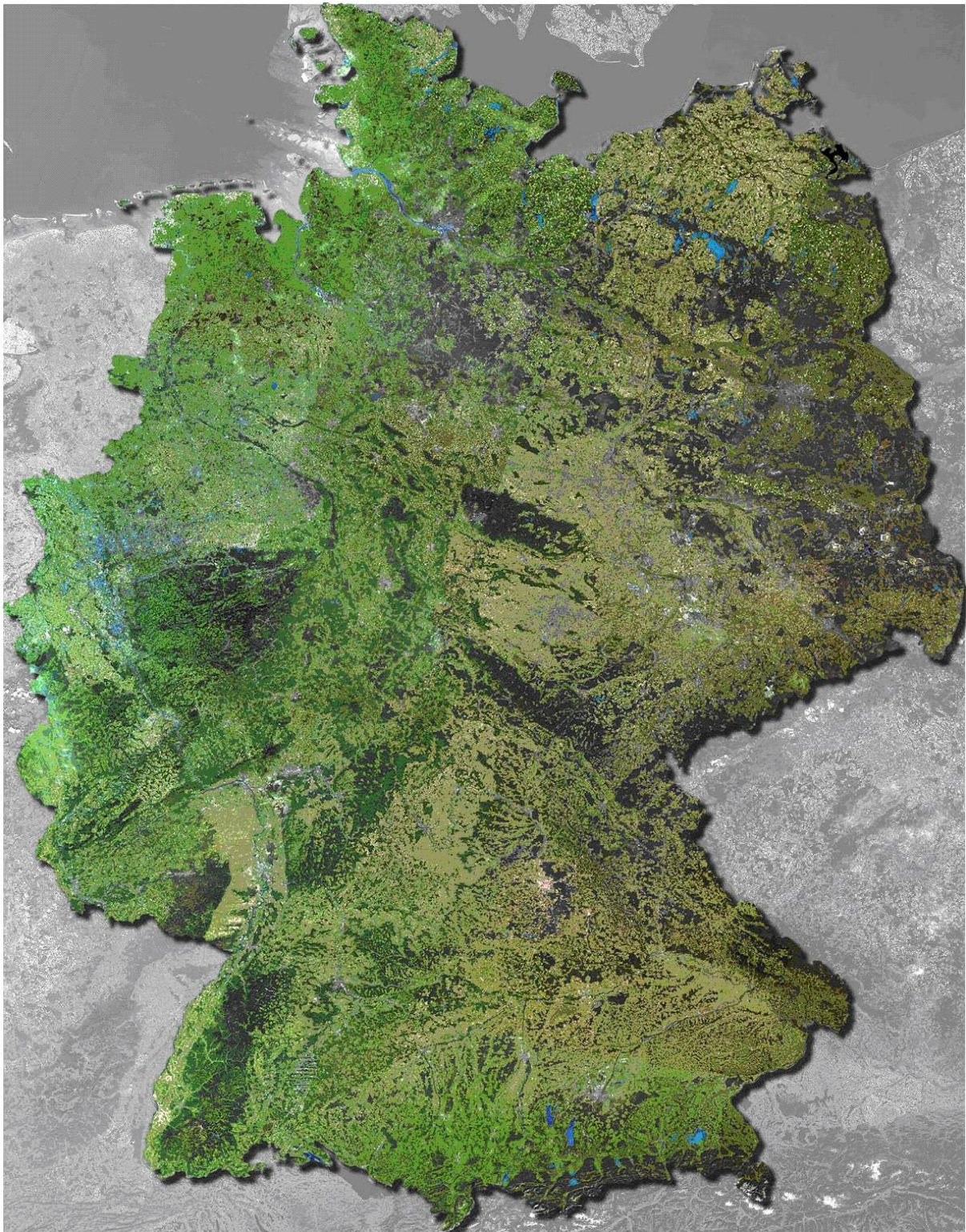


Fig. 1: Euro-Maps – high resolution satellite image mosaic of Germany

Technical Approach

In most cases, built-up areas of municipalities consist of different delineated zones where one specific housing type is predominant in each zone. Using these housing types built-up areas can be classified into several categories and subcategories on the basis of high resolution satellite and ancillary data.

The complete vector coverage of built-up areas in Germany consists of 24 different classes with the following main categories:

- Building Density (e.g., Detached Housing, Housing Blocks, Industrial Areas)
- Storeys (e.g., Single/Multiple Family Housing, High-rise Buildings)
- Special Classes (e.g., Railway Stations, Hospitals, Trade Centres, Airports etc.)

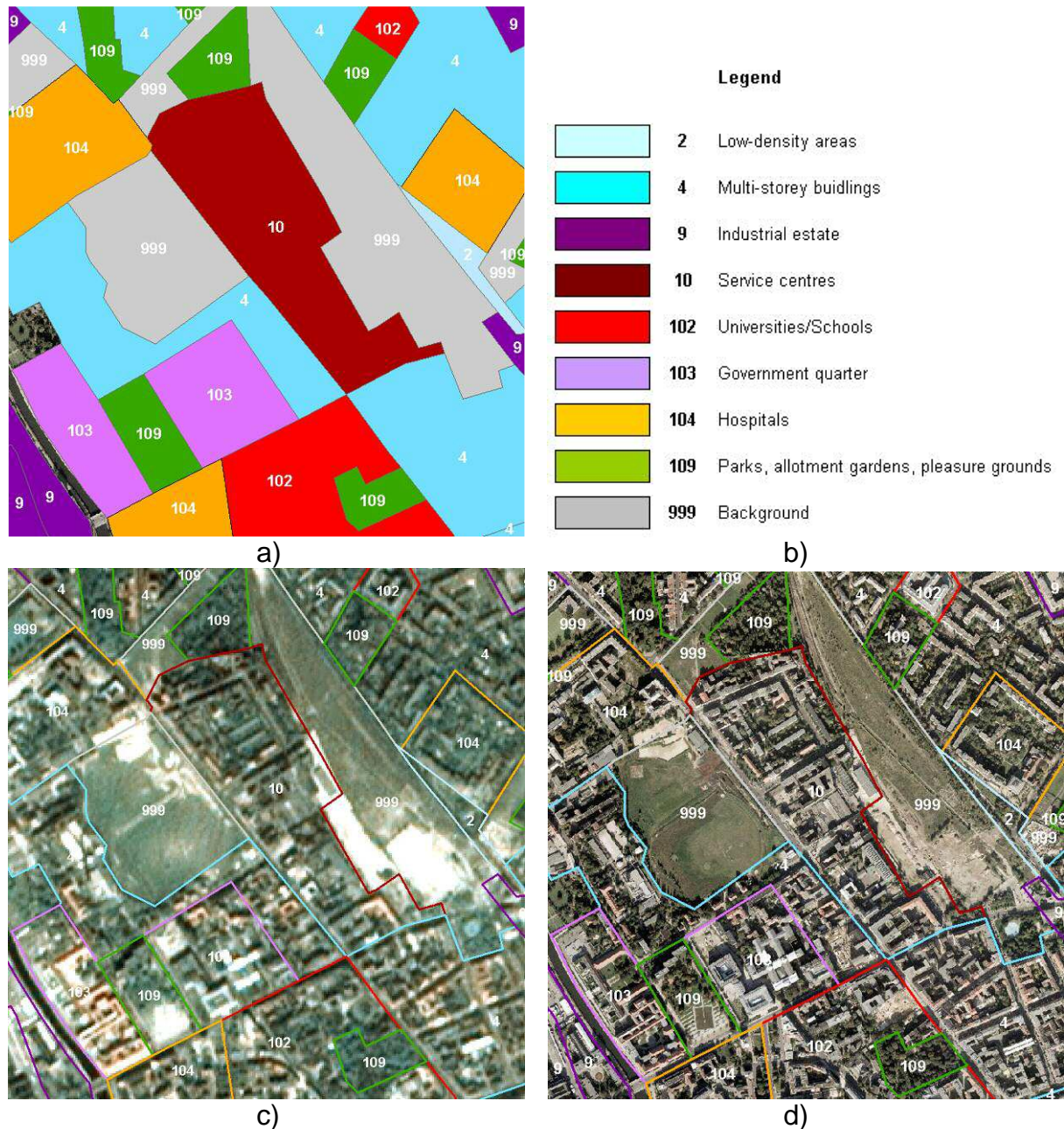


Fig. 2: Berlin example from the country-wide urban clutter data
a) Urban classification
b) Legend
c) Subset of high resolution satellite image mosaic of Germany - EuroMaps (5 m)
d) Subset of orthoimage (0,4 m) used for verification

The delineation of urban classes was realized via visual interpretation and on-screen digitizing techniques. The interpretation was supported by a dedicated proprietary

software (GeoFIS) designed to streamline the production, has been applied to map the urban areas in detail in order to ensure fast processing and reliable attributing. GeoFIS works in a two-window mode to enable the visualisation of at least two information layers. The GIS functionality also allows the display of ancillary vector data such as municipal boundaries or previously derived classification results. The vector module of GeoFIS enables a multifunctional handling of the polygons such as dissection, connection and merging and avoidance of intersections. GeoFIS is connected with an MSAccess database that is updated and expanded continuously during the mapping exercise.

Because the built-up areas are developed in a very diverse regional manner the delineation of urban classes was carried out step by step for each federal state to ensure homogeneity of the data set over the whole of Germany. Normally, the boundaries of the built-up areas were drawn along the streets. In cases with very wide streets, stream courses or other linear elements the boundary was placed in the middle of the linear object.

The quality and consistency of GAF clutter data are among the highest commercially available and are based on longstanding experience, streamlined technology, robust extraction techniques and approved quality assurance procedures.

Verification

The verification of the urban clutter data set for the whole of Germany was performed by the client E-Plus Mobilfunk GmbH & Co. KG, a German mobile network operator. The performance was determined as being better than the required 95 % for the class delineation and the positional accuracy (standard deviation) was better than 15 m and thus fully compliant with the required specification.

The verification exercise was performed randomly using the above mentioned ancillary data and was for some specific areas based on very high resolution orthophotos (0.4 m).

Conclusion

The vector coverage of built-up areas is a unique urban land use data set covering the whole of Germany. It consists of 24 different urban classes outlining different settlement geometries and densities as well as special urban zones such as trade fairs or industrial areas. At the moment no other land use data set available on the market offers a comparable country-wide mapping accuracy with a minimum object size between 0.5 - 2 ha (depending on the urban object class).

The product serves E-Plus Mobilfunk GmbH & Co. KG mainly for strategic network planning to ensure an optimal network quality in those places with high/increased demand and to serve special user groups and localities with specific services. Due to the great success of the urban clutter data set in physical and strategic planning of mobile networks, E-Plus Mobilfunk GmbH & Co. KG is planning a continuous updating of the urban clutter data set.

The exclusive availability of "EuroMaps", a high resolution satellite image mosaic of Germany and neighbouring countries, was the ultimate precondition for the generation of this product at reasonable costs. The high resolution (5-m on the ground) as well as the high positional accuracy (RMSE 90 % < 12 m) of the image data, in combination with their homogeneity, make EuroMaps well suited for a wide range of tasks in the fields of thematic planning, mapping and visualization up to a scale of 1:20,000. The orthorectified product consists of approx. 400 single images (Multispectral/PAN Merges) resulting in the above mentioned country-wide satellite

image mosaic "EuroMaps". Euro-Maps will be updated regularly by up-to-date satellite data to ensure a reliable and actual data basis. The high resolution urban clutter data set and country-wide satellite image mosaic Euro-Maps can be used for many planning and mapping purposes. Distribution of both data sets is made by GAF AG.