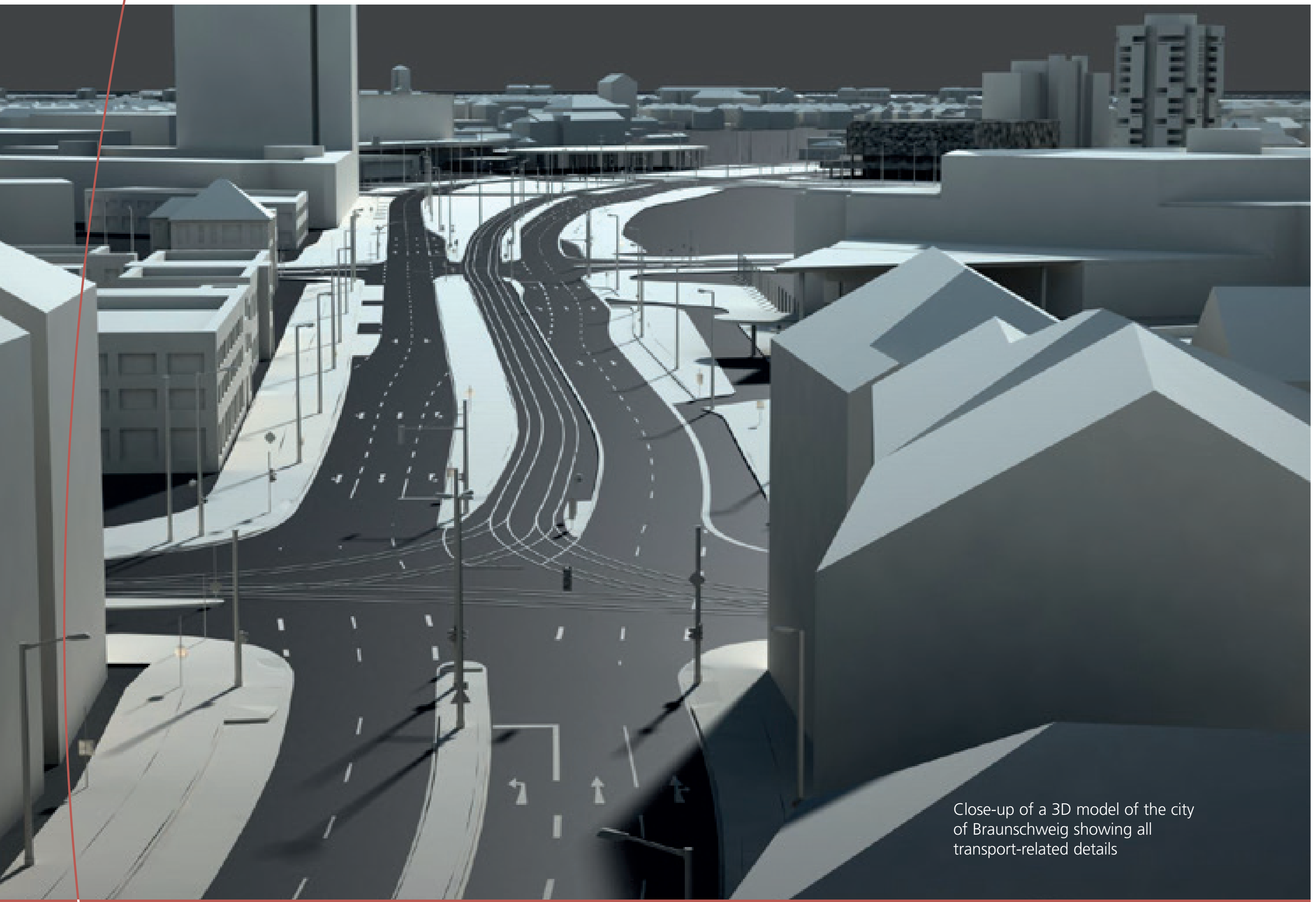
DIGITAL URBAN PLANNING



Close-up of a 3D model of the city of Braunschweig showing all transport-related details

A unique database is being created in DLR's cross-sectoral 'Digital Atlas' project

By Rüdiger Ebendt

Cities are growing, and with them, so are the demands on urban planning. For transport planning in particular, the needs of many groups – citizens, city authorities, vehicle manufacturers and transport companies – must all be taken into account. They all want congested traffic areas to be as safe to use and as free of disruption as possible. Achieving this requires access to reliable information and data. Such data should, wherever possible, come from a single source, rather than numerous ones that are based on different assumptions. This is the only way of ensuring that they can be combined and evaluated in a meaningful way. In DLR's cross-sectoral 'Digital Atlas' project, researchers from 10 DLR institutes are developing a database that will enable better design and organisation of urban planning and energy supply.

The DLR research junction in Braunschweig. Various sensor systems record the traffic situation to better understand the behaviour of road users.

The project's primary focus is on geodata – digital information that can be assigned to a spatial location on Earth's surface. This includes data from moving traffic on the ground, on water and in the air. The researchers are accessing information from satellites, aircraft and ground-based sensor technologies as they collect their data. The cross-sectoral project benefits from the different fields of expertise of the DLR institutes involved, with researchers working in the fields of aeronautics, space, energy transport and security, as well as in the fields of data collection and socio-economic analysis.

Layer by layer

Each map consists of individual layers that highlight specific topics. These might be types of roads, the distribution of vegetation and trees, or the location of solar power systems. This enables urban planners to assess the necessary roads and transport connections – not only within a city, but also in the surrounding area. In addition, comparisons can be made with other cities across the globe. Metadata describe the maps in greater detail, allowing the user to quickly assess the topic in question or the spatial accuracy and resolution of the map. They are also able to perform a search using keywords.

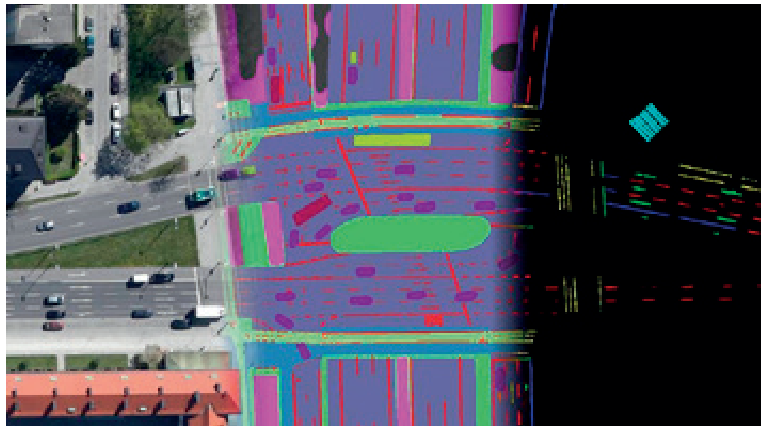
Braunschweig in 3D

In an initial subproject, the DLR Institute of Transportation Systems generated a 3D model of Braunschweig largely automatically, using sources such as cadastral information, aerial images and survey data. Wherever possible, thematic maps derived from raw data were processed and verified in this way. This process is gradually being developed into an all-encompassing geodatabase for all modes of transport. To ensure that the 'virtual' database represents reality as closely as possible, the researchers are studying various use cases with different modes of transport. They then compare the data from these use cases and use them as the basis for the Digital Atlas.

Satellites and aircraft capture the condition of roads

The condition of the roads plays an important role in traffic safety and fuel efficiency. Cracks and potholes cause damage that continues to spread if it is not detected early enough. This is also an important issue for automated or autonomous vehicles. In order to adjust their speed and driving style appropriately, the sensors of such vehicles must not only be able to recognise infrastructure and obstacles, but also lane markings and the condition of the road surface. Until now, creating road maps has been a laborious task, requiring specialised vehicles to drive along all of the roads. This is time-consuming and expensive. Positional data in cities and narrow streets are also often only accurate to within a few metres due to the 'shadowing' effect of densely packed buildings and structures that cause signal blockages and reflections.

The Remote Sensing Technology Institute and the Microwaves and Radar Institute in Oberpfaffenhofen are now investigating new methods to acquire the necessary data using satellites and aircraft equipped with imaging radar sensors and high-resolution camera systems. These data can be recorded in a much shorter timeframe and make it possible to determine the position of objects to within 10 centimetres anywhere in the world. This requires highly accurate reference points, which are obtained from satellite data.



Neural networks can make categories such as buildings, roads and vegetation visible in an aerial image, and even extract lane markings.

WHAT IS A GEODATABASE?

Spatial data, otherwise known as geodata, are acquired and managed in a geodatabase. They are structured using a spatial data model based on a coordinate system. Such models include the following:

- geometric data such as the location and extent of building and landscape objects,
- topological data to describe the spatial relationships between the objects,
- thematic or descriptive data, such as the colour of a house, and
- nominal data – that is, purely descriptive information such as the name or location of an object.

By combining overlapping aerial images, researchers create a surface model and what is referred to as an orthomosaic – a distortion-free, true-to-scale representation of Earth's surface. All roads, lane markings, masts, buildings and vegetation are depicted and integrated into the Digital Atlas. Intelligent algorithms identify objects using machine learning and categorise them. The researchers determine the condition of the roads using black-and-white radar images. Small differences in brightness within the images provide information about the roughness and material properties. By comparing these images with ground-based reference data, it is possible to determine the roughness value in the millimetre range.

The Modular Aerial Camera System (MACS) acquired images of the harbour area in Bremerhaven for the creation of high-resolution maps

Intelligent models show traffic volume

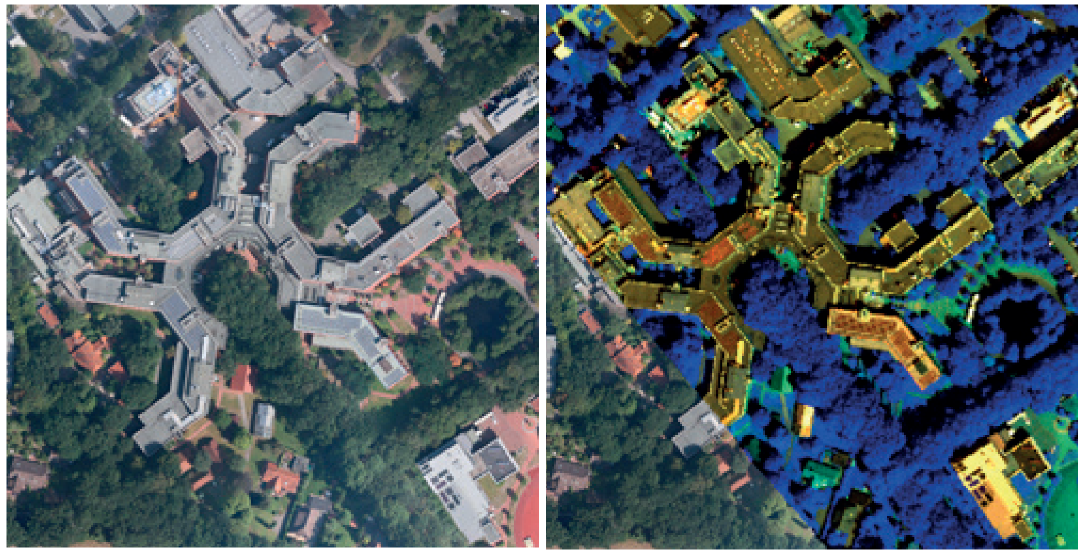
The Digital Atlas is also intended to model future developments and the consequences of implementing changes. Traffic model simulations serve this purpose and show the resulting impact on mobility. These may include the introduction of new means of transport, the expansion of infrastructure, or restrictions for certain road users. Such models require various types of data – information about the population demographics, possible travel destinations, and transport infrastructure and services. However, there is often a lack of precise knowledge about the size and spatial distribution of the population. With this in mind, the DLR Institute of Transport Research is developing new methods for determining traffic volumes. These new methods have the advantages that they require less data, and that the data that they do use can be collected worldwide using remote sensing. This makes it possible to derive traffic volume models for any region in the world.

The main sources of information for these types of models include data relating to land use, settlement patterns, as well as density and type of buildings. DLR's German Remote Sensing Data Center obtains such information from high-resolution satellite and aerial image data. These can be used to determine the distribution of the population within an area. The researchers are also using freely available data from the OpenStreetMap project, particularly those relating to road networks. This enables them to calculate how easily destinations within an area can be reached from a particular location using various means of transport. The researchers are drawing upon these and other data to develop a model of the overall traffic volume. Such models can then be used to investigate the impact of new mobility options, such as dial-a-bus services and other types of on-demand transport, on mobility behaviour.

Dynamic maps for safe and secure ports

Keeping track of people and goods in ports is particularly difficult. The DLR Institute of Optical Sensor Systems and the DLR Institute for the Protection of Maritime Infrastructures are looking into the creation of dynamic two- and three-dimensional maps in real time. Special sensor systems designed and developed by the institutes are used for this purpose. Real-time implementation is also an essential part of their work. The maps help authorities and emergency personnel with security-related tasks, and port authorities and terminal operators to quickly identify and assess critical situations, such as the danger posed by suspended loads or unauthorised access to the site. The first step is the image data acquisition by an airborne flight campaign and the production of high-resolution maps. Artificial intelligence algorithms then identify ships, road users and other objects, such as freight containers, from images acquired on the ground. Software also determines their exact position and integrates the objects into a situational picture. This results in a combined system comprised of aerial and ground images and the associated evaluation algorithms. These dynamic maps are also ideal for making autonomous traffic in ports safer.

Three-dimensional, real-time image of port area in Bremerhaven. Left: Camera image with objects that have been automatically identified by artificial intelligence and colour-coded according to their shape. Right: Preliminary 3D model of the surroundings with details of the position of an unknown or unauthorised person in the area.



The building of the Institute of Networked Energy Systems and the Wechloy campus of the University of Oldenburg. Left: optical image, right: hyperspectral image. Solar power systems are detected in the hyperspectral images using artificial intelligence techniques. This helps to predict the amount of solar power more accurately.

Predicting solar power production in cities

When is power from private solar power systems fed into the electricity grid, and how much do these contribute? Power grid operators urgently need an answer to these questions in order to be able to integrate renewables into the grid. This requires information about solar PV systems on rooftops and in open spaces, preferably collected in an automated way. The DLR Institute of Networked Energy Systems is conducting research in this field together with the German Remote Sensing Data Center. In order to identify solar power systems, researchers are analysing optical and hyperspectral high-spatial-resolution data acquired during flights over urban areas in Germany. Hyperspectral sensors perceive a continuous spectrum of electromagnetic waves, so they can identify objects more accurately on the basis of their spectral properties. The optical and hyperspectral images are used to create digital elevation models and determine building outlines.

For the automated detection of solar power systems, the software must be able to distinguish between different elements in order to avoid misclassifications. Roofs like this are used for test purposes; here, both solar-thermal and photovoltaic elements can be seen, but also a roof window, which must not be incorrectly labelled as a solar power system.

FlexiGIS is an open-source model for the simulation of urban energy infrastructure developed at the DLR Institute of Networked Energy Systems. FlexiGIS can be used to model power generation in urban solar power systems – based on examples and use cases of the city of Oldenburg. This data help scientists to forecast solar irradiance with spatially and temporally high resolution by combining them with data from meteorological satellites. This assists network operators in grid control and thus supports the stability of the power grid.

Clear catalogue for different user groups

These four different use cases illustrate the complexity of this cross-sectoral project. In further applications, the aim is to expand the geodatabase and methods to as many modes of transport as possible, for example rail transport, and to include new types of mobility. However, the results obtained can only be used properly and to their full extent if the Digital Atlas is structured in a clear and comprehensible way. For this reason, future research will focus on the further development of a user-friendly geodata catalogue. All of the datasets will be stored there and clearly labelled. At the end the project, the Digital Atlas will be used in further research projects and, in the long term, will be made accessible to government and industry.

Rüdiger Ebendt works in the Data Management and Knowledge Discovery Department at the DLR Institute of Transportation Systems and is the scientific lead for the Digital Atlas cross-sectoral project.

THE DLR DIGITAL ATLAS CROSS-SECTORAL PROJECT

Participating institutes:
Institute of Transportation Systems (Coordination)
Institute of Vehicle Concepts
German Remote Sensing Data Center
Microwaves and Radar Institute
Remote Sensing Technology Institute
Institute of Optical Sensor Systems
Institute for the Protection of Maritime Infrastructures
Institute of Space Systems
Institute of Transport Research
Institute of Networked Energy Systems

Duration: four years (2018–2021)
Budget: six million euro