

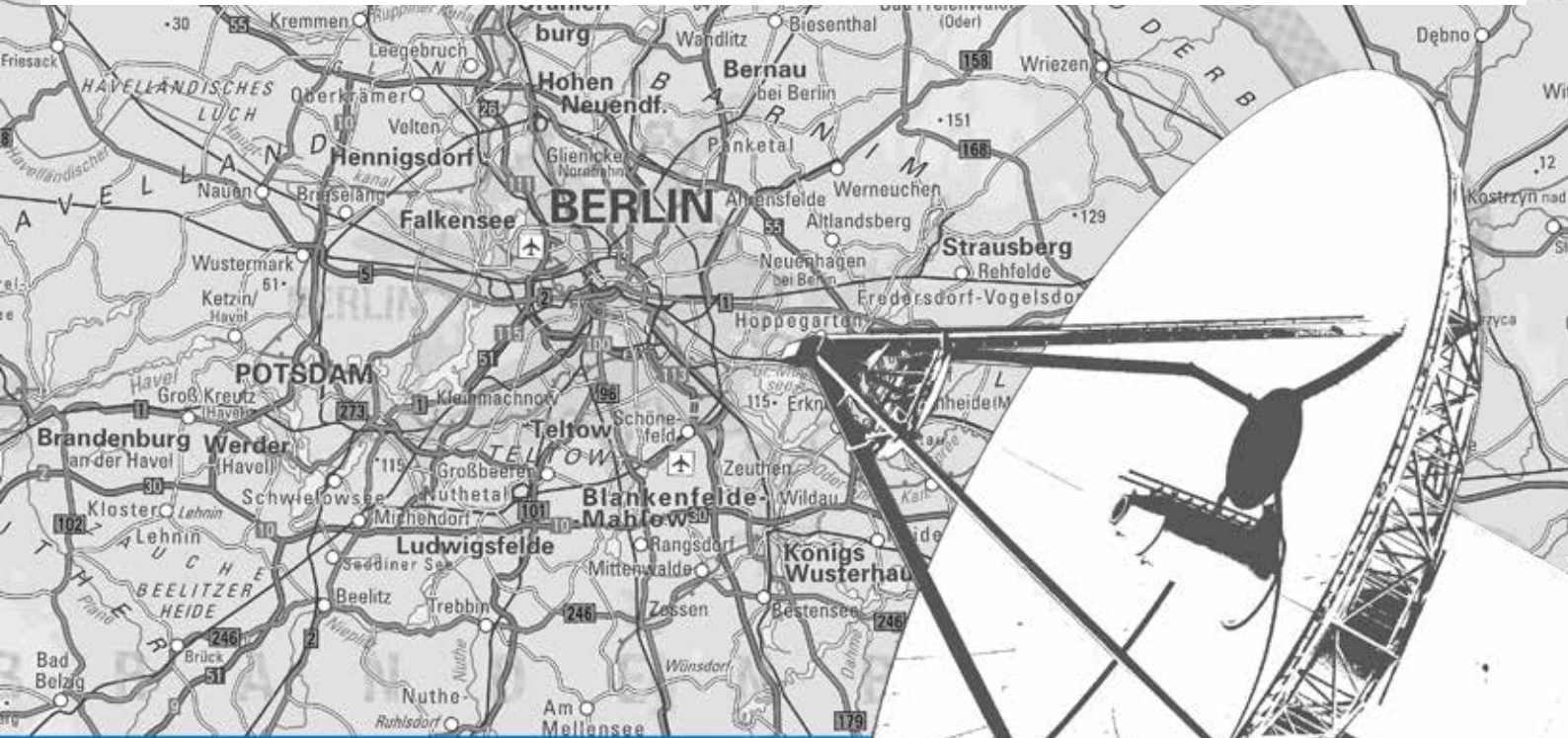


Federal Agency for
Cartography and Geodesy



BKG

Wir geben Orientierung.



Leading the way



Leading the way

Federal Agency for Cartography and Geodesy

Pandemic, climate crisis, people fleeing their homes – as a society, we have to overcome major and numerous challenges. If you want to influence these phenomena, you have to be able to measure them and localise them. The question of “Where?” is therefore of crucial importance.

Surveying, and therefore also the Federal Agency for Cartography and Geodesy (BKG), plays a central role in answering this question. Our motto “Leading the way” applies to major social issues as well as to very practical applications: will the navigation system get me safely to my destination? Will my cellar be flooded during the next heavy rainfall? Is a satellite endangered by space debris? BKG is almost always involved in answering these questions in one way or another.

Global challenges need global solutions. Our work only works in co-operation with partner institutions around the world, which is why international cooperation is part of our everyday practice. Join us on an exciting journey through the diverse tasks of the Federal Agency for Cartography and Geodesy.

Yours



Prof. Dr. Paul Becker
President and Professor
of the Federal Agency for Cartography and Geodesy

Preface

Prof. Dr. Paul Becker



Leading the way

Our motto sums up what the Federal Agency for Cartography and Geodesy stands for: as Germany's central authority for geoinformation, we answer the question of "Where?"

We provide up-to-date official geospatial data for Germany – digital and analogue, on the internet and on paper. For example, this data helps your navigation system to get you safely to your destination. When authorities, police and civil protection organisations have to make important decisions, they rely on our maps.

We also pool geospatial data from the German administrative landscape and are involved in international projects.

More than 350 experts work at BKG in Frankfurt am Main, Leipzig and Wettzell in the Bavarian Forest.

BKG is a higher federal authority within the portfolio of the Federal Ministry of the Interior and Community. Our legal mandate is to depict Germany on the map.

Geodesy

[dʒi:'ɒdɪsi]

The science of measuring and mapping the earth's surface. This also includes determining the geometric shape of the earth, its gravitational field and its orientation in space.

Cartography

[kɑ:'tɒɡrəfi]

The art, science and technology of making and using maps.

We're putting Germany on the map!

For the overview. For forecasts. As a basis for decision-making.

Thousands of years ago, people used maps to get a picture of the world. Our modern maps look different today, but they still serve the same purpose: they provide orientation. Presenting local conditions clearly helps to better understand geographical contexts. The basis for linking different pieces of information spatially is always a map, which can look very different.

Digital...

Can a river valley be built on or is it at risk of flooding during heavy rainfall? How long will it take me to get to the nearest hospital?

With our digital atlases and web services, we at BKG make your big and small decisions easier. No matter whether you are planning a route by car, looking for the ideal location for the construction of a supermarket or need to answer the question of where the new wind farm should be planned.

...and analog

Today you probably navigate with your mobile phone; in the past, you probably had paper maps in your hand more often. They are still in demand today, and not just when the mobile phone network is unreliable. In an emergency, paper maps are an invaluable aid that the police, technical relief organisations or the Federal Foreign Office often use.

At BKG, we are at the forefront when it comes to ensuring that you have the right map in the right situation.

Digital or analogue – you decide!



Specialist information – is strong together

The more complex the question, the more aspects need to be considered when answering it; this applies to urban planning just as much as it does to the question of how we manage the energy transition. This is why we at BKG bring together specialist information from a wide variety of sources and present it in a clear and easily understandable way. For experts, but also for interested citizens.

We collect building blocks

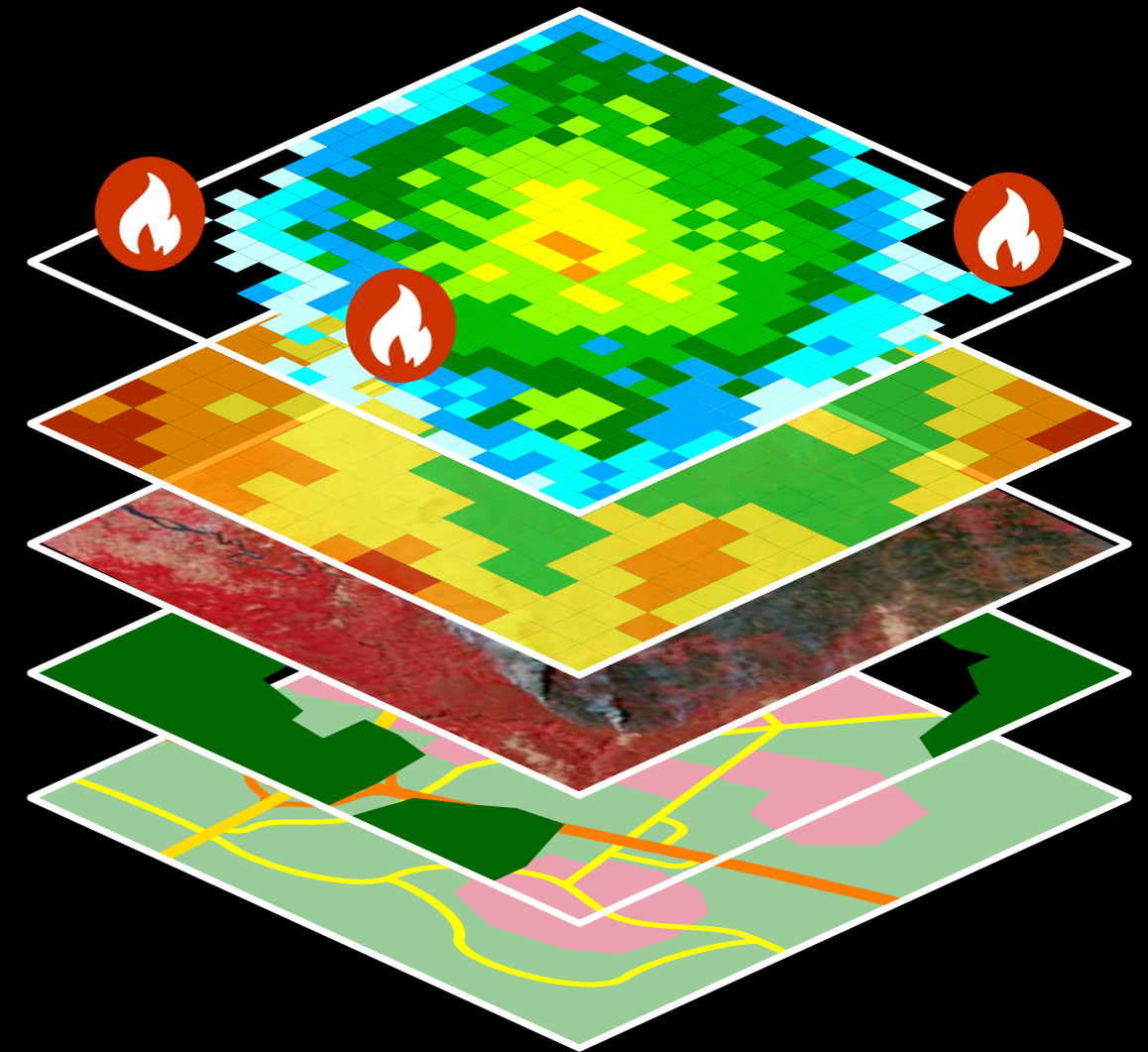
From Aachen to Zwickau – German authorities store valuable data treasures that need to be unearthed. Information from water management, agriculture and forestry as well as weather data play a role in advancing the expansion of renewable energies. We pool the services of 24 federal authorities and hundreds of state authorities. We make this data available in a modular system – the users themselves determine what the result looks like. This takes the simple map into a new dimension.

We also look beyond the borders of Germany. The Sentinel satellites of the European Copernicus earth observation programme constantly provide us with information about the earth's surface from orbit. They determine, for example, the colour of the sea surface and vegetation and thus provide valuable insights into the state of our planet.

Open to all

The data from the Open Street Map community also contributes to the diversity of the offering. In this crowdsourcing project, almost eight million people collect geospatial data to create a freely accessible map of the world. Content that is missing from our official data sets, such as bus routes or cycle paths, is also recorded. Areas for which there are no current official maps are also recorded.

At BKG, we are therefore setting up a system to integrate this data into our products and services for federal authorities.



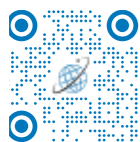
The combination makes the difference

At www.geoportal.de we provide an insight into the entire German Spatial Data Infrastructure (GDI-DE). This is where we collect data from many different authorities and institutions and present it in a clearly organised way. Politics, administration, business, science and the public can access maps on a wide variety of topics. One example: if you want to move to the countryside to work from home in the future, you can overlay the maps on broadband availability and building land prices. Where fast internet and low building land prices overlap, it is worth looking for property.

Almost all of the data in the geoportal originates from the public administration and is freely accessible; the federal, state and local authorities work very closely together here. The most comprehensive geospatial data pool in Germany comprises more than 350,000 data records and is updated on an ongoing basis. Particularly in federally structured Germany, a standardised data basis facilitates decision-making.

The geoportal provides the basis for this – free of charge and always up-to-date.

www.geoportal.de



Drought, heat, forest fires, floods

A few hot days don't cause a drought, but what if it doesn't rain enough for a long time? Do street trees need to be watered to keep them alive? Or should they no longer be irrigated because otherwise people would run out of drinking water?

The climate crisis is making such questions more frequent and more pressing. Our digital atlases can help to find the answers.

In the so called "Dürreatlas" (Drought Atlas), for example, we collect information on soil moisture, precipitation, wind and temperature. The data can be analysed individually or in combination. Especially the possibility to analyse time series, makes the Dürreatlas an important tool. The atlases on heat, forest fires and floods work on the same principle.

All atlases are interactive so that users get exactly the data they need. We have prepared analysis levels for overlaying; of course, everyone is also free to interpret the data themselves.

www.bkg.bund.de/atlanten





For example, if the Federal Foreign Office asks for information on the humanitarian situation in a refugee camp, our experts compile images and data precisely. How many tents does the camp consist of? How fast is it growing? What is the situation at the border crossings? From the SKD maps, those responsible can derive recommendations on how German authorities should prepare for the arrivals.

The experts at SKD also have the right data for enquiries relating to the climate crisis: how does the vegetation in a forest area change over the course of a dry year? Is the forest recovering or have trees finally died? High-precision satellite images are used for this purpose, on which even individual treetops can be distinguished.

Always ready for authorities – with satellite images

Football World Cup, summit meetings, Fridays for Future demonstrations – wherever many people come together, everything can be peaceful. Nevertheless, you should be well prepared for anything.

That's why we offer a special service for federal organisations: the Satellite-Based Crisis and Spatial Information Service (SKD) produces maps from satellite images that are customized for specific applications.

Germany in 3D – the “Digital Twin”

Mapping the landscape on maps, integrating a wide range of specialist information – this is not enough for some of the challenges of our time. That’s why we at BKG are going one step further.

The “Digital Twin” is a digital, intelligent 3D image of the real world, in which all the fundamental geobjects – from trees to traffic lights to high-rise buildings – are in. This makes it the basis for simulations in environment, safety, transport and spatial planning.

In a pilot project, the Hamburg metropolitan region was flown over with measuring aeroplanes equipped with laser scanning technology. These flights are to be extended to the whole of Germany in future. From the aerial photographs and the map data from BKG, we are building a 3D model that represents the federal territory with a resolution of at least 30 centimetres. This model is enriched with

information from a wide range of specialist disciplines. It combines map data and specialist information at the highest resolution and offers unique possibilities.

Better planning for the future

The “Digital Twin” serves as the basis for simulations of a wide range of future scenarios. Above all, the digital world can also be used to visualise the effects that different decisions will have in the real world. This allows optimal solutions to be developed without time pressure. What happens if there is a large-scale power cut? How will the microclimate in the city change if fresh air corridors are blocked?

The “Digital Twin” helps to prepare a rapid response to a disaster, but it is also equally suitable for planning long-term measures.



Capturing the situation with the latest technology

We also face technical challenges in order to utilise new sensors and sources of geoinformation.

See through walls

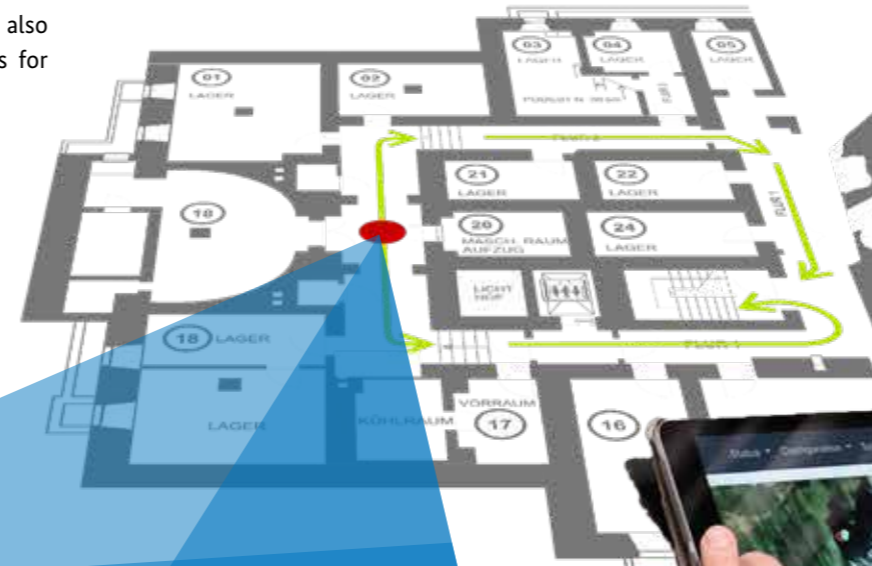
The Global Positioning System (GPS) helps us to orientate ourselves outdoors, but it quickly reaches its limits indoors. Together with partner authorities, we are developing innovative systems for indoor navigation that work autonomously even in difficult environments.

When emergency services rescue trapped people, they often put themselves in danger. The operations centre should know exactly where the helpers are at all times; the helpers need a map, to help them find their way inside the building. To this end, we are researching the use of the latest technology: inertial navigation systems, which consist of several sensors for changes in movement. With their help, position data can be transmitted in real time, even if no GPS signal is available.

Maintaining an overview

Aerial photographs are often taken from helicopters or with the help of drones to record the situation in crisis situations. In order for the images to be used as a true-to-scale map, they have to be processed using complex calculation methods. In addition, the images are labelled with coordinates and important information is highlighted. This results in aerial maps that are customised for the respective situation.

Our experts use their expertise to support security authorities, for example, in interpreting aerial images. We also work together to develop a comprehensive process for further processing the aerial images.



Geodesy – we measure the world

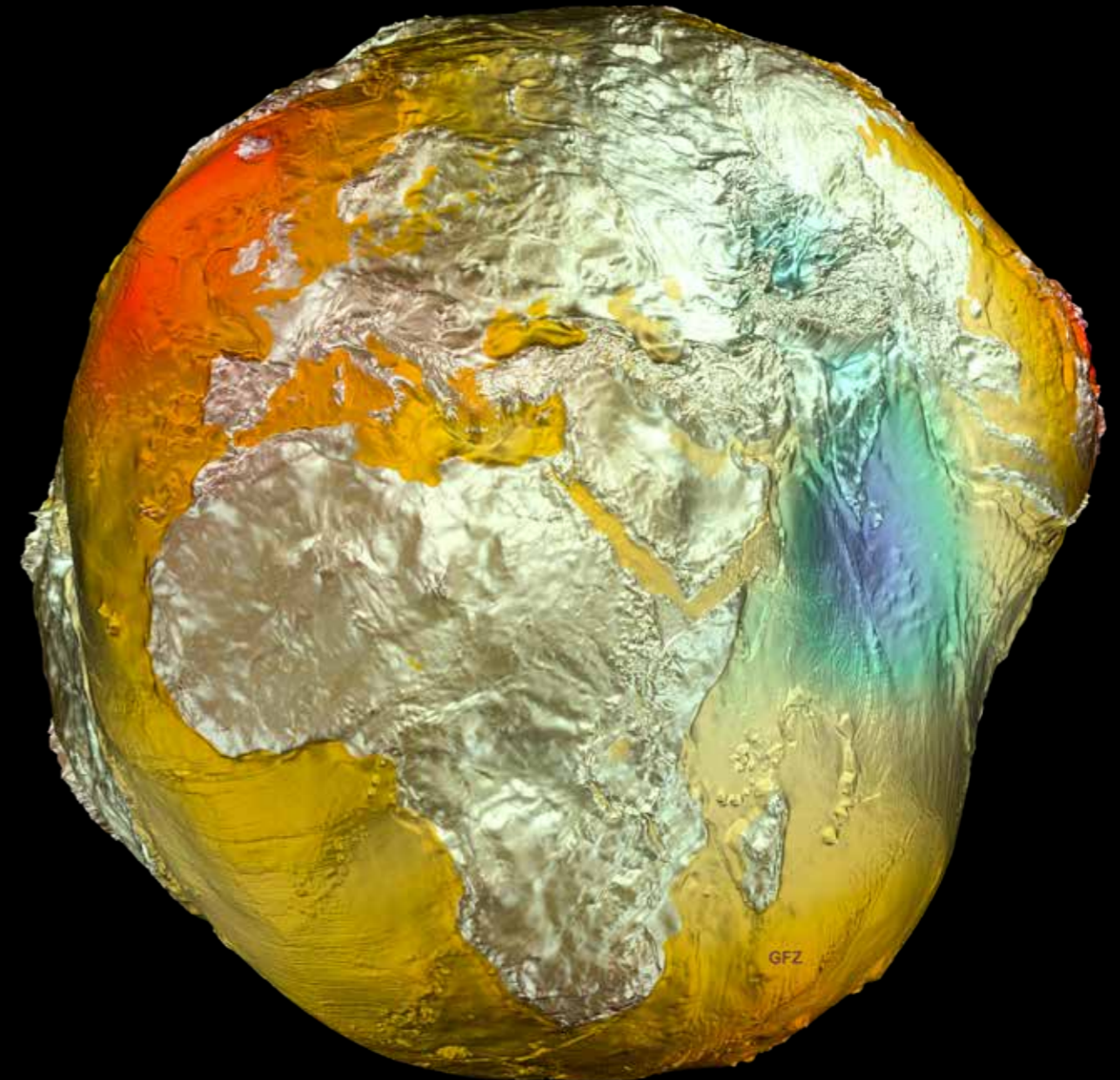
For exact coordinates and heights

Maps, navigation apps and the “Digital Twin” all have one thing in common: they need standardised and fixed reference points. In order to determine the position of the individual objects – i.e. longitude and latitude – reference systems are required that are determined by fixed points.

Our earth is not the perfect sphere that globes make us believe. In fact, its gravitational field is more like the irregular shape of a potato. It is also constantly changing: continents drift, humans scratch the earth’s crust through mining, agriculture and road construction. The earth itself changes its position in space and rotates at different speeds. Even the sea level is not so easy to measure. Its height varies with gravity, ocean currents, temperature and salt content.

Many coordinates are necessary for our modern life. Both our own on earth and those of the earth in space. We do a lot at BKG to determine these coordinates: we operate geodetic observatories to determine the earth’s rotation to the millisecond. We determine and monitor the orbits of satellites using laser measurement techniques. We derive coordinates from fixed points to provide the “framework” for positioning. We operate measurement networks to calculate exact altitudes and determine the gravitational acceleration of the earth.

In short, we are creating the basis for everyday life in a digital society in which the answer to the question “Where?” has become a matter of course. Everyone benefits from the results of this work, even if they are not always aware of it.



No navigation without geodesy

An everyday situation: you are travelling by car in an unfamiliar city. Your navigation system guides you. The GPS shows you the way. So simple. So good. But how does the navigation system know your position?

The answer is: from navigation satellites. They orbit the earth and send their signals to receivers worldwide. In order to determine the position of your car on earth, the satellites first need to know their own position in space.

Networked worldwide

This requires geodetic observatories around the world. We operate one of the best known and most modern together with the Technical University of Munich in Wettzell in the Bavarian Forest. However, global geodetic tasks require a worldwide network of observation stations. That is why we are also active in Antarctica and South America.

We work with a network of observatories and analysis centres worldwide to determine the orientation of the earth in space. This includes the actual orientation of the rotation axis, the current rotation speed and the difference between the satellites' atomic clocks and our "actual" time.

But what and how exactly do we measure so that the satellite positioning works and your sat nav shows you the right way?



Signals from space

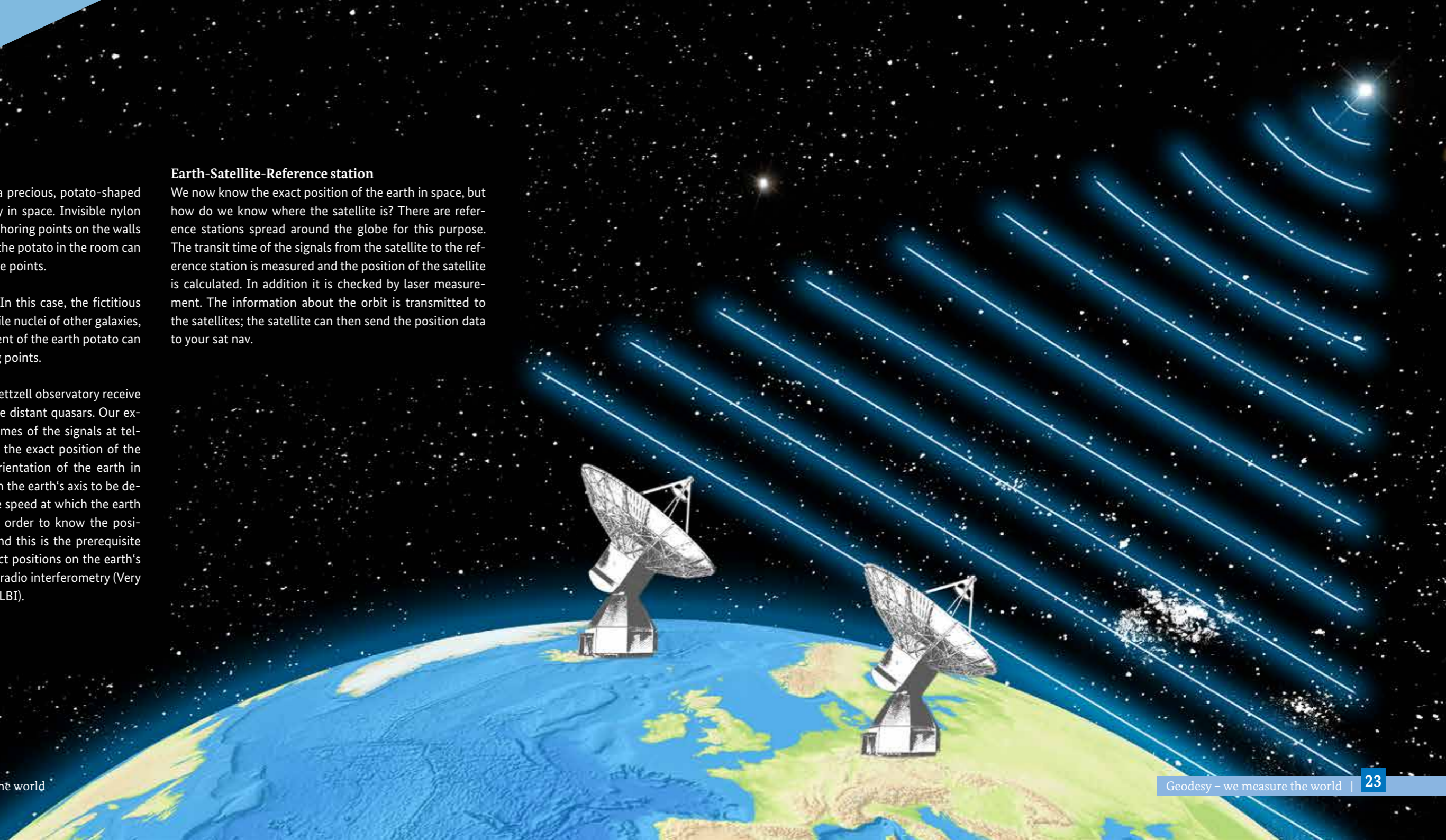
Let's imagine that the earth is a precious, potato-shaped art installation that floats freely in space. Invisible nylon threads connect the work to anchoring points on the walls of the museum. The position of the potato in the room can be precisely determined via these points.

The same applies to the earth. In this case, the fictitious anchoring points are the immobile nuclei of other galaxies, so called quasars. Every movement of the earth potato can be compared to these anchoring points.

Three radio telescopes in our Wettzell observatory receive the natural radio waves from the distant quasars. Our experts use the different arrival times of the signals at telescopes worldwide to calculate the exact position of the telescopes on earth and the orientation of the earth in space. This allows fluctuations in the earth's axis to be derived, as well as variations in the speed at which the earth rotates. These are important in order to know the position of the earth as a whole. And this is the prerequisite for being able to determine exact positions on the earth's surface. This technique is called radio interferometry (Very Long Baseline Interferometry, VLBI).

Earth-Satellite-Reference station

We now know the exact position of the earth in space, but how do we know where the satellite is? There are reference stations spread around the globe for this purpose. The transit time of the signals from the satellite to the reference station is measured and the position of the satellite is calculated. In addition it is checked by laser measurement. The information about the orbit is transmitted to the satellites; the satellite can then send the position data to your sat nav.



We deliver the position on the earth – accurate to the centimetre

Global satellite-based navigation systems make it possible to determine your location anywhere in the world. In principle, this is accurate to the metre everywhere. At BKG, we calculate correction factors to make the satellite information for the navigation systems even more precise. Using geodetic measurement methods, the results are even accurate to within a few centimetres.

Although the term GPS (Global Positioning System) has become established as a synonym for positioning, the navigation system in your car most likely receives data from all Global Navigation Satellite Systems (GNSS):

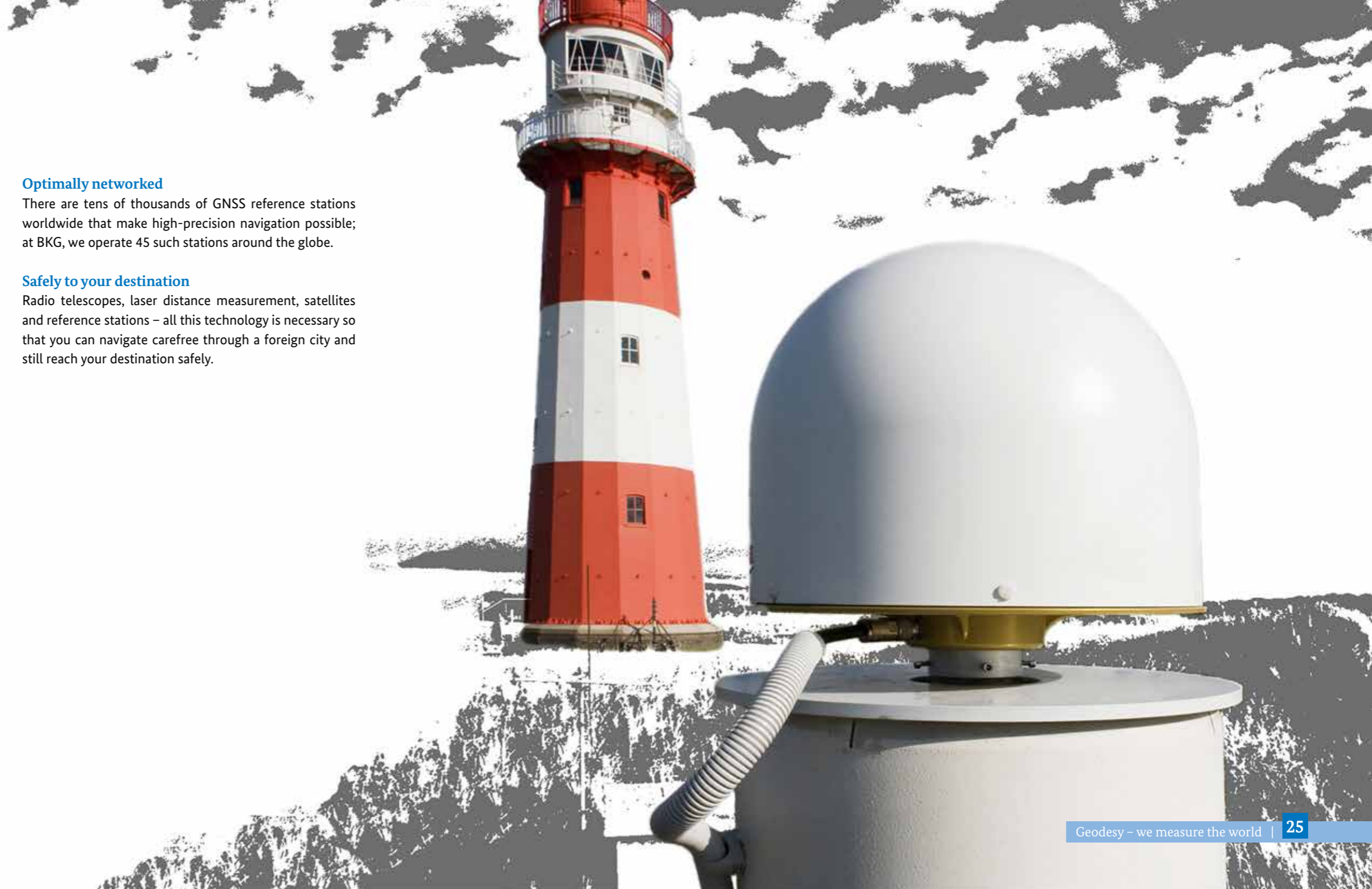
- GPS, operated by the USA
- Galileo, operated by the European Union
- Glonass, operated by the Russian Federation
- Beidou, operated by the People's Republic of China

Optimally networked

There are tens of thousands of GNSS reference stations worldwide that make high-precision navigation possible; at BKG, we operate 45 such stations around the globe.

Safely to your destination

Radio telescopes, laser distance measurement, satellites and reference stations – all this technology is necessary so that you can navigate carefree through a foreign city and still reach your destination safely.



We measure gravity – for precise heights

The gravitational acceleration g is 9.81 m/s^2 – that’s what you learn at school. This average value is sufficient for school lessons, but not for precise technical applications. On the one hand, gravity depends on the location, on the other hand it can also change over time. When calibrating a precision balance, for example, the local gravity value must be considered. This also applies to height measurements during construction work – otherwise the dyke will be too low or the new bridge will lead to nowhere.

Gravity values were determined using pendulums as early as the end of the 18th century. Today, we at BKG use modern laser and even quantum technology for this purpose. We supply the national gravity standard and operate sophisticated measuring equipment for this purpose: the gravimetric reference station at the Wettzell Geodetic Observatory, several mobile gravimeters and a nationwide network of fixed points, the “Deutsches Schweregrundnetz”.

We also set the standard when it comes to height. Since 2016, the “German First Order Levelling Network 2016 (DHHN2016)” has been Germany’s height system. To this end, a network of 677 nodes was laid across the country and surveyed over a period of seven years.

International cooperation is essential when it comes to heights, because: zero is not equal to zero. While Germany has used the Amsterdam Ordnance Datum as a reference since 1879, Switzerland bases its altitude data on the sea level of the Mediterranean at Marseille.

At BKG, we create a reliable database at the highest international level for gravity values and elevation data. It is the basis for the work of federal and state authorities, for industry and also for our own services.





Space weather and space debris

We observe to protect satellites

The satellites are in danger. Solar storms can damage the electronics and even cause a total failure. And debris, for example from earlier space missions, can collide with the satellites. Both can lead to massive damage.

Observe the sun

Our sun emits charged particles that form the so-called solar wind. This solar wind varies in intensity and usually has no consequences. Sometimes, however, it turns into a solar storm and can cause considerable damage in our high-tech and networked world. The power supply, navigation systems, radio and mobile phone signals and, of course, satellites of all kinds can be considerably disrupted or even damaged. Improved warning methods are absolutely essential.

This is why we also operate a solar observation telescope at our geodetic observatory in Wettzell in the Bavarian Forest. The measured values of the sun's radiation are used to predict solar storms and to assess their hazard potential. This means that instruments on the ground and in space can be switched off in good time and protected from damage.

Warn of debris

Our observatory is also able to determine the orbits of large space debris by measuring distances with lasers. This measurement data can help to warn satellites and space stations of collisions in good time in the future. This will give them the opportunity to correct their orbits to bring themselves to safety. It will also protect people on earth from the damage that uncontrolled re-entry of space debris into the atmosphere can cause.



BKG as a global player

International networking on behalf of the earth

What does the climate crisis have in common with autonomous vehicles? What do the United Nations' sustainability goals and satellite navigation have in common? The answer is short: the position! The connecting element of modern, sustainable living also lies here in the "Where?"

Sustainability through exact location information

For example, one of the goals of the United Nations 2030 Agenda is "Zero hunger!" Whether the goal has been achieved is assessed using the indicator "Agricultural area under productive and sustainable management".

The "Where?" is provided by earth observation satellites such as Sentinel. Its images provide information on whether a field is lying fallow or whether wheat ready for harvest is growing on it. Each of the 17 goals, from "No poverty", "Good health and well-being" and "Affordable and clean energy" to "Life below water", contains geoinformation.

Further examples: the climate crisis is causing sea levels to rise. A global network of reference points is needed to measure the rise. The same applies to autonomous driving. Here, too, stable location information that is always available and accurate to the millimetre is needed. At BKG, we are networked in many international co-operations. In this way, we help to ensure that our modern social life functions smoothly.

Excellent geodesy

The United Nations has chosen Germany to establish a centre of excellence in geodesy. The "Global Geodetic Centre of Excellence (GGCE)" was set up on the UN campus in Bonn. This centre will coordinate efforts to better integrate the countries of the southern hemisphere into the global geodetic networks. It will also promote the open exchange of geodetic data. With the observatories in Wettzell in the Bavarian Forest and O'Higgins in the Antarctic as well as the Argentine German Geodetic Observatory in La Plata, Argentina (AGGO), BKG already operates important points in the global network of reference stations.

With geoinformation

... against the climate crisis

We are part of the United Nations Global Geospatial Information Management (UN-GGIM) network set up by the UN. The Committee of Experts on UN-GGIM is a network of “geo-relevant” intergovernmental organisations. The aim is to integrate national geospatial data into the European and international environment. In order to better counter natural disasters, for example, geospatial data on changes in sea level or movements of the earth’s crust must be viewed in a globally standardised coordinate system of the earth.

... for more sustainability

UN-GGIM also coordinates the handling of geo-information worldwide. Geographical and statistical information is very important for calculating whether and how the 17 Sustainable Development Goals (SDG) of the United Nations are being achieved.

... for development cooperation

The Integrated Geospatial Information Framework (IGIF) supports developing countries in particular in collecting high-quality official geospatial data and establishing an efficient system for geospatial data management. We help to disseminate the necessary knowledge in these countries by organising workshops and providing advice.

... for Europe

Geoinformation is essential for achieving the European Commission’s goals. A Green Deal and a Europe fit for the digital age will only work with a sound basis of geoinformation. We are a member of the steering committee of the European network EuroGeographics. One of its tasks is to support the European Commission in establishing a European spatial data infrastructure with official data.



The virtual research centre of BKG

Gauss Centre for Geodesy and Geoinformation

There is no progress without research. Further developments in line with the current state of the art and science as well as new processes and technologies are the basis of what we do. That is why we have always worked closely with universities and research institutes.

Research at the cutting edge

For this reason, we are building a virtual research centre: the Gauss Centre for Geodesy and Geoinformation. This is where we award contracts for research topics that are burning under our nails. Universities and research institutions will carry out projects on behalf of BKG in order to gain new insights into various aspects of geodesy and geoinformation. The research results will then be directly incorporated into our work.

Summarised under the slogan “Geo meets Data Science and Fusion“, for example, research projects are planned to analyse 3D geospatial data and land cover time series. Capturing and analysing such data worlds and making them available for various applications is complex and time-consuming. To do this, differently structured geospatial data must be merged and combined. Other topics deal with the role of geodesy in the context of the climate crisis and environmental monitoring. Further studies will be carried out on the possibilities and benefits of geodetic information, data and products.





How to get our products

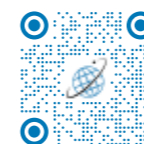
For federal authorities. For the economy. For everyone.

The results of our work are available in numerous data and product centres.

For printed maps, digital atlases or geospatial data sets, for example, our service centre is the central point of contact – here you will find everything at a glance, including contact persons and advice. Free federal data is available for download under open data licences. You can order all other official German geospatial data via our convenient online shop system – with comprehensive information on availability, up-to-dateness, quality and possible uses, terms of use and subscription included.

The printed maps of BKG are available as folded maps and wall maps in the following scales 1:200 000 to 1:1 million in bookshops or online.

www.bkg.bund.de/produkte



Whether standard maps or customised requirements – we provide public administrations, business, science and interested citizens with practice-oriented services and products. A quality management system ensures that users only receive the best products.



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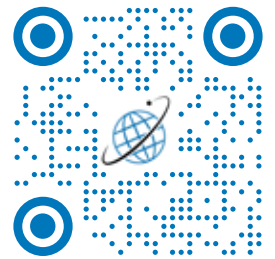
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