

Geodesy: The invisible backbone of modern life

What is geodesy?

Geodesy is the science of measuring and understanding the size, shape, and orientation of the Earth, as well as its gravity field. Geodesy establishes the fundamental spatial reference systems required for creating maps and supporting navigation systems, such as GPS, as well as for land surveying and monitoring changes in the Earth system, such as tectonic movements or rising sea level. Geodesists use a variety of tools, including both Earth- and space-based instruments, to collect the precise data required for these complex calculations and models.



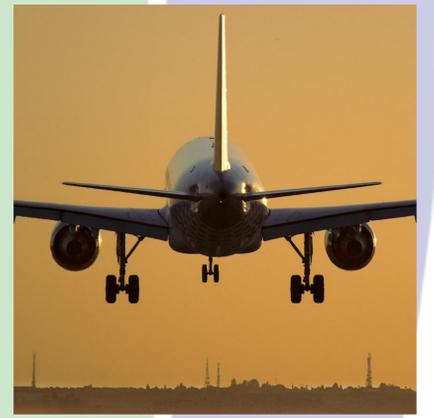
Framing our World: Geodesy provides the basis for positioning, navigation, and timing

Geodetic reference frames, such as the International Terrestrial Reference Frame (ITRF), provide the stable foundation for precise positioning, navigation and timing. They are essential for satellite observations, climate monitoring, disaster management and aligning global data. Recognised by the UN as crucial for sustainable development, these systems enable to detect subtle changes of the Earth and power tools such as mobile phone location services, precision farming and land administration. Without them, modern science and technology would not be possible.



Monitoring the Earth: Geodesy records the changes of our planet

The Earth is in constant motion: tectonic plates move, glaciers melt, sea level rises, and gravity changes. Geodesy allows us to measure and understand these processes with millimetre precision. By monitoring crustal movements, earthquake effects, and volcanic activity, geodesy contributes to risk reduction and geophysical understanding. At the same time, satellite-based geodetic measurements are vital for tracking climate change, showing how ice sheets shrink, oceans expand, and mass redistributes. This data is essential for environmental policy, international climate agreements, and models of future change.



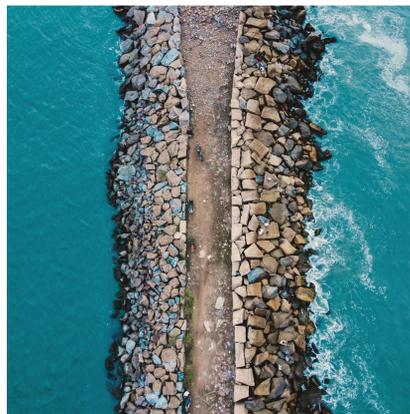
Shaping the Path: Geodesy is essential for safe navigation and mobility

Modern mobility relies on geodesy, which provides the precise reference frames used by Global Navigation Satellite Systems (GPS, GLONASS, Galileo and BeiDou) to determine positions anywhere and at any time. This geodetic foundation supports safe air travel, disaster response and everyday location-based services. For researchers, it is essential for monitoring changes to the Earth system, and for society as a whole, it underpins infrastructure and enables us to move confidently through the world.



Building the Future: Urban planning and infrastructure development are not possible without geodesy

Geodesy provides the precise positioning and elevation data on which modern cities depend for safe and resilient development. It supports the design of infrastructure, land and resource management, and the monitoring of structural stability in projects ranging from bridges to smart cities. Accurate geospatial data also informs policymaker decisions regarding land use, risk zones and sustainable growth. As urbanisation and climate change accelerate, geodesy helps to ensure that cities remain innovative, efficient and durable.



Saving Lives: Geodesy plays a central role on disaster management and risk reduction

GNSS-based systems provide crucial early warnings of landslides, tsunamis or volcanic eruptions, buying valuable time to save lives. Satellite geodetic data also track longer-term threats such as land subsidence, glacier collapse and sea level rise, helping governments and emergency services to prepare evacuations, design response strategies and strengthen infrastructure. In an era of increasing environmental hazards, geodesy is an essential yet often overlooked protector of lives and livelihoods.



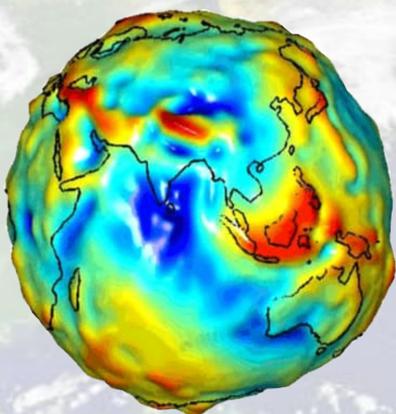
Keeping Time: Geodesy ensures the crucial knowledge for timekeeping

Geodesy is the foundation of modern timekeeping, accounting for the Earth's rotation and mass movements, which influence how time is measured. It aligns atomic clocks with the planet's actual rotation, thereby ensuring the accuracy of Coordinated Universal Time (UTC). This precision is vital for navigation, telecommunications, financial operations and scientific research. Without geodesy, global time systems would gradually become out of sync.



Mapping the Earth's Surface: Geodesy determines the geometry of the Earth

Geodesy provides the precise measurements needed to accurately model the Earth's surface, including its shape, elevation and features. This knowledge is fundamental for accurate mapping, definition of national borders, infrastructure planning and management, and environmental monitoring. Scientists use geodetic surface models (both on land and at sea) to study phenomena such as sea level rise, landslides and natural hazards, while governments rely on them to manage land resources and respond to climate challenges.



Measuring the Earth's Gravity: Geodesy studies the force that shapes the Earth

Gravity is much more than a force that keeps us on the ground; it is critical to understanding the structure and changes of the Earth system. Geodesy measures gravity variations that reveal the distribution and transport of mass beneath the surface. Gravity measurements are essential for accurate height determination on land and in the oceans. Gravity variations provide insights into global processes such as climate change and mass transport between and within the different components of the Earth system. The study of gravity is key to monitoring the Earth's motion and supporting applications in navigation, climate science, environmental protection and resources exploration.



Observing the Earth from Space: Geodesy quantifies changes in the Earth System through satellites

The Earth is under constant observation by an increasing number of satellites orbiting our planet, forming a network of space-based observatories that provide insight "from above" into the movements and transformations of our planet. Dedicated satellite missions monitor different components of the Earth system: atmosphere (air), hydrosphere (water), cryosphere (frozen water), lithosphere (solid Earth) and biosphere (living beings), providing critical data on climate change, geophysical processes and human-induced transformations. Geodesy is responsible for the accurate determination of satellite orbits, which in turn are essential for reliable measurements of the changing Earth.



Determining the length of day: Geodesy measures how Earth rotates and wobbles

Why are the days getting longer, and why is the Earth wobbling? Geodesy answers these questions by monitoring the Earth's rotation through Earth Orientation Parameters (EOPs). These parameters track changes in the Earth's rotation and orientation, which are influenced by the atmosphere, oceans, and solid Earth. Geodesy uses geodetic techniques such as GNSS, VLBI, SLR and DORIS to measure these changes with precision, supporting satellite navigation, orbit determination and time systems. This knowledge deepens our understanding of the Earth's dynamics, including the effects of climate change and geophysical processes on its rotation.



Measuring the Space: Geodesy is essential for space exploration

Geodesy extends beyond Earth, providing the precise reference systems needed for space exploration. The International Celestial Reference Frame (ICRF) and the Earth Orientation Parameters (EOPs) link Earth-based observations to the cosmos, enabling accurate spacecraft navigation and mission planning. Planetary geodetic systems allow scientists to map and monitor surfaces of bodies like Mars and the Moon, supporting exploration and geophysical studies. As humanity ventures deeper into space, geodesy remains the foundation for navigation, mapping, and understanding other worlds.

Curious about geodesy?
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