

Technology Brief 29

Mapping the Entire World in 3-D

Mapping software has become increasingly indispensable in the 21st-century industrialized world. Giving verbal directions to someone's house has been replaced with directing them to Google Maps with the relevant address. Even more exciting and controversial, however, is the growing suite of 3-D **virtual globe** mapping software. Of these, arguably the most famous is the currently free Google Earth software. These packages allow the user to fly in virtual space around the world, into cities and remote areas and (in densely mapped areas) to view their own backyards, streets signs, and local landscapes; Google Sky includes virtual, navigable representations of the Moon, Mars, and the night sky. The tools are becoming an enabler for a new generation of armchair historians, archaeologists, demographers. They have already been used in search and rescue operations. How do these packages work? Where does this data come from? How is the world mapped?

Planes, Satellites, and Automobiles

Data for these packages is acquired by specialized companies (including Google itself) that make use of satellites, aircraft, and (more recently) large fleets of specially equipped vans. The majority of data comes from several satellites orbiting earth financed by either national governments or private companies. For example, the U.S. National Aeronautics and Space Administration (NASA) has the long-standing Landsat 7 program which has 30-m imaging resolution and scans the earth in about 16 days. The European Space Agency's ERS and Envisat satellites perform similar functions. All of these satellites perform functions other than visual spectrum imaging; some have infrared sensors, radar sensors, temperature sensors, etc. Several commercial satellites are now in orbit whose primary function is to map the globe in high-resolution mode; DigitalGlobe's WorldView-2 satellite, for example, provides 0.46 m spatial resolution—although not all data are publicly available. Most of these satellites maintain sun-synchronous orbits, which means that their orbits loop over or near the north and south poles and cross the equator twice on each loop. In this type of orbit, the satellite “visits” a given place at the same local time each visit, which is great for maintaining constant lighting

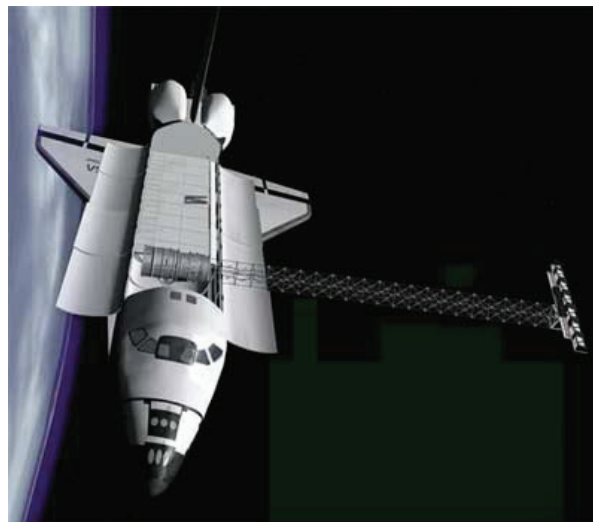


Figure TF29-1: The Shuttle Radar Topography Mission used an antenna located in the payload bay of the shuttle, and a second outboard antenna attached to the end of a 60-m mast. (Courtesy of NASA.)

for satellite images. Additionally, 2-D visual information is supplemented with digital elevation model (DEM) data collected by NASA's Shuttle Radar Topography Mission (SRTM). The SRTM (**Fig. TF29-1**) consisted of two radar antennas deployed on the space shuttle **Endeavour** during the 11-day mission of STS-99 in February 2000. A sample product is shown in **Fig. TF29-2**.

Aircraft imaging complements the satellite data, although it is more expensive and available in limited areas. Several companies have launched fleets of specially equipped vans with multiple cameras, laser distance sensors, and on-board computation to collect, merge, and store high-resolution, three-dimensional data at street level. Additionally, Google Earth allows for user-inputted 3-D information and models. **Figure TF29-3** shows one such vehicle developed by TeleAtlas. Hundreds of similar vehicles roam the earth; the cameras provide images over 360° around the vehicle, and a laser system measures important distances like bridge and building heights; GPS tracking hardware records the vehicle's position; and onboard computers synthesize everything and store it. As these vehicles visit more and more places, the 3-D map of the world continues to grow.

Imaging Software

To produce a navigable, virtual representation of our globe, all of this data is then compiled, corrected, and

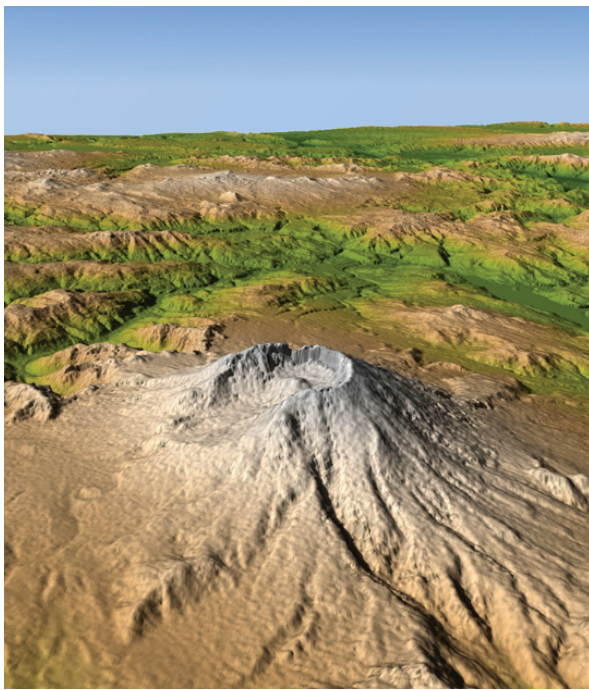


Figure TF29-2: A shaded relief image of Mount St. Helens in the state of Washington. (Courtesy of NASA.)

merged. This is not just a massive storage operation. Often, imagery comes from multiple sources that do not match exactly, there may be gaps between images and, very commonly, the color of the images must be corrected and made consistent. Fine-scale errors often are detectable with these map programs when data is incorrectly merged or have different dates; for example, pictures of a city might incorrectly show data from adjacent areas taken before and after major events, stitched together. Problems with incorporating 3-D topographical data with the visual information are still common. For public-accessible programs, not all data is taken at the same time nor with the same frequency; for example, Google Earth guarantees that image data is no more than three years old. More expensive commercial software is often more timely.

Beyond the compilation and merging of datasets, programs like Google Earth are increasingly integrating their software with both other software and mobile hardware. For example, Google Earth interfaces with both Wikipedia and the Google search engine as well as an increasing suite of information-providing programs. In a similar manner, some versions of commercial virtual



Figure TF29-3: A TeleAtlas van showing the imaging and laser equipment and the computation hardware inside the van.

globe programs can interface with GPS position-finding devices. Such programs take waypoints and tracks from the mobile GPS devices and merge them with available topographic, imaging, and other virtual globe datasets.