Leica Geosystems Solution

Leica Geosystems GPS installed on the Stromboli Volcano

Leica Geosystems Total Station installed on the volcano's slope

The Istituto Nazionale Geofisica e Vulcanologia (INGV) is the Italian institute for monitoring volcanic activity. The Italian region is one of the most volcanically active on earth and the INGV is at the forefront of Volcanic Research. Over the past 10 years, volcanologists have realised the benefits of using GPS for gathering continuous, real-time and highly accurate information about the movements before an eruption. In February 2003, the INGV installed Leica Geosystems' GPS equipment on the highly active volcano of Stromboli. These instruments enabled Dr. Mario Mattia and his team to track displacements on the volcano in real-time, just before a series of eruptions. Not only was the data useful for ensuring the safety of the island's inhabitants - for the first time, scientists have data that show the movement of the mountain in the vital minutes leading up to a paroxystic explosion.

- when it has to be right

Leica Geosystems

The isle of Stromboli

The main goal of the INGV's research is learning more about physical processes that can be considered the root of all volcanic activity. The use of GPS and live wireless links to the volcano opens new possibilities for the scientists.

"Our work can be considered as the 'new deal' of volcanology because we are abandoning the concept of the 'recognition pattern' of visual observation and of instrumental data. We have approached the quantitative concept of the knowledge of the physic of the causative process" explains Dr. Mario Mattia, the chief geologist from the INGV.

Living on a "bomb"

Stromboli is a composite volcano, forming the northernmost island of the Aeolian Archipelago and is located between Sicily and the southern part of the Italian mainland. Composite volcanoes are particularly dangerous because of their tendency to erupt in an extremely explosive manner. Although it has been almost permanently active during its history (several chroniclers from the Greek epoch mentioned its constant activity), this tiny island on the Tyrrhenian Sea is also a home to people who live in the two villages of Stromboli and Ginostra.

Despite its unquestionable beauty, Stromboli is a hazardous island on which to live. Not only do its volcanic eruptions pose a risk to two local villages, they create devastating tsunami waves that can cause severe damage to the Sicilian Islands and theItalian mainland's coast. For instance, the eruptions in 1919 and in 1930 killed 10 people and injured dozens. In the last century, ballistic ejecta emitted during explosions destroyed many buildings and fires caused severe damage to crops.

However, the people of the region are not alone. They are constantly watched by a group of scientists from the Catania section of the INGV who monitor volcanic activity on Stromboli – Dr. Mario Mattia and his team.

On 28 December 2002, after a 17-year period of moderate activity, the Stromboli volcano suddenly erupted. The pressure of lava created an eruptive fissure from which lava outpoured. Within 30 minutes the lava had reached the sea – almost 1 kilometre away. In the days to follow, two landslides generated a 10m high tsunami that caused severe destruction on the island and some damage to the Aeolian archipelago and the northern coast of Sicily. Fortunately, these events occurred in winter. It is frightening to imagine the devastation that might have occurred if the tsunami had been unleashed at the height of the tourist season.

Adapting real-time GPS to the Volcanic Environment

The December events prompted the INGV decision to set up a GPS network aimed at real-time monitoring of the volcano's movements. The scientists used Leica SR530 receivers, equipped with the Leica AT502 and Leica AT504 antennas.

There are a multitude of challenges associated with the continuous operation of a real-time GPS system in any harsh environment. Of prime importance is the safety of personnel. Apart from the obvious danger of volcanic activity, the ideal location for the GPS reference station was far too hot for scientists to remain long enough to carry out a conventional installation. Once installed, the GPS is vulnerable to volcanic activity itself.

Although Leica Geosystems' instruments are built to the highest environmental specifications, the INGV built a reinforced concrete structure to protect the system against volcanic activity such as debris flung from the volcano and the extreme heat. A very important aspect of the structure was that it was self-installing. To facilitate this, the INGV used the services of a military helicopter to ensure rapid and safe installation.

Another challenge was power supply. The instruments are powered with energy from solar panels, which reduces the power consumption.

"Installing a new station is always a difficult task. However we have a lot of experience in this field. In particular, during the 2002 crisis on Stromboli we designed a new type of 'self-installing' station, dedicated to areas impossible or dangerous to reach. In order to minimize the risk we used military helicopters for logistical support to drop concrete cages with GPS" says Dr. Mario Mattia.

Leica Geosystems equipment in a concrete cage

The highly accurate position data is sent from GPS receivers through a radio-bridge to San Vincenzo Observatory in the village of Stromboli where information is collected and archived. This system provides scientists with fast real-time data that enables an early warning to be given to the population of large regions of Southern Italy potentially affected by large-scale tsunami.

One reference station was finally destroyed by lava flow on February 15th 2003. The other two instruments continued to provide valuable data until they were also destroyed on the 5th April 2003. When the reference station was destroyed, there was concern that the volcano would trigger another major landslide – a major threat to the island's inhabitants. However, the data recorded by the GPS allowed scientists to determine that the movements were not consistent with those which would trigger a landslide. As a result of the data, the cost and distress of a major evacuation was avoided.

The experience gained is of great scientific importance. Scientists studying physical processes of volcanic eruptions now have access to high precision, real-time data showing the movement that occurs right up to the moment a violent eruption.

Automatic Measurements of Slope Stability with Theodolites

At the same time Total Stations were used to monitor prisms strategically located on the volcano's slopes. The instrument chosen was a Leica Geosystems TCA 2003 Total Station equipped with GeoMoS software.

The new system was called THEODOROS, which is an acronym for THEODOlite and Robot Observatory of Stromboli. The system measures 17 strategically located reflectors 48 times per day. The properties of prisms allow scientists to take measurements in even more extreme environments. As with conventional monitoring, it is very important to have a range of technology to suit different tasks.

Future Directions

Current surveying technology allows scientists to perform real-time, detailed monitoring of ground deformation. The achievable accuracies in 3D positioning are suitable for both scientific and early warning purposes.

The strategy that was implemented on Stromboli allows Civil Protection Authorities to appropriately manage the volcanic crisis, warn and evacuate population endangered directly by the volcano and by the imminent tsunami wave. The INGV is installing another GPS system to continue the valuable research and monitoring service.

The INGV and Dr. Maria Mattia

Dr. Mario Mattia is a geologist and has worked on volcanoes since 1995, when he was involved in the installation of the first GPS permanent station in Vulcano Island (Aeolian Islands, Italy). He has developed software and technological solutions for GPS permanent stations on volcanoes from the beginning of his professional career. He is responsible for all of the GPS stations on Sicilian volcanoes and is a member of the INGV committee that is implementing the national Italian GPS network. He has published more than 20 articles in national and international reviews of geophysics and volcanology.

The INGV was born in 2000 as a merger of several Italian institutes whose activities were related to geophysics and volcanology. In particular, the Catania section of INGV is the result of a fusion between two different institutes: the IIV (International Institute for Vulcanology) and the Sistema Poseidon. Alfred Rittman, one of the most important Volcanologists of the past century, founded the IIV in 1969. In 1999 the monitoring activities of IIV where separated in another institution, called Sistema Poseidon, but this institution lasted only 2 years before the birth of the INGV.

Concrete reference station destroyed by the volcano.

Italian Volcanologist installing the Leica Geosystems antenna

Whether building a house or a bridge, an office complex or a new road, you need reliable measurements. So when it has to be right, professionals can trust Leica Geosystems Surveying & Engineering to help them collect, analyze, and present spatial information.

With a long heritage of technology leadership in pioneering solutions to measure the world, Leica Geosystems Surveying & Engineering is best known for its broad choice of products and services including TPS total stations, GPS global positioning systems, levels, construction-site lasers, and machine guidance systems, through to comprehensive, integrated solutions for infrastructure and deformation monitoring.

Those who use Leica Geosystems products and solutions every day trust them for their reliability and the value they deliver, and trust in the superior support network.

Reliability, value and service from Leica Geosystems.

When it has to be right.

Leica Geosystems AG
Heerbrugg, Switzerland

www.leica-geosystems.com

- when it has to be **right**

Leica Geosystems