Italy: Leica Geosystems in the universe of mobile telephony

A new partnership between Telecom Italia Mobile (TIM) and Leica Geosystems Italia means that a national GPS network now exists throughout Italy, able to support professional GPS users with precision positioning for various applications and in numerous market segments. As well as providing a DGPS differential correction over a mobile telephone network, TIM's network is used to optimise the use of its antennas and is able to monitor the network for radio frequency leakages, supporting scientific documentation regarding the extent and disposition radio frequency electromagnetic fields – an important issue with health and environmental implications.

Distribution of the GeoTIM network

The TIM Group (Telecom Italia Mobile), which is present not only in the Italian market but also in Latin America and within the Mediterranean basin, is a market leader in Europe particularly with regards to the number of lines. The TIM Group had 24.2 million lines on the national market on 30th September 2002. If we also consider the Group's foreign customers, TIM reaches an overall total of 37.3 million lines.

TIM has adopted the customized technology and solutions offered by Leica Geosystems Italia for all its requirements regarding measurement, checking and positioning of the antennas for the diffusion of the GSM and UMTS signals. TIM and Leica Geosystems Italia have developed a collaboration that goes far beyond that of a simple customer / supplier relationship. Together they have devised a series of solutions that are being introduced to the market today, with innovative services such as the transmission of the DGPS differential correction on a mobile telephone network. A professional operator may receive such corrections in real time on his mobile phone, and with just one GPS receiver, he can carry out precise positioning, or download the data required for Post Processing differential correction from the **www.business.tim.it** website.

The GEOTIM Network

In Italy, the implementation of the law regarding the definition of radio frequency electromagnetic field limits that are compatible with human health, represents a strategic opportunity for TIM. By adopting a network infrastructure and suitable tools for the correct georeferencing of mobile telephony installations, the impact of radio frequency electromagnetic fields can be

The strong points of the GeoTIM network can be summarized as follows:

- **Uniform distribution over the entire national territory:** The fact that TIM has a considerable number of radio stations distributed throughout the territory (urban, interurban, rural, mountainous regions) has simplified the identification of sites suitable for the installation of a permanent GPS station (maximum visibility, absence of interference, structural stability, etc.), which has rendered GeoTIM the only network with uniform national coverage.

- **organization within the IGM95 national geodetic network**

- **ASI (Italian Space Agency) certification:** certain GeoTIM stations will become part of a group of stations managed by ASI within the European Reference Frame (EUREF); ASI will issue a weekly data certification for the differential correction produced by the GeoTIM network, therefore offering national and international significance and credibility, even in scientific circles.

- **easy network interconnection:** GPS data travels within an intranet business network (equipped with a high-capacity backbone and an elevated number of POP addresses), which allows for the integration of individual GPS stations and the creation of a truly integrated GPS network. A management platform for the entire system (LMP) allows for the concentration of data within a single collection center, which also functions as the customer's service access point.

- **Network-monitoring system:** GeoTIM monitoring is managed in a similar manner to other TIM network infrastructures.

- **reliability of service and timely maintenance interventions:** TIM's presence within the territory and their on-site intervention capacity allows for the optimization of station restore times, guaranteeing high service reliability.

monitored. This opportunity resulted in the need for a project aimed at the realization of a network of GPS reference stations (which currently number 34), called GeoTIM, the first of its kind among mobile telephony operators in Italy. By means of this network, TIM has developed an instrument that is essential for meeting institutional requirements (Local Health Care Services, Regional Agencies for Prevention and the Environment, Ministry of Communications, and other public administration agencies), in that it provides scientific documentation regarding the extent and disposition of volumes in reference to their own radio stations, as well as the distances between these same stations and public buildings (schools, hospitals, etc.).

During its construction, in addition to acquiring know-how in an uncommonly large sector for a mobile telephony operator, the company began to realize the inherent value of the resource at hand, which could focus its interest on what is now a mature market. The availability of a GPS network for precision positioning, is an excellent form of support for performance optimization in various market sectors. These inlcude areas such as GIS mapping, topographic and cadastral surveys, technological network management, the management of natural and environmental resources, intelligent transport, and precision navigation.

The reference stations currently consist of a GPS geodetic, double frequency, 12 channel L1/L2, C/A and P code, RTCM and RTK receiver and a local server that manages the station itself and interfaces with the business intranet network. This allows connection to the management platform for the entire system (LMP) as well as to the alarm monitoring system.

The antenna is a choke-ring type. This guarantees phase center stability, effective multipath protection, and also ensures the possibility of tracking satellites even at low-level elevations.

The Geodata Service

The TIM GeoData service, which was conceived with the aim of making GeoTIM network data available to external clientele, was commercially launched in September 2002. The availability of a national infrastructure for precision positioning allows for the expansion of new market segments in multiple sectors. As already mentioned, GPS differential correction data is available according to the two classic access modes already used by professionals with differential GPS instrumentation, post-processing and real-time.

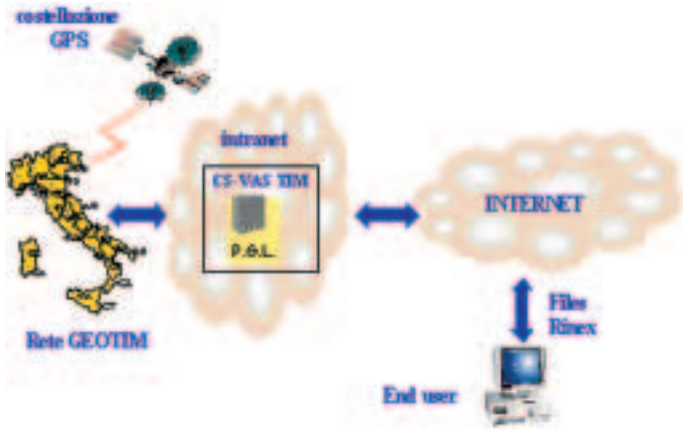
Post Processing Service

The GPS stations periodically send time files containing data for differential correction, formatted according to the RINEX (Receiver Independent Exchange format) international standard.

The GeoData Post Processing service assumes that the customer carries out his GPS survey with a rover unit, which records the measuring session. Subsequently, he connects to the web site www.business.tim.it from his Internet station.

Following the login phase (insertion of the User-ID and Password), he will access a page from which he can:
- select the desired GPS station;
- select the data sampling rate (1, 5, 15 or 30 seconds)
- insert the desired date and time slot

Selection of the desired GPS Station



Architecture of the GeoData in Post Processing Service

Selection of the frequency, data and time slot

Time files available for customer download

In response to the query, the LMP supplies a list of existing files (maximum 30-days old), the possibility of downloading those required and, through the use of specific software, post-processing of the field measurements to refine the accuracy of results.

Real Time Search

The GPS stations continually transmit differential correction data to the LMP, in accordance with the RTCM SC-104 (Radio Technical Commission on Maritime Communication, Special Committee 104) international protocol standard, Release 2.2.

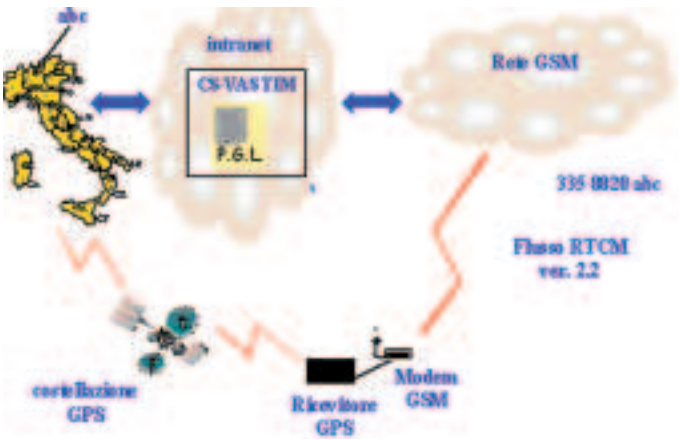
The GeoData Real Time service requires the customer to activate a telephone connection with the LMP by dialing a TIM radiomobile number for the desired GPS station, from a GSM mobile phone (with active SIM card), that is connected to a GPS rover receiver.
When the connection is made, the GPS measurement session begins and continually receives the requested data at a speed of 9.6 Kbits/s, performing differential correction directly on the field and obtaining highly accurate data.

The GeoTIM network constitutes the first homogeneous and certified national system nucleus for georeferencing. The related GeoData service allows customers to use the network across the entire national territory.

The "APOGEO" Procedure

With the development of radiomobile technologies from 2G (GSM) systems to 3G (UMTS) systems and value added services based on localization, the need has also arisen to add an ever-increasing number of radio stations to the network, with limited and controlled radio coverage. In order to do this, it is necessary to have frequency planning and radio coverage simulation tools that use highly reliable databases for network design. TIM has therefore applied stricter accuracy standards concerning the correct positioning of sites and the precision with which antenna design parameters are practiced, obtaining not only a network of permanent GPS stations but also professional instrumentation kits. Following numerous tests carried out on products from various companies that operate in the sector land survey instruments, TIM's technical staff selected Leica Geosystems Italia as their supplier. Leica was chosen because it allowed TIM to obtain a wide range of perfectly reliable instruments, and with consideration of the extreme variability of environmental situations in which they must operate. Each kit consists of a GPS SR530 receiver with all the accessories necessary to perform both Fast Static and Real Time analyses, and a fully motorized TCRM1102 laser station for topographic surveys. Undoubtedly, the strongpoint of the kit is the topographic instrument, the technical characteristics of which distinguish it from those of other companies. Such characteristics include precision distance (3mm) and angle (2") measurements, a reflectorless range (>150 m), and maximum laser divergence of 100 m (1.5mm x 3mm). In particular, the maximum laser divergence is very important for distinguishing two points very close together when measuring across long distances. The use of the PCMCIA card both inside the GPS receiver and the topographic instrument is also a highly useful form of support for customizing other potential functions (for example: direct calculation of the tilt and the azimuth).

In order to increase the accuracy of the business databases, on which all the activities related to the design, construction, maintenance, and optimization of the network are based, the APOGEO (Antennas Procedures On Geographic Enhanced Orientation) operating procedures were developed and patented by TIM both in Italy and abroad. These procedures define the operating methods for the accurate measurement of geographic coordinates (latitude,



Selection of the frequency, data and time slot

longitude, and altitude), orientation with respect to geographic north (azimuth), inclination with respect to the vertical (tilt) and altitude from the ground, of radio station antennas using the above-mentioned professional instrumentation. The APOGEO procedures have become an integral part of the technical testing standards and contracts with supply and installation companies that operate for TIM. In this way, TIM accepts the facilities only when their conformity to the design specifications has been verified by applying these procedures.

In general, each radiomobile installation irradiates the signal from multiple cells (directions) installed on a towering structure (pylon, pole, building) by means of appropriate supports. Each cell is made up of multiple antennas (fixed electromagnetic sources) the support structures of which may vary from one installation to another. The element to which all topographic survey operations required by the APOGEO procedure therefore refer, is a single antenna.

The identification of the geographic coordinates (latitude, longitude, and altitude) of the antennas in the WGS84 system and of their tracking angle on the horizontal plane (azimuth), with respect to geographic north, generally requires the completion of a mixed survey. These are based on simultaneous GPS instrumental surveys (eg. Leica SR530) and topographic surveys (eg. Leica TCRM1102). In fact, bearing in mind that the points to be surveyed are inaccessible, it becomes necessary to record two or more reciprocally visible points in the vicinity of the

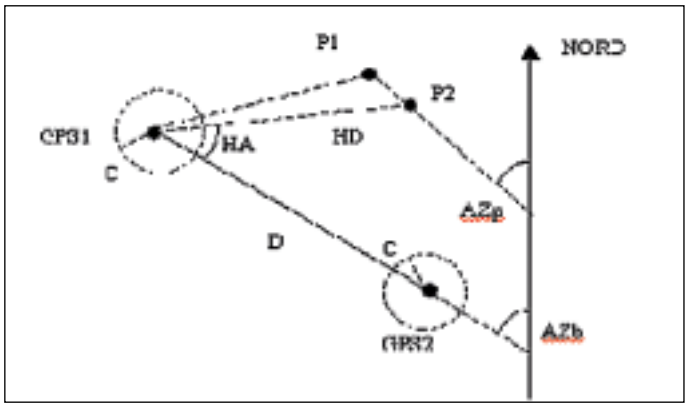
The use of the following instrumentation and, subsequently, the APOGEO procedure, is intended to promote:

- increased accuracy in the installation, maintenance, and optimization processes by the companies that operate for TIM, through the verification of the conformity of equipment to project specifications. With these instruments, errors that could occur with the use of conventional instruments normally employed by installers of mobile telephone systems (inclinometers, compasses, altimeters, etc.) are eliminated.

- qualitative improvement of the network in terms of coverage and protection from interference, thanks to increased precision in the calibrating of antenna tracking. Furthermore, given the greater sophistication of future UMTS systems, this will be an increasingly important consideration.

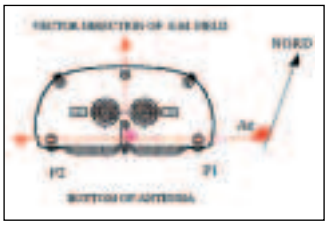
- greater reliability of the business databases necessary for the design of the network, for the supply of added-value services (eg. services based on localization), and for the processing of impact area data necessary in order to conform to the electrosmog regulations now in force.

- performing necessary remote verification of the antennas, while guaranteeing the safety of personnel (TIM or suppliers') directly involved in the actual surveying activities.



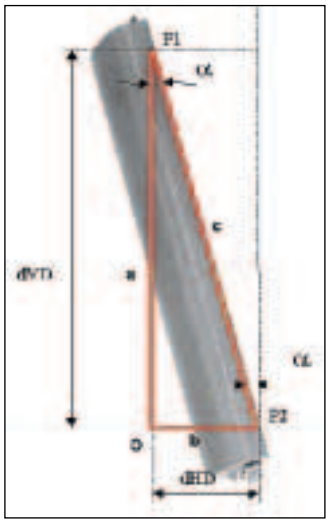
Antenna points

Frontal view of Antenna

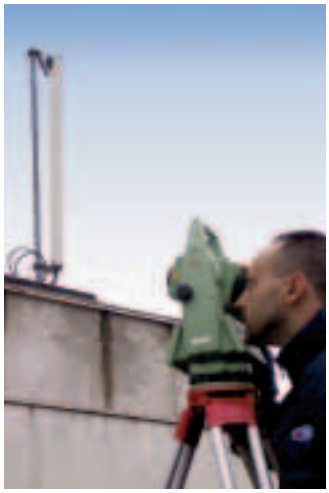


Rear view of Antenna

Coordinates and Azimuth measurement



Antenna tilt and height measurement



antennas by means of GPS, from which the points on the antennas are visible, and as such detectable by a topographic instrument, which in turn are capable of recording angular measurements (azimuth directions and zenith angles) as well as distance. For the coordinates (determined in WGS84), the point at the base of the antenna is measured, while the two points on the same horizontal plane are measured for the azimuth.

The position of GPS vertices in relation to points on the antenna to be measured must planimetrically define triangles, preferably equilateral triangles, in order to optimize planimetric precision.

The calculation of the antenna tracking angles of the on the vertical plane (tilt) and the height of the antenna from the ground may be performed by using the topographic instrument only, positioned on opportune vertices (not GPS), from which the points to be measured are visible. More specifically, the calculation of height in relation to the ground is performed by determining the difference based on the measurements of the incline distance and the zenith angle. Therefore, calculation of the tracking angle on the vertical plane (tilt) is always determined by measuring the azimuth directions, the zenith angles, and the distances to both the identified points, lying on the same vertical.

It is important to emphasize that a higher or lower level of complexity in performing an on-site survey, even with equal antenna dimensions, is strictly related to local logistic limitations. It is obvious that a survey of a radio station in the suburbs

TIM Antenna site

with each antenna installed on the same pylon is much quicker and easier than that of a radio station in an urban area on the roof of a building with each antenna on its own pole. It is therefore always necessary to adapt such procedures to the specific conditions of each individual site.

TIM Group

Leica Kit for TIM consists of GPS SR530 and TCRM 1102