

Europe's GALILEO Global Navigation Satellite System

Galileo in Poland



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The American GPS system has now become a popular utility, used in many domains of everyday life. However, new technology triggers new applications, and new applications require improved tools. It is now clear that GPS alone will not be able to satisfy all needs

The European Community and the European Space Agency (ESA) engaged in many years of discussions on the possibility of establishing a satellite system similar to GPS. Conceptual and technical work was launched at the beginning of the 1990s; formal and political support for the project came later. In 1999 the European Council underscored the strategic importance of the satellite navigation program and asked the European Commission to take all the measures necessary to implement it, and it was then that the name "GALILEO" was coined. Financial decisions were also taken, enabling the start of the regular specification and development phase. Since then, GALILEO has been developed as a joint program of the ESA and the EU.

Poland became a member of the European Union in May 2004, and thus it also formally became one of the owners of the future GALILEO system. It comes as no surprise, therefore, that we have been interested in the GALILEO project since the very beginning. However, our ability to get involved was very limited. Not being a member of the ESA, and before becoming a member of the EU, Poland had no official platform for participating in the work on GALILEO, and even less in making decisions. But thanks to traditional contacts with the ESA and professional cooperation with research units in different countries, a certain contri-

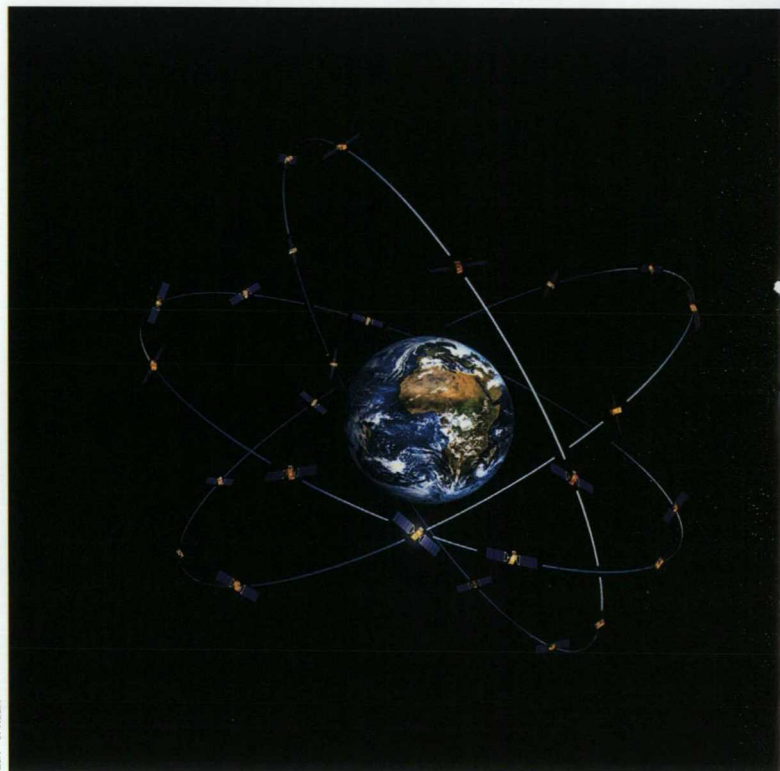
bution to the GALILEO work did indeed become possible.

What innovations does GALILEO bring over GPS? First, it rests upon a legal and political foundation. GPS is under the exclusive control of one country and is not subject to international conventions or treaties. GALILEO, on the other hand, will be an international system and will be regulated by rules defined by the EU members and confirmed in treaties with other interested countries. GALILEO will accept liability in the event of malfunction or service interruption. GALILEO is slated to offer five different services:

The **GALILEO Open Service** is defined for mass-market applications. It will provide signals for timing and positioning, free of charge. Combined GPS/GALILEO receivers will probably become very popular.

The **Safety of Life Service** is intended mainly for air navigation, but also for all applications where a degradation in system performance can endanger lives. It will pro-

The Galileo System constellation



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vide information about the quality of the signal received by the user.

The **Commercial Service** is aimed at market applications requiring higher-quality performance, and will be provided on a paid basis. It consists in two encrypted signals that are added to the open access signal. Access will be controlled at the receiver level, using access-protection keys.

The **Public Regulated Service** is designed for governmental applications and services like the police, firemen, ambulance, military and customs services. It will be controlled by administrative bodies.

The **Search and Rescue Service** will be used for humanitarian search and rescue. It will provide a return link, facilitating rescue operations.

A kind of Open Service is now available through GPS. It has been in use in Poland for years in various fields, allowing a wealth of experience to be accumulated. Geodesy, marine navigation, car traffic control and other applications have been developed in our country. One special domain where some interesting results have been achieved is time measurement and transfer.

Time measurement technology lies at the heart of the satellite navigation system. Distances are measured by means of time interval measurement. A GPS (or GALILEO) satellite is in essence a "flying atomic clock" and the whole system constitutes a huge constellation of clocks of the highest precision. The time scale of the GPS system as a whole is defined by a battery of more than one hundred cesium frequency standards and maser atomic clocks at the US Naval Observatory. Each GPS receiver contains a time and frequency standard, ready to synchronize with the satellite signal.

In the domain of time measurements, some interesting results have been achieved at the Borowiec Astrogeodynamical Observatory of the Space Research Centre, Polish Academy of Sciences. Working in cooperation with the International Time Bureau in Paris, Polish experts have developed the TTS2 GPS time receiver, enabling distant clocks to be compared with an accuracy of 10^{-8} sec. The next generation of this receiver, providing an accuracy one order of magnitude higher, is now in the final stage of preparation. TTS2 instruments have been sold



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The Time Transfer receiver developed at the Astrogeodynamical Observatory of the PAN Space Research Centre

to a number of time observatories around the world.

Using this advanced time comparison technology, the atomic clocks in operation in Poland have been connected and combined into a network that produces the national time scale for Poland. The following laboratories belong to this network:

1. The Time and Frequency Laboratory of the Central Office of Measures (GUM), Warszawa: three Cs (cesium) clocks + one H (hydrogen)-maser.
2. The Borowiec Astrogeodynamical Observatory of the Polish Academy of Sciences: two Cs clocks + one H-maser (in procurement).
3. Institute of Telecommunications, Warszawa: two Cs clocks.
4. The Central Laboratory of the Polish telecom company TPSA, Warszawa: two Cs clocks.
5. The Tele-Radio Research Institute, Warszawa: one Cs clock.
6. The Center for Military Metrology, Zielonka: one Cs clock.
7. Polish Air Defense Center (SOM): one H-maser.

The Lithuanian Time and Frequency Standard Laboratory of the Semiconductor Physics Institute in Vilnius is also linked to this network as a partner.

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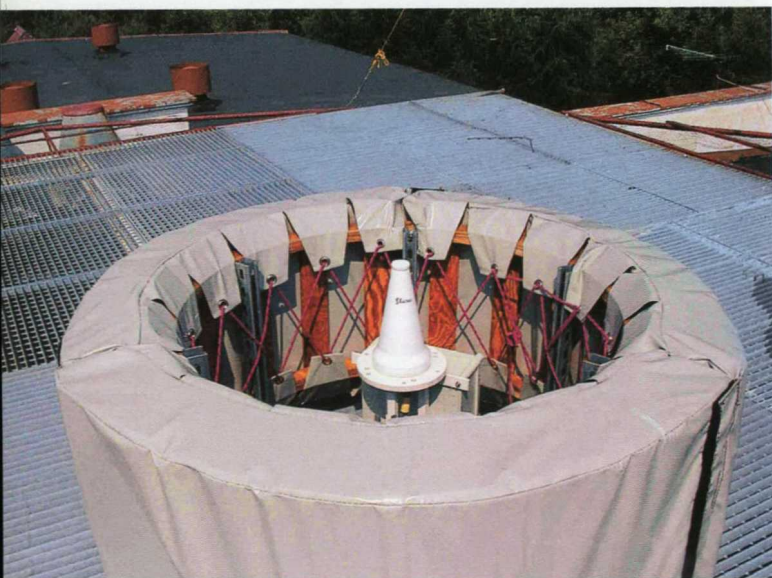
The clocks at the Central Office of Measures are compared using an HP5335A electronic counter; clocks from the other laboratories are compared via GPS multi-channel connections. The Polish time scale is linked to the International Coordinated Time and International Atomic Time through the Central Office of Measures and the Borowiec Observatory using multi-channel GPS receivers, the TTS-2 developed at the Borowiec Observatory.

Being so equipped, the Borowiec Observatory responded to the call for proposals issued by the Galileo Joint Undertaking, requesting the design of the Galileo Time Service Provider infrastructure and activity. A proposal was submitted jointly with other renowned laboratories from the UK, Italy, Germany and France. At the moment we do not yet know the results of the evaluation

accuracy of the current services from about 10 m to better than 2 m. A second important feature of EGNOS consists in sending information about the quality of signals, an "integrity flag." These improvements enable GNSS to be employed in aerial navigation, one of the most important users of satellite navigation technology. EGNOS is one of the three inter-regional, interoperable satellite-based augmentation services (the other two are the US WAAS and the Japanese MSAS). Full EGNOS operation is planned to start in 2005. EGNOS will be the first stimulus for European-led navigation services, and as such will pave the way for the Galileo services. It is considered to be a forerunner of GALILEO and it is included in the GALILEO operational structure.

The technical basis for EGNOS consists of three geostationary satellites disseminating EGNOS signals and a network of ground stations collecting the data necessary for calculating corrections and integrity warnings. A network of so-called Ranging and Integrity Monitoring Stations - RIMS - covers the region with 34 points. One of these stations is located in Warszawa, in the building of the Space Research Centre, Polish Academy of Sciences.

Preparations for the installation of the Warszawa RIM Station started in 1997 with the visit of ESA and EC experts to discuss different options for the EGNOS ground network. The PAN Space Research Centre expressed an interest in the project, although there were formal limitations because Poland was not a member of the ESA (and still is not today). Nevertheless, after long negotiations taking the SRC's technical readiness to host the installation into account, a contract with the ESA was signed in 2001 paving the way to the establishment of the station. The project received support from the National Committee for Scientific Research (KBN) enabling the technical adaptation of the facility as well as the scientific investigation of the local environment. The location of the station in Warszawa was motivated by several factors. It is on the eastern edge of the region covered by EGNOS, and in a large city with good communication and transportation links, yet in a part of Warszawa not affected strongly by radio pollution. The roof of the building of the SRC is flat and strong enough to host antennas, and no ma-



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RIMS receiver antenna mounted on the roof of the PAN Space Research Centre

of this bid, but we are confident that our contribution to the time base of the Galileo system will be substantial.

The GALILEO satellite navigation system is slated to become operational in 2008. But in the meantime, the European Commission, the ESA and the European Organisation for the Safety of Air Navigation (Eurocontrol) have decided to install a European regional augmentation to the American GPS and the Russian GLONASS systems - called the European Geostationary Navigation Overlay Service (EGNOS). This is a kind of improvement made to the existing systems, by disseminating correction data that improve the

major radio emission source is in the vicinity. The SRC's team of specialists was prepared to work on EGNOS and to analyze the data collected. The instrumentation was provided by the ESA, while integration and tuning of the system was performed jointly.

The station's ceremonial opening was held on 27 September 2004 in Warszawa, attended by prominent representatives of the government of Poland - the deputy minister of science and information technology and the deputy minister of infrastructure - as well as by the vice-president of the Polish Academy of Sciences and delegates from the ESA. It is now operational and is satisfying system specifications.

In parallel to the development of the station, considerable work has been done on the testing and application of EGNOS. The Satellite Geodesy and Navigation Department of the University of Warmia and Mazury in Olsztyn took part in the international project ESTB (EGNOS System Test Bed). Signal-in-space became available starting in 2002, with improved quality and coverage. A number of testing measurements were taken on the sea, in the air and on the ground. Different kinds of receivers were tested and the parameters of the whole system were investigated on the territory of Poland and beyond. Results are very optimistic: the accuracy of the position determination achieved with EGNOS is much better than expected from the system specifications. An error level of ± 1 m for horizontal components is characteristic for most of the EGNOS coverage region.

The future implementation of GALILEO will bring with it a range of new applications. Some of them are being developed based on the existing GPS technology, but will be improved and adapted to Galileo in the future. One good example is the Geodetic Active Network developed in cooperation with the National Office of Geodesy and Cartography. The aim of this project is to improve services in surveying and mapping and different kinds of precise positioning, and to make them more precise. At present 10 stations are active in the south of Poland while a few others provide reference data. When completed, this system will be easily adapted for dual GPS/Galileo use. GALILEO activity in Poland is coordinated by the "GALILEO Information Point" established by the Space Office of the PAN Space Research Centre.



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More information about it can be found at the web site <http://galileo.kosmos.gov.pl/>.

One of the Galileo satellites

The above-mentioned contributions to EGNOS serve as a good illustration of Polish organizations' general approach to European space activity, which is actually handled by two organizations: the ESA and the European Community. The GALILEO program is financed by both of the latter, in equal shares. Poland is now a member of the European Union and it has an Agreement of Cooperation with the ESA. On the basis of this agreement, the ESA decided to locate the EGNOS RIMS station in Warszawa. However, there is an assumption that with time Poland will become a member of the ESA as well, with full rights - otherwise, the ESA's investment in our country and entrusting precious instrumentation to the Polish institute would be difficult to justify. Both sides understand that in the long run Poland must be involved in space activity on a level comparable to other European countries. A good example for comparison is provided by Spain's involvement. The GNP of Spain is about 3.5 times greater than that of Poland, but Spain's space investments are greater by a factor of 50. Such disregard for space by the Polish government can not continue, because the country will be deprived of the benefits provided by space systems like GALILEO. ■

Further reading:

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