*Galileo*

# Europe Building Global Satellite Navigation Net

by Lothar Komp

In May 2003, after years-long negotiations among the member nations of the European Union (EU), and despite interference by political maneuvers from Washington, the European governments finally gave the green light to the building of the first satellite-assisted positioning and navigation system specially conceived for civilian uses. European Space Agency official Claudio Mastracci announced contracts for the first *Galileo* satellites on July 11. Already in the Fall of 2005, the first four satelilites should be hurled into their 24,000 kilometer-high Earth orbits, with the aid of European or Russian launch rockets, and thereby the feasibility of the technological project should be proven.

The remaining 26 satellites will follow by 2007, so that in the year 2008, the *Galileo* system can be put into full operation. Any inhabitant of the Earth equipped with a simple receiver, whether in Spitzbergen, in the Pacific, or in the Antarctic, will be able to determine his geographical position to within the precision of one meter, at any time, and without cost. *Galileo* will represent the basic infrastructure for countless uses—even such as those with which private enterprises can gain considerable earnings. At the same time, Europe, with this project, will demonstrate its readiness to ensure its own technological independence and sovereignty in fields decisive for the future.

Actually, the Pentagon has long claimed that *Galileo* is entirely unneeded. For there already exists the American Global Positioning System, GPS for short. And Russia has achieved a satellite navigation system with GLONASS, although it is no longer completely and immediately responsive. Both systems, GPS as well as GLONASS, were developed for military purposes and are subordinated today in case of crises—which have become more frequent in the meantime—to military priorities.

Until May 2000, the Pentagon could, if it thought necessary, make the GPS unavailable for civil uses underway worldwide, whenever this appeared advantageous for military reasons. And that, without any warning. Since then, in an attempt to hinder the European *Galileo* competition, that principle of "selective accessibility" to GPS has been replaced by "selective inaccessibility." Now, it is only in the actual region of crisis that the radio signals of the 24 GPS satellites would be made unusable or interrupted; GPS would remain in service for all other regions. But outside the United States, the signal could be degraded to a further extent sufficient to reduce the accuracy of position-location to a 10 meter circle. (Prior to May 2000, that degradation of accuracy would have been down to a 100 meter circle.)

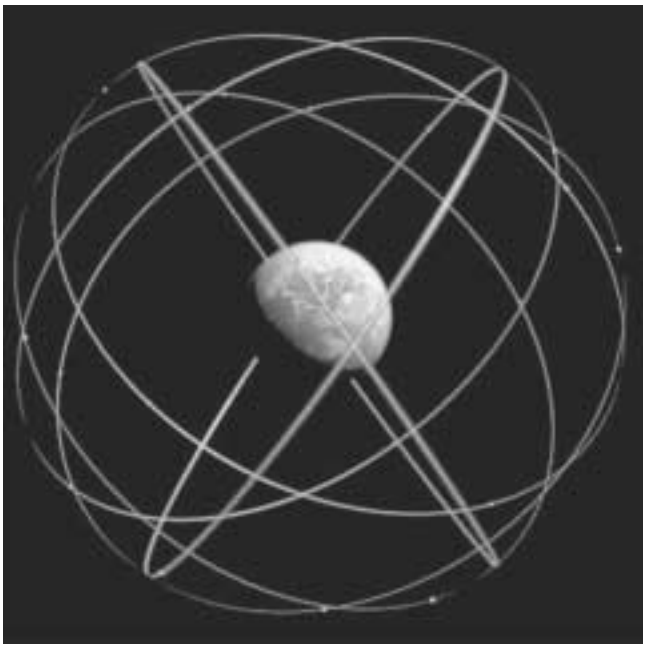
## An Advance in Technologies

But the GPS system possesses further disadvantages, particularly as it is 30 years old. Its precision is very strongly dependent upon location and point in time, and can occasionally wander out to dozens of meters. In the North and South Pole regions, which are important for airline traffic, GPS is—depending on the configuration of the satellites' orbits at any time—often not available. And in heavily populated city districts the signal has proven to be too weak. The GPS technology will soon be upgraded. But even with GPS III, according to an assessment by American experts (an August 2001 study by the Volpe National Transportation Center of the U.S. Department of Transportation), these shortcomings will not be entirely eliminated.

In comparison to GPS, *Galileo* will use newer technologies, more satellites, more favorable orbits, and not least, a global network of ground stations. By an early point, enterprises which are using the services of *Galileo* should be able to be informed about possible errors if they arise. And in the case of actual problems, the management association for *Galileo* will be liable for fixing them. This responsibility is a basic condition for private firms to be able to sell customers products which call on the *Galileo* system. The exact determination of geographical positions requires that the satellites be in condition to be capable of making extremely precise determinations of time. *Galileo* will use rubidium atomic clocks for this purpose, which in each Earth orbit gain or lose only a couple of nanoseconds (billionths of a second), and will be regularly corrected from the ground stations.

The 30 *Galileo* satellites will be distributed over three great-circle orbits around the Earth, which make successive angles of 56° from the Equator. Accordingly, nine of the satellites will at any moment mark out a regular nonagon around each great circle, which nonagon will rotate around the Earth within 14 hours. The tenth satellite in each great circle orbit will be held in reserve; should any satellite fall out of orbit, a substitute is immediately available. The satellites' orbits are so chosen that at any time and in any place on the surface of the Earth, at least four *Galileo* satellites will stand sufficiently high above the horizon. At best, six to eight satellites will be in clear sight, which makes possible the determination of position to within centimeters. Each satellite weighs 650 kilograms (about 1400 pounds) and is supplied with 1,500 watts of power by solar cells.

The first four *Galileo* satellites must be ready for service by Feb. 13, 2006 at the very latest; otherwise, the frequencies



*A schematic of the 30 space-navigation satellites of the* Galileo *system distributed along great-circle orbits which make successive 56° orbits with the Equatorial plane. The EU's system is planned to use more satellites and more advanced technology than the U.S.-operated Global Positioning System, and be dedicated entirely to civilian rather than military uses.*

reserved for the project by hard negotiations at the last radio-frequency conference of the International Telecommunications Union would be forfeited.

The overall cost for the building of the *Galileo*) system will run from 3.2-3.4 billion euros, just as much as is required to build 150 kilometers of Autobahn highway in a densely populated area. It is expected that in roughly a decade, when heavy use of *Galileo* has been established, the economic value added by this system every few weeks, will be sufficient to make up the entire original cost. The basic use of *Galileo*—to determine positions precisely to within a meter—will then cost nothing to the economy, and the acquisition of an instrument for this purpose will have become free. But *Galileo* will offer additional income-earning services of higher-value output for commercial and professional uses.

At first, worldwide traffic—on roads and streets, rails, water, or in the air—will be primary. The European Commission estimates the value of *Galileo* for air and sea traffic enterprises, from 2008-2020, at about EU15 billion. For example, aircraft will no longer have to "slalom" between air-traffic radar-control zones, and can choose more direct, shorter routes. It is hoped that from such improved flight control will result in drastic reductions in flight delays. In the future, transport firms will equip their trucks, rail cars, or containers with individual *Galileo* senders, and be able to determine their locations precisely at any time. Drivers could be kept well aware of traffic or local events on their routes. At some point, the *Galileo* connection may belong to the standard equipment of every automobile. Then an entire array of additional uses are conceivable.

## For Economy and Infrastructure

Another center of gravity of potential uses of *Galileo* lies in rescue services of all kinds: fire departments, police, emergency medical and ambulance services, ocean or mountain rescue. Thanks to its precise position-finding, persons in danger will get help faster. The satellites will play an important role in city planning, as well as in carrying out large public building projects. Already in the building of the Öresund Bridge linking Denmark and Sweden, location-finding by means of the GPS was necessary, and allowed the building consortium to lay the path of the bridge with maximum precision. In banking, the telecommunications industry, and in the proper maintanence of electricity grids, the use of exact location and time data from the *Galileo* system is also being planned.

For example, the exact time reading, to within less than one-thousandth of a second, from *Galileo* will allow a technique of monitoring electricity grids which is much more advanced than today's method. With the aid of instantaneous high resolution of voltage disruptions registered by control stations, the sources of disruptions could then immediately be located to within less than 300 meters—the distance between two high-voltage towers. The great blackout in the Northeast and Midwest of the United States this past August, with its billion-dollar consequences for the economy, could probably have been prevented with such a system. In addition, the condition of bridges or other infrastructure projects can, with *Galileo*), be permanently monitored.

While the future uses of the system are not yet fully foreseeable, its economic potential in the coming decades can be crudely evaluated. In November 2001, PriceWaterhouse Coopers completed a so-called cost-benefit analysis, whereby for each euro invested in the *Galileo* system from 2008-2020, roughly 4.6 euros in earnings (in total, an estimated EU17.8 billion) will be generated. This analysis was limited to the economic value generated on the basis of better controls of air and water traffic. The space technology division of TU Munich expects, for the years 2007-2017, a market in excess of EU42 billion for *Galileo* services, consisting of EU22 billion in services earnings and EU20 billion in end-user instrument sales. In the sphere of European aerospace industries as a whole, a gross business of EU100 billion is likely to come into play.

A study by the European Commission estimated the total market potential of *Galileo,* through 2015, at EU270 billion. Another study put the annual benefit to the economy, up through 2015, at more than EU50 billion. At the same time, this latter figure corresponds to some 100,000 highly-skilled jobs.

*There will be nine operating satellites (and one reserve) along each great circle orbit, enabling precise determination of both time and position to within one meter anywhere on Earth at any time, and often to within centimeters. The benefits range from transportation to monitoring electric grids to guiding emergency responders, and many basic uses of the system will be free.*

## International Cooperation

Already now, it is clear that *Galileo* will not remain merely a European opportunity. Its advantages relative to the existing GPS system are too clear. For some time, China, India, Japan, Russia, Ukraine, and Canada, among others, have expressed concrete interest in participating. The European Union (EU) on Sept. 18 concluded an agreement with China, whereby China will take part to the extent of EU300 million in investment. On the same day, in Beijing, the Chinese-European Technology Training and Cooperation Center was dedicated. The Vice President of the EU Commission, Loyola de Palacio of Spain, remarked there: "China will help make *Galileo* into the world's leading infrastructure in the growing market for position-location services." Her negotiating partner, China's Minister for Science and Technology Xu Guanhua, explained: "China supports *Galileo* and plans an active participation in construction as well as deployment, to the advantage of both sides."

A public-private joint undertaking will be responsible for setting up the system; of which partnership, at first, the European Union and the European Space Agency ESA have control. Private firms, including the small firms of the *Mittelstand,* are expressly invited to take part in the joint undertaking. And even in the case of China's share in the project, participation should follow a similar process.

Naturally, China will also build its own, regional satellite navigation system, Beidou (the Great Bear), at the same time. And Japan will build a competitor to the GPS; by 2008 the Quasi-Zenith Satellite System should be in operation. In it, four satellites will be launched into a geo-stationary orbit 36,000 kilometers above the Earth, and thereby permanently cover Japan as well as the Asiatic-Pacific rim. Already now, there are 10 million passenger cars in Japan with electronic navigation systems, and 10 million households equipped with satellite receivers.

The European consortium Galileo Industries will play a major role in the building of *Galileo.* It is a combination of Alcatel Space Industries of France, Alenia Spazio of Italy, the German firm Astrium GmbH, Astrium Great Britain, and Galileo Sistemas y Servicios of Spain. After long disputes, a division of labor among them was agreed upon in March 2003. The headquarters of Galileo Industries will be in Munich. The city's mayor Christian Ude hopes, as a result, for "some 10,000 new jobs in the Munich region." Germany will thereby take the system lead in the manufacture of the satellites. The central engineering office will, on the other hand, be established in Rome. France is responsible for the ground stations, Great Britain for the antenna systems.

## Technological Declaration of Independence

In sharp tones, the European Commission, in a March 2002 published document, protested against the "endless arguments from the American side." The U.S.A., it said, "defender of the basic principle of free competition, in this case is doing everything to strike down competition from a field in which its hegemony could be endangered." Thus, the United States "takes an amazing degree of care to show, and constantly to 'warn' its European friends that *Galileo,* in its opinion, is still not profitable. The credibility of such a pronouncement is naturally doubtful, when it comes from a threatened competitor. It shows all the more how much the success of a competing system is feared." Moreover, the document recalled "the United States' start [in space] in the 1960s, when it offered the Europeans to launch their satellites without charge. Had they accepted this 'generous' offer, Europe would surely never have won more than half of the world market for satellite launches with *Ariane.*"

The decision for *Galileo,* like that of the 1960s in favor of Europe's own launch vehicle, will with good reason be characterized as a kind of European "declaration of independence" in space travel and related advanced technology sectors.