

NEW TECHNOLOGIES FOR BETTER LIFE : THE GLOBAL POSITIONING SYSTEM AND THE NEW EUROPEAN PROJECT “GALILEO”

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Abstract

It is an indisputable fact that today technologies are used for many different needs. Using them for all those applications that everybody recognises as essential, they actually show us the right way to develop all those new services that we need to work in an easier and faster way. Today technologies give us the way to be connected with everybody, everywhere and anywhere; new technology's frontiers show us how to manage information in so many different ways that we couldn't even imagine since few years ago; they finally became essential in our life.

One of the most important technology branch, in which our country has been leading edge for long time regards innovations: exactly about those, today there is a great opportunity in the aerospace field.

Our country in fact, will have the chance to be involved in working on an European project (Galileo) which will develop a new Satellite Positioning System: this adventure will give us the possibility not only to create new business for our local region (/Lazio) or our nation (Italy) but it will let us free from depending on the actual working Satellite System, which is the only one usable by western countries: the GPS (this is a positioning system actually working under total control by the U.S. government who has the possibility to shut it down in any moment for national security, blinding all those systems around the world that count on it).

By the science and aerospace technology point of view, projecting and building up new kind of artificial satellites around the world for the new system,

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will give up the chance to realize new functionalities, giving the population new services in order to create a superior quality of life, following all those growth standards people are actually used on.

At the same time, realizing such an ambitious project will create the opportunity to keep in touch or create new contacts with political or financial partners in other nations, helping the globalization and sharing more and more information (know how) that we all need to reach great results.

Aim of the present work will be to show all those applications already given by the operating Positioning System (GPS), in order to compare them with all those new applications that will be given by the new Galileo System, projected for all the activities of our social life.

Introduction

Aerospace technology innovation belongs to the development of satellite's services since December 1993 which is the start up time for GPS system (Global Positioning System) operated by the USA (Department of Defense).

This system has been projected and developed, in the beginning, only for military use (the gulf war) and today it is still totally owned and operated by the DoD, giving positioning information with a ± 30 m precision about real localization: it sends latitude and longitude to a receiving terminal which can be located everywhere over the surface (it is important to underline the presence of an ERROR).

To determine latitude and longitude and to create the correct way to get from one point to another one, the GPS receiver uses all those information collected by the military satellites that fly around the planet: NAV.S.T.A.R. (Navigation Satellite with Time and Ranging).

During the same period, even the Russian federation developed its own positioning satellite system Glonass (Global Navigation Satellite System) that we can consider similar to the GPS system.

Both systems work on two different frequencies (a military and a civil one) in order to guarantee two different functionalities levels.

Last but not least, at the end of last century, many European partners decided to project a new system: Galileo.

The Global Positioning System

GPS system has normally 18 satellites flying around the planet, they work on 6 different elliptical earth, skewed of 55° to the equator floor level (this means that we have three satellites each orbit) and they complete a full revolution phase of 12 hours each, 20,200 km far away from the planet.

Such a number of satellites flying around the planet for one system only (we also have other satellites ready to be used for substitution) belong to the fact that we continuously need to have at least four satellites oriented with an altitude of 15° on the horizon in any planet position.



Fig. 1 - GPS satellite constellation.
Source: ESA documents 2003

In fact the positioning system works on a space triangulation given to the instruments by an instant positioning and by the real time in which the satellites (at least 3 of them) send the signal.

Estimating how long time signals take to get to the receiver, the GPS system calculate how far the satellites are from the point and, knowing their instant position, it can calculate the exact grid reference. All calculations, which are very complex, are estimated by the GPS receiver which is so structured in three different logical levels:

- ◀ A receiving antenna for radio signals
- ◀ An area in which the system decrypt and estimates signals
- ◀ A display area in which all data are clearly shown to the users

Estimating the GPS error

As we said before, due to its military first use, the GPS system has an important limitation given by the presence of an estimated and estimating error, which is calculated on the position given to the users: this is an error that can be corrected by estimating (earth stations use to do this job) the difference between all information, send by the satellites GPS belonging to their orbit's positions, in comparison with the certified position of GPS receivers (all GPS receivers estimate their position calculating the time of arriving of all the data related with the delay of receiving them). If we exactly know where we are (it means where the planet receiver is) and where the satellite position is the same time (estimating its position not through the signal received, but calculating all data belonging to the satellite's orbit) we can easily estimate how big is the error due to the propagation of the signal through the atmosphere. So it can be rather simple to create a kind of grid of points around the station, in order to estimate the margin of error of each point to enlarge the estimated area related to the calculated GPS error.

Many stations, in order to estimate the GPS error, are located all over the European area and each of them points out an error model which becomes valid for its own area. In this way it has been created a perfect correcting data grid: by a certain point of view we can imagine it as a great number of positioned certified stations on which all corrected signals of the satellites are located. All data are continuously on line and even corrected, due to the fact that signal's propagation through the atmosphere relates to the different conditions of the atmosphere itself.

All those corrections' estimated factors are continuously sent to the WAAS/EGNOS satellite in order to be finally sent to the users' terminals through the GPS L1 frequency. The terminal that receives the data select them using the grid of nearest points and uses them with all those receiving satellites in order to estimate their position.

Actually the GPS covers up not only the Europe area, but also north Africa including Morocco, Tunisia, Algeria and Libia.

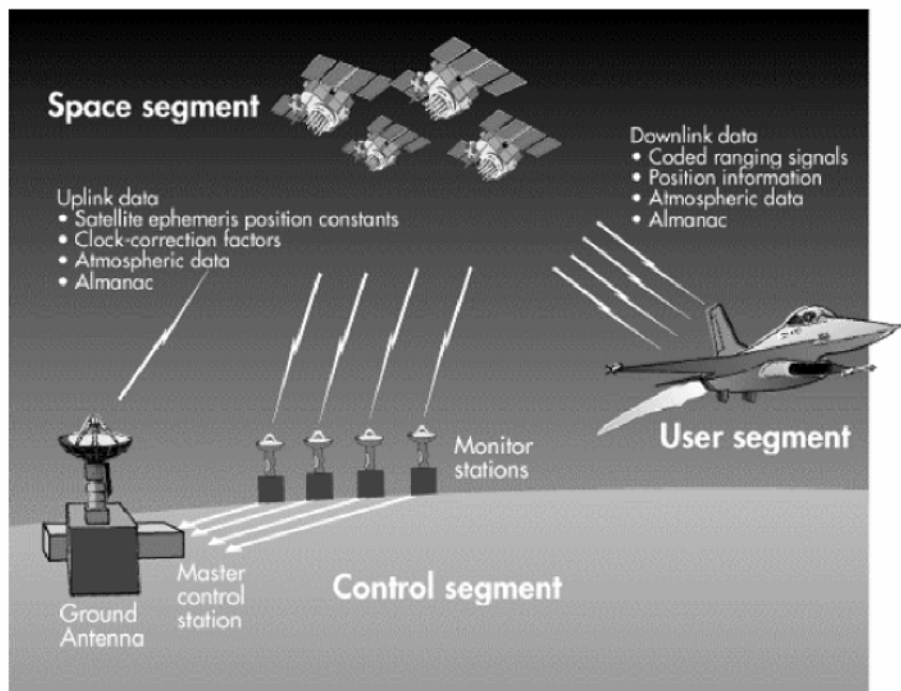


Fig. 2 - GPS space segment
Source: ESA documents 2003

GPS infrastructure

The GPS system is actually based on three principal segments: space, control and customer.

The **Space segment** is based on 24 satellites flying on 6 different orbit levels; they fly around the planet on ellipses skewed of 55° on a distance of 20,200 km from the terrestrial planet during a 12 hours' period.

This means that their positions are always in the same place at the same time (referred to stars' position), even if they recover those positions four minutes in advance for each day.

The control Segment is based on 5 land stations (Hawaii, Kwajalein, Isola dell'Ascensione, Diego Garcia, Colorado Springs), 3 receiving antennas positioned on the land (Isola dell'Ascensione, Diego Garcia, Kwajalein) and 1 master station (MCS) next to Falcon AFB in Colorado.

This last station (Master station) passively recognises all those satellites flying over it, memorizing their data. Those information are then valuated by the MCS to determine the correct satellite's orbits in order to update navigation's data of the satellites. Updated data are so transmitted (through the antennas) to each satellite flying around the planet. The correct position of all monitoring stations has been calculated respecting the Geodetic World System of 1972 which comes under the name of WGS-72.

Since 10th June 1987 the new standard recognised is the WGS-84.

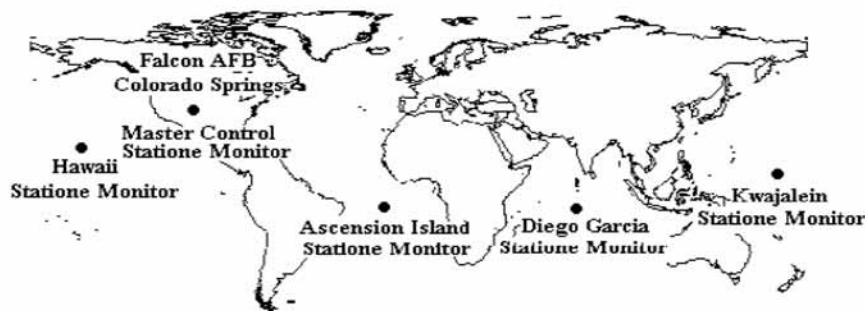


Fig. 3 - Land station of control segment.

Source: ASI 2000

The customer segment is based on a complex system of antennas and receiving technologies (microprocessors), obtaining on time and with great precision the correct position and speed of the customer.

The GPS system is actually operated by 24 satellites (three of them are hold on reserve) of NAVSTAR class 2S and 5 land stations; on board of each satellite there are 2 Caesium atomic clocks and 2 Rubidium atomic clocks in order to be sure about a correct redundancy.

All satellites actually flying belong to the Rockwell International indus-

try but in the next few years (approximately 5 yrs) 21 new satellites will be launched around the planet, following a Lockheed Martin developing project, that will deeply update all technology's items, in order to reach the perfection.

For what concerns about length of life of all the satellites actually flying, we can say that it should be next to 7 yrs even if we have some evidence of satellites still operating since 1990.

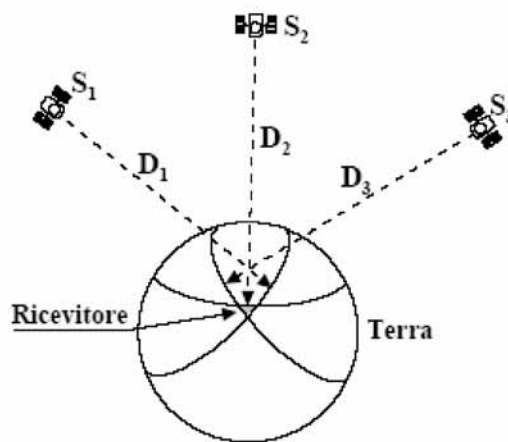


Fig. 4 - Landing position using 3 position.

Source: ASI 2000

The GPS system, as said before, was projected for military use and opened its knowledge to civil applications only in a second time; due to this reason we have important problems related to both technical and political aspects.

By the technical point of view, even if the system is actually working world wide, we can not forget the fact that it has something like a bug related to the precision calculated on land position. It is well known the fact that the GPS system brings an internal error that we can not actually correct; the error relates to the not perfectly evaluated position of each user (whoever he or it is we have a range of 10 to 20 sqm of failure) principally due to the ionization of the atmosphere lower parts.

It means that each position calculated could not be exactly perfect, with a small % of error.

By a second point of view, (we can call it political) the GPS system it's totally owned by the Department of Defense of the USA: this

means that in any occasion, to prevent national security, the DoD could decide (without considering anybody else's interest) to voluntarily correct and open the error range or even blind the system for unknown period.

So there is a question we want to answer to: what it could happen in this eventual situation or what it could occur to all those people that should count on a non perfect estimated land position?

To answer all those questions, trying to solve those problems in a correct way, many European countries decided to start a new project to develop a perfect positioning system: they called it GALILEO.

Galileo Project: an opportunity to develop new technologies and to increase social development

The only positioning system actually working, GPS, clearly presents many problems that bring to us a non perfect system; in fact it could fail by a technical point of view or it could be controlled by political decision due to national (USA through the Department of Defense) or international crisis, not granting a 24h operating service.

The actual chance to have an alternative system to GPS, this time especially projected for civil uses, based on new satellites' technology and so no more controlled by any military force or Department that could react to national security, could and will represent enormous advantages.

First of all it will make everybody sure about the fact that it will be a 24 hrs working system, giving also a new kind of evaluated precision (land position) that will open the way to many civil uses not even thought until this moment: it will be developed for managing transportation, enforcing security systems, directing and managing traffic flows to reduce traffic congestions, controlling environmental impact and damages.

The new Galileo System will have the must to offer different type of services such as position, navigation and time measurement; it will develop the world market of satellites' services opening new way towards other commercial sectors: from transportation (vehicle positioning, road mapping, speed control, etc...) to social services (managing old or slow people services), justice (border control), environmental and agricultural impact.

Developing Galileo Project

Galileo project belongs to the first 90's but only during last four years its realizing phase received a strong impulse and Italy, represented by primary high technologies companies, started acting as an important factor. One of those companies, Finmeccanica, will be heading responsible for the mission control and for a "Performance centre" (Telespazio "Finmeccanica - Alcatel" and Regione Abruzzo signed an agreement to build, into 2008, the new Control Center for Galileo Project which will be located in the Fucino's Space Center), while Alcatel-Alenia Space Italia will be responsible for the integration and validation of the all programme.

Lazio Region has directly invested 7 millions euro for two years' program Test Range of Galileo, into the Rieti country, in order to involve the area itself in the project of the Aerospace Technology district.

Unfortunately, actual situation of international agreements signed for developing the project, is living a delicate phase, due to the different opinions that all participants are showing up. Finding out a common solution for more than 15 countries in fact, it is not so easy. It is necessary to create compromises solutions in order to pass over different positions: principally regarding a military one (French opinion) and a civil one (English). It means that there are still two different point of view, one thinking about the project as a civil solution and another one still thinking about it as a military option.

This situation causes deep delays on the UE development program: actually the first and more important problem to face with, regards the nomination of the country that will address the new Agency to control the navigation system. Most nominated countries are actually Italy and Germany and both offer success chances. That is the reason why the decision is so difficult: no one of the two countries intend to give up to its chances.

On the other hand, being the heading country on managing Galileo Project means to reach a leader position on the European side, giving a good impression and achieving industrial results.

But, actually, what it is really important for ESA (European Space Agency) it is to reach a decision in order to let the Galileo Project start up its first realising phase.

Starting up such an important project will surely increase market job and will develop high technology knowledge on both European and Italian side. In fact Global Positioning Systems actually represents an

important market; it grew up more than 25% each year (last years period) and could represent a potential growing market of 10 billions dollar in the next 5 years. This is such a big amount of money that can let us understand as both systems, GPS and Galileo could live and operate at the same time, sharing potential market; but this possibility it is not so well accepted by the USA industry that doesn't want to loose his leading position.

Global market value for Galileo project, on next 20 yrs, is estimated on being 8 billions euro and about 150,000 new job positions all developed in an high technology system. We can also underline 18 millions euro that will belong to Italian Aerospace Agency.

Once became operating, Galileo will be the first positioning satellite system projected only for civil uses that, on European plans, will substitute the actual USA GPS (even if, on official sites, it is supposed to be subsidiary to it). Politically this will be a very important step due to the reason that it will allow Europe to be free on managing its own system, without depending on prejudiced decisions taken by the DoD of the USA. This will be a new system that rises up and develops its technological characteristics for civil and not military uses granting flexibility and commercial versatility.

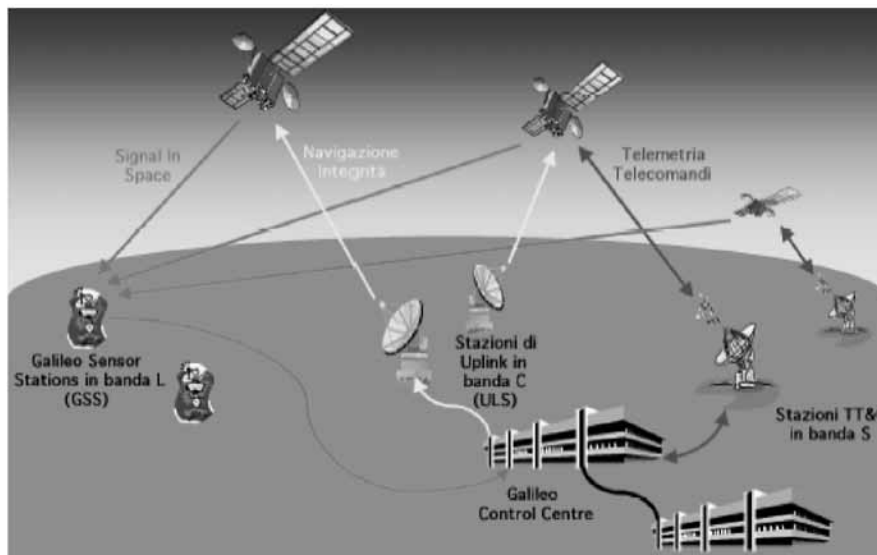


Fig. 5 - Galileo infrastructures.
Source. ESA documents 2005

Even by a strategic point of view it will be an important challenge, because it gives to the entire world a strong economic, industrial and technological message that will be spent by the UE in future on many different fields, achieving that commercial and political influence it hasn't still had until this time.

Developing new technologies

Following the intent of both UE and all of those Companies involved on Galileo development, (first of all car, civil aviation and telecommunication companies), the new system will connect a small receiving satellite with a cellular phone in order to furnish its localization within one meter to its real land position; it will create (as said before) nearly 150,000 job sites, 100,000 of which will be highly technology specialized, and it will bring 10 billions euro of income for each operating year. More than this, it should create an infrastructure market and services for more than 275 billions euro related to the year 2020.

By the users' point of view, Galileo will offer facilitations regarding a total precision and reliability that will give the chance to localize goods, vehicles and people with a precision that will be ten times more perfect than the GPS system; it will also offer a continuous transmission signal due to the contemporary sending data of, at least, 4 satellites by each point of the globe (the GPS system uses only 3 of them). The best achieved precision of the system is related to the new kind of projected satellites, that will provide a more powerful signal able to guarantee dependability and efficiency.

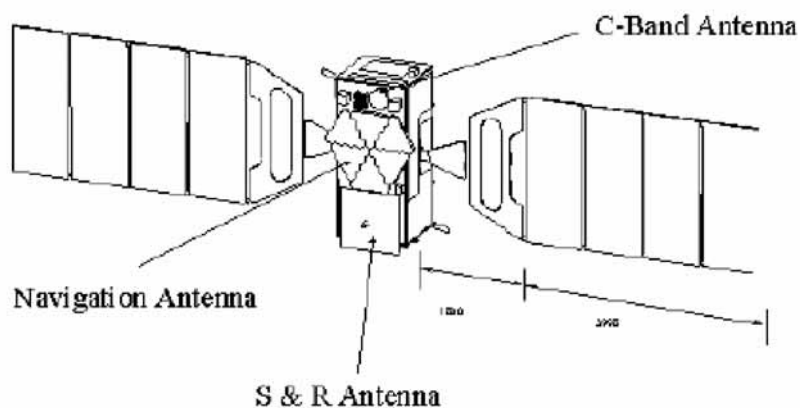




Fig. 6 - Galileo satellite constellation.

Source: ASI 2002

All satellites projected and launched around the planet for the GPS program were estimated to live no more than 7 yrs but, even flying through the famous magnetic storm of 90's, many of them are still operating. Anyway, Galileo system will be based on a triple dynamic positioning (such as GPS), but it will have a fourth satellite which will be used for verifying the position and so, it will give to the entire system that precision expected from it.

Rockets' vectors that will drive all satellites up to their orbits will be the "Arianne" (the most important space project actually belonging to the European space agency).

At the top of its efficiency, the system will operate 27 satellites keeping 3 of them ready to be used in substitution, flying on three different orbits' levels (24,000 km medium flight high).

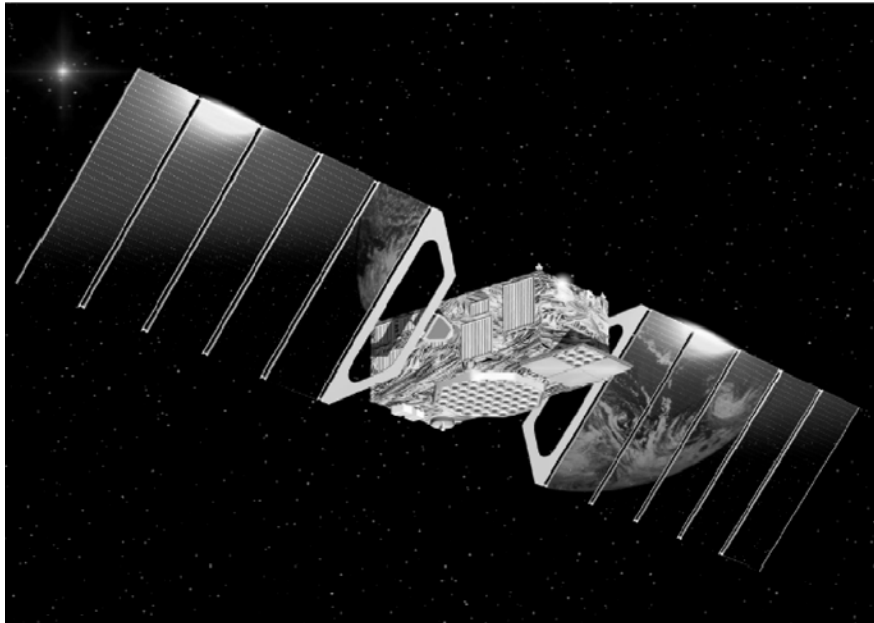


Fig. 7 - Galileo satellite.

Source: ASCA 2002

Uses and perspectives

What will really bring the Galileo System in our life as for new? Knowing exactly our land position, with an error level not still useful as for today, will create new chances and innovations today still unimaginable for our life style.

The future Galileo options, given by personalized services, will allow everybody to use cellular phones as interfaces through which we will download time after time all those positioning information we could need in any occasion.

Beginning with first applications, Galileo will offer anytime and anywhere a global positioning system totally safe. More important will be the chance to find out isolated or needing help people. Today civil defence is already organized to find out survivors in environmental disaster; the new European system will increase precision on localizing them, giving more operating options: we will have in fact the possibility to help senior citizens or disabled persons by furnishing an easier way to indicate their position in emergency situations, using an automatic signal sent by the new

SOS Phone system (Galileo should even be very important on starting up the new European emergency number E 112 that will be used for finding out all those people in many emergency situations, such as: fires, earthquakes or water flood) .

But Galileo will be varied employed:

★ Implementing the SAR (Search & Rescue) system, which represents a rescue system based on the Cospar-Sarsat satellite net using special transponders; those transponders will send the emergency signal directly to the land laboratory giving a total recover all over the globe in faster time. In those situations, people sending the signal will even receive a signal back to be sure about the fact that the emergency call has been received. This is a great innovation concerning about the feed back that will be received.

★ Galileo will be used on air transportation by giving more information in take off or landing situations, in all weather conditions (especially fog, rain . etc...); all aircrafts will fly directly to the arriving airport instead of moving from a radar area to another one (zig-zag); aircrafts positions' will be under safe control opening new flying zones, avoiding crash risks.

★ It will be fundamental on developing the new AIS (Automated Identification System) for navigation system , which will be used to avoid and prevent crash events or damages.

★ It will support car traffic control, introducing new systems such as the "Advanced Driver Assistance Systems", that will be used to avoid collisions, help drivers in fog or night situations and introducing automatic moving.

★ Car industries are now advertising their customers about new positioning systems available to give more information not only about position but also about traffic situation; this will create a new faster way of moving, saving fuel and reducing air pollution.

★ Truck and train carriers will be informed in time about all positions recovered by their vehicles, in order to prevent steals and fraud.

★ Companies of taxi are already using positioning systems to help their drivers on saving time in car traffic situation, offering a better service to all their costumers.

★ Environmental uses: monitoring farmers with the new system will help on reducing and controlling chemical fertilizer or pesticide use.

★ Weather information for better weather forecasts and more information for monitoring climate's changing.

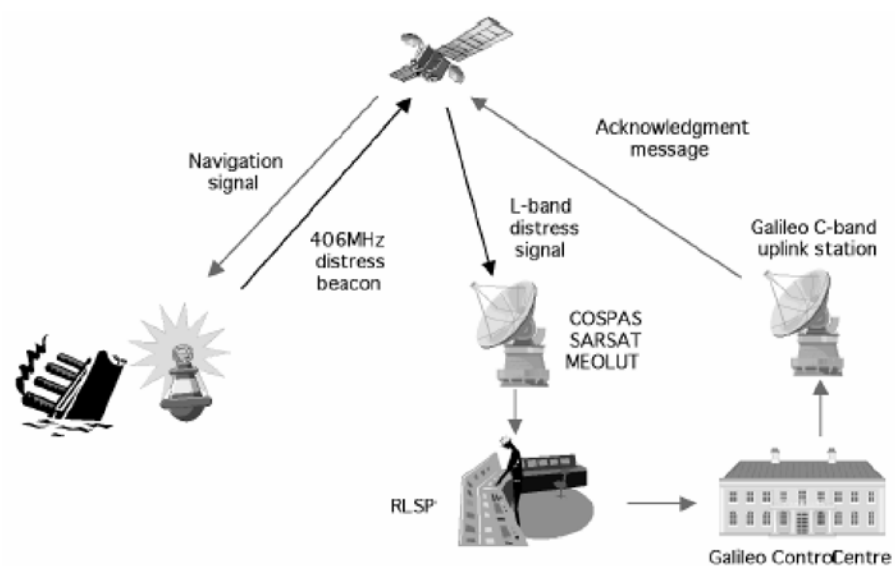


Fig. 8 - Search & Rescue system operated by Galileo.
Source: FILAS 2002

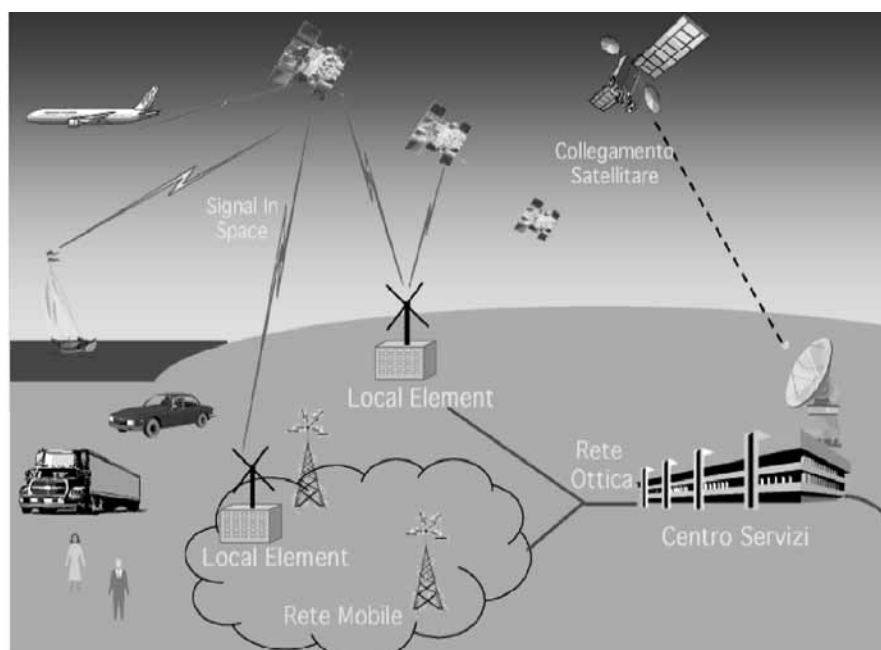


Fig. 9 - Galileo system applications.
Source : ESA documents 2003

★ Mountains, forests, lakes, rivers and even seas but also animals and plants will be continuously observed with such a precision level today still unknown; space observation will be even very important for planet preservation in next years.

As we can see from all those examples, the Galileo system will open the way to many different uses that will also increase the market job's actual situation, on a better life evolution.

Last but not least, we want to point out one service related to the so called "absolute time". Today we have many systems (mobile phones, digital tv, internet services etc...) that couldn't work without a perfect synchronization based on a perfect and standard time.

Flying with the 30 satellites that will be lunched around the planet, there will be atomic clocks brought to the space that will show until the 15 decimal places.

Galileo system will so become a speaking clock.

Conclusions

This work intended to evaluate all new challenges that Galileo system will or could bring to all costumers and users, all those new possibilities that such an important project will create for aerospace industries in both technology and know how development fields. I really wanted to point out how important could be and will be to have a new technology able to indicate with such a precision the right position on the planet opening the way to new discoveries in the actual global civilization.

Unfortunately, we need to underline all new and actual information coming from Bruxelles, that open new landscape on Galileo developing project.

In fact, we have to face the reality understanding that the project is having many problems: problems related to the fact that actually, it seems very difficult that the 8 european industries' pool (Finmeccanica, Eads, Thales, Alcatel, Aena, Hispasat, Immersat, TeleOp), who were supposed to co – finance the project, will really be able to. It wouldn't have been the aim of the present work to analyse the problems related to this situation, but it is surely obliged to report what is going on. Probably it will be necessary to redefine all finance agree, in order to push the project towards a public participation to refinance it; this actually seems to be the only chance to complete the Galileo system.

Not choosing this new way, could mean losing all those opportunities that such a project could offer; we will lose the opportunity to develop many of those technologies that could be fundamental for our future; it will also represent a step backward that will oblige all customers and systems operating to go on counting on the old GPS system.

What it clearly seems to us, is that we really have the opportunity to open a second eye on the world but we could decide to go on looking at it with only one eye which could even be a little blind.

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