

THE MUNICH SATELLITE NAVIGATION SUMMIT 2007

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The Summit was held for the 6th successive year in the *Residenz* in Munich from 6 to 8 March, organised by the Institute of Geodesy and Navigation, chaired by Prof. Günter Hein, of the University of the Federal Armed Forces (FAF) in Munich.

More than 400 participants from 28 countries had registered for the annual event. Like in the foregoing years, the Summit was of high quality. High ranked representatives from the European Commission (EC), from governments, research and development (R&D) and from industry presented their views in short presentations on the topics of the different sessions, followed by discussions in the panel and with the floor.

A climax during the 2006 Summit was the presentation of Theodor Hänsch, director of the Max Planck Institute of Quantum optics and sharer of the 2005 Nobel Prize for physics for his work on femtosecond laser frequency combs, which has the potential for ultra precise atomic clocks.

This year the organisers had invited the German astronaut Thomas Reiter for the Closing session, who



ESA astronaut Thomas Reiter just back from 6 months at the ISS.

had just returned from a six months stay at the International Space Station (ISS). Thomas – who holds a Master degree in Aerospace technology from the FAF University - has almost one year space experience in total, including stays at the Russian MIR and at ISS. He told the audience with great enthusiasm about his ISS flight, supported with beautiful pictures and videos from space. The audience appreciated to hear that part of the navigation tools in the shuttle and in the ISS consists of GPS receivers.

General Impressions

The general impression of your author is that the GNSS landscape has changed considerably in the last couple of years. To name a few elements that appeared during the presentations and discussions:

- Galileo Industries has been renamed into the European Satellite Navigation Industries (ESN Industries) for legal reasons. The Galileo Joint Undertaking (GJU) has handed over responsibilities to the European GNSS Supervisory Authority (GSA), the renamed Galileo Supervisory Authority. Deliberations between the GSA and the earmarked Galileo Concessionaire (the Merged Consortium MC) have not been finalised yet; it could drag on into 2008, if ever successful. The Galileo test satellite GIOVE-A was launched in December 2005 and is performing extremely well. Launch of GIOVE-B is planned for the end of 2007. On 5 March 2007, ESA awarded a contract to Surrey Satellite Technology Limited to build a third experimental satellite GIOVE-A2. This extra satellite will help to maintain the ITU frequency filing and facilitate further development of ground equipment. The launch is planned for the second half of 2008.
- Although 24 satellites are nominal, 30 GPS satellites are healthy now, including three IIR-Ms with the new frequency L2C and five of these ready to be launched. The first launch of the GPS IIR-F satellite with L5 on board will be in May 2008.

- The new L1C frequency will be transmitted from the GPS block III satellites, planned for 2013.
- President Putin has ordered to speed up the Glonass program; budgets are made available until 2011. All Russian government users shall be equipped with either Glonass-alone receivers or GPS/Glonass receivers. There are now 10 healthy Glonass satellites available, three M satellites are in orbit waiting for operational use. End of this year 18 Glonass satellites will be available for navigation over Russian territory. End of 2009 there will be Glonass FOC and global coverage. End 2007 decision will be made for possible CDMA signals on Glonass-K satellites for increased interoperability.
- The GPS augmentation system WAAS is performing well in the USA; it is increasingly used in air traffic.
- The augmentation system EGNOS is becoming mature and will be ready for certification for Safety of Life operations in mid 2008.
- Japan prepares for operations with the augmentation system MSAS, interoperable with EGNOS and WAAS.



The panelmembers of the opening session from left to right: Pedro Pedreira, executive director of the GSA; Giuseppe Viriglio, director of Telecommunication and Navigation of ESA; Erwin Huber, Bavarian Minister of Economic Affairs; Guenter Hein, Institute of Geodesy and Navigation of FAF University; Matthias Ruete, director general DG-TREN of the EC; and Ralph Braibanti, US State Department.

- Japan proceeds with the regional GPS augmentation QZSS; first launch in 2009.
- India proceeds with its regional GPS augmentation system GAGAN.
- India has launched a new program for an independent regional satellite navigation system IRNSS with seven satellites.
- China participates in the Galileo program, but is developing a global satellite navigation system BEIDOU-2 (COMPASS) with 35 satellites as a

follow up of the regional BEIDOU-1 system.

- Deliberations and signing of co-operation contracts are taking place between US and EU, EU and Russia, US and Russia, Russia and India, US and Japan, etc. etc. Main technical issues are compatibility and interoperability, where compatibility means that the systems do not "hurt" each other (interference) and interoperability means that the systems can be combined in one receiver for a merged position and time solution better than from each system alone.

The Opening Session

The opening session in the late afternoon of the first day was held this year in the beautiful restored *Allerheiligen Hofkirche* of the *Residenz München* (Court church of All Saints). The Bavarian Minister Erwin Huber opened the Summit.

Matthias Ruete of DG TREN of the EC and the director of the GSA Pedro Pedreira gave overviews of the history, status and plans of Galileo and EGNOS as part of the EU Lisbon Agenda on innovation. They both blamed Industry (the MC) for the delay in the Concession talks. It was disappointing that no representative of the MC participated in this session to give his view on the delay. In a later session this issue was further discussed.

Ralph Braibanti of the US State Department was the head of the US delegation in the US/EU deliberations on GPS/Galileo issues. He also mentioned the co-operation contracts of the US with Japan (largest GPS user outside USA) and India. The US also participates in the International Committee on GNSS of the United Nations (UN-ICG). *Interoperability is the key success for all*, he emphasised.

Giuseppe Viriglio director of Telecommunication and Navigation of ESA finalised the opening speeches with the roles of ESA in the European satellite navigation developments.

The panel discussion was led by Prof. Günter Hein. Matthias Ruete was asked what would happen when the deliberations with the MC would fail; would that be the end of the Galileo program? Ruete hastened to confirm that the GSA contract negotiators have plans B, C, etc for such a case. Stopping the Galileo project is a scenario far up in the alphabet or better ... non-existent.

Getting Updated

The second day started with the session "Getting updated". Sylvain Loddio of ESA started with an overview of the latest developments in EGNOS and Galileo. On 1 January 2008 operations of EGNOS will be handed over to the European Satellite Service Provider (ESSP) in Brussels. There are now

40 reference sites of EGNOS in 21 countries. In 2007/2008 the finalisation of the Qualification review will take place. Extending the service area to North Africa will be the next step.

In 2009 the IOV (in orbit validation) phase of Galileo will be finalised with 4 healthy satellites in orbit. FOC is expected between 2010 and 2012 (as ESA is not part of the Concession deliberations, Mr Lodo did not touch on this subject). All signals from GIOVA-A perform significantly better than GPS and Glonass. The clocks on GIOVE-A perform according to specifications.

More than 1000 persons in the EU are now working on the Galileo project; over 400 subcontracts are managed under ESA control. The Signal-In-Space Interface Control Document (SIS-ICD) is available on the ESA website www.esa.int.

Col. Mark Crews gave an update on the GPS program. The 30 healthy satellites were mentioned above. The User Range Error (URE) - this is the standard deviation in the range measurement due to system errors, excluded ionosphere, troposphere, multipath and receiver errors - is now 0.71 m averaged over 30 satellites. A joint statement on co-operation on compatibility and interoperability with Russia was signed on 14 December 2006. The EU-US working groups on GPS and Galileo co-operation met 5 times and produced a joint statement on 24 March 2006. Agreements were reached on issues as time-offset, geo reference and interoperability of L5 and L1C. Four meetings were held with the Japanese on common signals with the QZSS system.

Sergey Revniviykh updated the audience on Glonass. The 19 April 2006 Directive from the President speeded up the program which is approved and budgeted until 2011. The objective is a performance comparable to GPS and Galileo. Interoperability by means of CDMA signals on the future Glonass-K satellites is discussed; the decision will be taken in 2007. Options are Glonass-L5 interoperable with GPS-L5 and Glonass-L3 interoperable with Galileo E5b. Apart from the 10 healthy satellites, there are 3 Glonass-M satellites in space waiting for operational status. Two launches of 3 satellites each are planned for the coming time.

Originally the Japanese QZSS system was planned to have the functionalities navigation, communication and broadcast for land applications. The program was too ambitious and by Government Directive of March 2006 the only functionality will be navigation with a step by step development. The system uses three satellites in highly elliptic orbits, whereby always 1 of 3 satellites will be near zenith, providing extra availability in urban canyons etc. The availability in the Ginza area of Tokyo will be

almost 100% with GPS + Galileo + QZSS. The first launch will be in 2009, followed with validation and launch of the next 2 satellites.

The GAGAN augmentation system is developed by the Indian Satellite Research Organisation (ISRO) in co-operation with the Indian airport authorities. Apart from corrections and integrity messages for L1 and L5, the satellites will transmit L1 and L5 ranging signals. Twenty reference stations are planned over the Indian continent to determine the difficult ionosphere model data over India.

The Indian Regional Navigational Satellite System (IRNSS) will be developed in 6 - 7 years as an all Indian system with 3 GEO's and 4 geosynchronous satellites with 29° inclination. All satellites have continuous radio visibility from India. Ranging signals will be transmitted in two separate bands in the S-band. Dual frequency receivers will achieve a 9 metre horizontal accuracy and 12 metre vertical on Indian Territory.

Prof. Per Enge presented the status and future of the WAAS program. At this moment there are about 20 millions WAAS enabled GPS receivers on the market. The objective for the WAAS program is vertical guidance for landing to 220 ft altitude independent of ionospheric storms. This requires apart from WAAS an airport Ground Based Augmentation System (GBAS) and airport communication.

At this time 19 Boeing wide body aircraft are equipped with WAAS/GBAS. Airbus is planning certification for 2007. At Memphis airport 104 approaches have taken place with the new configuration without integrity alarms.

The ESSP will extend the EGNOS system with Ranging and Integrity Monitoring Stations (RIMS) in Morocco, Egypt, Algeria and Israel. The system will provide three services. The open service is free to access but will give no guarantees. The commercial service will provide a guaranteed service and is also available on other communication channels through the EDAS service. The safety of life service provides almost real time integrity. Test flights at Valencia airport have shown successful results.

The Munich Flashlights

The EADS Company presented new developments on the use of pseudolites for security and defence applications. A self calibrating network of pseudolites can be dropped by parachute in an area of interest to increase availability, geometry and accuracy.

Kayser-Threde is developing the precise timing facility for the Galileo Control Centre; delivery is

planned for early 2008. The company also delivered the six pseudo Galileo transmitters for the GATE project.

The GATE transmitters are placed on 6 mountain peaks in the Berchtesgarden area, providing a test area for Galileo receivers and applications. The first results showed a standard deviation of 1.55 m in the range error. The operation readiness for clients is planned for June 2007. A great number of clients have registered for tests in the GATE area. GATE can even play an important role in the further evolution of Galileo II.

The Institute of Geodesy and Navigation of the FAF University is doing R&D on a PC based software GNSS receiver. Such receivers will be very flexible in implementing new frequencies and new signal characteristics. Also other sensors like inertial MEMS, map matching and other aiding means can be integrated in a flexible way. The GIOVE-A signals were received at FAF university with a standard deviation of 50 cm.



Javad Ashajee of JAVAD Navigation Systems during his provocative speech.

Galileo at the Crossroads

ESN Industries experienced serious delays with the GIOVE-B satellite. The forecast is that the launch will take place in December 2007. Expected lifetime is 2 – 3 years.

The satellite will be the first in space with a Hydrogen Maser clock on board. ESN Industries is also working on the first four “real” IOV satellites which are planned to be launched in 2008.

Jean-François Bou, representative of the Galileo MC, was cautious in his presentation on the progress of the concession deliberations. System hand over is a complex operation, he emphasised. Transfer of responsibilities will be progressive. The roles of the GSA, ESA and the Galileo Operating Company (GOC) must be defined accordingly.

Carlo des Dorides, head of the Concession depart-

ment of the GSA was more specific. Agreements have been reached in November 2006 on the financial structure of the deal, the market risk, the performance risk, the completion risk, the cost risk of overrun and the overall risk management structure. Issues to be agreed on are: design risk, overall cost envelope, EGNOS integration and 3rd party liability regime. Negotiations have stopped since December 2006 “due to lack of convergence in the MC stakeholders group”.

Dorides said that the contract cannot realistically be finalised in 2007. Should the negotiation process fail to make steady progress, the GSA will go for the best alternative.

The head of the Galileo Unit of EC-DG-TREN, Paul Verhoef, expected tough discussions in the coming weeks in Transport Council, ESA Council and GSA meeting where the progress of the Galileo project will be on the agenda. The bad thing about the delay is that industry and users cannot plan involvement and investments in Galileo due to delay in the program, he said.

GNSS Industry

In the following session representatives of GNSS receiver industry were asked whether they were starting, waiting or had no interest in Galileo/GNSS applications.

Javad Ashajee, CEO of JAVAD Navigation Systems presented some tantalising propositions to the audience. But first he expressed that he is most supportive to the Galileo project. His US company became associate member of the European Industry Group “Galileo Services” (as did the Canadian company Novatel) and developed GPS/Glonass/Galileo receivers for R&D purposes.

Javad’s propositions:

- Galileo cannot be funded by the private sector
- Galileo can only survive as a military system
- Galileo should not look for funding from China, India, Israel, etc
- Galileo should not weaken US-Europe strong historical, political and social ties.

He proposed as solution to make GPS a 75% US – 25% EU partnership and Galileo a 75% EU – 25% US partnership to pave the way for a Universal GNSS (UGNSS). The audience appreciated of course his provocative approach.

Other GNSS receiver industries such as Septentrio, Trimble and Novatel expressed that they still believe in the advent of Galileo. However, they have invested a lot in Galileo receiver development and require no longer delays in the build up of the infrastructure. Also the issue of licences from the GSA to build (combined) Galileo receivers for

the market needs to be solved on short notice.

The Public Regulated Service of Galileo

A number of Government representatives from EU countries discussed the potential of the PRS service. This service is meant for governmental use for law enforcement, emergency services, etc. The service is only accessible for registered users and will be guaranteed in times of crisis. For the Concessionaire the service will not be a "cash cow", as the member states have required access on non-commercial basis.

An inquiry has been sent to all EU member states to find out the potential use of the service. The answers of the member states were very different ranging from "potential use" to "most likely use". The UK representative was most sceptical; many issues have to be resolved before the UK will consider use of PRS.

It was said that since a few months NATO has expressed interest in the use of PRS. No further details were mentioned.

All presentations and discussions considered, your author did not get a positive impression on the willingness of EU member states for PRS use. Successful pilot projects could change that attitude.

Going Global

The 3rd day was mainly focussed on the international scene of GNSS. The US industry stressed the importance of international co-operation. The US export control, however, is felt by US industry as a major hurdle for the free exchange of information on GNSS between the US and the rest of the world.

GNSS has grown into a global utility. Prices of receivers are still going down and there is still a huge consumer market not served by GNSS yet. In the US, only 25% of the cars are equipped with routing systems. The market in Asia is growing at high speed. The international consumer market is more difficult than the professional market. Consumers do not care about frequencies or signal characteristics, they want that it works and meets their needs: *"I don't care about satellites, I just want my GPS"*. Talking about availability: if one sums up all outages of GPS from the beginning, there were 11 days of outage over 60 yrs of satellite service!

The International GNSS Service (IGS) is a federation of over 200 worldwide national agencies, universities and research institutions in more than 80 countries. The IGS provides GPS satellite orbits to 5cm accuracy and precise positions (5mm) of 350 worldwide reference stations. IGS participates in

the unification of the African reference frames in the 53 African countries, each with their own geodetic reference. "Catch the Earth" is an IGS project to better understand the earth parameters such as polar motion, earth rotation, geoid models, etc.

Australia covers about 3 to 5% of the world market of GNSS for the 20 million population of which 99% lives in the 5 major cities. The Ground Based Regional Augmentation System GRAS supports air traffic in Australia. This system would be specific helpful for countries that do not have access to SBAS.

Australia would be an ideal test area for the interoperability of the upcoming and existing GNSS systems mentioned above, as all systems have coverage over Australia.

Shanghai organises the World Expo in 2010; they expect 140 million visitors. The Shanghai Galileo Industries Consortium wants to play an important role in the EXPO by creating awareness for the huge potential of Galileo and other GNSS systems for the Chinese market.

A special session was devoted to Glonass interoperability. The Russians are working on reducing the difference between the timeframes of GPS and Glonass from 30 ns now to 2 – 6 ns in the next generation. The geo reference of Glonass is close to ITRF. Presently the combined GPS/Glonass receivers are only used in the professional market. For better access to the consumer market CDMA transmissions are considered for the next generation satellites.

US industry will not consider use of FDMA Glonass in the future highly accurate three frequency receivers which will be possible with the advent of new signals on GPS and Galileo.

Finally

The audience of the Summit had a positive spirit to the immense potential of GNSS for a diversity of applications. To sum up:

A wide variety of interoperable GNSS infrastructure will become available in the next decade. The potential for *timing* applications for banking, power grids, mobile telephone networks, etc is generally underestimated. The consumer market is just becoming to emerge; annual growth with double digits percentages is expected.

The black page of GNSS developments is the delay – or possibly the failure – of the contract negotiations for the future operation of the Galileo system; *Europe: roll up your sleeves and get things done!*●