## Receiving Weak GPS Signals Indoors

# Workshop on Satellite Navigation

*For the third time the European Space Agency (ESA) held a workshop on satellite navigation user equipment technologies; Navitec 2006. The conference centre of Estec in Noordwijk, the Netherlands, was filled with scientists from all over Europe from Finland to Portugal. The eleventh to thirteenth of December the conference filled the two Newton conference rooms with parallel sessions. The topics varied from receiver technologies and developments to carrier phase algorithms and indoor and urban navigation. The fourteenth of December there was a course on the Galileo system.*

By Huibert-Jan Lekkerkerk and Job van Haaften

*Berchtesgaden (source: www.gate-testbed.com)*

### GATE Test Bed

One of the topics at the conference was the GATE test bed in southern Germany. Dr Günter Heinrichs presented the recent developments and expectations. GATE stands for Galileo Test- und Entwicklungsumgebung (Galileo test and development environment).

The European satellite navigation system Galileo will be operational round 2010 That means the development of Galileo based applications and products becomes more and more important. For the testing of these applications and products the GATE test bed is developed. A ground based realistic test infrastructure using Galileo signals (pseudolites), especially covering the needs of receiver manufacturers and application developers. It will be operational from the first of May 2007. It is located in the southeast of Germany and uses six transmitters of which one is at Berchtesgaden, that is about 20 kilometres south of Salzburg, Austria. The project is financed by the German Ministry of Education and Science and it is lead by IfEN GmbH, the system will be operated by the German Space Agency (DLR).

The target groups for the usage of GATE are developers of Galileo receivers and combined receivers Galileo/GPS, developers of applications for Galileo such as Location Based Services and Telematics and professional users of navigation and positioning technologies and services. For instance applications for flight navigation, public transport and search and rescue can be tested. GATE can be used for a fee based on the length of period it is used.

Berchtesgaden was selected for one of the pseudolites because the transmitters must be located high above the test area and to ensure permanent good visibility because of a low risk of signal obstruction due to topography, buildings or vegetation. The other five antennas will be or are already mounted on existing transmit stations of other operators. They are very compact and inconspicuous having a length of about 30 centimetres. The GATE test bed is a worldwide trendsetter for realistic tests with Galileo signals. Czechia and Italy already showed their interest to IfEN for their own test infrastructure.

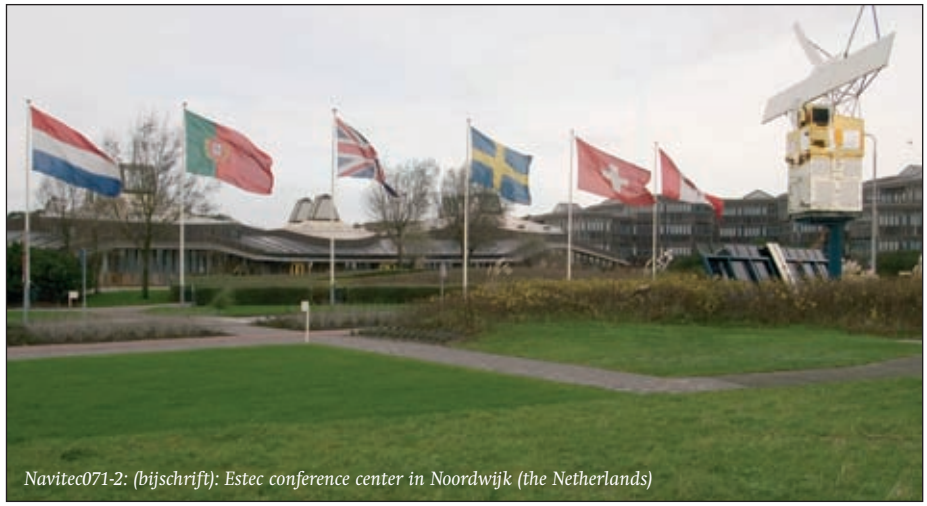
### Errors

During the sessions a lot of attention was given to error migitation. A number of new techniques (algorithms) for reducing multi-path are currently under development. First results from, amongst others, the German Aerospace Center, showed that a new algorithms can effectively reduce multi-path in a static receiver.

Furthermore a lot of attention was given to more advanced ionospheric prediction models. But as with the multi-path correction techniques, all is still in the development phase and not yet ready to be implemented in the GPS receivers.

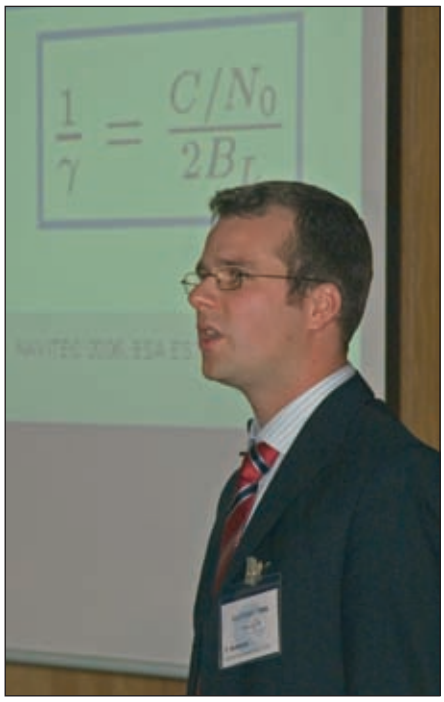
P.F. de Bakker from Delft University (Netherlands) presented the results of a study on the 'effects of Radio Frequency Interference on GNSS Receiver output'. In short they showed that the effect of RFI for Galileo is similar to that of Galileo, but that a slightly higher powered signal is needed to achieve the same results. Furthermore, it was shown that the largest errors do not occur on exactly the carrier frequency, but on a frequency that is equal to the first zero (when using Bi-Phase Shift Keying – BPSK). This signifies that, when RFI is suspected, the actual interfering frequency can be a couple of MHz away from the GNSS band that it is disrupting.

The effect of GPS on Galileo (or vice versa) was also investigated. First results showed a,



*Navitec071-2: (bijschrift): Estec conference center in Noordwijk (the Netherlands)*

# User Equipment Technologies




*Mr. E. Antreich of the German Aerospace Center (DLR) during one of his presentations.*

theoretical, maximum of around 0.2 dB on the Galileo E1 (GPS L1) frequency. This is within the tolerances, but still gives a degradation of the signal of around 6%, with GPS being at the disadvantage due to the higher power signals involved in Galileo.

Furthermore a study from the German Aerospace Institute showed a method for cycle slip detection in single frequency RTK receivers. The tests were performed in static mode, but could just as easily be adapted to moving applications, according to the presenter E. Engler.

## Indoor Navigation

A number of sessions were devoted to Indoor and Urban navigation. One of the presentations was from Nordnav, a small company from Sweden. They have pioneered an innovative technique for receiving weak GPS signals indoors. The method they use is placing an external antenna outside the building, where it has a clear view of the sky. This antenna transmits it's signals to the indoor reference receiver which also has it's own antenna.

The reference receiver allows the user to measure the exact signal levels on every satellite, compare the fading between the indoor and outdoor signals, characterize the multipath effects on every satellite signal, and measure the effects of the multipath on the navigation performance.

This information is then used to search for the same satellites indoors. In order to find the satellites at all, a very high sensitivity is needed indoors. As an example, near a window the reception strength is around -140 dBm but this drops to around -156m dB when measuring inside an elevator. This drop may seem small, but every -3 dBm reduces the signal strength by half.

Tests with the Nordnav set-up showed that satellites could even be tracked inside an elevator. According to Nordnav they can track satellites up to -170 dBm using this receiver.

The receiver is used to test high sensitivity chipsets against an absolute reference. Tests with the reference receiver have shown that most 'high sensitivity' chipsets were able to 'see' the satellites. However they were almost all giving incorrect positions. With the NordNav set-up the position accuracy in the elevator was between 15 and 25 meters. Similar tests performed by the Delft University showed similar results for commercial, off the shelve, receivers such as the TomTom One.

*Poster sessions giving the outline of some new study or product.*

Using Buoys for Extending WAAS Networks

Besides presentations given by speakers, there were also a number of poster sessions giving the outline of some new study or product. One interesting poster, jointly created by Nasa and the university of Barcelona, discussed the use of GPS buoys for extending Wide Area and Virtual Reference networks far into the sea. In this study a GPS receiver that was both located kinematically hundreds of kilometres from shore and at the same time provided information to the network.

This important since it would allow networks to be extended over the oceans, while at the moment the networks only use data from ground based stations. Extending the network would make the accuracy of the corrections better in both the marine as well as the land-based solutions.

The tests were both performed during days of high and low ionospheric activity. It was found that using this technique, extending networks is feasible.

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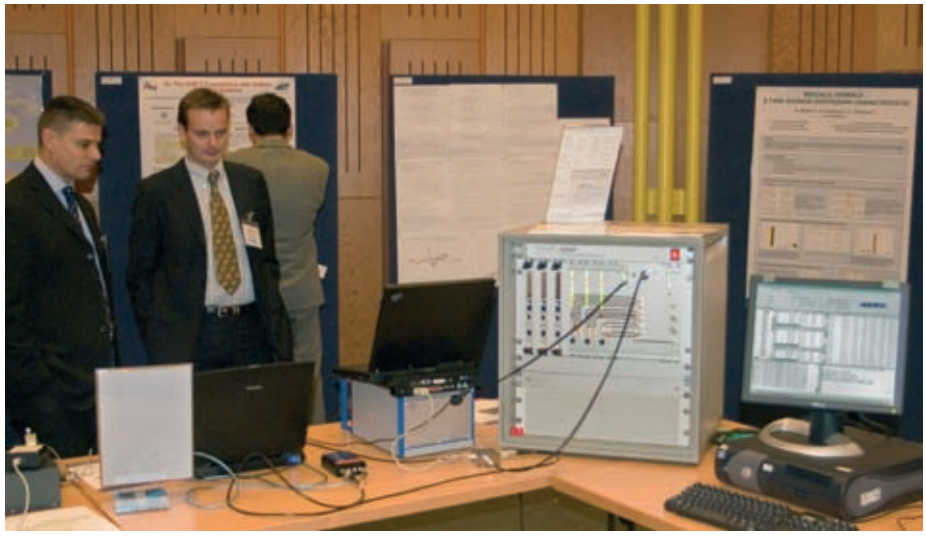
*www.nordnav.com*
*www.gate-testbed.com*



*Satellite signal generator and Nordnav indoor reference receiver in the poster session room*