GNSS Receiver with an Open Interface

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Key words: GNSS, RTK, Boards, Receiver

SUMMARY

Here the research project "GOOSE" is described. It is a funded project in Germany. The aim is to develop a new hardware for the reception of GNSS signals. With this hardware, a completely new approach istaken. There is an open software interface, which allows the user access to all signals coming from the satellite back and implement their own software. For this venture are three partners have found that complement each other perfectly. The Fraunhofer Institute with 15 years of experience in the development of GNSS hardware that UniBW with over 20 years' experience in the field of software development and the navXperience GmbH, a young company that has already established itself with the production of GNSS antennas on the market and with this research project will enter into the receiver development. We describe in this document the tasks and objectives of the project and the partners.

ZUSAMMENFASSUNG

Hier wird das Forschungsprojekt "GOOSE" beschrieben. Es ist ein in Deutschland gefördertes Projekt. Ziel ist es, eine neue Hardware für den Empfang von GNSS Signalen zu entwickeln. Mit dieser Hardware wird ein völlig neuer Weg eingeschlagen. Es gibt eine offene Softwareschnittstelle, die dem Nutzer erlaubt auf alle Signale, die von den Satelliten kommen zurück zugreifen und eigene Software zu implementieren. Für dieses Wagnis haben sich drei Partner gefunden, die sich optimal ergänzen. Das Fraunhofer Institut mit 15-jähriger Erfahrung in der Entwicklung von GNSS Hardware, die UniBW mit über 20-jähriger Erfahrung im Bereich der Softwareentwicklung und die navXperience GmbH, ein junges Unternehmen, das sich mit der Herstellung von GNSS Antennen bereits am Markt etabliert hat und mit diesem Forschungsprojekt auch in die Empfängerentwicklung einsteigen wird. Wir beschreiben in diesem Dokument die Aufgaben und Ziele des Projektes und der Partner.

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1. TARGETS OF THE PROJECT

1.1 Introduction

The satellite navigation system Galileo is the first non-military positioning system. It is await that the user can work with the system in the early 2016. With the combination of GPS, GLONASS and Galileo ascend the numbers of solutions for precise satellite navigation. The market potential in the construction industry (machine control) and in the agriculture (precise farming) is growing up. Also the surveying market evolved and the prices for the equipment are going down. Especially for these segments, we like to develop our new GNSS board.
Nearly all base technology manufactures came from North America. Trimble, Navcom, Topcon (Headquarter Japan) and Javad are from the United States. Novatel and Hemisphere (now a Chinese Owner) come from Canada. In Europe we only have one manufacture from Belgium.
The technological advantage of these North American companies is very large. The world's largest manufacturer, Trimble, was establish in 1978. Since 1982 Trimble developed GPS technology and currently has about 5,300 employees and an annual turnover of approximately 1.6 billion U.S. dollars. Catch up on this advantage is enormously difficult and either only be overcome with a lot of money and work force or with new concepts and ideas.Each of these manufacturers has developed its own firmware for its respective products. This firmware encapsulated and the users are not accessible. This is understandable from the manufacturer's opinion - after the firmware is valuable property through which customers should be long-term commitment to their respective owners. The change to a competitor prevented that the specifications of interfaces for other devices and tools are not made for freely accessible. An example of this is the measurement of the water vapor in the atmosphere by means of the GNSS technology. As to the absence of special firmware, software must installed on external computers and cannot be integrate.Another disadvantage for the user of the above described "black box software" is that he does not know the method by which the "RTK Engine" (a software that calculates in real-time cm-level positions) he works and thus cannot check the quality of the coordinates generated reliable. The user has to trust the information from the manufacture.
Through the existing oligopoly, the producers largely dictate the selling price. At the same time, this approach complicates the participation of other developments on the market by the manufacturer to keep prices artificially high for their boards. This is for the consumer, but especially for the development of satellite technology, an unsatisfactory situation that can be correct only through genuine competition.

1.2 Technical Targets Of The Project

The technical objective of the project is the development of a GNSS receiver development platform for research and engineering at universities, institutes and companies. In the course of which a blank created, which can be providing the necessary hardware components and used as a development platform. In addition a "Smart Antenna" a combination of GNSS receiver and antenna precise, developed with the same architecture as a prototype of a precise receiver. Furthermore it should arise an open software interface for the development platform and the "Smart Antenna" make possible with software developers to write their own software for both receivers. In addition it is demonstrated by software examples of how the interface can be used to calculate a PVT or an RTK solution and thus also to evaluate the performance of the receiver.

2. STATE OT THE SCIENCE

A good starting point for the analysis of the prior art is the website of the "open source" GNSS receiver project GPL GPS. The hardware platforms used there based on the Zarlink GP4020. The activities seem but unfortunately with a tutorial of GNSS Solutions to end the ION2006. A similar approach the "University of New South Wales" utilizedwhose Namuru V1 receiver was used in the course of a project of DLR. In addition the Namuru-V1 receiver set up the Zarlink GP4020. Disadvantage of this approach was that the hardware built on an ASIC chipset, which could not be sell in large quantities and its technology was obsolete after some time in terms of hardware channels and processor used. Zarlink, now named as Microsemi, refer to their website to a new development environment. Sigtec navigation PTY Ltd. this split in 2004 and became independent from Sigtec to SigNav. SigNav purchased in September 2011 by u-blox. The open development platform is not available for purchase from u-blox. All development kits of u-blox are indeed configurable, but only provide a ready PVT solution. The advancements of the Namuru receiver V2 and V3 are developments with FPGA solution designed specifically for LEO-Input use, special methods used to get a space-qualified, radiation-hardened solution rather than a highly accurate solution of the necessary computing power. The Aquarius Firmware can control the new versions of the Namuru receiver. In addition a wide range of approaches to Software Defined Radio (SDR) are found, but all have the disadvantage that although under laboratory-like circumstances show near real-time performance, but unsuitable for realistic scenarios in the outer region, due to their size, weight, energy consumption etc. are. In contrast, resulting in GOOSE platform is to maintain the high precision of the asphalt platform and simultaneously be connected via a high-speed data interface with an x86 machines as a primary development platform. This creates an equal in terms of comfort of a SDR platform, in terms of speed a far superior development environment with the possibility in a next step to make the Software (PVT / RTK and application SW) running on the platform itself. Thus the method implemented by users on the SW development platform directly to a future commercial version of the receiver (which is created in a project on the "GOOSE" following phase) are applied.

3. WORK PACKAGE NAVXPERIENCE

3.1 Previous Works of navXperience

The navXperience GmbH has developed in 2010 their precise GNSS antenna on market. For the 3G + C GNSS antenna for all navigation systems and frequencies, an environmentally resistant housing developed that has passed without difficulty the MIL-STD 810G testing. In 2012 the product range expanded. 3G + C maritime has a slightly higher gain and optimized for the additional receipt of the L-band correction signals. A further development is the + C G4G reference antenna. This has an even higher gain and an optimized multipath suppression. NavXperience has a complete product range for precise navigation and positioning. In another project a web interface was developed for a GNSS receiver (see 4.2.2) which allows you to configure GNSS receiver entirely via the Internet. This process incorporated into the project to provide a user later this convenient configuration option available.

3.2 Interface from navXperience

The user software is an open interface. The user have full control over the configuration and assignment of the individual receiving channels. There are the filter coefficients of the loop filter and the integration times and the distance of the correlates can be adapted to the respective needs. Proprietary algorithms to close the loops as VDLL or Kalman filter can be used, different discriminators are provided to choose. A large number of measured values - including raw pseudo range and carrier phase measurements - should be able to read and use for their own position calculation algorithms, satellite selection strategies etc. The API is flexible enough for a variety of applications. At the same time well documented and specifies the main task of navXperience will be to coordinate this interface to obtain possible applications and their requirements of its customers and the related specifications of the project partners and this document so that the resulting document will be served as a guide for other users. The precise description of the interface, both from a technological standpoint and from the geodetic point of view is crucial for the acceptance of the recipient as a development platform.

4. WORK PACKAGE FRAUNHOFER

4.1 Previous works of Fraunhofer

Fraunhofer IIS is based on a sixteen years of experience in development of GNSS receivers. The FP7 project "Galileo Receiver for Mass Market Applications in the Automotive Area" under recipient developing the basis for successful positioning laid with multi-frequency receivers. In the BMWi project FAMOS and in FP7 GNSS application project ASPHALT this technology expanded for use in the automobile and for the control of asphalting machines. Especially with the most recently developed ASPHALT platform achieved in the area of receiver precision of the prior art. The complete control of receiver hardware via a fast serial interface with an x86 PC implemented in the project BaSEII14. This comfortable development environment gets widespread acceptance of the Fraunhofer development team. The project originated in the GOOSE ASPHALT precision is to be associated with the comfortable development environment of base to a precise development platform with an open software interface. The respective system has disadvantages in ASPHALT the limited channel capacity and processing power, and at the BASEII for SMEs, universities and institutes to build expensive, should be fixed.

4.2 Hardware Development Platform

The Fraunhofer IIS will develop and qualify the recipient developments of the FP7 project ASPHALT, a receiver platform that will meet the requirements of a reference receiver to the millimeter range. Proven solutions from ASPHALT how the configurable frontend should taken from the existing receiver and known weaknesses, such as insufficient space in the configurable hardware, will be correct. The processor will be realize on the new platform as a separate component and no longer as a "system on chip". Thus, the computing power of the processor increased many times over. Complicated carrier phase analyzes, the inclusion of different sensors in the position solution, as well as elaborate conclusions on the atmosphere be calculate on the receiving platform. The resulting GNSS development platform is connect via a fast serial interface to a standard PC. This platform should work but mobile and independent of mains voltage. Therefore the idea is that the primary development platform is an upgraded commercial PC which has a fast connection direct access to the receiver hardware. If all functions are implement to the extent and the software on the PC shows the desired result, the same software can be compile with a cross-compiler for the processor located on the GNSS development platform and installed as firmware in a next step. The platform used separately from the PC as a standalone GNSS receiver. The internal interfaces of the receiver to make available to users in the form of an application programming interface (API). Therefore the possible configuration options and available records to go far beyond what is currently offering commercial receiver.

5. WORK PACKAGE UNIBW

5.1 GOOSE RTK System

The GOOSE platform is unique because it relays the UniBw's precise positioning expertise on linux environment for real-time process and improves the quality of GNSS carrier phase ambiguity based positioning. The software unit tests the hardware platform and the Application Program Interface (API) and ensures that other navigational applications are implementable by using the platform and the API. One of the main driving forces of this work is to reach the highest possible positioning accuracy which is strictly depending on the data link latency in synchronized RTK demonstration software.

With multi-constellation RTK receiver including GPS, Galileo and Glonass signals, the number of visible satellites increases providing a positioning redundancy of 78 satellites other than nominal 24 GPS satellites. The redundant satellite signals increase the precision of the solution by rejecting poor quality measurements that may cause inaccurate position estimates.

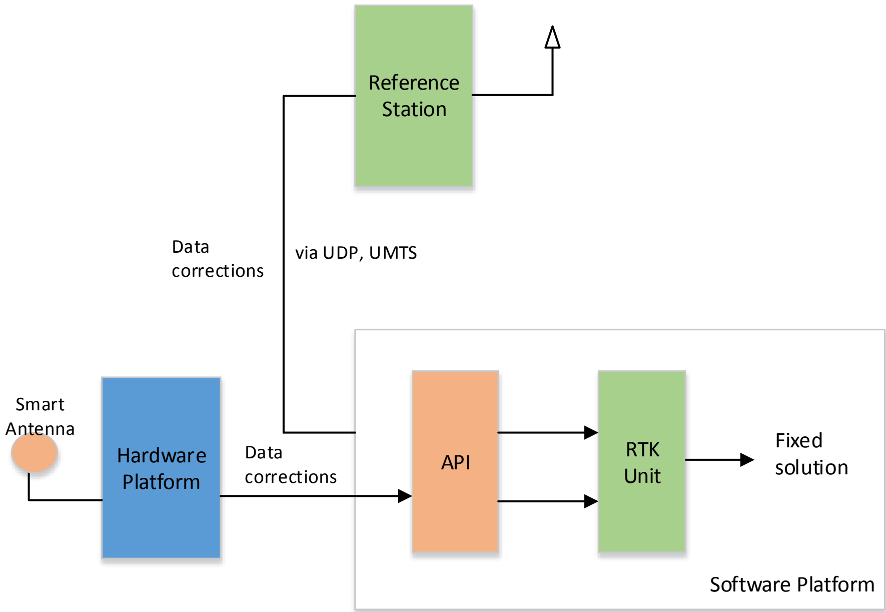

Figure 1*GOOSE setup*

The demonstration software supports the real-time transmission standard RTCM 2.3 and RTCM 3.1. for data transmissionUMTS network in conjunction with UDP is used.

5.2 Overview of the RTK Unit

RTK is one of the most precisepositioning techniques usedin GNSS. RTK positioning system is based on a rover and a reference station that is supplying real time correction data at a fixed location to the rover.By using correction dataat the receiver,RTK provides cm-levelaccuracy of user positions in real-time. The performance of RTK depends on baselinelength namely the distance between the receiverand the reference station, ambiguity fixing precision, multipath, ionospheric and tropospheric errors.

Enabling reliable integer ambiguity fixing resolution in precise carrier phase RTKpositioning is the principle requirement. The receiver acquires reference station correction data and performs double difference code pseudoranges and correlator values. The double difference correlator values are then used to form the double difference carrier phase values[1]. The further process of the RTK unit can be described within three steps. In the first step, code and carrier phase estimations are used by Kalman filter to fix float carrier phase ambiguities. Then via LAMBDA method and integer boot strapping integer ambiguities are estimated. In the final step the rover position is fixed using integer ambiguities.

5.2.1 Data link communication

The RTK system relies on two main criteria a cost efficient high data rate communication link and a low power consumption platform. The data link between reference station and receiver is a critical point in RTK system, since a failure or latency in corrections may degrade the system performance [1]. By using radio or GSM based modems the data rate is low and give significant cost for transferring the data stream. Therefore UMTS network is used to receive data corrections from reference station. The RTK correction data is received from a reference station installed at a fixed location developed from UniBw[2].

A particular importance is given to test campaigns. A baseline test with less than 200 m in UniBw campus via WLAN and longer baselines up to 100 km in Munich adjacent cities using UMTS network are foreseen as represented in Figure 2. In general, RTK systems work properly within baselines less than 10 km, on the other hand RTK positioning with baselines less than 100 km is more challenging.

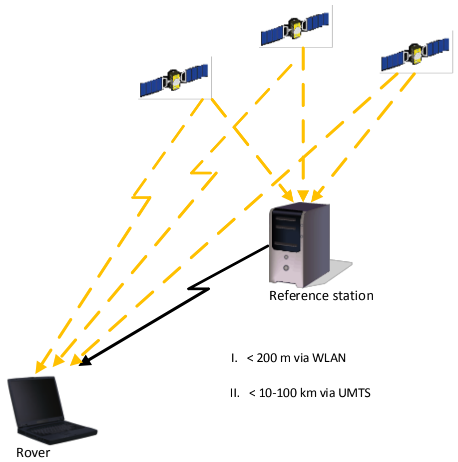

Figure 2*Data link communication in the RTK system*

5.2.2 Network Time Synchronization

For optimized time synchronization between reference station and rover can be achieved by using the Network Time Protocol (NTP). This means that a precision of less than 30 ms are possible[1]. NTPis used for synchronizing the clocks of computer systems over packet-based communication networks and uses the connectionless UDP transport protocol. NTP has been specifically designed to allow reliable timing networks with variable packet delay. Time differences are smaller by NTP in wide area networksthat are less than a tenth of milliseconds[3]. NTP is available for almost all computers because the Linux NTP daemon has been ported to many operating systems.

6. CONCLUSION

There is a high risk for all parties involved to develop this new receiver platform. Is it from the market ever wanted an open interface on a GNSS receiver to have? Does the hardware and development platform really wish from the Users? These questions remain open and can be answer only by the users. As already Alexander Graham Bell said, "Don't keep forever on the public road, going only where others have gone, and following one after the other like a flock of sheep. Leave the beaten track occasionally and dive into the woods. Every time you do so you will be certain to find something that you have never seen before. Of course, it will be a little thing, but do not ignore it. Follow it up, explore all around it; one discovery will lead to another, and before you know it, you will have something worth thinking about to occupy your mind. All really big discoveries are the results of thought."

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BIOGRAPHICAL NOTES

Dirk Kowalewski

1987 – 1991 Technische Fachhochschule Berlin Dipl.-Ing. for Geodesy
From 2001 Founder and director of the Geo.IT Systeme GmbH
From 2009 Founder and director of the navXperience GmbH
2009 – 2012 Research projects: MoDeSh with GL and HSVA: Motion and Deformation of Ships
From 2010 developing precise GNSS antennas
From 2012 Member of the working group AK 3 "Measurement method and Systems" DVW Germany

Matthias Overbeck

He received his Dipl.-Ing. (master) degree in 1999. Since September 1999 he is working at the Fraunhofer Institute for Integrated Circuits (IIS) in the department power efficient systems on the topic hardware development for GNSS receivers. Within this scope he developed digital baseband hardware like signal conditioning, correlators and microprocessor for FPGA and for ASIC for an assisted GPS/EGNOS receiver for mobile applications. He gathered also profound skills in the design of an application specific DSP for signal acquisition, tracking and the PVT solution for the same application. Moreover he has developed a rapid prototyping platform on FPGA basis for GPS/Galileo prototype receiver. In 2009 he has overtaken for Fraunhofer the technical leadership of the GSA-project Galileo Receiver for Mass Market Applications in the Automotive Area (GAMMA-A). Since 2013 he is the Group Manager of Precise GNSS Receiver at Fraunhofer IIS.

Dr. Günter Rohmer

He received his Dipl.-Ing. (master) degree from University of Erlangen in 1988 and his PHD in 1995. He is working for the Fraunhofer Institute for integrated Circuits IIS since 1988. From 1996-2000 he was Head of the Research Group: Low Power System Design at Working Group "Wireless Telecommunication and Multimedia Technology". Since 2000 he is the head of a department developing localisation technologies, mainly technologies for combined GPS/EGNOS/GALILEO receivers for different applications. His department is also working in inertial sensor systems and navigation, multi sensor systems and sensor fusion, high precision microwave localisation systems for sport applications, power management systems for communication transceivers and navigation receivers and low power communication modules for embedded systems. Since 2008 he is responsible for the facilities of Fraunhofer IIS in Nürnberg, developing localisation and communication technologies with a staff of 70 people. He is also lecturing "Satellite Navigation" at the University of Würzburg.

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