TREASURE
TRAINING RESEARCH AND APPLICATIONS NETWORK TO SUPPORT THE ULTIMATE REAL TIME HIGH ACCURACY EGNSS SOLUTION

# NEWSLETTER

ISSUE 1
November 2017
Project Coordinator Dr Marcio H.O. Aquino

## WELCOME TO THE 1ST EDITION OF THE TREASURE PROJECT NEWSLETTER!

**Marcio H.O. Aquino Coordinator of TREASURE**

Marie Skłodowska-Curie Actions (MSCA) Innovative Training Networks (ITN) are funded through the European Union's Horizon 2020 Research and Innovation Programme, and aim to support the career development and training of researchers with a focus on innovation. We at Nottingham are lucky enough to coordinate one such network, TREASURE, Training, REsearch and Applications network to Support the Ultimate Real time high accuracy EGNSS solution – welcome to the first edition of our project newsletter! TREASURE was formed to provide specialist training in the strategic and emerging area of European GNSS. Collectively, GNSS (Global Navigation Satellite Systems)...

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**Juliana Damaceno**
**ESR1**

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## EXPERTS VOICE

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**Roberto Prieto-Cerdeira**
European Space Agency ESA/ESTEC

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**Martin Schmitz**
Geo++ GmbH

[read more]

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# FROM THE COORDINATOR

Marie Skłodowska-Curie Actions (MSCA) Innovative Training Networks (ITN) are funded through the European Union's Horizon 2020 Research and Innovation Programme, and aim to support the career development and training of researchers with a focus on innovation. We at Nottingham are lucky enough to coordinate one such network, TREASURE Training, REsearch and Applications network to Support the Ultimate Real time high accuracy EGNSS solution – welcome to the first edition of our project newsletter! TREASURE was formed to provide specialist training in the strategic and emerging area of European GNSS. Collectively, GNSS (Global Navigation Satellite Systems) include systems such as the US Global Positioning System (GPS) and the Russian GLONASS, as well as new systems like China's Beidou and most importantly Europe's Galileo. Galileo is what we call the European GNSS (EGNSS) and is to be fully operational around 2020, therefore the EU's recognition that there is a pressing need to invest on research and training in this area. Within this framework, our project was one of just 109 projects selected among 1611 proposals covering all areas of research in the MSCA ITN H2020 Call 2016, a testimony to the importance of this niche research field. This is especially so because GPS has clearly been the frontrunner of all these satellite systems and has dominated the market for more than two decades now. EGNSS is aimed at changing this market unbalance and is the main focus of TREASURE, which concentrates on its use in support of applications demanding high accuracy positioning and navigation.

Although GNSS is routinely used in smartphones and in-car navigation with an accuracy of a few meters, it can deliver centimetres in real time if advanced techniques and error modelling are employed, especially if different systems (e.g. GPS, GLONASS, Galileo, Beidou) can be used in combination, in what we call 'multi-GNSS'. Extracting the best possible real time accuracy of multi-GNSS is key to boost the use of Galileo in support of a range of applications. Just as an example, one remarkable new market for GNSS is in the global Agri-Tech sector. By 2025, the world's population is expected to reach 9.2 billion people, presenting a unique challenge in terms of global food production. Precision agriculture technology relies heavily on high accuracy GNSS positioning to give farmers access to real-time precise data gathering and analysis, maximizing production, reducing costs and minimizing environmental impact. For obvious reasons, the precision agriculture market for GNSS receivers is set to grow significantly in the next few years. More importantly, achieving high accuracy positioning with GNSS may be the key to inspiring new applications that can arise when multi-GNSS techniques are fully developed. The aim of TREASURE is to gather a special group of young researchers in the light of this exciting opportunity, to undertake coordinated cutting edge research that will promote EGNSS in this multi-GNSS context, with Galileo at its forefront. I am glad to say that we have during the summer recruited this special group of people, and that they are entirely on board our project and highly motivated to achieve this goal!

TREASURE's cohort of 13 young researchers is now in place and will be given the necessary gap-bridging innovative training through our unique network of industrial, research and academic beneficiaries. In that regard TREASURE responds to the much desired involvement of end users and businesses, by bringing together top Universities, research Institutes and leading companies, with extensive track record and experience in a wide breadth of disciplines.

To demonstrate the TREASURE concept and its market prospects, the project will pave the way for the development of a service that can ensure the enhanced real time high accuracy positioning that is desperately needed. I am confident that TREASURE will provide the right platform to enable the ultimate real time high accuracy EGNSS solution!

We aim to keep you posted on our project events and developments through our website (www.treasure-gnss.eu) and newsletter, also offering a platform to promote an open debate on the issues dealt with by the project. Enjoy the reading!

# SHORT ARTICLES

## The first TREASURE summer school – the ESRs perspective

The first Summer School of the TREASURE project was a unique opportunity for the fellows to meet and learn the basics of Global Navigation Satellite Systems, an intriguing area of great interest world-wide. To break the ice, the school started with a really well organized team building event in the sports center of the University of Nottingham in the UK. The second step was a week of well-presented lectures, given by experts in GNSS, covering factual aspects and providing an industrial perspective on the subject of study by the fellows for the next 3 years. The summer school closed on a high note, with the fellows travelling to the project associate partners CNHi premises in Basildon for a field demonstration of a GNSS-guided tractor system. Between the lectures, the fellows became acquainted with their new colleagues during coffee and lunch breaks. The 13 young researches that compose the TREASURE project are from a variety of countries, namely: Brazil, US, Sweden, Turkey, Italy, Spain, Greece, Iran and China.

The cultural differences made interactions fun and exciting.

For example, Chinese chopsticks versus fork and knife, different life experiences like seeing the aurora borealis for some, or the Amazon rain forest for others. For some fellows, this is the first time outside their home countries. At first the experience can be hard, just by being far away from family and friends and having to deal with the basic everyday challenges, such as cooking! However, these experiences are also an essential part of earning a PhD: learning new skills in all areas. The common feeling of the fellows in the school was: -"This TREASURE experience is always fun, people around are really kind, we are surrounded by interesting people." The unique concept of the project was made possible by the efforts between universities, companies and associated partners. Fellows were awarded a prestigious Marie-Skłodowska Curie grant and are registered as PhD students with their host institutions or local universities. For all the fellows, we have many things in common even though we are from different parts of the world and with different backgrounds. During the school I heard phrases like: -"Maybe even the water in this country has a taste different from mine, but it continues being water", and -"Maybe my English sounds different from the native speaks, but we can still communicate very well". During TREASURE all the fellows are going to have secondments in different countries with various companies and universities, -"we have the opportunity not only to boost our academic abilities, but also to learn new languages and experience new cultures".

For example, Kai Guo (ESR 7) is interested in the field of ionosphere scintillation and has been putting a lot of effort in studying this in order to improve GNSS robustness, especially in the ionospherically active equatorial and polar regions. He joined the TREASURE project at the University of Nottingham. He wants to improve his research abilities to a high level, as well as his English writing and speaking capabilities. The fellows are not only

researchers in TREASURE, but also PhD students, and they have the opportunity to conduct research by cooperating with companies and universities.

The project's 1st summer school was an opportunity for external students, such as Umberto Apponi (INGV/SET), to develop a deeper understanding of GNSS. Talking about the experience as an external participant, Umberto said "The international environment of the school was very good, ideal for sharing ideas about the research field, the topics presented covered really well the main aspects of this research area, explaining complex topics in an easy way, since the subject has a lot of information available nowadays, summarizing the system is a hard task".

Umberto highlighted the 'hands-on practical' group activity, where the fellows had the opportunity to present in a short time the result of a small piece of research work on space weather. After the exercise, we received feedback about the best way to speak in front of the audience. Umberto appreciated very much the summer school and he would certainly recommend external participants to join the next TREASURE summer school.

The ESR 11, Hossein Ghobadi from IRAN, said that – "The project is a multidisciplinary research topic, each fellow has his or her own goal to achieve, and we have different backgrounds and the result can be introduced to the market. So it is very significant.

I will have the opportunity to visit two prominent companies in Europe, I am so happy to have this opportunity. It can help to develop my career not only as a researcher but also as an engineer. Unfortunately I could not be in person at the first summer school because of visa issues to enter the UK, but I had a Skype connection and I could take part in the lectures, being really effective for me, with a good view about what I am going to do." The project is really interesting with really nice people collaborating and interacting. TREASURE provides a great opportunity for young researchers to study towards a PhD in a new country, and combine work and life experience with academic research. The summer school ended as a big global family of young researches full of willingness to innovate.

**Juliana Damaceno**
ESR1

# EXPERTS VOICE

## The role of GNSS within 5G

Demand for localisation is increasing in different market segments, with diverse requirements. Positioning, Navigation and Timing (PNT) is progressively considered as a utility, with a high level of expectations from the users in terms of accuracy, availability, integrity and resilience to external factors. In this context, the importance of the role of Global Navigation Satellite Systems is taken for granted, surely increasingly integrated with other positioning technologies and advanced sensors, the advantages of GNSS including among others global coverage, open access and compatibility leading to an increasing number of satellites compensating for some of the deficiencies in some environments, are very important assets to be exploited by the aforementioned applications.

This situation is evident in the ongoing 5G standardisation process. 5G wireless networks stands for fifth generation and refers to the next and newest mobile wireless standard yet to be set. 5G technology is expected to be a new mobile revolution in wireless market combining different wireless technologies (4G LTE, WiFi and 5G newly defined air interfaces) to cover new use cases and exploiting new frequency bands. 5G will be addressing many new types of users, ranging from low data-rate for narrowband Internet of Things (IoT) to ultrafast enhanced broadband exploiting technologies such as millimetre waves, small cells, massive Multiple-Input-Multiple-Output (MIMO) among others. Whitin 5G, positioning to be an integral feature in 5G, expected to be provided by hybrid solutions, that is a combination of external technologies (GNSS, inertial sensors, terrestrial beacon systems, ...) and 5G-internal technologies (Cell-ID, OTDOA, UTDOA, massive- MIMO, ...). The starting point for positioning support in 5G first release (Release 15) is linked to support for regulatory requirements (~50 m) using LTE as baseline, and expected to evolve in later releases. A number of interesting 5G use cases for positioning have been identified covering all verticals, including connected devices (exploiting only ranging signals, data obtained from 5G), low-power devices (e.g. Internet-of-Things), vehicle in urban environments (e.g. Vehicle-2-Vehicle, autonomous vehicles), robust timing devices e.g. network synchronisation

or Unmanned Aerial Vehicles (UAVs). In terms of accuracy, two categories may be considered, the Coarse Accuracy, starting from the already existing Location-Based Services; and the High Accuracy, with sub-meter positioning targets, and in many cases for liability-critical services. The 3rd Generation Partnership Project (3GPP) will be one of the key contributors to 5G as in the past they did for 3G and 4G/LTE. Although contributions to ITU-R IMT-2020 (the actual 5G standard) will be channelled through Standard Development Organisations, those standards are expected to be largely based on 3GPP inputs. The 3GPP unites seven telecommunications standard development organizations, known as "Organizational Partners" and provides their members with a stable environment to produce the Reports and Specifications that define 3GPP technologies. In this context, during 3GPP 4G LTE and 5G standardisation process, the interest on positioning aspects has been increasing significantly in particular for operators, different verticals, but also by chipset manufacturers (vendors) and other supporting equipment companies. There are a number of Study and Work Items on positioning aspects or including important areas related to positioning, and a Study Item entirely dedicated to positioning for 5G New Radio is expected to start in the Second Phase of 5G (for Release 16, to be completed before 2020). Even before 5G arrives, dissemination of high accuracy positioning corrections is already under consideration through 4G LTE broadcast/multicast. This includes both Real-Time Kinematic (RTK) and Precise Point Positioning (PPP) corrections, in a flexible way for the adoption of all GNSS new constellations and possibly new messages not yet included in existing standards, such as for example precise models for ionosphere and troposphere. In addition, timing aspects for network synchronisation are considered of critical importance for 5G and GNSS is observed as the fundamental stone for high quality time source in the network. The European Space Agency, first through the European GNSS Evolutions programme, and currently through H2020 HSNAV programme, has initiated preparatory activity for the evolutions of European GNSS in terms of system, segment and technology R&D activities. Galileo and its evolutions may be a key enabling technology in future wireless network positioning with advantages for high accuracy applications in different environments, and also with other possibly interesting GNSS differentiators related to support to integrity and authentication. Based on the above initiatives, it is very clear that all research projects within TREASURE have a very high potential to contribute to future positioning, navigation and timing on 5G.

**Roberto Prieto-Cerdeira**
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## SSR Technology for Scalable Real-Time GNSS Applications

Positioning by Global Navigation Satellite Systems (GNSS) has grown to be a significant market worldwide. GNSS technology is entering everyone's life at least since every mobile phone is equipped with a GNSS receiver. There is a wide range of GNSS positioning application with different needs and requirements. Especially positioning availability and accuracy are of interest and there is demand for ubiquitous precise positioning in real-time. At the same time, the variety of GNSS and signals is increasing. Among others, the European Galileo, the Chinese Beidou or the Japanese QZSS are approaching complete constellation.

Today's precise positioning applications require to simultaneously take GNSS observations on a reference station with known coordinates. A high correlation of the GNSS error components is assumed to derive real-time differential GNSS corrections, which are the lump sum of acting errors. The range measurements of a GNSS user are improved by applying the GNSS correction as measured by the nearby reference station. Since the observations of the reference station are used directly, this approach is classified as an observation space representation (OSR) technique.

The technique has been further enhanced using multiple GNSS reference stations in RTK networking applications. There, the network allows for further enhancements by de-correlating the different individual GNSS error components. The major error components are satellite clocks, satellite orbits, satellite signal biases and atmospheric effects, which are separately modeled and disseminated as GNSS corrections for precise positioning. Since the state of the

GNSS error components is determined, this approach is termed a state space representation (SSR) technique (Fig. 1). One major benefit of the SSR approach is its broadcast capabilities: the users themselves generate GNSS corrections valid for their own position from SSR. The user is no longer aware of the actual reference station and can rely solely on the SSR corrections provided by a GNSS correction service. This is an essential step to ubiquitous positioning services. Examples of real-time GNSS positioning with SSR technology today are Precise Point Positioning at decimeter level on a global scale and the centimeter level Japan-wide CLAS system of QZSS. The use of SSR is the most convincing and acknowledged GNSS augmentation technology to cope with the increase of new signals and new constellations as it offers flexible concepts to scale service performance, service area and required bandwidth for all GNSS. This is recognized by the industry and the scientific GNSS community. The synergy of Precise Point Positioning and RTK networking is channeled into SSR technology (Fig. 2).

SSR generation relies on accurate models to parameterize the influence of the atmosphere on GNSS measurements.
This means that SSR generation software will benefit from improved models but at the same time atmosphere researchers will benefit from readily available SSR data sets. Within the TREASURE project we expect that the experts from both sides will use this technology to generate new and valuable insights.
In the future scalable SSR applications will support both, global but also regional or local applications.

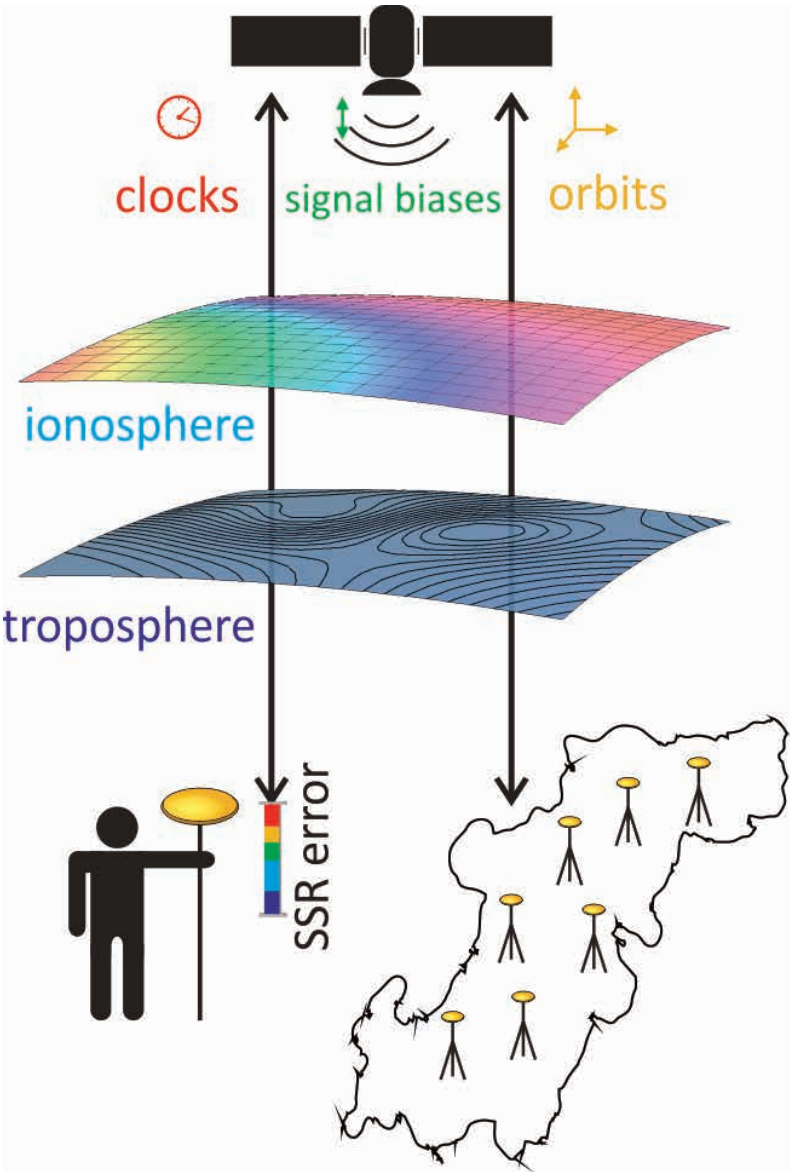



**Fig1:** The SSR (state space representation) technique.

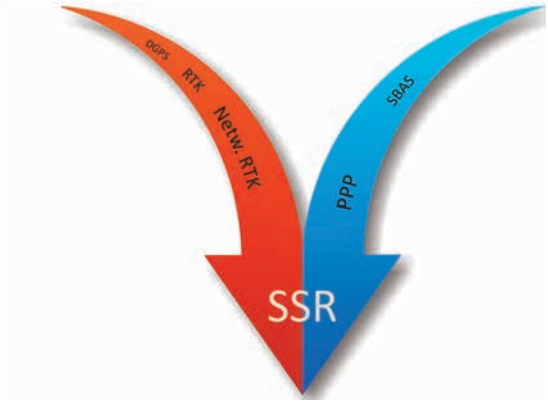



**Fig2:** Synergy of Precise Point Positioning and RTK networking.

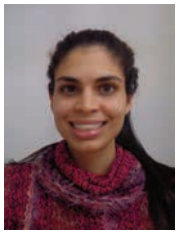
Even a paradigm change in the precise GNSS user algorithm will occur, as the commonly used relative GNSS reference station data is substituted completely by the SSR corrections applied to user's GNSS measurements. However, in the interim period, the SSR technology also allows to convert SSR corrections to OSR to support legacy positioning applications.

**Martin Schmitz**
Geo++ GmbH
Garbsen, Germany

# UPCOMING EVENTS

| EVENT | WEBSITE | DATE | LOCATION |
|---|---|---|---|
| 14th EUROPEAN SPACE WEATHER WEEK | http://www.stce.be/esww14/ | Nov 27 - Dec 1, 2017 | Ostend, Belgium |
| AGU FALL MEETING 2017 | https://fallmeeting.agu.org/2017/ | 11-15 December 2017 | New Orleans, Louisiana |
| 15TH CONFERENCE ON SPACE WEATHER, 98TH ANNUAL MEETING AMS | https://annual.ametsoc.org/2018/index.cfm/ | 7-11 January 2018 | Austin, Texas |
| ITM/PTTI - INTERNATIONAL TECHNICAL MEETING AND PRECISE TIME AND TIME INTERVAL | https://www.ion.org/itm/index.cfm & https://www.ion.org/ptti/index.cfm | January 29- February 1, 2018 | Reston, Virginia |
| MUNICH SATELLITE NAVIGATION SUMMIT | https://www.munich-satellite-navigation-summit.org/ | March 5-7, 2018 | Munich, Germany |
| EGU GENERAL ASSEMBLY 2018 | https://www.egu2018.eu/ | 8-13 April 2018 | Vienna, Austria |
| SPACE WEATHER WORKSHOP | http://www.swpc.noaa.gov/content/annual-meeting | April 16-20, 2018 | Westminster, Colorado |
| FIRST WORKSHOP TREASURE, "INITIAL DEVELOPMENTS AND INTERACTION WITH ACADEMIA AND INDUSTRY" | http://www.treasure-gnss.eu/events | 17 - 19 April 2018 | Rome, Italy |
| LOS ALAMOS SPACE WEATHER SUMMER SCHOOL | http://www.lanl.gov/projects/national-security-education-center/space-earth-center/space-weather-school/index.php | June 4 - July 27, 2018 | Los Alamos, New Mexico |
| SATELLITE 2018 | http://www.toulousespaceshow.eu/tss18 | 26-28 June 2018 | Toulouse, France |
| TOULOUSE SPACE SHOW | http://www.toulousespaceshow.eu/tss | 26-28 June 2018 | Toulouse, France |

# TREASURE PROJECT FELLOWS



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ESR2

Karl Bolgrem
ESR3

Hongyang Ma
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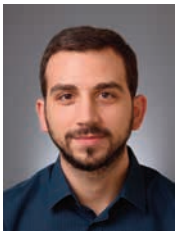
Caner Savas
ESR5

Wenjian Qin
ESR6

Kai Guo
ESR7

Brian Weaver
ESR8



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# TREASURE PROJECT PARTNERS

alezi teodolini
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Gter Innovazione in Geomatica, Gnss e Gis

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