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Editorial

Preface: The European Navigation Conference 2023 (ENC 2023) †

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1. Introduction

The European Navigation Conference 2023 (ENC 2023) took place at the European Space Research and Technology Centre (ESTEC) of the European Space Agency (ESA) in Noordwijk, The Netherlands, from 31 May until 2 June 2023.

ENC 2023 addressed Resilient Navigation, in its broadest sense, as the main theme. 'Navigation' comprises the art of monitoring and controlling a vehicle from its current position to an intended position along a route, with due recognition of constraints. Thus, the conference was structured to address resilience in those main navigation sub-functions.

Resilience in position determination concerns the robustness of individual components by considering redundancy, dissimilarity, specific algorithms, and data processing techniques. This applies to all elements of the Position Navigation and Timing (PNT) solution: the signal measurement domain, any infrastructural elements, service provision, and end-user implementation.

Over and above position determination, however, navigation resilience also requires vulnerabilities to be addressed in the various types of data used for navigation, including map information, various databases, routing/path construction, and guidance and control. Separate from those functional matters, application domains such as aviation, maritime, and surface navigation have widely different implementations. Examples of aspects that must also be considered in the context of overall navigation resilience are man–machine interfaces, function allocation between electronic elements and the human operator, crew complement, training and proficiency/skill base, developments in rules and regulations (ICAO/Aviation, COLREG/Maritime), and the quality and use of meteorological and oceanographic information and corresponding measures.

2. Sessions

In response to submitted papers considering the topics described above, the conference was organized into five tracks, comprising a total of 134 presentations arranged in 18 sessions, including one poster session, to enable the audience to attend presentations consistent with their personal interest. The audience count was 350 from around the world, including about 50 students from both the Netherlands and international universities. The program consisted of the following tracks and parallel sessions:

- GNSS and Hybridized Navigation;
    - Interference and Jamming;
    - Spoofing and Meaconing;
    - Performance Prediction, Monitoring and Assessment;
    - Alternative and Complementary PNT;
    - Multi-Sensor and Augmented PNT;
    - Advanced GNSS Techniques;
    - Integrity Algorithms;

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- Atmospheric Modelling and Sensing;
- High-Accuracy Techniques;

- Extra-Terrestrial Navigation;
  - Space Navigation;
  - Moon/Mars Navigation Services;
- AI, Machine Learning, Simulation and Testing;
  - Use of AI and Machine Learning;
  - Simulation, Testing, Analysis Tools and Results;
- Integral Navigation Systems;
  - Reference Trajectory Optimization;
  - End-to-End Navigation Systems;
- LEO PNT Developments;
  - LEO-GNSS Synergism;
  - LEO User Equipment Considerations.

3. Plenary Talks

A range of plenary talks was held, addressing contemporary requirements and developments in the field of navigation, the need for resilience and ways to achieve it.

Minister Mark Harbers' opening speech [1] addressed the subject quite elegantly, referencing astronomer Richard Carrington's observations of extreme sun activity back in September 1859 and, even in those days, the subsequent disruption of a range of services, including communication, navigation, and electrical power distribution. The example highlighted the need for resilience two centuries ago, but much more so in today's world, with the ever-increasing dependence on radio- and networked-computer-based navigation, communication, and other essential services.

Plenary talks included:

- Conference Opening Speech—Mark Harbers, Minister of Infrastructure and Water Management of the Netherlands;
- ESA ESTEC—Dietmar Pilz, ESA;
- Towards the Future of Satellite Navigation—Javier Benedicto, ESA;
- EUSPA—Pascal Claudel, EUSPA;
- Spaceopal—Marco Folino, Spaceopal;
- GPS Status Update—Robert Wray, US Space Force;
- Galileo Second Generation—Miguel Manteiga (ESA) and Heads of Industry;
- Lunar Navigation and Moonlight Programme Overview—Javier Ventura, ESA;
- Lunar Pathfinder Navigation Experiment—Pietro Giordano, ESA;
- U.S. President's National Space-Based PNT Advisory Board—Dana Goward (Resilient Navigation and Timing Foundation), Frank van Diggelen (Google), Terry Moore (Royal Institute of Navigation);
- LEO PNT Introduction—Sandra Verhagen, Delft University of Technology.
- FutureNAV LEO PNT In-Orbit Demonstration Program—Roberto Prieto, ESA;
- PULSAR LEO PNT GNSS Augmentations—Bryan Chan, Xona;
- Next Big Thing—Maarten Uijt de Haag, Technische Universität Berlin.

Of particular interest was an announcement regarding Galileo Second Generation (G2), including an on-stage ceremony. The ceremony involved contracts to Thales (Italy), Airbus Defence & Space (Germany), and Thales Six GTS (France) for system engineering and technical assistance in support of the full development phase of G2 [2].

Equally inspiring was the briefing by Lt. Col. Wray of the US Space Force (USSF). Mr. Wray oversees the team responsible for operating and maintaining the US Global Positioning System. He emphasized the international importance of the system, but also some key differences between GPS operation and that of other Global Navigation Satellite Systems worldwide, particularly GPS operation by the (military) USSF, with a

view to the specific signals and tactics designed to support American, allied and partner military capabilities.

The plenary talks were completed by Prof. Maarten Uijt de Haag, with his stimulating and dynamic speech 'The Next Big Thing'. Prof. Uijt de Haag took the audience from the elementary notions of navigating in the real world, employing sensors, PNT algorithms, and state estimation, as well as comprehension and prediction, to the examples, such as urban swarm navigation. He was looking forward to future challenges in the field of PNT, where many use-cases require complementary PNT approaches, using extensive forms of integration to meet the required navigation performance (RNP). To enable a rapid and cost-effective development cycle, good tools and interface definitions will be needed including All Source Positioning and Navigation (ASPN) and the PNT Operating System (pntOS) that both have been developed to support the growing interest in the Modular Open Systems Approach (MOSA) for PNT. Such new concepts will reflect the elementary system, but will use an extensive networking of the various operational elements to achieve an improved system-level optimum.

4. Outstanding Paper Awards

During the conference, the audience was invited to express their opinions and appreciation regarding the presentations they attended. This public vote resulted in nine ENC 2023 Outstanding Paper Awards, which were handed out by the technical committee at the end of the final day of the conference.

In addition, on that same occasion, Ms. Valérie Renaudin, Editor-in-Chief of the *IEEE Journal of Indoor and Seamless Positioning and Navigation* (J-ISPIN) handed out the Best Early Stage Research Award, for a preliminary analysis of early datasets in 5G positioning.

5. Acknowledgements

ENC 2023 would like to take this opportunity to express our sincere gratitude to all involved in making the conference a success, including the Netherlands Institute of Navigation, the Local Organizing Committee, the Scientific–Technical Program Committee, the International Advisory Committee, the technical directors, session chairs and co-chairs, the paper reviewers, and the editorial team, who all and without exception voluntarily spent considerable time and effort over a period of more than one year.

In particular, we would like to thank our conference partners (Figure 1):

Figure 1. ENC 2023 conference partners.

- ESA;
- EUSPA;
- Ministry of Infrastructure and Water Management;
- Samenwerkende Maritieme Fondsen of the Netherlands.

We extend our special thanks to our gold sponsors (Figure 2):

- GMV;
- Netherlands Aerospace Centre;
- Spaceopal;
- S[&]T.

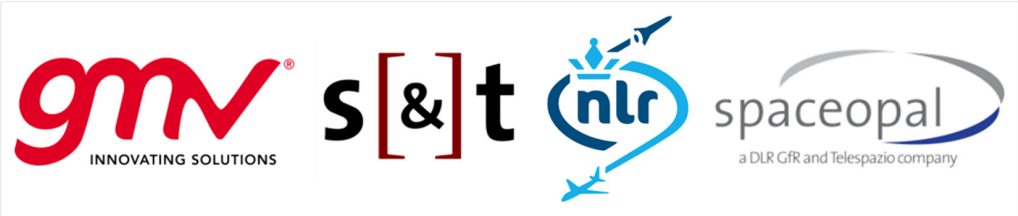

Figure 2. ENC 2023 gold sponsors.

In addition, we sincerely thank our silver sponsors (Figure 3):

Figure 3. ENC 2023 silver sponsors.

- Safran;
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We would also like to thank our media partners:

- Inside GNSS;
- European Journal of Navigation;
- IEEE Journal of Indoor and Seamless Positioning and Navigation (J-ISPIN);
- Delft Career Platform.

Finally, we sincerely thank all the authors who contributed to the publication of this volume. Thanks to their efforts, we believe that the scope and depth of these papers offers a great wealth of information, and we hope that you will enjoy reading this collection of peer-reviewed papers.

Conflicts of Interest: The authors declare no conflicts of interest.

References

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2. Galileo Second Generation Enters Full Development Phase. Available online: https://www.esa.int/Applications/Navigation/Galileo_Second_Generation_enters_full_development_phase (accessed on 1 July 2023).

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