RESEARCH AND TRAINING UNIT FOR NAVIGATIONAL ELECTRONICS
OSMANIA UNIVERSITY - HYDERABAD

One-Day Symposium on
CHALLENGES AND OPPORTUNITIES IN DESIGN AND DEVELOPMENT OF GNSS RECEIVERS AND THEIR APPLICATIONS IN BHARAT

Course Code: NERTU/SC/85
GNSS-23-1
16, FEBRUARY 2023

GNSS has become a ubiquitous technology, including the sectors related to surveying, defence, unmanned vehicles, agriculture, timing & synchronization, power engineering, communication networks, IoT applications, asset and vehicle tracking, aviation, road, rail, sea transport, etc. GNSS chips are also used to know the location and time of events, sensors, and devices. Similarly, many efforts are going to develop integrated navigation for more robust and accurate autonomous navigation with GNSS and other navigation sensors.

The GNSS market is expected to grow at a CAGR of 9.02%, from $175.19 billion in 2021 to $320.73 billion in 2028. The business can be divided into developing GNSS chipsets and integrating GNSS chipsets with different applications. It is high time in India to build GNSS chipsets and applications with GNSS chipsets, including NavIC/IRNSS. People are also exploring developing integrated autonomous navigation even when the GNSS is unavailable or denied, or intentional or unintentional jamming and interference occur. However, developing GNSS receivers or autonomous navigation requires expertise and infrastructure facilities from multiple fields and collaboration between experts, institutions, and industries.

The main aim of the symposium is to explore the possibility of collaboration between researchers, groups, and institutions working in the GNSS area for developing GNSS Receivers and their applications. In this symposium, leading scientists/academicians/engineers working in this field will present their work briefly and their future planning. Each presentation follows a 5-10 minute discussion. The expected participants of this symposium are academicians, scientists, engineers, research scholars, UG/PG students, and managers at all levels interested in pursuing research or technology development or collaborating in the areas of GNSS and autonomous vehicles.

Speakers, Topics, and Schedule

1. **09.00-10.30 Prof.Hari Hablani, IIT, Indore:** High-Accuracy GNSS- and NavIC-Aided Inertial Navigation of Flight Vehicles with RAIM and Segmented Dynamics.
2. **11.00-11.45 Prof.P.Laxminarayana, NERTU/OU:** GNSS/NavIC Software Receivers for Integrated Navigation, Research, Development of New GNSS signals and applications.
3. **11.45-12.30 Mr. Vinoj V Syamala, IISU/ISRO:** Acquisition and Tracking of GPS/NavIC satellites: A High dynamic case study.
4. **12.30-13.15 Dr.Anindya Bose, Burdwan University:** Experience with Compact, Low-Cost GNSS Modules for Research and Application Development
5. **14.00-14.45 Dr.Joshi Catherine, NGRI/CSIR:** Tectonic Geodesy in scaling the tectonic processes from the Earth to the Atmosphere
6. **14.45-15.30 Dr.Ashish Shukla, SAC/ISRO:** GNSS and NavIC Applications using Low-Cost Receivers
7. **16.00-16.45 Prof. Raj Kumar Pant, IIT, Bombay:** Precision Navigation System using Pseudolites Mounted on Airships
8. **16.45-17.30 Dr. Rajesh Tiwari, Nottingham University, UK:** Multi-Sensor Fusion and Integration Approach for Safe and Secure Navigation for Fully Autonomous Vehicles

ABOUT NERTU: The Research and Training Unit for Navigational Electronics (NERTU) was established in 1982. It is the focal point for research and training in Electronic Navigation in India. Since its inception, NERTU has successfully **executed/executing 67 sponsored consultancy projects and 84 short-term courses, conferences, and workshops in** signal processing, communications, and navigation. All the participants of the courses or funded projects are from various organizations like DRDO labs, ISRO labs, DST, MIT, ECIL, HAL, BEL, AICTE, ASL, and other R &D and academic institutions. It is the first University center to work in the area of Global Positioning System (GPS) and GPS Aided Geo Augmented Navigation (GAGAN) Systems. Recently, the NERTU team has developed a GNSS software receiver, running in real-time on a regular PC with an i7 processor. Similarly, developed the integration of NavIC with Low-cost MEMS IMU, a Speech-To-Speech Interface for Man-Machine Communication, and interested in collaborating with industries and other Research Organizations. NERTU is developing advanced algorithms/systems in the above areas in collaboration with CRL/BEL and IISU/ISRO.

Venue : NERTU Auditorium, OU
(Can Join In-Person or Online)
Time : 09.00AM – 06.00PM
Last Date for Registration: 14th February 2023

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Interested Participants can fill the registration form at
https://forms.gle/9DC6sEJ4AsZMWns99

REGISTRATION FEE (Indian Rupees)

Category	Fee including 18%GST Offline or Online
Students (Full Time)	Rs. 500/-
Faculty	Rs. 1000/-
Scientiss & Engineers from R&D, Industry	Rs. 5000/-

DD/Cheque should be drawn in favor of "The Director, Eqpt. Maint., NERTU, OU" Or online payment through NEFT to
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Talk 1

High-Accuracy GNSS- and NavIC-Aided Inertial Navigation of Flight Vehicles with RAIM and Segmented Dynamics

Speaker: Prof.Hari Hablani, IIT, Indore

Abstract: In this presentation, we will summarize a unique high-accuracy GNSS or NavIC-aided inertial navigation technique in which satellite-differenced and time-differenced carrier phase observables are used to estimate velocity, and pseudorange observables, differenced likewise, are used to estimate position – the so-called segmented dynamics approach [1]. Though time-differencing eliminates integer ambiguities in carrier phases, it renders velocity estimation susceptible to cycle slips or any other flaws in the signals. Furthermore, satellite-differencing correlates the noise in the differenced carrier phases, resulting in a nondiagonal measurement noise covariance matrix. The inverse of its square root is used to normalize the measurement sensitivity matrix. The QR transformation of this normalized matrix allows detection of the bias in any of the differenced carrier phase observables and its comparison with the maximum permissible bias in terms of *erfcinv* of the specified false alarm and missed detection probabilities. In addition, the measurement sensitivity matrix involves integral of the flight vehicle velocity over the GNSS measurement interval. To decouple the vehicle position from velocity, this integral is determined using the transition matrix history of the inertial navigation state vector comprising vehicle velocity, platform tilt, and accelerometer and gyro biases. The position vector is estimated using the high-accuracy velocity estimate and pseudorange observables. Flight test performance as well as performance in a simulation [2] of the above technique will be presented.

Biodata: Dr. Hablani is an INAE Professor and Technologist at Department of Astronomy, Astrophysics and Space Engineering, IIT Indore. During 2008-2018, he was a Visiting Faculty at IIT Kanpur, IIT Bombay, IIT Gandhinagar and IIT Indore. In these positions, he taught courses on spacecraft attitude dynamics, estimation, and feedback control; aided inertial navigation; Kalman filtering; and space flight mechanics. He conducted research with Ph.D., M. Tech. and B. Tech. students in satellite-based navigation of satellites, missiles and aircraft using NavIC (Navigation with Indian Constellation); spacecraft and payload attitude determination, attitude manoeuvres and precision pointing control; missile guidance with onboard radar and infrared sensors; and underwater vehicles navigation. Dr. Hablani was at the Boeing Company for twenty-six years, a Technical Fellow in his last position. There, he was responsible for design and analysis of precision pointing and control of surveillance and tracking and remote sensing spacecraft and payloads including rendezvous navigation, guidance, attitude determination and control; interplanetary spacecraft control; navigation and guidance of exo-atmospheric interceptors. He has numerous publications and awards, including The Aeronautical Society of India - Excellence in Aerospace Education award. He is an AIAA Associate Fellow. He was an Associate Editor (AE) of the AIAA Journal of Guidance, Control and Dynamics, and IEEE Transactions on Aerospace and Electronic Systems. He was an Engineer of the Year at Rockwell International. He is a Fellow of the Indian National Academy of Engineering. He earned his Ph.D. (with Gold Medal) at the Department of Aerospace Engineering, Indian Institute of Science, Bangalore, India, of which he is a Distinguished Alumnus.

Talk 2

GNSS/NavIC Software Receivers for Integrated Navigation, Research, Development of New GNSS signals and applications

Speaker: Prof.P.Laxminarayana, NERTU/OU

Abstract: At Research and Training Unit for Navigational Electronics (NERTU), Osmania University, a real-time NavIC software receiver is developed. Initially, a post-processing-based NavIC software receiver is developed using the IF data recorded at different places/institutions. It was tested with simulated data also. Further, the framework is changed to run the receiver in real time on a desktop PC. The present real-time software receiver is available in MATLAB and c/C++ and can also run on MATLAB or UBUNTU. Similarly, post-processing-based integrated navigation using the NavIC receiver and low-cost MEMS based IMU is developed in loosely and tightly coupled modes. In the loosely coupled mode, the Position and velocity of GPS, NavIC, and IMUs are synchronized for time using GPS/NavIC/IMU time stamping in the measurements. This presentation will present the performance of developed NavIC software receiver, its enhancements and integrated navigation. The plan of NERTU to develop Robust and Autonomous navigation for different applications and the possible collaboration with other institutes/organizations/industries will be presented.

Biodata: Dr.P.Laxminarayana has completed M.E. and Ph.D. at Osmania University Hyderabad. He has been working for Osmania University since 1994 and at present he is the professor and director of Research and Training Unit for Navigational Electronics (NERTU). He has also established and led the Multimedia and DSP group for Hyderabad Design Center of Analog Devices Inc., during 2003-2005. His is working in the areas of Speech and Audio Technologies, GNSS and Navigation Technologies. He is also passionate about start-ups and collaboration with other academic institutions, industries and R & D Labs.

Talk 3

Acquisition and Tracking of GPS/NavIC satellites: A High dynamic case study

Speaker: **Mr. Vinoj V Syamala, IISU/ISRO**

Abstract: Acquisition and tracking are the first set of activities to be done in a GNSS receiver. These activities are most critical in a receiver performance. The sensitivity of the receiver is determined mainly by the robustness of acquisition and tracking algorithm. The performance of the receiver under vehicle dynamics is depended on the algorithm reside in the tracking module. When a terrestrial receiver is considered, serial correlator based lower dynamic tracking module is sufficient. But when the receiver is moving in a rocket/ high velocity areal vehicle, the velocity can be as high as 10km/s and acceleration of 50m/s2. Also, very heavy vibration and shock are expected. The acquisition and tracking module should ensure the continuous availability of the GNSS measurement under all these circumstances. The general design steps of tracking algorithm for high dynamic receiver along with specific algorithms for maintaining the tracking under jerk is discussed in this talk.

Biodata: Shri Vinoj V Syamala received his B-Tech degree in Electronics and Communication Engineering from University of Kerala in 2005. After a short tenure in Accenture Inc, Bangalore, he joined ISRO as a Scientist/ Engineer in 2006. He worked in the area of instrumentation systems for liquid rocket engines for three years. He hnd then moved to Inertial navigation systems, navigation algorithm and flight software area. He has more than 14 years of experience in Inertial Navigation systems and GNSS receiver hardware, RF systems, Receiver algorithm, GNSS software design and development. Presently he is working as deputy division head of Checkout Systems and Satellite Navigation Division, ISRO Inertial Systems Unit, ISRO, India. He is currently pursuing M. Tech degree in Applied Electronics from Kerala Technological University, India. He has received ISRO team excellence award for new generation navigation system development and also ISRO Young Scientist Award during his career.

Talk 4

Experience with Compact, Low-Cost GNSS Modules for Research and Application Development

Speaker: Dr.Anindya Bose, Burdwan University

Abstract: Currently operating multiple Global and Regional navigation systems, Global Navigation Satellite System (GNSS) is used for myriads of applications. A global market for GNSS-economy and Location-based Commerce has evolved. User requirements for higher position solution quality at affordable cost have supported the development of various GNSS positioning techniques and different types of hardware. Compact (<100 gm), Low-Cost (<300 USD), Single frequency (CLS), and dual-frequency (CLD) GNSS modules are the latest introduction in the GNSS hardware series, which have excellent potential for GNSS Positioning, Navigation, Timing (PNT), non-PNT science applications and real-life solution development. The short presentation will first showcase the CLS and CLD modules from various manufacturers, followed by the results of the studies on the applicability of the modules for positioning applications. Further, experience in atmospheric probing using such modules would be presented together with the scopes for cost-efficient, real-life application development

Biodata: Dr Anindya BOSE is working as Senior Scientific Officer in The University of Burdwan, India with teaching and R&D responsibilities. He is alumnus of CSIR-National Physical Laboratory, New Delhi and ISU, Strasbourg, France, recipient of URSI Young Scientist Award; Fellow, IETE, India, Member, IEEE, ISRS, ASI and IGNSS. His research interests include Global Navigation Satellite System (GNSS), Microwaves Antenna and RF Communications.

Talk 5

Tectonic Geodesy in scaling the tectonic processes from the Earth to the Atmosphere

Speaker: Dr.Joshi Catherine, NGRI/CSIR

Abstract: The capability of GNSS over the last 35 years has improved much beyond its design to estimate 3D positions with millimetre-level precision with respect to a global reference frame and has contributed to considerable advances in geophysics, seismology, atmospheric sciences, hydrology and natural hazard science. Information on weather and climate can be extracted from the delay of GPS signals during their transmission from satellite to receiver through ionosphere and troposphere. Reflected GPS signals are valuable for environmental applications. To understand the crustal deformation and earthquake occurrence processes both in the intra and inter plate regions of India, CSIR-NGRI has established 100+ GNSS stations all over India in Andaman-Nicobar Islands of Andaman-Sumatra subduction zone, parts of the Himalayan arc, Indo-Burmese Arc (IBA) and in the Indian shield. These GPS measurements provide estimate of strain accumulation and deformation processes thereof.

Biodata: Dr. Catherine JK did M.Sc(Tech) in Geophysics from Andhra University and Ph.D. from Osmania University. Dr.Catherine is presently Principal scientist at CSIR-National Geophysical Research Institute, Hyderabad. Postdoctoral studies were carried out at University of Califoria, Berkeley. Dr.Catherine's research areas include GPS data processing, analysis, interpretation and modeling to understand crustal deformation and mechanism of earthquake occurrence processes and seismoionospheric studies. The research work has been published in 45 research papers.

Talk 6

GNSS and NavIC Applications using Low-Cost Receivers

Speaker: **Dr.Ashish Shukla, SAC/ISRO**

Abstract: India has developed its own navigation system NavIC which is transmitting L5 and S band signals from GEO and GSO orbits. Various applications are being developed using these signals in India. However, to make NavIC more popular, one of the most feasible way is to develop Low-cost NavIC/GNSS receivers. Once these low-cost receivers are available with Pseudorange and carrier range observables, various NavIC/GNSS applications such as Differential GNSS, Precise Point Positioning, Precision Agriculture, Location Based Services (LBS) can be developed.

Biodata: Dr Ashish Kumar Shukla is working as a scientist in Space Applications Centre (SAC), ISRO, Ahmedabad, since May 2005. He received his Ph. D. Degree in Mathematics from Lucknow University, Lucknow in year 2003. He is working in the field of Satellite navigation for more than 17 years and has contributed significantly in Satellite navigation programs of ISRO. He had privilege to work in India's two most significant navigation programs: GAGAN and IRNSS since their inception. Currently, he is working in IRNSS User Receiver Development project and is a member of the team which has developed NavIC user receiver and NavIC Payload Test Receiver. Dr Shukla is also Deputy Project Director (DPD) of Reusable Launch Vehicle (RLV) project of ISRO for Pseudolite System and he is leading the team which has developed Pseudolite Based navigation System for precise landing of aerial vehicles such as RLV. His research interests include development of navigation algorithms and applications for NavIC, GAGAN, Pseudolite and LEO GNSS. He has more than 55 publications in peer reviewed journals and conferences. Dr Shukla is recipient of Team Excellence Award of ISRO and National Geomatics Award-Technology.

Talk 7

Precision Navigation System using Pseudolites Mounted on Airships

Speaker: Prof. Raj Kumar Pant, IIT, Bombay

Abstract: This talk presents the results of modeling and simulation of a system based on pseudolites (PLs) mounted on stratospheric airship platforms (SPFs), to provide precision navigation to a moving object within a specific coverage area. The specific aim of this study is to determine the effect of movements of the SPFs, and the PL monitoring time on the accuracy of positioning of a moving object. The system has been simulated in MATLAB, and consists of a control station, six ground stations, and four PLs mounted on SPFs. The positions of the PLs on the SPFs are intermittently monitored by the ground stations, and transmitted to the control station, which calculates the exact position of the PL antenna. Using this information, the user receiver calculates its own position, which is frequently updated to provide navigation. It is seen that due to a bi-level calculation in determination of user position, the errors in determination of pseudolite position magnify the error in user positions. Further, the reduction in monitoring time is seen to substantially reduce the errors in user position determination, but may require more advanced hardware.

Biodata: Prof. Rajkumar S. Pant has Bachelors, Masters and Ph.D. degrees in Aerospace Engineering. His areas of specialization include Aircraft Conceptual Design, Air Transportation, and Optimization. He has been a member of faculty of Aerospace Engineering Department at the Indian Institute of Technology Bombay since December 1989.

Prof. Pant is an alumnus of College of Aeronautics, Cranfield University, UK, where he earned his Ph.D. under Commonwealth Scholarship Scheme, and IIT Madras, where he did his Masters in Aeronautical Engineering. He has also worked for five years in Hindustan Aeronautics Limited in the Design & Engineering Department at Kanpur (3.5 years) and Nasik (1.5 years) Divisions. In 2002, he set up a Lighter-Than-Air (LTA) systems laboratory at IIT Bombay, which has undertaken several R&D and Consultancy projects related to design, development and demonstration of LTA systems. He has been an international member of AIAA's Lighter-Than-Air Technical Committee for over a decade starting 2007, and was the Chairperson for 2014-16. He has published and presented > 270 scientific papers, of which > 190 are in international journals and conferences. He has also visited several top-ranking institutes and universities all over the world. Prof. Pant was a visiting faculty at Department of Mechanical and Aerospace Engineering at Nanyang Technological University in 2016, and Department of Aerospace & Ocean Engineering at Virginia Polytechnic Institute and State University in 2010-11. He was a visiting researcher at Instituto Tecnológico de Aeronáutica, Brazil in 2012, Texas A&M University in 2011, Cambridge University in 2008, and Imperial College London in 2006. In 2102, he was appointed as a Special Visiting Researcher under the Science Without Borders program of the Brazilian Government for a three-year project related to design and development of Hybrid Lighter-Than-Air systems. Prof. Pant was honoured with the D P Joshi Excellent Teacher Award in 2014, Hotchand and Jamunabai Lala Teaching Award in 2021, and Departmental Award for Excellence in Teaching in 2022. In 2019, he was felicitated by Institution of Engineers (India) as an Eminent Engineering personality in Aerospace Engineering. Recently, he received Special Recognition in Academic Excellence (Faculty-National category) award by Institution of Engineers (India), as part of 4th Biennial International Conference on Nascent Technologies in Engineering held in January 2021.

Talk 8

Multi-Sensor Fusion and Integration Approach for Safe and Secure Navigation for Fully Autonomous Vehicles

Speaker: Dr. Rajesh Tiwari, Nottingham University, UK

Abstract: The level of automation for a vehicle has been clearly defined by six levels, outlined by the Society of Automotive Engineers (SAE) in the J3016 standard for vehicular automation within a dynamic environment. The maximum level of vehicular automation, when navigating a real-traffic environment, can only be achieved through the complete reliance of onboard sensors. A single and/or only augmentation system cannot be considered to meet the safety and integrity requirements of road users when navigating in a level 5 autonomous environment. The review of research conducted in last few years is presented in this paper. The purpose of this research is to propose a multi-sensor approach for integrity monitoring within a level 5 autonomous environment. The system will fuse data from dual GNSS (Global Navigation Satellite Systems) RF receiver (for heading) and an Inertial Measurement Unit (IMU) with a 6-degree freedom and LiDAR for reliable precision in GNSS signal denied environment and object detection for collision avoidance. This approach is tested within a controlled test track environment and public roads to validate the reliability of this multi-sensor approach.

Biodata: Rajesh Tiwari, PhD, is Honorary Fellow of the University of Nottingham, Nottingham UK. He is a Fellow of Higher Education Academy. He was involved in Antarctic Scientific Expedition to investigate the space weather phenomena and its effect on GNSS signals in the Antarctic region. He worked as a Graduate Research Assistant in University of Calgary, Canada. Research Associate and Teaching Fellow at Newcastle University, UK. He received prestigious international young scientist award, URSI, the Best paper presentation award ION, USA and many best lecturer awards in Newcastle University. He His research interest: GNSS signal processing, GNSS software defined receiver, sensor fusion for the autonomous vehicle. Currently actively involved in designing integrity solutions for the Autonomous vehicles. He is involved in various European Space Agency project, and regular panel member of the UK Space Agency. Dr Tiwari published more than 25 and product licence in GNSS receiver.