

2020 European Navigation Conference (ENC 2020)

**Dresden, Germany
23-24 November 2020**

Pages 1-532



**IEEE Catalog Number: CFP20B81-POD
ISBN: 978-1-7281-4430-6**

**Copyright © 2020, The German Institute of Navigation (DGON)
All Rights Reserved**

****** This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number:	CFP20B81-POD
ISBN (Print-On-Demand):	978-1-7281-4430-6
ISBN (Online):	978-3-944976-27-3

Additional Copies of This Publication Are Available From:

Curran Associates, Inc
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: (845) 758-0400
Fax: (845) 758-2633
E-mail: curran@proceedings.com
Web: www.proceedings.com

CURRAN ASSOCIATES INC.
proceedings
.com

ENC 2020 Table of Content

Novel Concepts on GNSS Signal Design serving Emerging GNSS User Categories: Quasi-Pilot Signal...1

Stefan Wallner, Jose Antonio Garcia Molina, Gustavo Lopez Risueno, Jörg Hahn, Jean Jacques Floch, Francis Soualle, Till Schmitt, Giacomo da Broi, Mahamoudou Ouedraogo, Thomas Wörz, Gerarda de Pasquale, Cesar Vazquez and Matteo Paonni

Precise Point Positioning for next-generation GNSS...23

Patrick Henkel

Robust Satellite Navigation in the Android Operating System using the Android Raw GNSS Measurements Engine and Location Providers...34

Damian Miralles, Dong-Kyeong Lee, Andriy Konovaltsev, Lothar Kurz, Sherman Lo and Dennis Akos

Efficient tracking of joint Galileo OS data and pilot components...46

Johannes Rossouw van der Merwe, Fabio Garzia, Alexander Rügamer, Muhammad Saad, Matthias Overbeck and Wolfgang Felber

Impact of Robust Interference Mitigation on GNSS Timing...56

Daniele Borio and Ciro Gioia

Radar Inertial Odometry with Online Calibration...69

Christopher Doer and Gert F. Trommer

Multipath Location Methodology for Ground Based Augmentation Systems...79

Osman Kalden, Petra Pisova, Nicolas Douchin, Bertrand Carreras and Ajay Vemuru

Framework to Classify Railway Track Areas According to Local GNSS Threats...89

Daniel Gerbeth, Omar García Crespillo, Fabio Pognante, Alessia Vennarini and Andrea Coluccia

Using the Ferromagnetic Fingerprint of Rails for Velocity Estimation and absolute Localization of Railway Vehicles...100

Bernd Kröper, Martin Lauer and Max Spindler

European GNSS Service Centre (GSC): Current Status and Future Evolutions to Deliver Added Value Services...110

Pedro Gómez, Emilio González, Ana Senado, Ignacio Fernández-Hernández, Jesús David Calle and Aitor Álvarez

Promising directions of orbital group GLONASS development using CDMA - new signal's type...120

Iurii Vygonskii, Iurii Voloshko and Nikolay Leonidov

Japanese GNSS Future System Evolution in the 2020-2030 Perspective...130

Takeyasu Sakai

Universal ranging code generator of GNSS signals...140

Olga K. Mikhaylova, Ilya V. Korogodin and Ivan V. Lipa

Ziv-Zakai Bound and Multicorrelator Compression for a Galileo E1 Meta-Signal...150

Carolin Schwalm, Christoph Enneking and Steffen Thöler

The CHIMERA solution: performance assessment...159

Mario Nicola, Micaela Troglia Gamba and Beatrice Motella

GNSS Signal Quality Monitoring Based on a Reference Station Network...169

Sergey Nikolskiy, Anton Bredenbeck, Topi Rikkinen, José Vallet, Michelle Koivisto, Salomon Honkala, Zahidul Bhuiyan and Sarang Thombre

Considerations for message design of new satellite navigation signal...179

Jae Hee Noh, Deok Won Lim, Gwang Hee Jo and Sang Jeong Lee

A study on new secondary codes for GNSS...186

Gwang Hee Jo, JaeHee Noh, JinHyuk Lee, Deok Won Lim and SangJeong Lee

Precise Orbit Determination of the Kepler Navigation System - a Simulation Study...192

Grzegorz Michalak, Karl Hans Neumayer and Rolf König

Evaluation of optical ranging and frequency transfer for the Kepler system : preliminary laboratory tests...202

Ramon Mata Calvo, Janis Surof, Juraj Poliak and Raphael Wolf

Optical Clock Technologies Enabling Advanced GNSS...211

Thilo Schuldt, Martin Gohlke, Markus Oswald, Josep Sanjuan, Timm Wegehaupt, Tim Blomberg, Jan Wüst, Ludwig Blümel, Vivek Gualani, Klaus Abich and Claus Braxmaier

Augmenting the Time and Frequency Transfer Capabilities of Galileo...217

Pacome Delva, Clément Courde, Etienne Samain and Uros Kostic

Interference Mitigation and Miniaturized Antenna Array Spatial Pattern Compensation with STAP...225

E. Pérez-Marcos, S. Caizzzone, M. Cuntz, A. Konovaltsev and M. Meurer

A Frequency Agile Dual-Band GNSS Receiver Front End with Anti-Jamming Capabilities...235

Faisal Ilyas, Safwat Irteza, Noshawan Shoaib and Hammad M. Cheema

A Multi-Site Quad-Band Radio Frequency Interference Monitoring Alerting and Reporting System...241

Aiden Morrison, Nadezda Sokolova, Jan Erik Håkegård, Torleiv Håland Bryne and Laura Ruotsalainen

Detection of GNSS Spoofing using NMEA Messages...251

Dong-Kyeong Lee, Damian Miralles, Dennis Akos, Andriy Konovaltsev, Lothar Kurz, Sherman Lo and Filip Nedelkov

Impact of non-idealities on GNSS meta-signals processing...261

Andrea Nardin, Fabio Dovis and Beatrice Motella

Doppler as a Quality Indicator for GNSS-based Urban Navigation - an Evaluation with Different Receivers and Clocks...269

Lucy Icking, Fabian Ruwisch and Steffen Schön

Simulation-based Analysis of Multipath Delay Distributions in Urban Canyons...280

Simon Ollander, Friedrich-Wilhelm Bode and Marcus Baum

Multipath and NLOS detection based on the combination of CNO values and a fish-eye camera...290

Juliette Marais, Syed Ali Kazim, Yann Cocheril and Cyril Meurie

A Linear Regression Model of the Phase Double Differences to Improve the D3 Spoofing Detection Algorithm...303

Gianluca Falco, Mario Nicola, Emanuela Falletti, Hien Van Nguyen and The Vinh La

Adaptive notch filtering against complex interference scenarios...317

Johannes Rossouw van der Merwe, Fabio Garzia, Alexander Rügamer, Iñigo Cortes Vidal and Wolfgang Felber

First Results of GLONASS-Only CDMA+FDMA Integer Ambiguity Resolution...327

Peter Teunissen, Safoora Zaminpardaz and Amir Khodabandeh

Performance Evaluation Of Geodetic Real Time Kinematic Units Under Various Signal Reception Conditions...337

Rebekka Handirk, Andreas Piter, André Jensen, Vanessa Koppmann, Julia Mainz, Christopher Nagel, Yannick Breva, Lucy Icking, Johannes Kröger and Steffen Schön

Improving reliability and efficiency of RTK ambiguity resolution using multiple rover receivers connected to the same antenna...347

Xiao Hu, Paul Thevenon and Christophe Mababiau

Environmentally Dependent Adaptive Parameterization of a GNSS-aided Tightly-Coupled Navigation Filter...357

Jan-Jöran Gehrt, Wenyi Liu, David Stenger, Shuchen Liu and Dirk Abel

Towards a new GNSS observation weighting strategy for terrestrial applications...367

Nourdine Ait Tmazirte, Syed Ali Kazim and Juliette Marais

A Promising Distributed Position and Orientation System with Flexible Baseline for Array SAR Applications...377

Yanhong Liu, Xiaolin Ning, Jianli Li, Chunyu Qu and Wen Ye

Adaptive Localization Configuration for Autonomous Scouting Robot in a Harsh Environment...386

David Obregón, Raúl Arnaú, María Campo-Cossio, Michael Pattinson, Smita Tiwari, Alejandro Nicolás, Ander Ansuategui, Carlos Tubío and Joaquín Reyes

Comparison Between Adaptive Extended Kalman Filters for Accurate Fine Alignment Process...394

Itzik Klein, Ilan Rusnak and Yaakov Bar-Shalom

Development of an error-state Kalman Filter for Emergency Maneuvering of Trucks...404

Martin Wachsmuth, Axel Koppert, Li Zhang and Volker Schwieger

On-Board GPS Augmentation through RADAR Altimeter Aiding for Precision Approach and Landing of UAS...411

Andrew Videmsek and Maarten Uijt de Haag

SINS/GNSS Aided by Autonomous AHRS for a Small UAV...423

Veronika Kulakova, Aleksandr Markov and Artem Sokharev

Comparison and Evaluation of Clock-aided and Classical Multi-GNSS Flight Navigation...433

Ankit Jain and Steffen Schön

Effects Of Equatorial Ionospheric Scintillation For GNSS Based Positioning In Aviation...443

Jens Berdermann, Hiroatsu Sato, Martin Kriegel, Takeshi Fujiwara and Toshiaki Tsujii

Changing from Magnetic to True Tracks in Aviation...451

Bart Banning, Anthony MacKay and Paul Hickley

Message Design for a Robust Time Signal using Distance Measuring Equipment (DME) Pulse Pair Position Modulated (PPPM) Pseudo lite...459

Sherman Lo and Yu-Hsuan Chen

Mode N - A new Navigation System & A-PNT Concept for Aviation...469

Steffen Marquard and Franz Madritsch

Equivalent Circuit for Phase delay in a Medium Frequency Antenna...478

Lars Grundhöfer and Stefan Gewies

Cooperative Environment Recognition Utilizing UWB Waveforms and CNNs...484

Maija Mäkelä, Jesperi Rantanen, Julian Ilinca, Martti Kirkko-Jaakkola, Sanna Kaasalainen and Laura Ruotsalainen

Ranging Based Wireless Positioning with Accurate Estimation of Bias Errors...492

Mohamed Khalaf-Allah and Oliver Michler

Impact of Unknown Digital Map Errors on Satellite-based Navigation in Railway...500

Anja Grosch and Omar García Crespillo

Need and Approaches for Norm-Compliant Qualification for Satellite Based Train Localization - Evaluation - Assessment- Certification - Approval...512

Eckehard Schnieder

Highly Accurate Video-Based Train Localization - replacing Balises with Natural Reference Points...523

Darius Burschka and Christian Robl

Measurement Methods for Train Localization with Onboard Sensors...533

Oliver Heirich, Benjamin Siebler, Stephan Sand, Andreas Lehner and Omar García Crespillo

Positioning Approach for Train-Infrastructure Interaction Assets Health Status Monitoring...543

Ramin Moradi, Michael Hutchinson, Yuheng Zheng and Michael Roth

Geo-Distributed Simulation and Verification Infrastructure for safe train Galileo-based positioning...552

Cosimo Stallo, Alessandro Neri, Pietro Salvatori, Francesco Rispoli, Olivier Desenfans, Juliette Marais, Antonio Águila, Beatriz Sierra, Ricardo Campo, Daniel Molina, Susana Herranz, Xavier Leblan and Giuseppe Rotondo

Towards an Integrity-Based GNSS Measurement Quality Model for an In-Depth Understanding of Localization Dependability...562

Arne Geffert, Andreas Dodinoui, Tianxiang Lan and Uwe Becker

Realistic position error models for GNSS simulation in railway environments...572

Syed Ali Kazim, Nouridine Ait Tmazirte and Juliette Marais

Detection of GNSS Multipath with Time-Differenced Code-Minus-Carrier for Land-based Applications...581

Maria Caamano, Omar García Crespillo, Daniel Gerbeth and Anja Grosch

Future GNSS Infrastructure for Improved Geodetic Reference Frames...593

Susanne Glaser, Grzegorz Michalak, Rolf König, Benjamin Maennel and Harald Schuh

Rapid Initialization for Long Baseline RTK Positioning: Combined GPS+Galileo+BDS+QZSS+GLONASS with Partial Ambiguity Resolution...603

Andreas Brack

High-Performance Pulsed Laser-Pumped Rb Clock for GNSS...612

Etienne Batori, Nil Almat, Christoph Affolderbach, Florian Gruet and Gaetano Mileti

Enhanced Robustness and Spoofing Resistance by Galileo PRS Processing...622

Alexander Rügamer, Fabio Garzia, Daniel Meister, Johannes Rossouw van der Merwe, Simon Taschke, Xabier Zubizarreta, Florian Kunzi, Ricardo Monroy Gonzalez Plata, Santiago Urquijo, Christoph Miksovsky, Wolfgang Felber and Jan Wendel

Tropospheric delays derived from ground meteorological parameters: comparison between machine learning and empirical model approaches...630

Luca Miotti, Endrit Shehaj, Stefano D'Aronco, Jan Dirk Wegner, Gregor Moeller, Alain Geiger and Markus Rothacher

Fast Ionospheric Correction Algorithm for Galileo Single Frequency Users...640

Mainul Hoque and Norbert Jakowski and J A Cahuasquí

EGNOS System Evolutions in Europe and within the International Multi-SBAS context...650

Didier Flament, Carlos Lopez, David Thomas, Xavier Derambure, Katarzyna Urbanska, Jean-Manuel Melinotte and Arnaud Boisseau

Global ARAIM for Dual Constellation - Design, Development and Experimentation...663

David Hagan, Joseph Griggs, Urielle Houssou, Alessandra Calabrese, Fernando Bravo Llano, Guillermo Fernandez Serrano, Emad Adridar, Josep Montolio, Alex Ramonjoan and Mercedes Reche

Opportunistic Positioning Using Unsynchronized References...673

Matija Rezar, Erik Strumbelj, Giacomo Pojani and Chris Marshall

GNSS Positioning and Navigation - A Foundational Element of Digital Farming...683

Hieu Tran, Wei Cao, Marcus Reutemann, Liwen Dai, Ralph Ostermeier and Georg Kormann

Integrity Concept for Sensor Fusion Algorithms used in a Prototype Vehicle for Automated Driving...691

Grischa Gottschalg, Matthias Becker and Stefan Leinen

GNSS Probabilistic Single Differencing For Non-Parametric State Estimation Based On Spatial Map Data...701

Paul Schwarzbach and Oliver Michler

Online Estimation of Near-Surface Water Current Fields Using Horizontally Mounted ADCPs on Inland Vessels...711

Martin Kosch, René Zweigel and Dirk Abel

Robotic service concepts for the port of tomorrow: Developed via a small-scale demonstration testbed...721

Vincent E. Schneider, Cosmin Delea, Johannes Oeffner, Benjamin Sarpong, Hans-Christoph Burmeister and Carlos Jahn

A prototype for a Multi-GNSS orbit combination...729

Pierre Sakic, Gustavo Mansur and Benjamin Männel

A System Study about a Lunar Navigation Satellite Transmitter System...740

Miriam Schönfeldt, Antoine Grenier, Anaïs Delépaut, Daniel Blonski, Jörg Hahn, Pietro Giordano, Javier Ventura-Traveset and Richard Swinden

Spaceborne GNSS-Receiver Heritage Leveraged on New Space...750

Markus Schütz, Stefan Zehetmayer, Kai Zajac, Johannes von Borany, Martin Laabs, Franz Zangerl, Roman Zangl, Dirk Plettemeier and Manfred Sust

A Spaceborne GPS Receiver for Electric Propulsion Driven Geosynchronous Satellites...760

Yu Nakajima, Toru Yamamoto, Ryo Harada, Satoko Kawakami and Susumu Kumagai

Error analysis of typical starlight refraction model...770

Zhang Shaoxiong and Wang Kedong

Towards centimeter accurate positioning with smartphones...779

Anja Heßelbarth and Lambert Wanninger

Evaluation of Network Real Time Kinematics contribution to the accuracy/productivity ratio for UAS-SfM Photogrammetry...787

Stamatia Panagiotopoulou, Athanasia Erkeki, Emmanuel Vassilakis, Antonios Antonakakis, Panagiotis Grigorakakis, Vasiliki Protopapa, Georgios Tsiostas and Konstantina Vlachou

Allystar low power/small chip size dual-frequency RTK solution...798

Altti Jokinen, Ryan Yang, Yi-Fen Tseng, Hongtao Yu, Mingo Tsai, Gary Hau, Ali Pirsiavash and Marco Mendonca

Filter De-Noising Method Using Long Short-Term Memory...808

Truong Ngoc Tan, Ali Khenchaf, Fabrice Comblet, Pierre Franck, Jean-Marc Champeyroux, Olivier Reichert

PPP Performance with Large TEC Gradient and Mitigation Methods...816

Yan Xiang, Wei Wang, Xin Chen and Wenxian Yun

Ionosphere Monitoring and Prediction Center...826

Martin Kriegel and Jens Berdermann

Modeling Of The Delayed Ionospheric Response With The TIE-GCM Model...836

Erik Schmölter, Jens Berdermann, Christoph Jacobi and Norbert Jakowski

Spatial Analysis of the Correlation between Scintillation Parameters and MP & ROTI...845

Chendong Li, Craig Matthew Hancock, Sreeja V. Veetil and Chong You

Space Weather Bulletins as part of a User Test Campaign for GNSS service users...854

Corentin Liber, Erwin De Donder, Antoine Calegaro, Sophie Chabanski, Robbe Vansintjan, Jennifer O'Hara and Alexi Glover

Global Navigation Satellite Systems Contributing To Space Weather Services For Civil Aviation...864

Kirsti Kauristie and Pegasus Team

gmvBRAVE as engineering, analysis and validation platform for SBAS Systems...869

Oriol Escrigas, Carlos Cuesta-Martínez, Julián Barrios, Javier Arenas, Begoña Ochoa and Eric Arnal

End-to-End ARAIM demonstrator: magicARAIM suite...879

Guillermo Fernández Serrano, José Gabriel Pericacho, Konrad Janicki, José Celada, Fernando Bravo, Miguel Angel Fernández, David Rodríguez, Victor Manuel Esteban and Julián Barrios

Multi-Constellation DGNSS - A Time to Revise Definitions...889

Sergey Averin, Andrey Gapon and Pavel Ignatev

Galileo Open Service Navigation Message Authentication: Exploitation in the Frame of an E-Security Infrastructure...898

Gianluca Marucco, Michele Ligios, Sisay A. Chala and Peter Rosengren

New Opportunities for Mass-Market Applications of Real-Time Variometric Velocity Estimated Using Android GNSS Raw Measurements...908

Marco Fortunato and Augusto Mazzoni

An Innovative Way to Promote Walking via a Smartphone Pedestrian Navigation Application...919

George Papageorgiou

High Accuracy Navigation for the Mass Market - the FLAMINGO Initiative...928

William Roberts, Joshua Critchley-Marrows, Maria Ivanovici, Malgorzata Siutkowska, Valentin Barreau, Laurent Arzel, Soufian Ayachi, Alex Lopez, Xavier Banque-Casanovas, Miquel Garcia, Thiago Tavares, Maria Kirova, Patrisia Costenco, Krzysztof Kanawka and Adam Piech

Infield Agriculture GNSS Assessment Showing EGNOS Benefits...938

Jimmy Bruzual, Elisabet Lacarra, Joaquin Reyes González and Clayton Post

Galileo Enhanced Solution for Pest Detection and Control in Greenhouses with Autonomous Service Robots...948

Michael Pattinson, Smita Tiwari, Yuheng Zheng, Dimitrios Fryganiotis, María Campo-Cossío, Raúl Arnau, David Obregón, Jon Martin, Carlos Tubío, Iker Lluvia, Oscar Rey, Jeroen Verschoore, Dalibor Húska, Libor Lenza, Joaquin Reyes Gonzalez

Autonomous Navigation Module for Tracked Compost Turners...958

Eva Reitbauer, Christoph Schmied and Manfred Wieser

Kalman Filtering Versus Voting: Which Strategy is Best for Multi-Sensor Localization?...968

Tianxiang Lan, Arne Geffert, Andreas Dodinoiu and Uwe Becker

Performance Analysis of Low-Cost Receiver in an Urban Environment - Test Results of a Tram in Oslo...977

Christian Rost, Mohammed Ouassou, Rune Hanssen, Anders Solberg, Kenneth Bahr, Marius Sommerseth and Michael Erneland

Jamming an Uncalibrated GNSS Array Receiver of Distributed Antenna Elements for Concealed Installation in Passenger Cars...987

Marius Brachvogel, Michael Niestroj, Sören Zorn, Michael Meurer, Syed N. Hasnain, Ralf Stephan and Matthias A. Hein

Requirements for sensor networks as part of the digital road...997

Raimo Harder and Uwe Plank-Wiedenbeck

BIM-based simulation of intelligent transportation systems...1004

Kay Smarsly and Mahsa Mirboland

Increasing Quality of Maritime Communication through intelligent Speech Recognition and Radio Direction Finding...1014

Ole John and Maximilian Reimann

Collision Risk Model for Encounter Situation Assessment Based on Empirical Observations...1021

Arne Lamm, Julius Möller and Axel Hahn

Innovative Assistance for e-Navigation oriented Voyage Planning and Ship Collision Avoidance...1032

Knud Benedict, Michael Baldauf, Michael Gluch and Sandro Fischer

Ship Traffic Organization with Moving Havens: Ship and Shore Perspective...1043

Thomas Porathe

Estimation of worldwide ship emissions using AIS signals...1053

Constance Ugé, Tina Scheidweiler and Carlos Jahn