Location

Carl-Cranz-Gesellschaft
Argelsrieder Feld 22, bldg. TE 03,
D-82234 Wessling-Oberpfaffenhofen

Participants will receive details to the seminar location as well as a list of nearby accommodations with the confirmation of registration. Please note that the accommodation is not included, and participants are asked to make their own hotel accommodation.

Fee

EUR 2.630,--
CCG is a non-profit organisation, exempt from value-added tax in Germany. For foreign seminar locations the local tax regulations are applicable. Members of CCG receive a discount of 10 %. Student discounts are available on request. Discounts cannot be combined.

Invoice is to be paid within 14 days of invoice issue date by direct deposit only.

Registration

Please register up to 2 weeks before the seminar via E-Mail anmelden@ccg-ev.de or online at www.ccg-ev.de
You will receive a confirmation E-Mail with further information.

Further Information

For more information about our organization please contact:
Carl-Cranz-Gesellschaft e.V.
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D-82234 Wessling-Oberpfaffenhofen

Tel. +49 (0) 8153 / 88 11 98 -12
E-Mail ccg@ccg-ev.de / Internet www.ccg-ev.de

For more information on the content of the seminar please contact

Prof. Dr.-Ing. Bernd Eissfeller, University of the Federal Armed Forces, Munich, D-85577 Neubiberg
Tel. +49 (0) 89 / 6004-3017, E-Mail: bernd.eissfeller@UniBw.de

Substitutions and Cancellations

Substitutions of participants may be made at any time. Cancellation of an accepted registration later than 14 days prior to the start of the seminar is subject to a 25% cancelation fee. No shows will be billed for the entire seminar fee.
CCG reserves the right to cancel a course up to 14 days before the course's beginning in case of low number of participants or for other significant reasons. Furthermore, CCG reserves the right, against the announcement in the programme, to possibly replace at short notice a lecturer and also the lecturer's topic. Any claims for damages shall be excluded.

GPS/INS-Integration and Multisensor-Navigation

Who Should Attend

Project Managers and system engineers, scientists of different disciplines, engineers, developers, and other technicians, who would like to get a broad overview on modern multi-sensor integration and navigation and the underlying technologies and concepts.

Focus

Availability, continuity, integrity and accuracy requirements lead to the fact that no commercial navigation system can solely rely on a single sensor technology. Thus, the seminar is focused on the architecture of state-of-the-art and future integrated multi-sensor navigation systems. In the first part of the course the key sensor and algorithmic technologies are presented (strapdown inertial technology, GNSS, Kalman Filter, GNSS/INS integrity, map matching, terrain-based navigation). In the second part specific multi-sensor integration architectures for future-oriented application fields will be outlined. The seminar should help to understand, design and evaluate the performance and cost-efficiency of GNSS/INS and integrated multi-sensor systems.

Language

English

Material

Each attendant will be provided with detailed course material in English.

Lecturers

Johann Dambeck	Prof. Dr.-Ing.	MBDA, Schrobenhausen
Bernd Eissfeller Thomas Pany Thomas Kraus Max Hofacker	Prof. Dr.-Ing. habil. Univ.-Prof. Mag. Dr. M. Sc. M. Sc.	University of the Bundeswehr ISTA
Andreas Schütz	M. Sc.	Rheinmetall Technical Publications GmbH, Penzberg
Markus Markgraf	Dipl.-Ing. (FH)	DLR, GSOC, Oberpfaffenhofen
Omar Garcia Crespillo	Dr.-Ing.	DLR, Oberpfaffenhofen
Thomas Köhler	Dr.-Ing.	Beratungsunternehmen Dr.-Ing. Thomas Köhler
Torben Schueler	Prof. Dr.-Ing. habil.	Geodetic Observatory, Wettzell
Volker Schwieger	Univ.-Prof. Dr.-Ing. habil.	University of Stuttgart
Ralf Ziebold	Dr. rer. nat.	DLR, Neustrelitz

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Sensorik / Erkundung

Seminar SE 3.05

GPS/INS-Integration and Multisensor-Navigation

October 14 – 18, 2024
Oberpfaffenhofen near Munich

Scientific Coordination

Prof. Dr.-Ing. Bernd Eissfeller
University of the Federal Armed Forces
Munich, Neubiberg, Germany

Seminar Outline

Monday, October 14, 2024 10.00 – 16.30

10.00 – 10.15 **Welcome, Organization**

10.30 – 12.00 **Introduction to Inertial Navigation**
B. Eissfeller History, mathematical & physical fundamentals, basic principles & assumptions, Schuler tuning, accuracy classes, platform & strapdown systems, initial & transfer alignment, simplified error propagation, vertical channel problem, status of inertial technology, integrated navigation, rationale for integrated navigation, basic principles, examples, outlook and future trends

13.00 – 14.30 **Inertial Sensors**
B. Eissfeller Mechanical gyroscopes (SDF, TDF, ESG, DTG), optical gyroscopes (FOG, RLG), Cold Atom Interferometer (CAI), MEMS (vibrating beam, vibrating plate, vibrating ring & shell) technology and performance, pendulum and vibrating string accelerometers

15.00 – 16.30 **Changing GNSS Environment: Interference, Jamming and Spoofing**
T. Kraus Theory about interference and its influence on receiver, overview and classification of interferences (intentional and unintentional), detection and mitigation of interferences and hardware/front-end requirements. Introduction to spoofing and meaconing attacks with examples of known incidences and possible detection strategies

Tuesday, October 15, 2024 08.30 – 16.30

08.30 – 10.00 **MEMS Inertial Sensors**
B. Eissfeller Coriolis effect, electro mechanical mass–spring system, system model MEMS vibrational gyro, challenges: Bias, scale-factor stability, noise effects, temperature & vibration dependent effects, different implementations: Silicon-MEMS versus Quartz–MEMS, structures, SWOT analysis, performance

10.30 – 12.00 **Strapdown Algorithms**
J. Dambeck Reference systems, nonlinear 6DoF kinematic differential equations of motion, Euler angles, quaternions, singularities, integration algorithms

13.00 – 14.30 **Error Propagation in Inertial Navigation Systems**
J. Dambeck Total vs. error state space, linearization, discretization, dynamic system in state space formulation, stability, observability, stochastic inertial measurement error models

15.00 – 15.45 **Terrain Aided Navigation**
J. Dambeck Altimeters, principle of terrain contour matching, alternative realizations, error sources, digital terrain elevation data, integration with IMU/GPS

15.45 – 16.30 **Autonomous Navigation for Stand-Off Weapons**
J. Dambeck Autonomous navigation, navigation system architecture and design for cruise missiles, interrelation with guidance & control, system test principles, KEPD350

Wednesday, October 16, 2024 08.30 – 17.30

08.30 – 10.00
10.30 – 11.15 **GNSS Receivers and Errors**
T. Pany GNSS signals and propagation (delays, filters, multipath), receiver architecture (analogue/digital domain) and types, acquisition, code/carrier tracking and errors, observation equations, time synchronization message decoding, positioning, vector tracking loops and other loop aiding concepts, receiver NCO feed-back; illustration with MATLAB and software receiver real-world data

11.15 – 12.00
13.00 –13.45 **Kalman Filter Theory**
B. Eissfeller Stochastic processes, continuous versus discrete dynamic system, discrete observation equations, derivation of linear Kalman algorithm, Wiener & least-squares filter, modifications for special cases, numerical issues

13.45 – 14.30
15.00 – 15.45 **Kalman Filter Exercise and Demonstration**
A. Schütz Basic Examples, Selected GNSS Kalman Filters, GNSS/INS Kalman Filter Examples, Demonstration of different INS (SAGEM Sigma 30, Litton LN-3 Starfighter, etc.) and INS Initialization Methods.

15.45 – 16.45 **GNSS/INS Integrity Monitoring**
Safety requirements, error over-bounding in Kalman filtering, Fault detection and exclusion in GNSS/INS systems based on innovations & separation solution. Redundant INS systems. Protection level computations & examples.

16.45 – 17.30 **Unmanned Aerial Vehicles (UAVs)**
M. Hofacker Classes of UAVs and the used navigation systems, position control of modern drones and legal framework of the UAV usage, presentation of UAV navigation system issues on real-world projects of UniBwM

Thursday, October 17, 2024 08.30 – 16.30

08.30 – 10.00 **GNSS/INS Integration**
B. Eissfeller Motivation for GPS/INS integration, overview on coupling principles w.r. to accuracy, availability, integrity, continuity, GPS P-V-A filter, GPS/INS filter, coupling principles in detail: separate, loosely – tightly (position, raw data), ultra-tightly, deeply, advantages and disadvantages, examples for commercially available systems and developments, typical applications

10.30 – 12.00 **Multisensor-based provision of nautical data for safe ship's navigation**
R. Ziebold Challenges for PNT provision for the automation of ships, maritime PNT system concept, onboard provision of PNT data (classical, INS approach, PNT Unit), applications of multisensory-based vessel positioning

13.00 – 14.30 **Map Matching Applications**
V. Schwieger Digital maps, matching and aiding techniques, accuracy considerations for road and rail, applications for car navigation systems and driver assistance systems, quality requirements

15.00 – 16.30 **Space Systems**
M. Markgraf Orbit & attitude determination of spacecraft, AOCS design and sensors for satellites at different orbits, rendezvous & docking, launchers

Friday, October 18, 2024 08.30 – 12.00

08.30 – 10.00 **Civil and Military Aviation**
T. Köhler Modern integrated aircraft navigation systems, typical multi-sensor scenario, civil versus military transport aircraft, flight management system fighters

10.30 – 12.00 **Gravity Field & Airborne Gravimetry**
T. Schüler Role of gravity field in inertial navigation, gravity induced errors, separation of inertial and gravity accelerations, gradiometry, determination of gravity vector, importance for airborne and submarine navigation.