



Munich Aerospace Summer School
22-24 June 2016 – Lake Ammersee

Programme

Flying Robots

Concepts and Challenges
of Aerial Autonomy

Munich Aerospace Summer School 2016

Flying Robots

Concepts and Challenges of Aerial Autonomy

The reputation of Unmanned Aerial Vehicles (UAVs) is improving. An increasingly positive media coverage and a higher number of private users have influenced public acceptance. UAVs deliver parcels, help with ocean exploration and earth observation and can also save lives: whether it be floodings, environmental disasters, emergency rescues in the mountains or at sea – still, a currently unclear legal situation hinders the deployment of UAVs. Consequently, benefits and potential risks have to be addressed and investigated.

At the Munich Aerospace Summer School academic and industrial experts will examine the Summer School's key topic Autonomous Flight from various perspectives.

Schedule

Wednesday, 22 June 2016

Presenter: Professor Werner Staudacher, Munich Aerospace Scientific Advisory Board

- from 11.00 a.m. Registration
- 12.00 p.m. Lunch
- 01.00 p.m. Dr Johann Bals, Munich Aerospace Executive Board**
Welcoming Remarks
- 01.30 p.m. Professor Matthias Gerdts, University of the German Armed Forces**
Matthias Rieck, Dipl.-Ing., Munich Aerospace Scholarship Recipient,
Technical University of Munich
Trajectory optimization for automatic and autonomous systems
- 02.30 p.m. Coffee Break
- 03.00 p.m. Peter Kortas, LL.M., Technical University of Berlin**
The Legal Situation of RPAS – Present Status and Future Perspectives
- 04.00 p.m. Professor João Tasso de Figueiredo Borges de Sousa, University of**
Porto
Unmanned Air Vehicles for Maritime Operations: from Vehicles to Networked
Systems
- 06.00 p.m. Dinner

see pg. 4 ff.

Thursday, 23 June 2016

Presenter: Professor Werner Staudacher, Munich Aerospace Scientific Advisory Board

- from 07.30 a.m. Breakfast
- 09.00 a.m. Professor Gerhard Hirzinger, German Aerospace Center (DLR)**
Robotic Assistance for Aerospace – From Robonauts in Space to the
Unmanned Aerial Vehicles
- 09.30 a.m. Dr Hans Tönskötter, Acentiss**
ELIAS – Optionally Piloted UAS Technology Demonstrator
- 10.30 a.m. Coffee Break

- 11.00 a.m.** **Dr Tobias Kiesling, IABG**
Operational Cyber Resilience and its Role in Future Autonomous Flight Scenarios
- 12.00 p.m. Lunch
- 01.30 p.m.** **Professor Friedrich Fraundorfer, University of Graz**
Camera Drones – Techniques, Applications and Possibilities
- 02.30 p.m.** **Meinrad Edel, Dipl.-Ing., Airbus**
Challenges of a Counter-UAV System
- 03.30 p.m. Coffee Break
- 04.00 p.m.** **Professor Maryam Kamgarpour, ETH Zurich**
Optimal Control for Fuel Efficient Aircraft Conflict Avoidance
- 05.00 p.m.** **Dr Konstantin Kondak, German Aerospace Center (DLR)**
Exploiting Robotic Technologies for Aerial Applications
- 06.00 p.m. Dinner
- 07.30 p.m.** **Professor Gerhard Haerendel, Max-Planck-Institut für Extraterrestrische Physik**
A Peek behind the Scenes of a Space Scientist's Life
- Presenter: Professor Bernd Häusler, University of the German Armed Forces

see pg. 7 ff.

Friday, 24 June 2016

Munich Aerospace Fellows Day

- from 07.30 a.m. Breakfast
- 09.00 a.m. **Munich Aerospace Research Group Meetings (parallel panels)**
- Autonomous Flight**, room: *Großer Saal*
 Security in Orbit, room: *Seminarraum 3*
 Geodetic Earth Observation (Prof. Datcu), room: *Bibliothek*
 Geodetic Earth Observation (Prof. Eineder), room: *Seminarraum 4*
 Aviation Management, room: *Seminarraum 5*
- 12.00 p.m. Lunch
- 01.00 p.m. Team Event for Munich Aerospace Scholarship Recipients
- 04.00 p.m. End of Event

Programme Details

Wednesday, 22 June 2016

Presenter: Professor Werner Staudacher

from
11.00 a.m. Registration

12.00 p.m. Lunch

01.00 p.m. Dr Johann Bals
Munich Aerospace Executive Board

Welcoming Remarks

01.30 p.m. Professor Matthias Gerdts
Munich Aerospace Research Group Leader
University of the German Armed Forces

Matthias Rieck, Dipl.-Ing.
Munich Aerospace Scholarship Recipient
Technical University of Munich

title. *Trajectory optimization for automatic and autonomous systems*

abstract. The development of autonomous and automatic systems is a highly interdisciplinary task with challenges on technological, legal, and algorithmic levels. Various fields such as mechatronics, sensors, data mining, control algorithms, path planning, mission design, human-agent interaction, communication, and legal issues, to name a few, play important roles.

This talk focuses particularly on the path planning aspect and discusses mathematical methods and concepts to control vehicles or vehicle components by means of optimal control and model predictive control. Such control paradigms are useful to perform tasks that are usually performed by a human. To this end, a core task is to provide trajectories which optimize a

given performance criterion (fuel consumption, comfort, safety, time, etc.) and obey constraints (collision avoidance, safety regions, control bounds, etc.). In order to solve these problems numerically, we apply direct discretization schemes and sensitivity updates to predict optimal solutions in the presence of perturbations. Applications from automatic driving and flight path optimization are presented.

bio. Matthias Gerdts is a Professor for Engineering Mathematics at the University of the German Armed Forces in Munich. His research focuses on control and sensitivity analysis with applications in automotive systems, robotics, and aerospace engineering.

Matthias Rieck is a Munich Aerospace PhD Fellow at the Institute of Flight System Dynamics at the Technical University of Munich.

02.30 p.m. Coffee Break

03.00 p.m. Peter Kortas, LL.M.
Technical University of Berlin

title. *The Legal Situation of RPAS – Present Status and Future Perspectives*

abstract. In the EU the legislative responsibilities for RPAS rest mainly with the national legislatures. Only for RPAS of 150 kg and more the EU has competence. German law provides for operation permits rather than technical certification and personal licensing. Such generosity is counterbalanced by operational restrictions (e.g. a maximum weight of 25 kilos, mandatory visual line of sight). The BMVI plans to loosen these restrictions by the end of 2017. Then again, the EU is about to take over legislative responsibilities in full. Following their “risk-based approach”, it is envisaged that future rules are tailored to three risk categories: open, specific and certified.

bio. Peter Kortas works as an academic aviation lawyer, author, lecturer and legal expert in aviation law.

04.00 p.m. Professor João Tasso de Figueiredo Borges de Sousa

University of Porto

title. *Unmanned Air Vehicles for Maritime Operations: from Vehicles to Networked Systems*

abstract. Current practices and major trends in Unmanned Aircraft Systems (UAS) for maritime operations are presented along with projections of future UAS maritime applications. First various aspects of the UAS program management, including organization, operator responsibilities, program operation and overall program costs are reviewed. Next, maritime aircraft missions and required capabilities are outlined, and current practices for both manned and unmanned aircraft are described. Technological trends relating to UAS are also discussed, focusing on developments relevant to maritime UAS operations. Finally, concepts for future UAS operations are presented, with emphasis on networked operations.

bio. **João Tasso de Figueiredo Borges de Sousa** is a Professor at the Electrical and Computer Engineering Department at the University of Porto (Portugal) and the head of the Underwater Systems and Technologies Laboratory.

06.00 p.m. Dinner

Thursday, 23 June 2016

Presenter: Professor Werner Staudacher

from
07.30 a.m. Breakfast

09.00 a.m. Professor Gerhard Hirzinger
German Aerospace Center (DLR)

title. *Robotic Assistance for Aerospace – From Robonauts in Space to the Unmanned Aerial Vehicles*

abstract. Robonauts in outer space – whether on moon, planets or in earth orbit – need one general, very important skill: to perceive their environment in 3D and to model it either in real-time or make use of a priori generated 3D models; and in case of free-floating to pre-calculate and master the recoil effect when grasping an object. Examples of this observation are given and related to the similar case of an unmanned helicopter with a robotic arm trying to autonomously grasp an object from the air. The topic 3D modelling of the world in real-time and offline is treated in more detail as well as problems which have to be solved when flying cameras with multicopters and planes, be it either for modelling landscapes and buildings or for autonomous collision avoidance in unknown environment, e.g. in caves or destructed buildings. Image-based sense and avoid approaches for preventing collisions with other flying objects in free sky, however, have to get along typically with 2D image information. Unmanned and optionally piloted solar-electric airplanes as developed by ELEKTRA UAS are typical users of the technologies mentioned.

bio. **Gerhard Hirzinger** is the former director (now advisor) of DLR's robotics and mechatronics center in Oberpfaffenhofen.

09.30 a.m. Dr Hans Tönskötter

Acentiss, Munich

title. *ELIAS – Optionally Piloted UAS Technology Demonstrator*

abstract. In the context of the Ludwig Bölkow Campus project EUROPAS, technologies for all-electric unmanned aircraft systems have been developed and tested. For the final flight demonstration the ELIAS aircraft has been changed over to an optionally piloted system (OPV) which allows automatic, preprogrammed flying with safety pilot on board. The ELIAS OPV system consists of the electric UL aircraft, the new automatic flight control system (AFCS), the innovative electronic datalink and the ground control station (GCS). To minimize risk extensive aircraft-in-the-loop simulations (ACIL) have been carried out at IABG/ACENTISS before starting with the flight tests. The OPV system is designed such that the pilot can takeover flight control in case of failure of the AFCS at all flight situations.

bio. **Hans Tönskötter**, Senior Manager for Airborne Systems at ACENTISS GmbH, is the Technical Coordinator of the EUROPAS Consortium and in charge of the EUROPAS technology development at ACENTISS.

10.30 a.m. Coffee Break

11.00 a.m. Dr Tobias Kiesling

IABG, Munich

title. *Operational Cyber Resilience and its Role in Future Autonomous Flight Scenarios*

abstract. Digitalization is an enabler for new application areas such as autonomous flight. However, due to the increase in IT pervasion and autonomous components, the back side is an increased vulnerability to cyber threats. To cope with the rising threat in complex interconnected infrastructures, we need to follow a resilience-oriented

view and utilize suitable methods and tools to achieve understanding of the consequences in potential cyber threat situations. This presentation introduces the notion of cyber operational resilience and shows how this can be applied to the air transport infrastructure at large with a special focus on aspects related to future autonomous flight scenarios.

bio. **Tobias Kiesling** is a Program Manager for Cyber Defence at IABG in Ottobrunn near Munich since 2014, where he is responsible for Portfolio-Management and Business Development in the area of Cyber Defence.

12.00 p.m. Lunch

01.30 p.m. Professor Friedrich Fraundorfer
University of Graz

title. *Camera Drones – Techniques, Applications and Possibilities*

abstract. Cameras and computer vision algorithms play a major role for many drone applications, ranging from image analysis of data acquired by drones to on-board flight control and navigation. This talk will discuss the potential of drones for 3D mapping using computer vision techniques and will give examples of applications ranging from mining to archaeology. In addition, the talk will also examine the possibility of using computer vision to create autonomous small scale drones, which are able to see and interpret their environment.

bio. **Friedrich Fraundorfer** is an Assistant Professor at Graz University of Technology, Austria. His research focuses on algorithms for drone image analysis and autonomous drone operation.

02.30 p.m. Meinrad Edel, Dipl.-Ing
Airbus, Ulm

title. *Challenges of a Counter-UAV System*

abstract. Incidents of UAVs violating security perimeters at airports, power plants, borders and prisons are covered in the news almost daily. The presentation will depict the threat of UAVs today and in the future, focusing on critical infrastructure, mass events and espionage. In order to characterize systems needed for protection against UAVs, there will be an analysis of UAV espionage and attack patterns for various defense scenarios. Consequently, a set of requirements for protection systems can be deduced. In conclusion, a theoretical example of a Counter UAV system for enhanced security of a soccer stadium will be discussed.

bio. **Meinrad Edel**, Dipl.-Ing., PMP, has been with Airbus since 1997. A former Project/Bid Manager for Electronic Warfare, he is now Director Sales Protection and Reconnaissance.

03.30 p.m. Coffee Break

04.00 p.m. **Professor Maryam Kamgarpour**
ETH Zurich

title. *Optimal Control for Fuel Efficient Aircraft Conflict Avoidance*

abstract. Air Traffic Management (ATM) is responsible for safe, efficient and sustainable operation in civil aviation. Currently, ATM imposes certain trajectory restrictions to guarantee safety and to ease the task of air traffic control (ATC) operators. Some of these restrictions result in non-minimal fuel consumptions and hence higher operating costs and emissions. We formulate fuel optimal conflict free aircraft trajectory planning as a hybrid optimal control problem. The discrete modes of the hybrid system capture the air traffic procedures for conflict resolution, e. g., speed and turn advisories. In order to solve problems of realistic dimensions arising from air traffic sector planning, we formulate a numerically tractable approach to solve the hybrid optimal control problem.

bio. **Maryam Kamgarpour** is an Assistant Professor at ETH Zurich Automatic Control Laboratory. Her research is on safety verification and optimal control of large-scale uncertain dynamical systems with applications in air traffic and power grid systems.

05.00 p.m. **Dr Konstantin Kondak**
Munich Aerospace Research Group Leader
German Aerospace Center (DLR)

title. *Exploiting Robotic Technologies for Aerial Applications*

abstract. Robotic technologies developed for terrestrial and space systems can be exploited for flying platforms. In parallel to enhancement of traditional applications focused on aerial sensor data acquisition (photo, film, infrared and multispectral cameras) robotics technologies open new applications where the flying robots have to interact with the environment physically, e.g. installation of sensor nodes, taking samples of soil or water in inaccessible areas and even assembly of structures. Using robotics technologies for cooperative control, the UAS can be extended with novel functionalities for landing on mobile platforms. These two application areas, will be presented in more details.

bio. **Konstantin Kondak** leads the flying robots group at the DLR Institute of Robotics and Mechatronics. His recent research interest is focused on simulation and control of multibody systems as well as on description and verification of complex technical systems and their missions.

06.00 p.m. Dinner

Fireside Chat

07.30 p.m. **Professor Gerhard Haerendel**
Max-Planck-Institut für Extraterrestrische Physik, Garching

title. *A Peek behind the Scenes of a Space Scientist's Life*

Presenter: Professor Bernd Häusler, Excellent Emeritus
University of the German Armed Forces

abstract. Professor Haerendel will speak about his experiences made as a space scientist throughout many decades and about his pioneering work in applying sounding rocket and satellite technology to study space plasma and magnetospheric physics identifying important processes associated with the formation of auroral arcs, artificial and natural comets.

bio. **Gerhard Haerendel** studied physics in Tübingen and Munich. In 1972 he became Director of the Max Planck Institute for Extraterrestrial Physics (MPE) in Garching and retired from the latter at the end of 2000. He is Honorary Professor at the Technical University, Braunschweig and Distinguished Professor of Space Physics at the International University Bremen (IUB)/Jacobs University. His teaching activities included Visiting Professor at the University of California, Berkeley and at the University of Iowa. He served in many positions in international space research organizations, among these for many years as Vice-President of the International Academy of Astronautics (IAA), as President of the Committee on Space Research (COSPAR), as chairman of several ESA advisory committees, and also as Dean of the Faculty of Engineering and Science at the Jacobs University. His awards and honours include the Theodore von Karman Award (2002) and the Jean Dominique Cassini Medal (2010).

Munich Aerospace organises a research network of currently more than 150 scientists engaged in the fields of aeronautics and space technology. The nonprofit association was founded by the Technical University of Munich (TUM), the University of the German Armed Forces (UniBw), the German Aerospace Center (DLR) and Bauhaus Luftfahrt (BHL), an aerospace think tank. The organisation's purpose is to systematically interlink the research activities of the four Munich Aerospace partner organisations aiming at developing the Munich area into a strategically important aerospace research centre.



**Munich Aerospace
Faculty for Aeronautics and Space e.V.**

Willy-Messerschmitt-Str. 1
D-82024 Munich-Taufkirchen
Tel. +49 (0)89 307 48 49-57
Fax +49 (0)89 307 48 49-79
info@munich-aerospace.de
www.munich-aerospace.de