Aerospace Information Technology
Topics for Internships and
Bachelor's and Master's Theses

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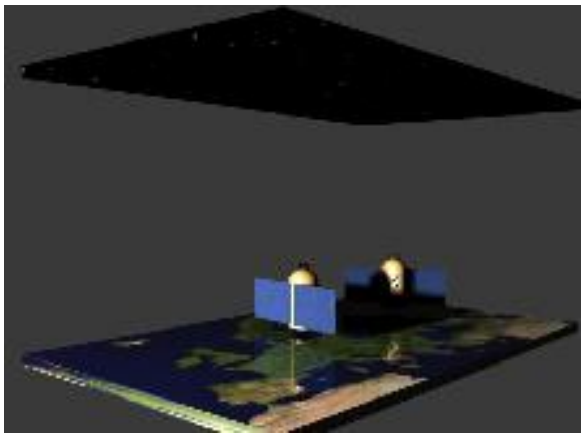
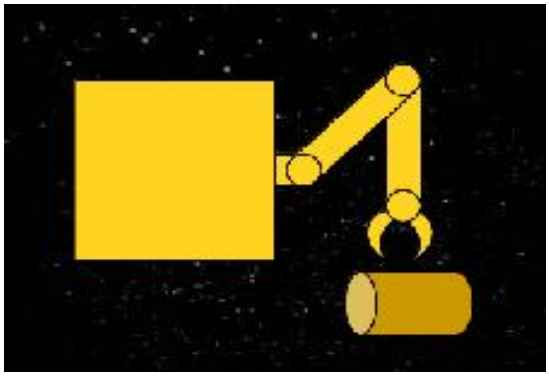
The Chair of Aerospace Information Technology addresses several research topics in the area of:

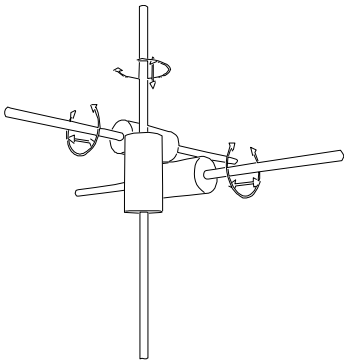
- Avionic systems for:
  - Space missions
  - Multicopters and Unmanned Aerial Vehicles (UAV)
  - Autonomous underwater vehicles (AUV)
- Real Time Control
- Sensing, optical navigation and radio navigation
- Mathematical models of physical systems
- Basis software for dependable and distributed systems

We like to offer the students the opportunity to work on these topics as part of a bachelor's or master's thesis or as part of an internship. We offer many topics related to ongoing research projects and we also support **own ideas and suggestions** by the students in the areas listed above.

Typically each topic covers a wide research area. According to the students capabilities we can formulate the thesis with emphasis on either **Software, Control, Electronics** or **Mechanics.** The scope of the students work will be discussed in cooperation with the applicants according to their individual skills and interests. Please note: Each of the following topics may be implemented in **several theses**, your task will be a subset of the topic, which we can define together.

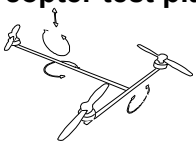
1. Avionic systems for space missions

Topic	Description and Requirements
Control of Orbit Manoeuvre simulation vehicles (AR, TW, SM)  	We develop an installation for air bearing vehicles based on a very plane smooth surface, so that the vehicles can move without friction. Translation and rotation is realized just as with typical satellites by thrusters (here with air) and reaction wheels. Our setup uses for navigation and orientation an artificial sky, an artificial ground terrain projection and a simulated GPS-like system. Among many experiments we will simulate maneuvers like **launching**, **approaching**, **catching** and **docking**. In several theses we will develop: • **propulsion** system and control • **docking** ports and control • **Arm** and control • **Navigation** aids (optical, radio, inertial) • Mathematical **models** Requirements (for several thesis): • C/C++ • Embedded programming (RODOS) • Fundamentals of closed-loop-control • Mechanical construction

Center of Mass Control of a Small Satellite using linear moving mass actuators (AR) 	Down on earth it is barely possible to test the 3D rotation of satellites. Therefore we build air bearing spheres that contain all the necessary components like sensors and actuators in order to design and test a real life 3D attitude control. A simple structure for moving 3 linear moving mass actuators will be designed and assembled in order to adjust automatically the center of mass. Requirements: • C/C++ • Embedded programming (RODOS) • Fundamentals of closed-loop-control • System modeling

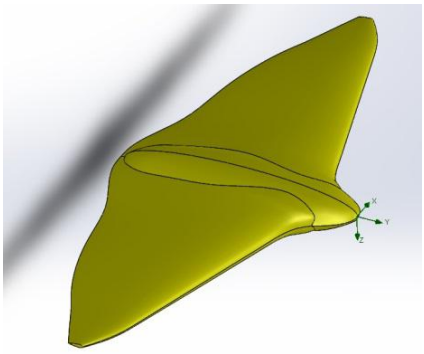
2. Avionic systems for Muliticopters and Unmanned Aerial Vehicles (UAV)

Topic	Description and Requirements
Interface to the Flight Gear Simulator (TM, SM) 	Flight Gear is an open source flight simulator. It provides a good documentation to its internal interfaces. Using UDP messages we shall be able to control the content of the displays. Requirements: • Linux • C++ • RODOS

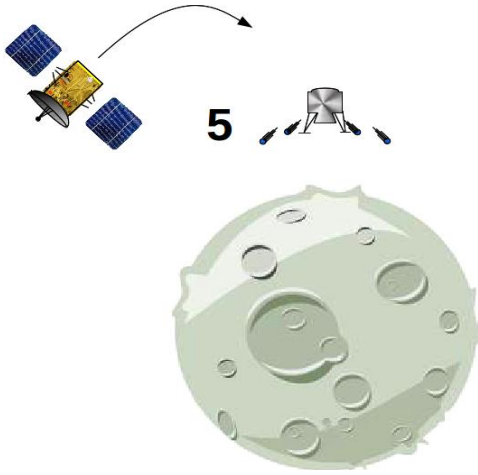
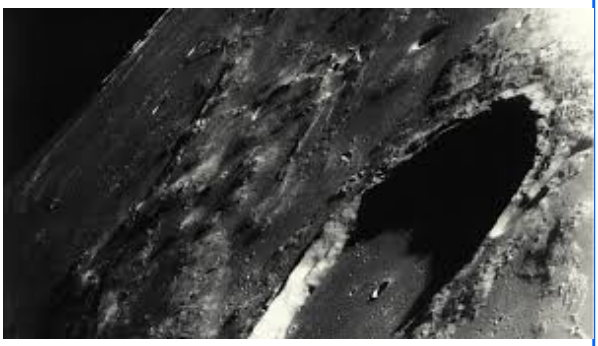
Extension of Ground Station for Multi-Quadrocopter Communication / Control Network (QA) 	In order to gain formation flying capability, the ground station will be extended to communicate and control with two quadcopters. Requirements: • Bluetooth (conventional) • C/C++ • Qt-class library
Collaborative Balloons (TM) 	A mission of 2 balloons performing a cooperative task will be defined. The balloons and their hardware and software components will be designed and implemented. Requirements: • C/C++ • Embedded Programming (RODOS) • Fundamentals of closed-loop-control • System modelling • Mechanical construction
Designing and development of 4Dof Helicopter test platform (AR) 	A helicopter test platform with 3 propellers and a resulting 4 degrees of freedom will be designed. Requirements: • C/C++ • Embedded programming • Implementation of the design • Testing and validating the system

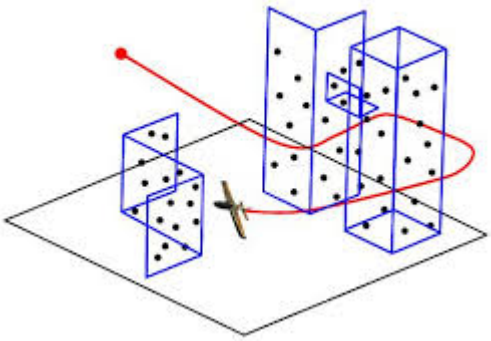
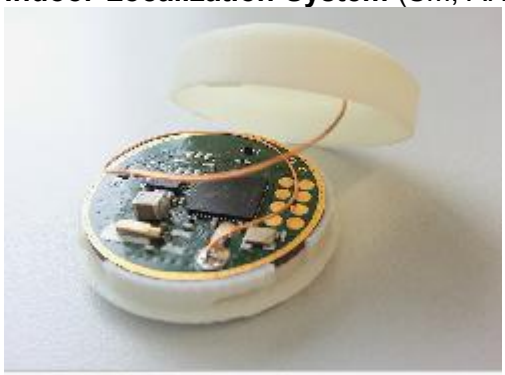
Manipulator programming and tests (NG) 	To attach a manipulator to our quadrocopter is the main idea of the project “Rettungshelfer mit Propellern” (lifeguard with propellers). We develop a quadrocopter with an robotic arm to support firefighters in emergency situations. In this topic the manipulator has to be programmed and tested in flight. Requirements: • C/C++ • Embedded programming

3. Avionic systems for autonomous underwater vehicles (AUV)

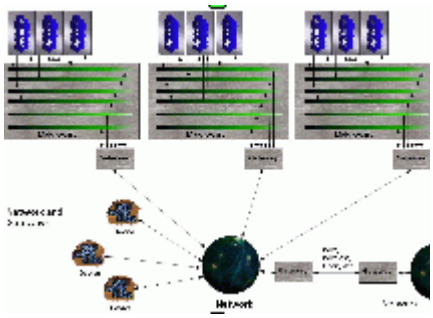
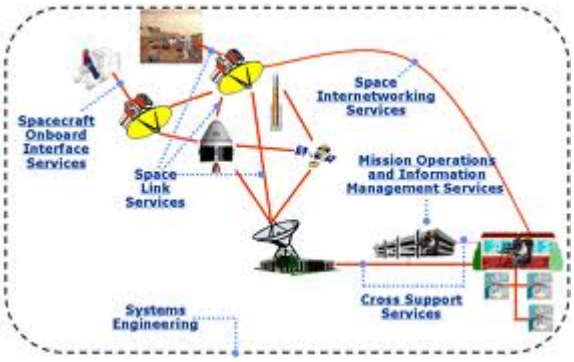
Topic	Description and Requirements
Avionics for the ROBEX Glider 	The theses will contribute to the ongoing ROBEX-project: http://www.robex-allianz.de/ We develop parts of the hardware and control system for an underwater glider. This shall be performed in several theses which could focus either on Hardware, Interfaces, Control, Models or Navigation. Requirements (distributed on several thesis) • C++ • Embedded Programming (RODOS) • Fundamentals of closed-loop-control • Hardware • Mechanical construction

4. Sensing, optical navigation and radio navigation

Topic	Description and Requirements
Optical navigation (SM)  	We study “relative” and "absolute" optical Navigation. Having an onboard catalogue of craters on the moon, we can compare or real time images to compute or position and attitude. Two spacecraft are flying in formation in orbit. They take pictures from the ground and interchange them. Comparing the own picture with the one from the other space craft we can compute the relative pose of both. Requirements: • C++ • Embedded programming (RODOS) • Mathematics • Image processing
Star sensor algorithms for 2D + Rotation Navigation (AR, TW, TM) 	In our Space Manoeuvre Simulation Facility we use air bearing vehicles on a glass plate. Below this glass plate we have a starry sky with 3000 Stars. We shall use a camera to look a small segment of thy simulated sky, and using similar methods like star sensors we determine our position (2D) and attitude (1D). Requirements: • C++ • Embedded programming (RODOS)

Quadrocopter SA & SLAM (NG) 	SA (Situation Awareness) and SLAM (Simultaneous Localization And Mapping (SLAM) is fundamental for an autonomous quadrocopter. The idea is to reflect the environment and the position of the quadrocopter with multiple sensors like optical (stereo vision, infrared / laser scanner, pmd) and other sensors (ultrasonic, radar). The work can base on already implemented parts. Requirements: • C / C++ • Embedded programming • Realtime programming
Indoor-Localization-System (SM, AH) 	A system for determining the position inside buildings will be implemented. RF-beacons and appropriate measurement methods will be used. Requirements: • C/C++ • Embedded programming (RODOS) • Fundamentals of RF-physics • Test- and measurement • Bluetooth LE
Precise Localization of Quadrocopter Using GPS, differential GPS and Open-source Software 'rtklib' (QA) 	Precise localization of quadrocopters will be implemented and evaluated using GPS. Provided GPS-position and GPS-raw-data will be transmitted to a base station. For co-operative flights we use two or more quadro-copters and compute their relative pose using differential GPS. • C/C++ • Embedded programming (RODOS) • rtklib • Bluetooth

5. Basis software for dependable and distributed systems

Topic	Description and Requirements
RODOS Extensions (SM)  	In many space missions and embedded control applications we use (our) real time operating system RODOS. RODOS is open source and is being developed in close cooperation with the German Space Agency - DLR. In several theses we aim to add the following functionalities: • Professional didactic tutorials (Lehramt Inf.) • Embedded JAVA on RODOS • IO processor for multicores running RODOS • Middleware interface for micro devices • Memory management unit for RODOS • FPGA router for the RODOS middleware • DS-Card booter for RODOS • CCSDS / IP communication libs for ground/space Requirements: • C++ • Embedded programming (RODOS)

Quality Assurance for current space mission developments 	We are developing software for real space missions. For this development we have to go throughout rigorous quality assurance procedures like reviews, tests and analysis. Requirements: • C++ • Embedded programming (RODOS)