



# Satellite Communications Laboratory

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# Introduction



# Goals

- ▶ Get hands-on experience in real satellite related projects
- ▶ Plan and organise your own projects
- ▶ Learn how to write a scientific report and give a presentation
  - ⇒ Ideal training course for your Bachelor thesis



# SatComLab Structure

- ▶ Each student is assigned to a group and topic
- ▶ Each group works individually
- ▶ Weekly group meetings with supervisor to discuss progress/problems
- ▶ Actual project work needs to be organised by the students
  - ▶ Our lab rooms can be used at any time
- ▶ 2 Workshops on satellite communication for all students
- ▶ Midterm presentation after you read into the project
- ▶ Final presentation and written report



# Time schedule

- ▶ Until Sunday evening (21<sup>st</sup> of October)
  - ▶ decide if you want to participate
  - ▶ send me a list of topics in order of preference
- ▶ Start of next week: Assignment to groups and first meeting
- ▶ Midterm presentation: Around mid December
- ▶ Workshops: Around November and January
- ▶ Final presentation: After the exam period (end of March)
  - ▶ Final report is due at least one week before the final presentation

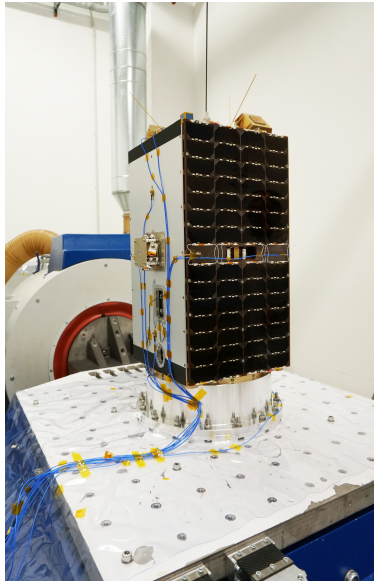
# Context

- ▶ We work on three active real satellite missions
  - ▶ European Student Earth Orbiter (ESEO)
  - ▶ MOVE-II
  - ▶ MOVE-IIb
- ▶ Mainly providing ground station software
- ▶ Used by many more satellite missions including ESAs OPS-SAT
- ▶ One stratosphere balloon every semester
  - ▶ MOVE-ON

# Context

- ▶ European Student Earth Orbiter (ESEO) mission
- ▶ Low Earth orbiter build by 10 different universities across Europe
  - ▶ Onboard camera
  - ▶ Radiation measurements in LEO
  - ▶ High rate S-Band communication experiment
- ▶ Our task: primary payload downlink
  - ▶ 3m mesh reflector on the roof of the N4 building
  - ▶ Industrial robot holding and pointing the reflector
  - ▶ Commercial off the shelf amplifiers and feed
  - ▶ Software defined radio receiver

# Context





# Context



# Context

- ▶ Munich orbital verification experiment 2 (MOVE-II / MOVE-IIb)
- ▶ 2<sup>nd</sup> and 3<sup>rd</sup> low Earth orbiter from TUM
  - ▶ Scientific Workgroup for Rocketry and Space Flight (WARR)
  - ▶ Chair of Astronautics (LRT)
- ▶ The satellite development has finished
- ▶ MOVE-II is in the US, being mounted on top of a Falcon 9
- ▶ MOVE-IIb is still to be built and tested
- ▶ Open tasks include improving the ground station and communication handling
  - ▶ Better receiver software
  - ▶ Better monitoring of the ground station status
  - ▶ More testing capabilities
- ▶ Launches are **Nov. 19<sup>th</sup> 2018** and start of 2019

# Context





# Topics

All topics are also available at  
[www.nav.ei.tum.de/sclab](http://www.nav.ei.tum.de/sclab)



# 1. SNR estimator

- ▶ Estimate current signal to noise ratio
- ▶ Required for optimal processing of other blocks
- ▶ Implemented as GNURadio block
- ▶ Possibility to test your work on with a real satellite
- ▶ Your results (if successful) will be used for the operation of real satellite missions

# 1. SNR estimator

**Supervisor:** Martin Lülß

**Requirements:**

- ▶ Experience in signal processing
- ▶ Programming (code will be in C++, testing in python)
- ▶ Linux command line

**Topics:**

- ▶ SNR estimation
- ▶ Maximum likelihood estimators
- ▶ GNURadio



## 2. Status monitoring/reporting

- ▶ Report status of receiver and transmitter to a central operations interface
- ▶ Log crashes, restarts, etc.
- ▶ Collect essential statistics to determine the link status
- ▶ Possibility to test your work with a real satellite / operator interface
- ▶ Your results (if successful) will be used for the operation of the MOVE-II satellite

## 2. Status monitoring/reporting

**Supervisor:** Martin Lülfi

**Requirements:**

- ▶ Experience in signal processing
- ▶ Programming in C++ and python
- ▶ Network protocols
- ▶ Linux command line

**Topics:**

- ▶ Digital receiver components
- ▶ GNURadio
- ▶ Link/status monitoring

### 3. Satellite channel simulator

- ▶ Simulate communication channel of a satellite mission
- ▶ Simulate typical satellite channel link effects
  - ▶ Attenuation
  - ▶ Noise
  - ▶ Delay
  - ▶ Doppler shift
- ▶ Implementation in GNURadio
- ▶ Your results (if successful) will be used to test and improve real current and future satellite missions

### 3. Satellite channel simulator

**Supervisor:** Martin Lülff

**Requirements:**

- ▶ Experience in signal processing
- ▶ Programming in C++
- ▶ Linux command line

**Topics:**

- ▶ AWGN
- ▶ Doppler shift
- ▶ Resampling
- ▶ GNURadio



## 4. OQPSK synchronisation (experts only)

- ▶ Phase and Timing recovery of a OQPSK signal
- ▶ Implementation as two GNURadio blocks
- ▶ Possibility to test your work on with a real satellite
- ▶ Your results (if successful) will be used for the operation of real satellite missions
- ▶ **This topic is very heavy for a single lab. Only pick this if you have experience with synchronisation.**

## 4. OQPSK synchronisation (experts only)

**Supervisor:** Martin Lülff

**Requirements:**

- ▶ Good experience in signal processing
- ▶ Good programming skills (in C++)
- ▶ Linux command line

**Topics:**

- ▶ OQPSK
- ▶ Maximum likelihood estimation
- ▶ Synchronisation (in the field of communication)
- ▶ GNURadio





# How to participate?

# Registration and group assignment

- ▶ Until **Sunday evening, 21<sup>st</sup> of October**:  
Decide whether you want to participate or not
  - ▶ Send an email to [martin.luelf@tum.de](mailto:martin.luelf@tum.de)
  - ▶ Include a list of topics (with order of preference) you would like to work on
- ▶ Students will be assigned based on registration date in TUMonline (position on waiting list)
- ▶ Students will receive an email with their group assignments and their supervisor contact information at the start of next week

# Closing notes

- ▶ If you have any questions
  - ▶ Send an email to [martin.luel@tum.de](mailto:martin.luel@tum.de)
  - ▶ Come to my office **N4404**
- ▶ Make sure you plan enough time for the course
  - ▶ 6 ECTS = 180h work  $\approx$  10h per week
- ▶ **Make sure the SatComLab is included in your study programme**
  - ▶ Bachelor EI is covered
- ▶ You can find this slides and the topic descriptions on [www.nav.ei.tum.de/sclab](http://www.nav.ei.tum.de/sclab)