Munich Center for Space Communications

Optical Ground Station for Free-Space Optical Communication Research and Experimentation

Robert T. Schwarz, Hung Le Son, Andreas Knopp
Institute of Information Technology
University of the Bundeswehr Munich
Neubiberg, Germany
www.unibw.de/satcom
papers.sp@unibw.de

Marcus T. Knopp, Alexander Köhler
Responsive Space Cluster Competence Center
German Aerospace Center
Wessling, Germany
{marcus.knopp, alexander.koehler}@dlr.de

Universität der Bundeswehr München

1. Introduction

Motivation of OGS as a part of the SeRANIS project

- Demonstration of new technology in space and on ground
- Open research environment for the optical community
- Research on influence of atmospheric effects of the optical channel

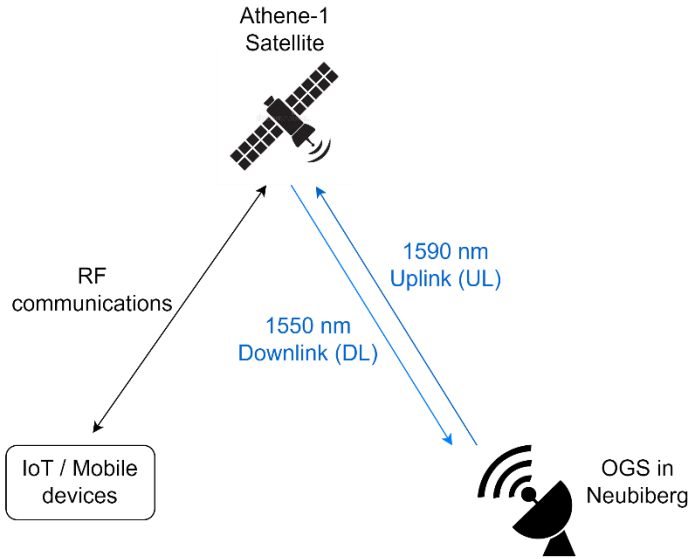

Fig. 1. Demonstration scenario in the project SeRANIS

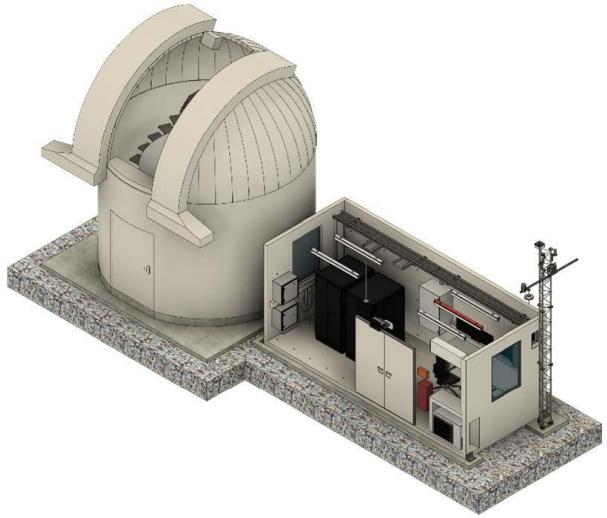

Fig. 2. Graphical illustration of the OGS in Neubiberg

2. System Description and Scientific Objectives

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System Description

- OGS with a 4.6m-diameter and 6m-high dome and a remote-control container
- Telescope based on the Nasmyth‘s design for various wavelengths 1000-1700nm
- High pointing and tracking accuracy sufficient for all kinds of LEO satellites

Parameter	ATHENE-1		Alphasat	
	UL	DL	UL	DL
wavelength / nm	1590	1550	1064	
mean source power / dBm	36	30	37	33.4
Tx aperture / m	0.075	0.02	0.075	0.124
Tx antenna gain / dB	105.5	94.3	109	113.4
Rx aperture / m	0.02	0.41	0.124	0.41
Rx antenna gain / dB	91.9	118.4	111.3	121.7

TABLE I. System description of uplink and downlink

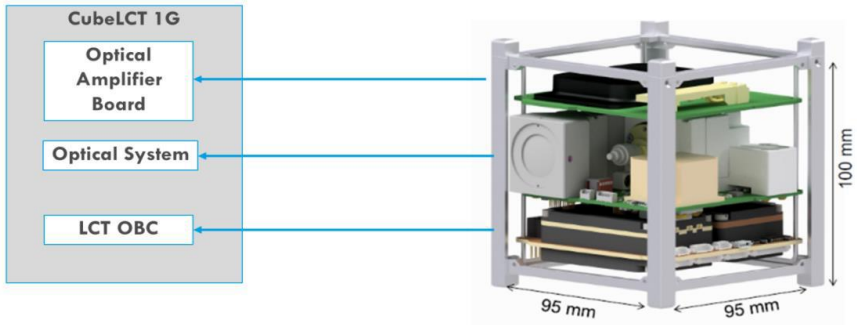

Fig. 3. Optical Terminal

2. System Description and Scientific Objectives

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Scientific Objectives

- Optical channel measurements
  - -> Compare with theoretical models
  - -> Evaluate signal processing techniques
- Coherent modulation schemes
- Space-based quantum key distribution

3. Link Budget Analysis

In a multiple-purposes OGS: A rough link budget estimation

- High estimated received power at detector (-23.5 dB for downlink and -29.5 dB for uplink)
- Possible data rate of 1 Gbps for DL and 100 Mbps for UL using avalanche-photodetectors-based receiver

Parameter	ATHENE-1		Alphasat	
	UL	DL	UL	DL
Transmit power / W		1		2.2
Pointing loss / dB	0	3	0	3
Link distance / km	891		38315	
Free space loss / dB	256.9	257.1	293.1	
Elevation angle / °	35		33.3	
Atmospheric losses / dB	1		1.5	
Optical loss Rx / dB	2	4	2	4
Power on detector / dBm	-29.5	-23.5	-42.4	-34.2

TABLE II. Link budget comparison

4. Availability and Visibility Analysis

Availability

- Wide-range availability of the satellites from 80°E to 60°W
- Wind speed median below 10 km/h with only a few extreme outliers

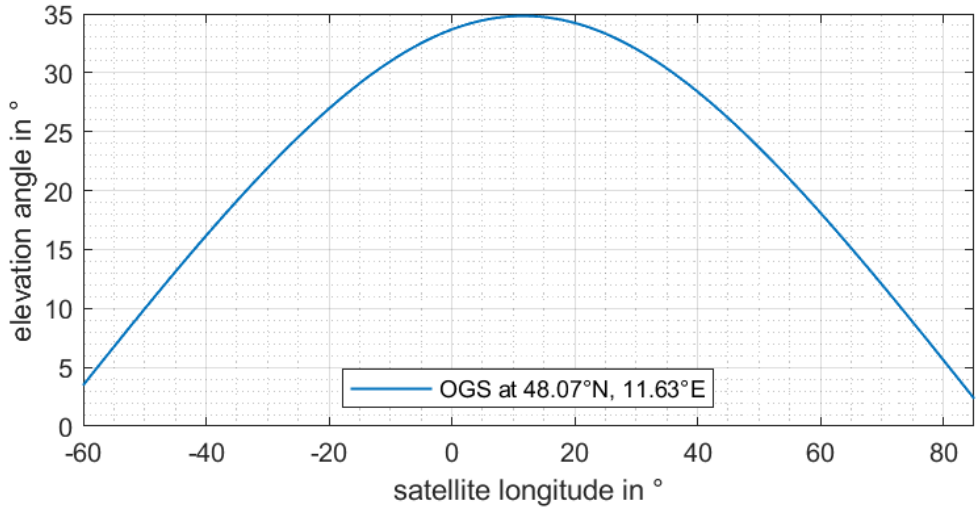

Fig. 4. Elevation angle of GEO at various satellite longitude

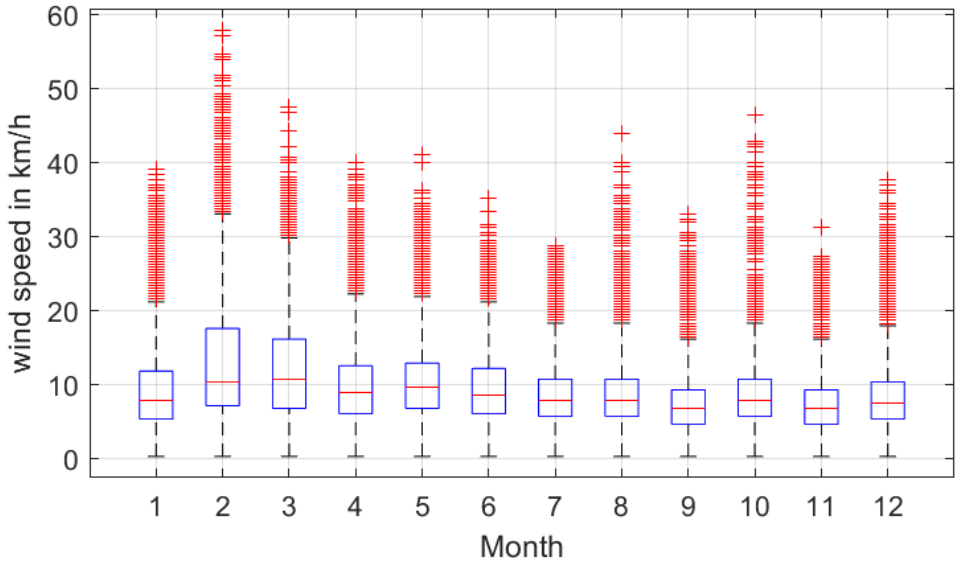

Fig. 5. Monthly wind speed in 2020 and 2021

4. Availability and Visibility Analysis

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Visibility

- CFC between 60% and 80% expected in Central Europe

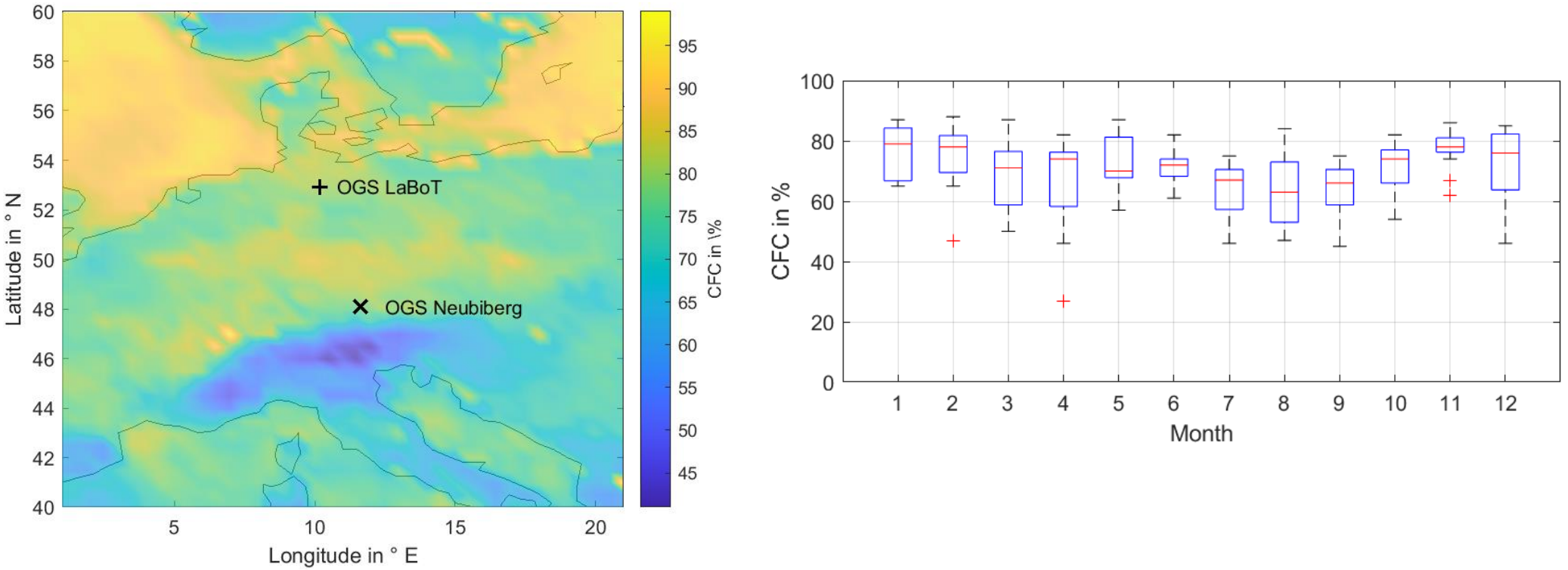

Fig. 6. CFC over Central Europe one-year average (left) and monthly average (right)

5. Conclusion

- Presentation of technical details and scientific objectives of the OGS at the University of the Bundeswehr Munich
- Realization of high speed up- and downlink
- Testbed for end-to-end over-the-air (OTA) measurements