

ERATOSTHENES Centre of
Excellence (ECoE)



ERATOSTHENES:

Excellence Research Centre for Earth Surveillance
& Space-Based Monitoring of the Environment

1st virtual EXCELSIOR International Technical Workshop

15 July 2020

Optical communications from Space to Ground



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DLR Space Operations and Astronaut Training



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This project has received funding from the Government of the Republic of Cyprus through the Directorate General of the European's Programmes, Coordination and Development

CONSORTIUM



Why optical communications in space?

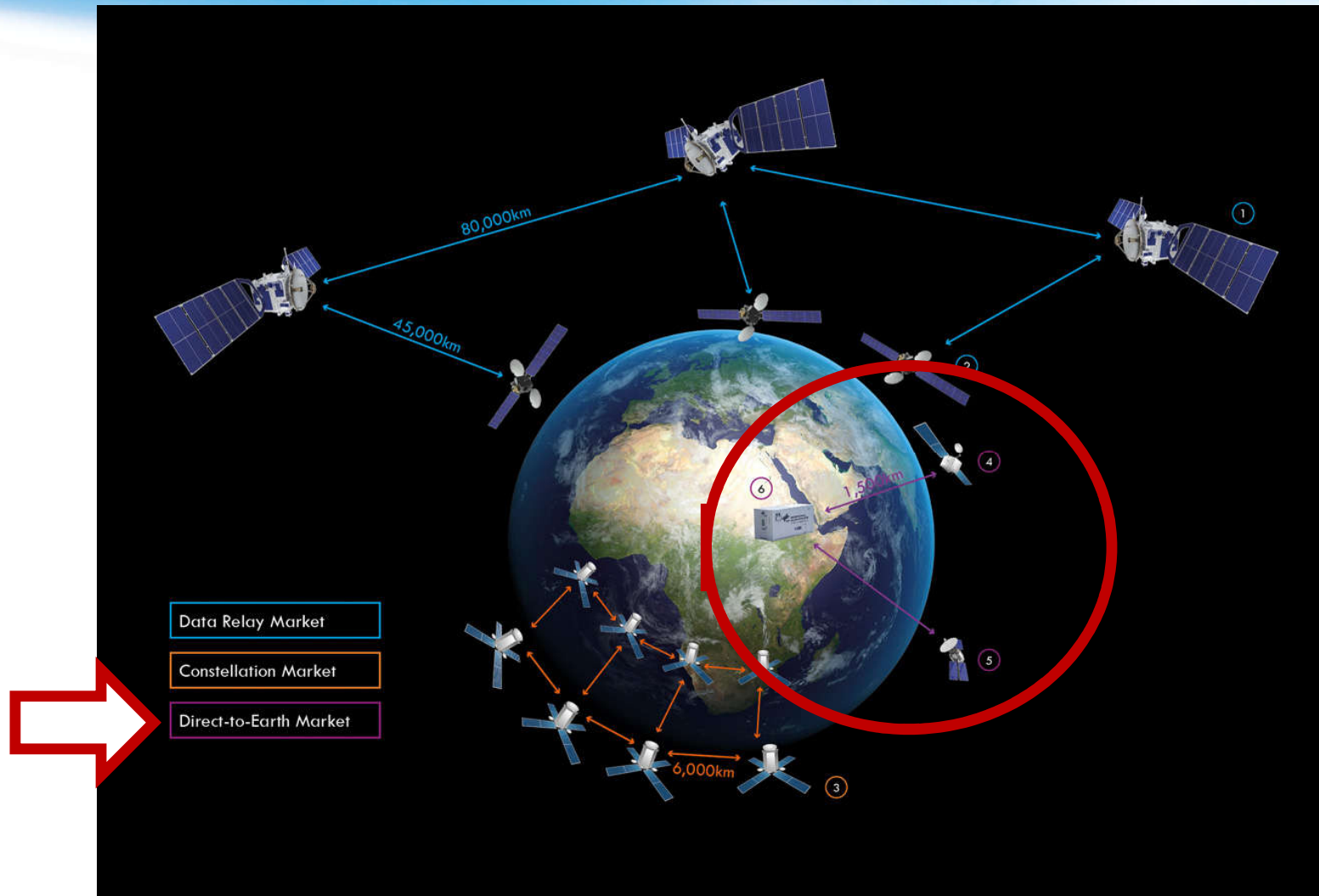
The status quo in RF communications

- Microwave spectrum has become a highly limited resource
- Demand for bandwidth and capacity is ever increasing

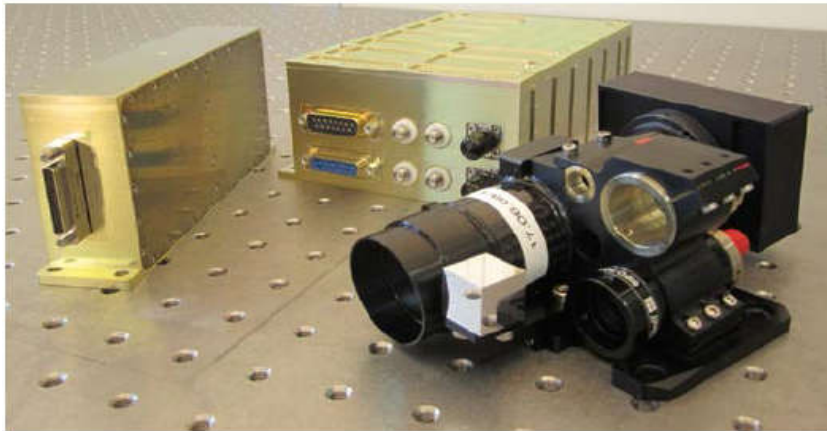
The future is optical

- Data rates in the Terabits per second range possible
- No frequency regulation
- Robust security
- Lightweight and power-efficient

Optical Space Communications



DTE Optical Space Terminals (DLR/Tesat)



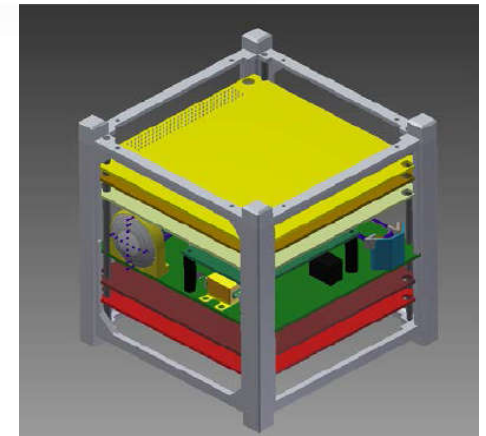
OSIRIS V2

1.65 kg, 37 W, 1 Gbps;
Closed-loop body pointing;
BIROS satellite (DLR);
Launch: 2016



OSIRIS V1

1.34 kg, 25 W, 200 Mbps;
Open-loop body pointing;
Flying Laptop satellite
(University of Stuttgart);
Launch: 2017



OSIRIS-4-CubeSats

250 g, 8 W, 100 Mbps;
Active beam steering
& body pointing;
CubeL satellite (Tesat
Spacecom);
Launch: 2020

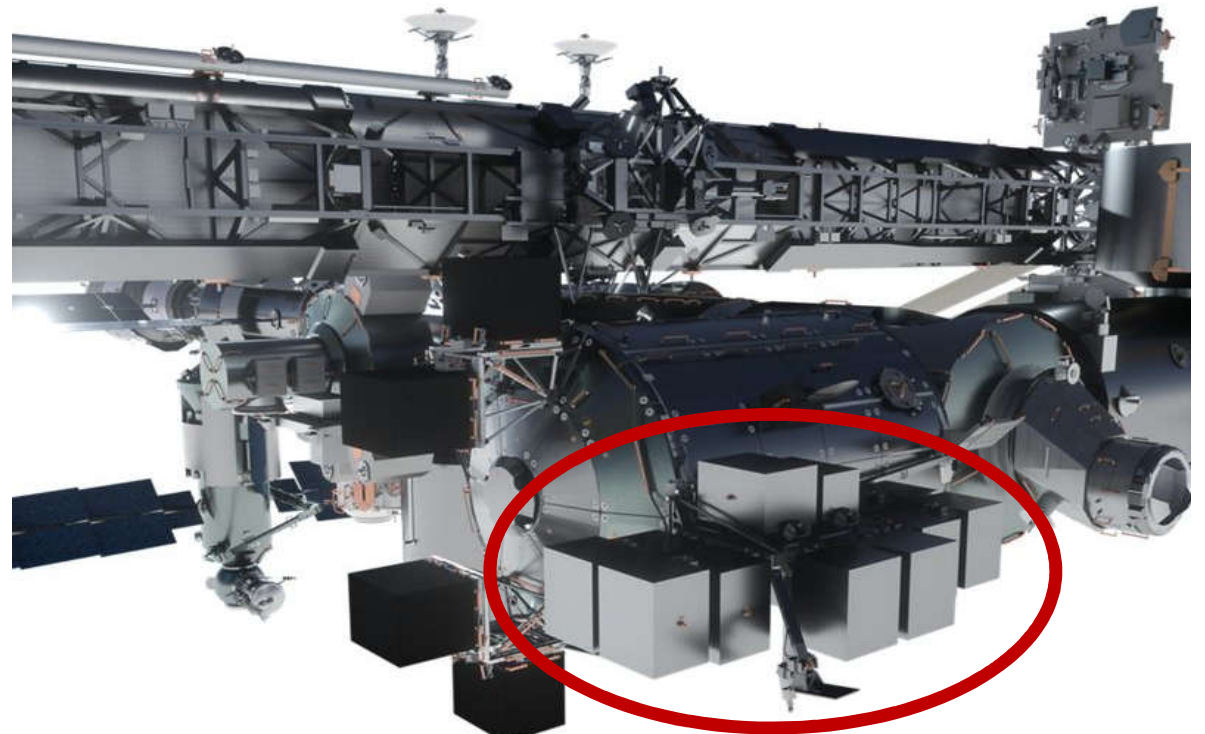
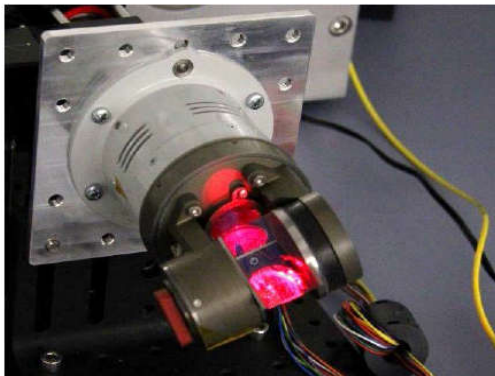
DTE Optical Space Terminals (DLR/Tesat)

OSIRIS V3 (TOSIRIS)

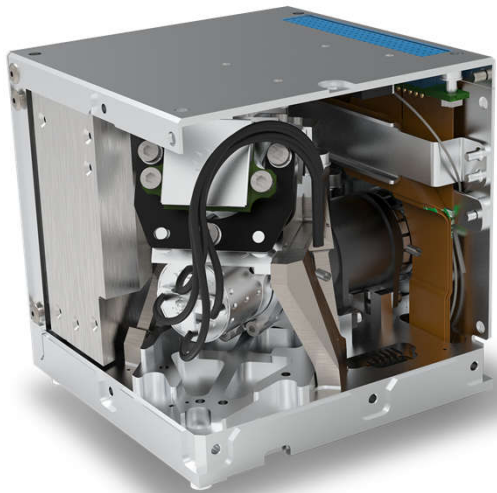
< 5 kg, 50 W, 10 Gbps;

Dedicated CPA; On-Board storage and computer;
Bartolomeo aboard ISS / Columbus (Airbus);

Launch: 2021



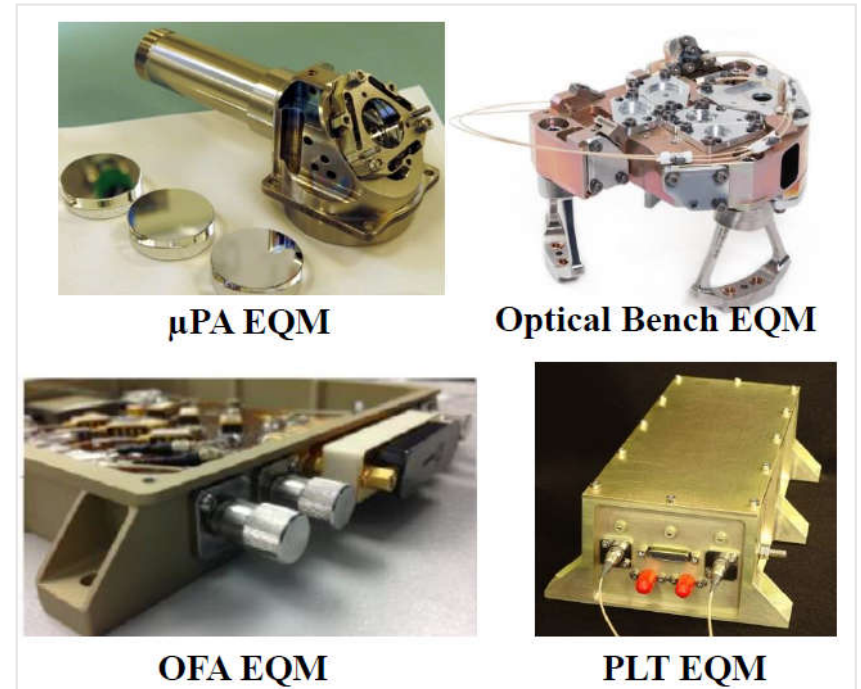
More DTE Space Terminals (Europe)



CubeCAT (TNO)
<1 U, 15 W, 1 Gbps;
On-Board storage;
Launch: TBD

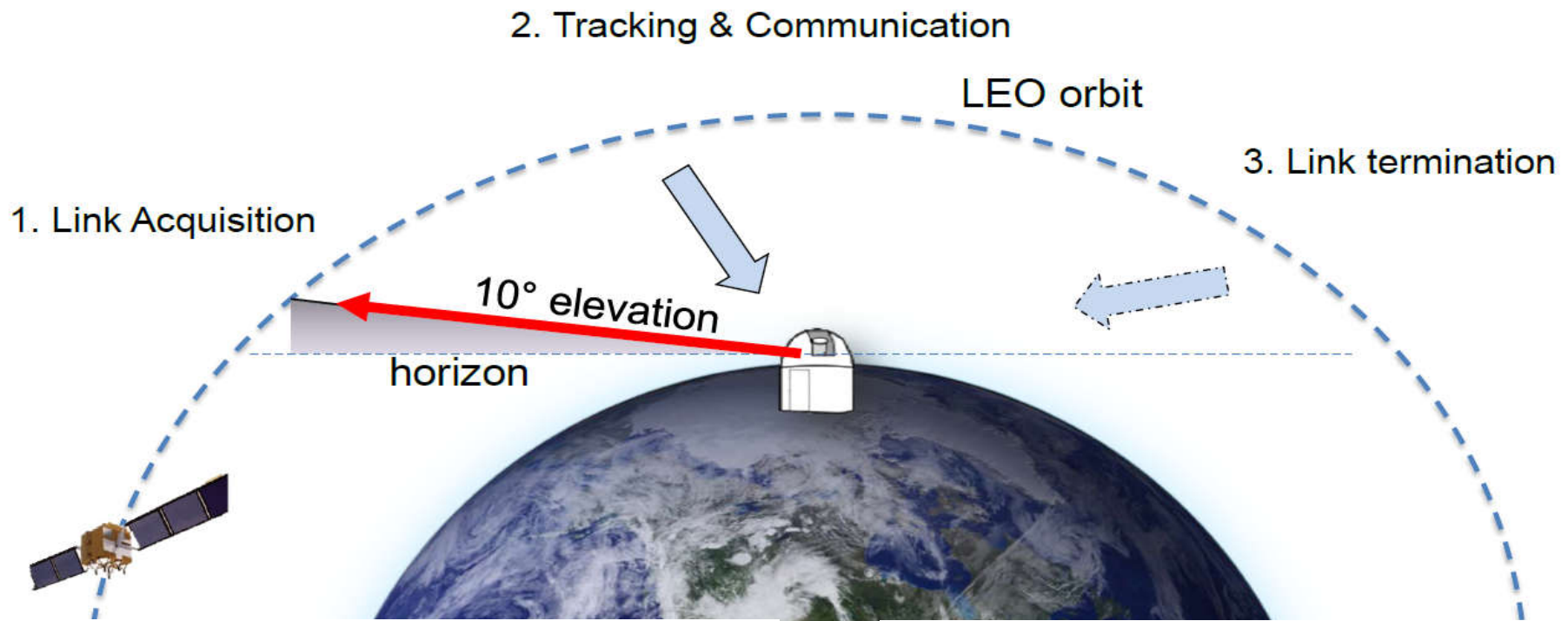
© FSO Instruments (2020)

Optel- μ (TAS)
8 kg, 43 W, 2x 1 Gbps;
Dedicated CPA;
On-Board storage;
SICH2.1 (Yuzhnoye);
Launch: 2020



© Thales Alenia Space (2015)

Direct-to-Earth Optical Downlinks



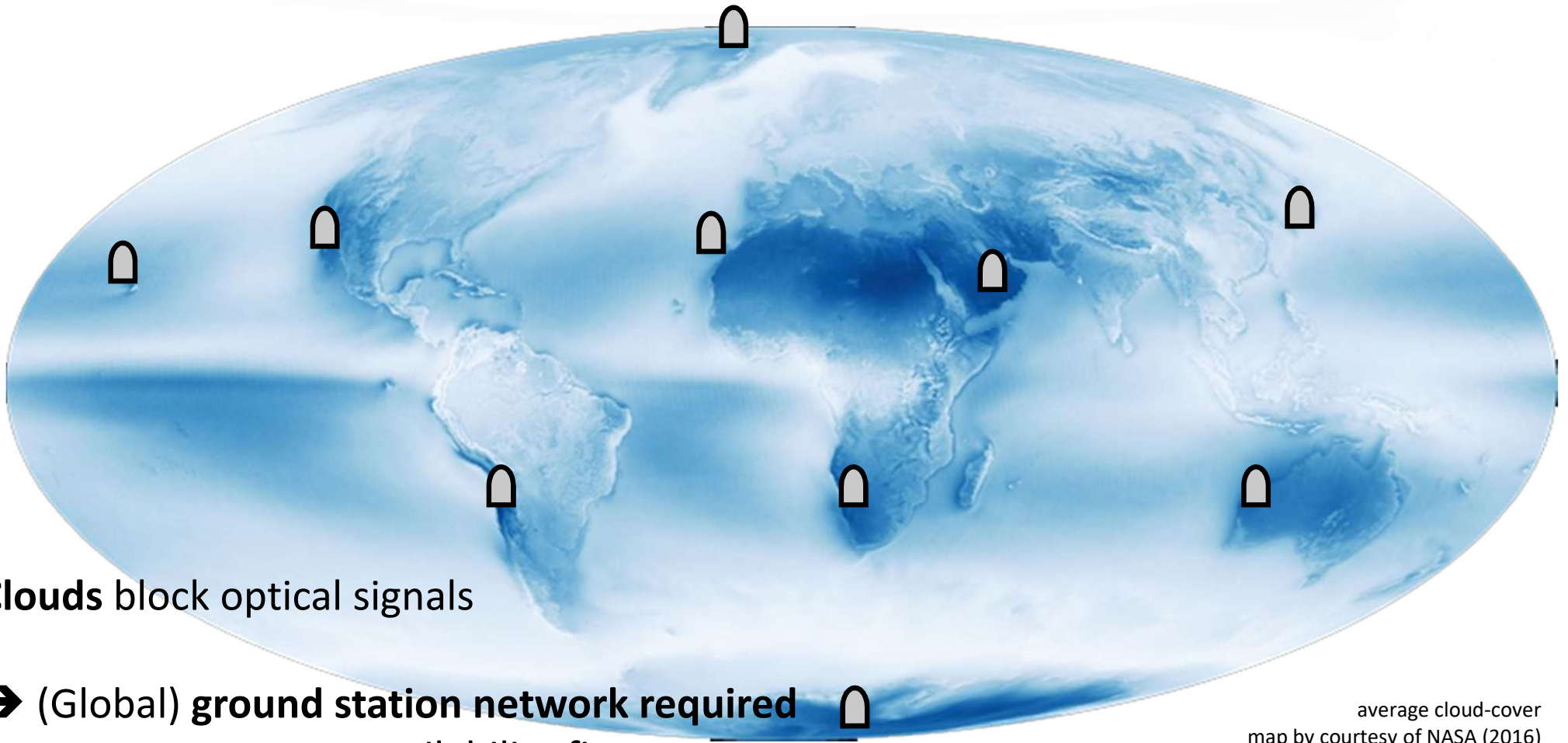
Index-of-Refraction Turbulence (IRT) deteriorates the signal on its way through the atmosphere

➔ Decent channel coding (FEC)

Variable link distance causes signal strength at the receiver to be highly dynamic

➔ Robust transfer schemes (IM/DD)

Availability of Optical LEO Downlinks

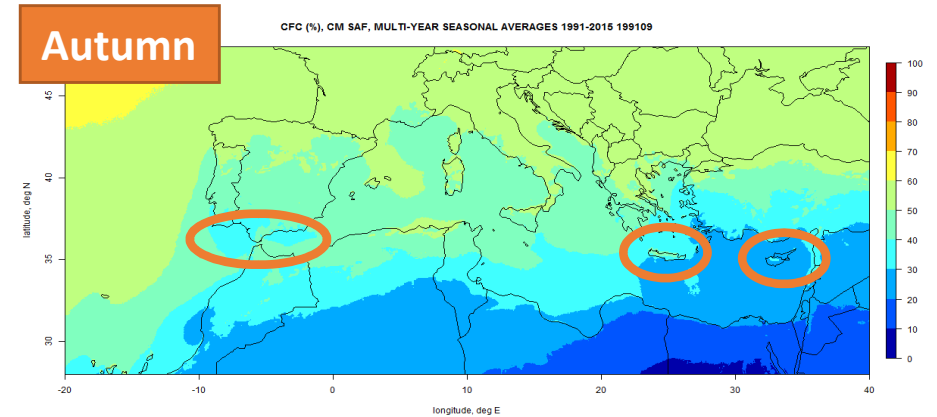
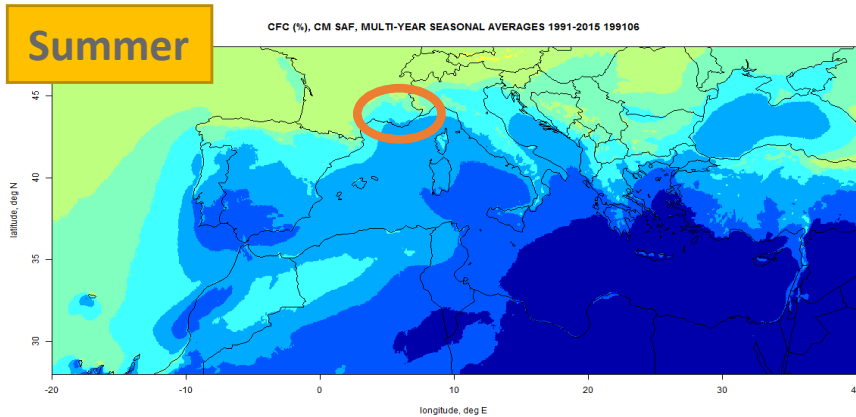
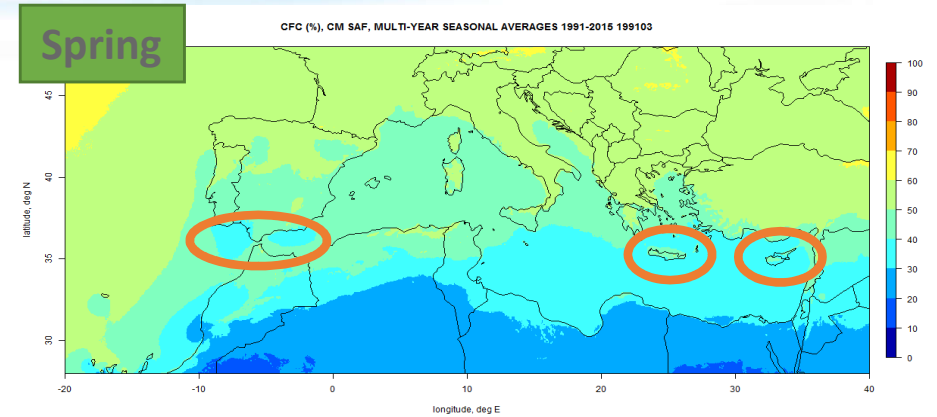
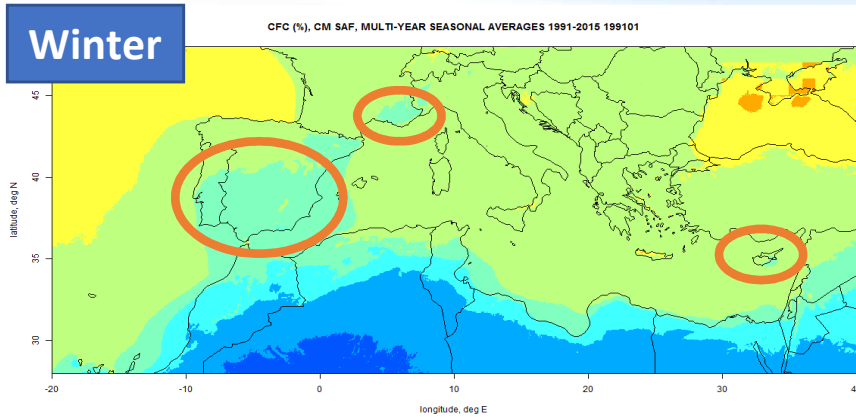


Clouds block optical signals

→ (Global) **ground station network** required
to ensure customary availability figures

average cloud-cover
map by courtesy of NASA (2016)

Cloud Cover Statistics in the Mediterranean



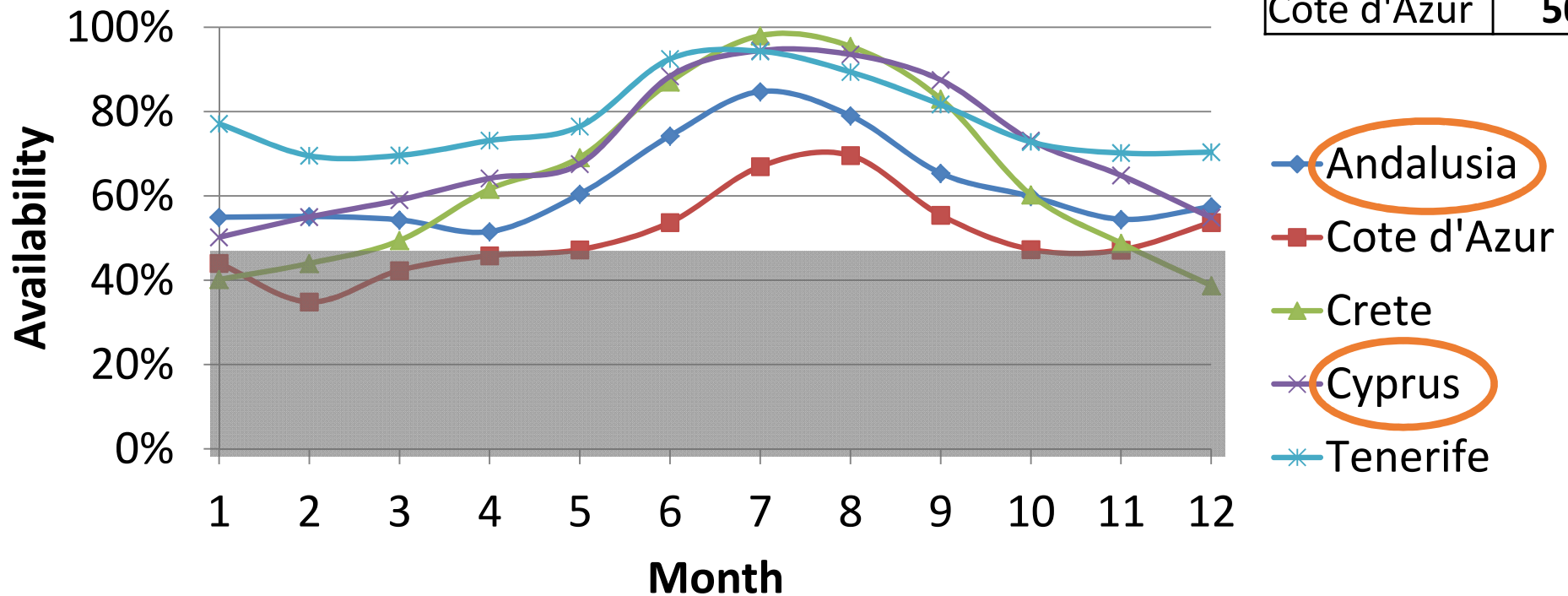
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➔ European **nucleus** of a global network has been initiated by ESA, DLR and KSAT

Station Availability Comparison

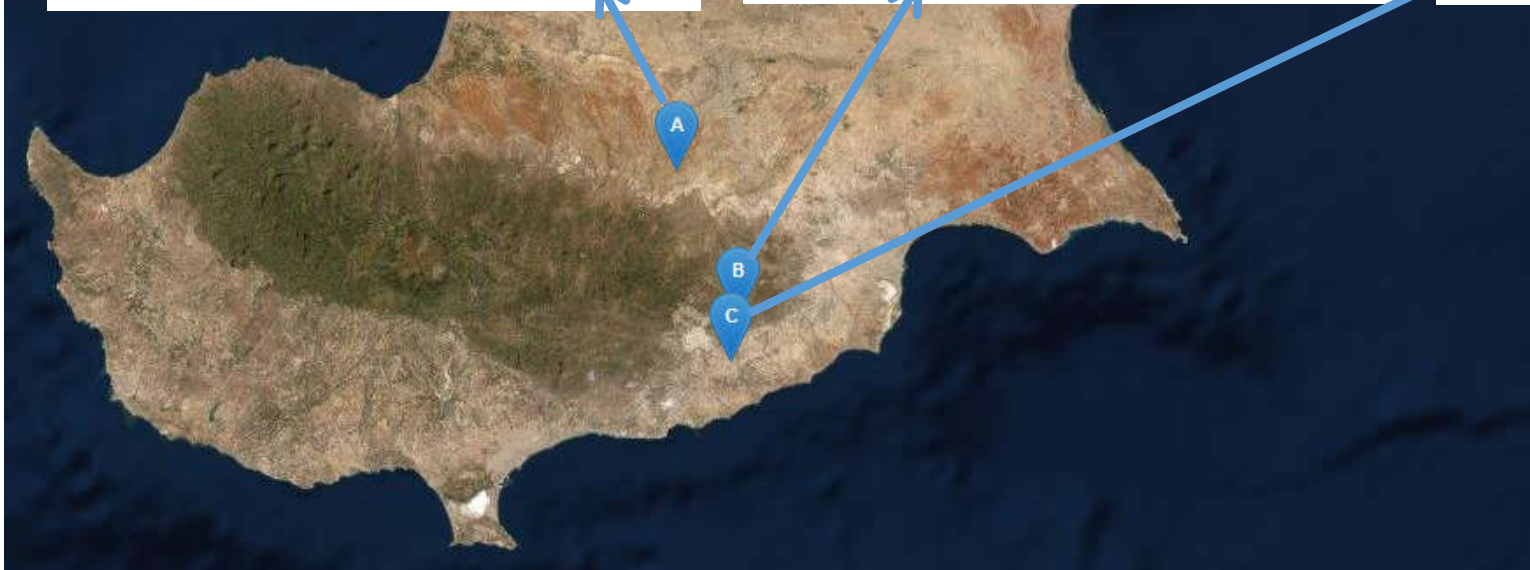
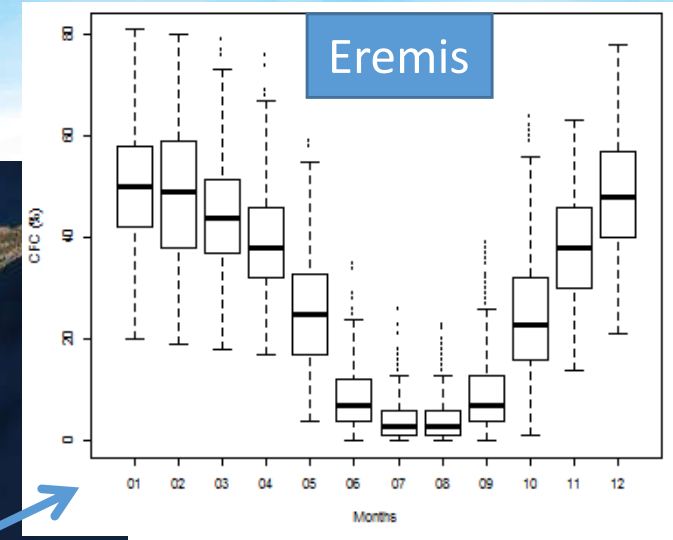
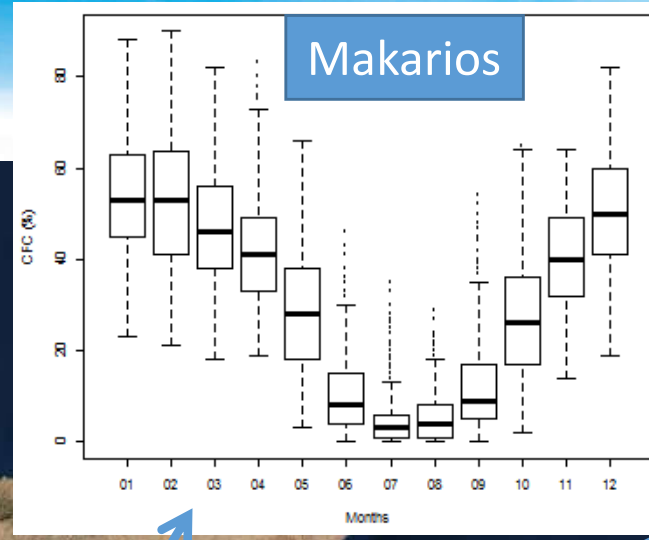
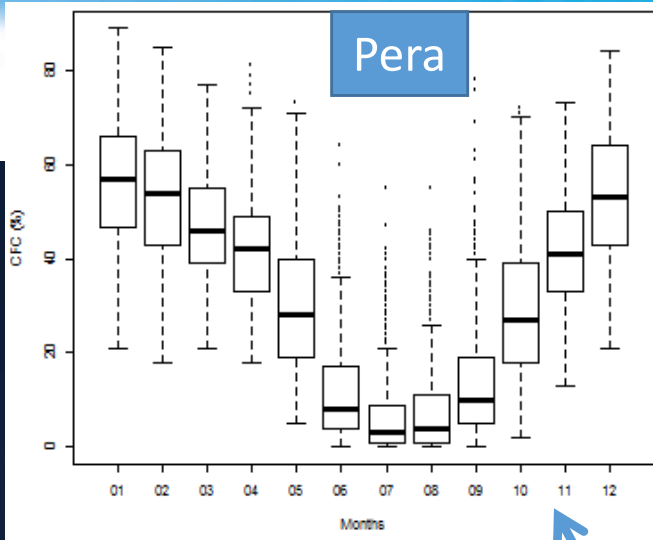
Station	Overall Avg.
Tenerife	78.33%
Cyprus	71.37%
Crete	65.08%
Andalusia	62.89%
Cote d'Azur	50.90%

ONUBLA Simulation (2009 - 2017)



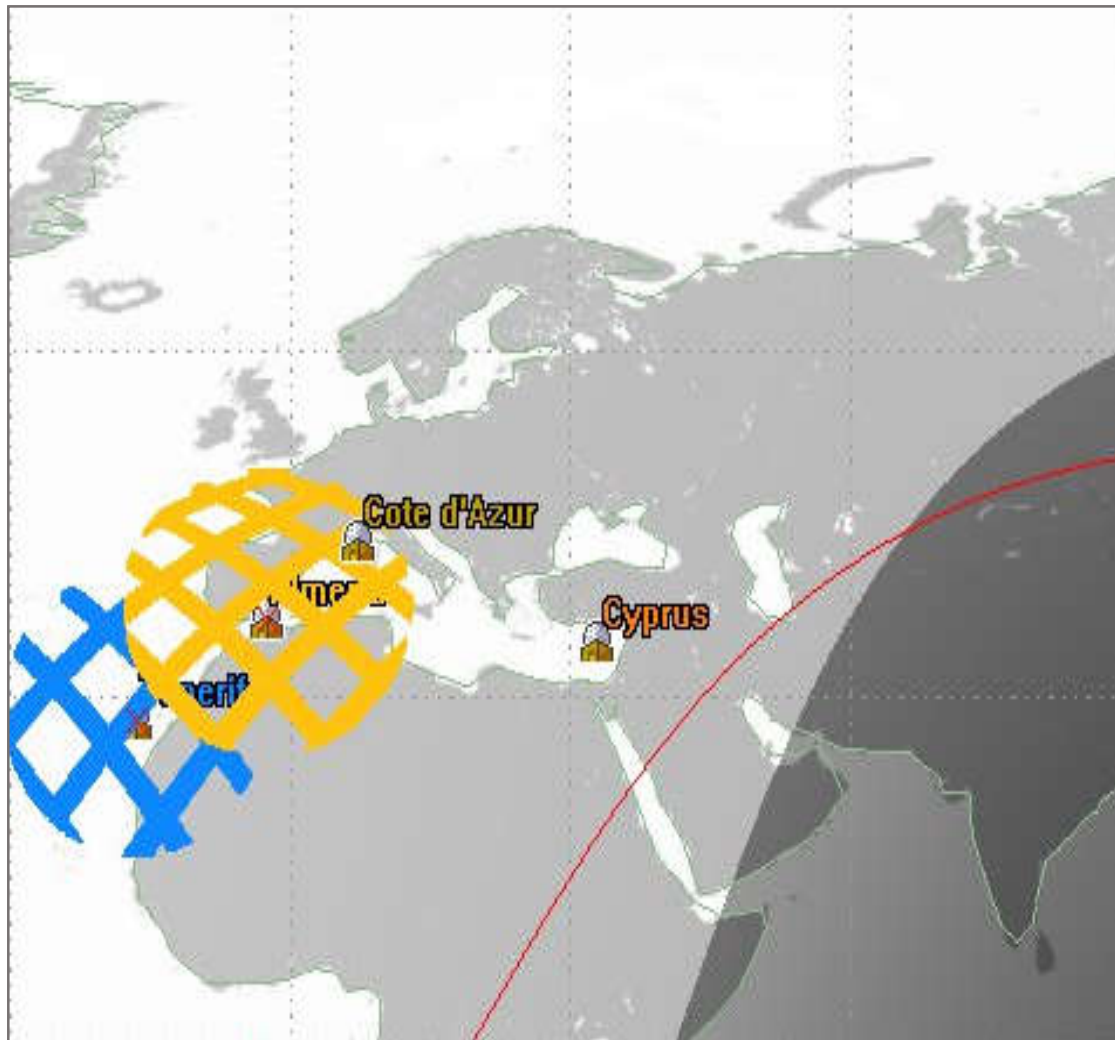
Analysis by courtesy of C. Fuchs (DLR-KN)

Station Availability Cyprus



Station	Overall Avg.
Pera	71.37%
Makarios	70.83%
Eremis	71.75%

Visibility at Selected Sites



ISS Orbit

Apogee: 409 km

Perigee: 402 km

Inclination: 51.6°

AoP: 17.9°

RAAN: 147.8°

Mean Anomaly:
 342.2°

1 month period

Free-space Optical Ground Antenna Tabernas – FOGATa



Remote OGS in Almeria

- Fully fletched ground station (including dome, sensors, etc.)
- Stationed at PSA in collaboration with DLR-SF and CIEMAT
- Remotely controlled from WHM
- Automated operations in the mid-term
- Contribution to nucleus OGS network (with ESA, KSAT)

THANK YOU FOR YOUR ATTENTION

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Proposal acronym: EXCELSIOR



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