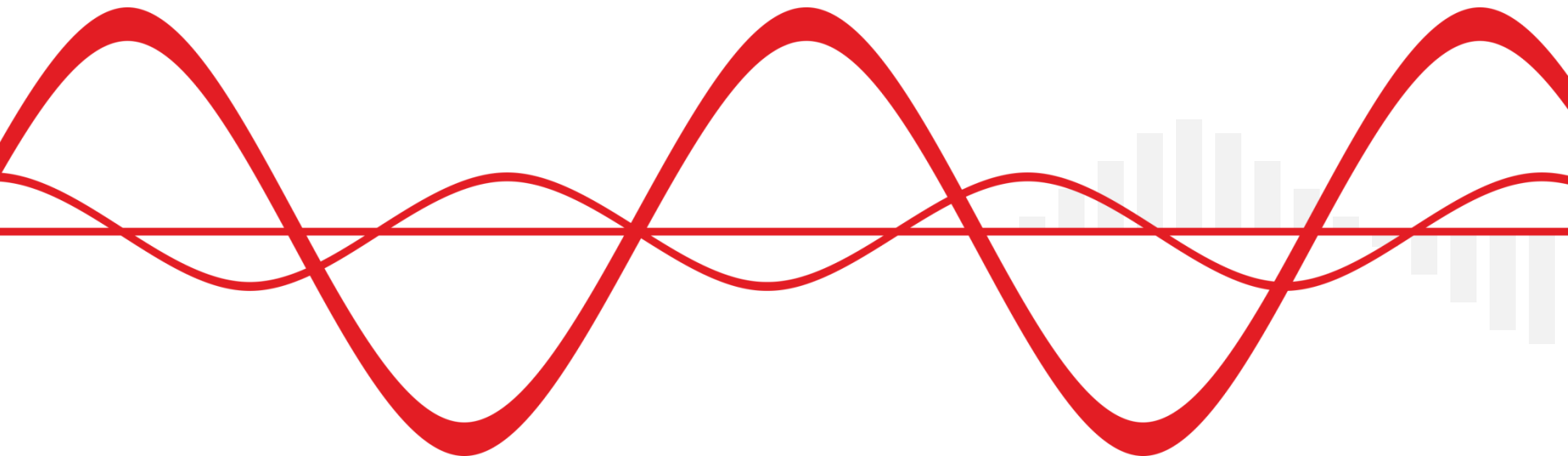


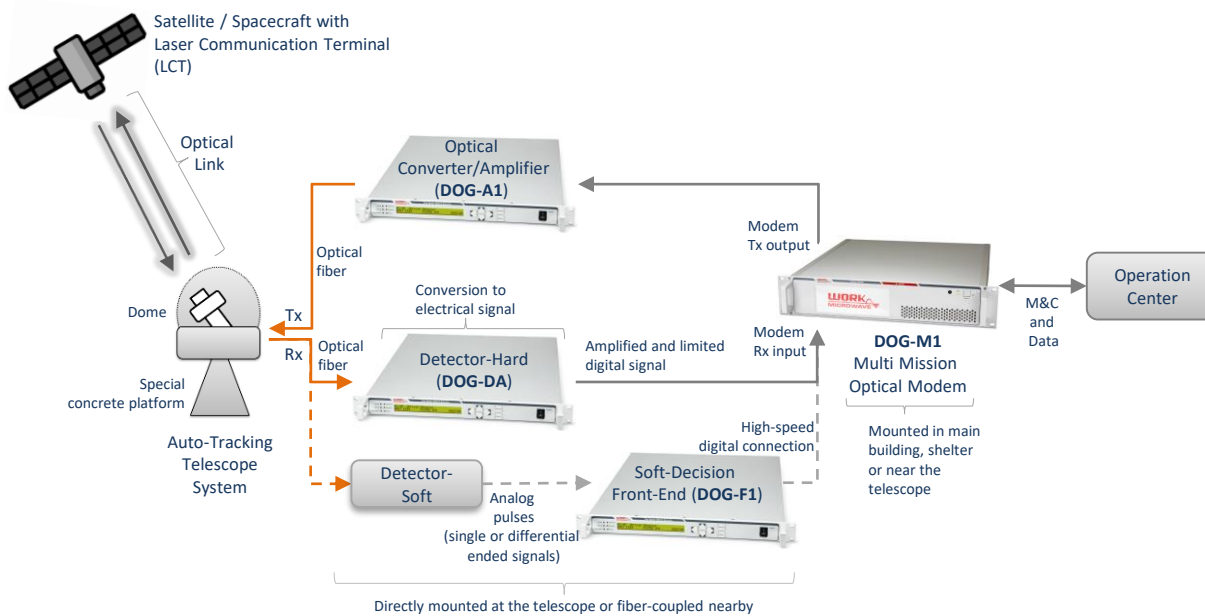


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# Digital Optical Groundstation

Overview





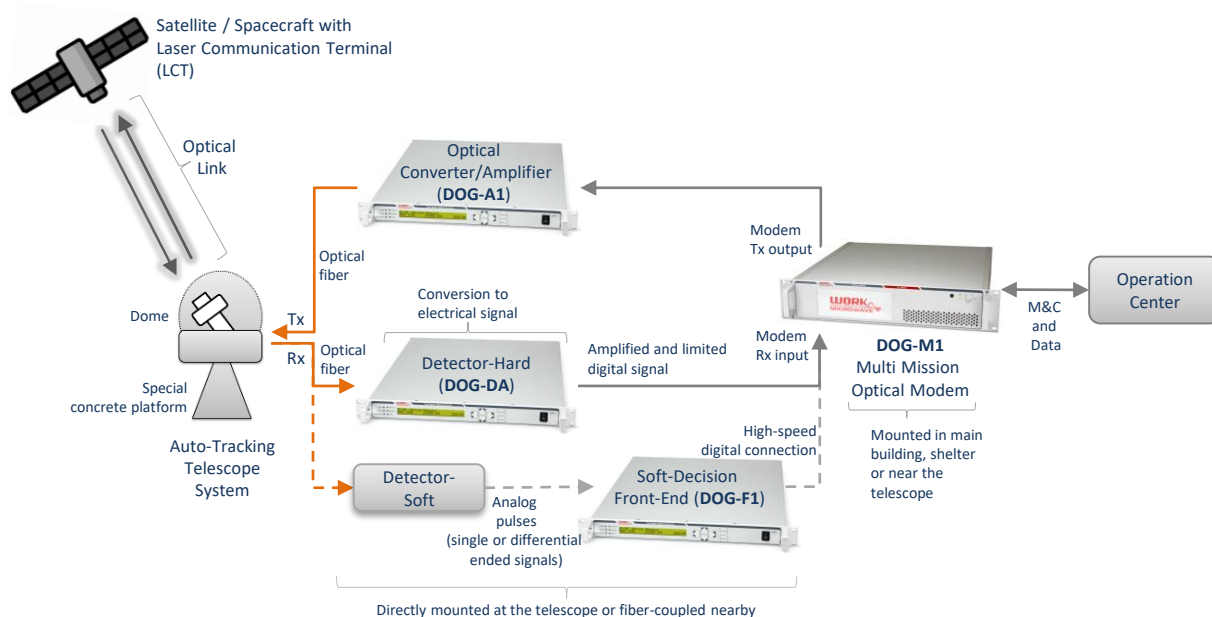
## What is DOG?

WORK Microwave's **Digital Optical Groundstation (DOG)** is a revolutionary end-to-end solution to establish **multi Gbaud & Gbit** optical links for both space-to-earth and earth-to-space directions.

It is a worldwide unique, field-proven commercial solution for ground segment.

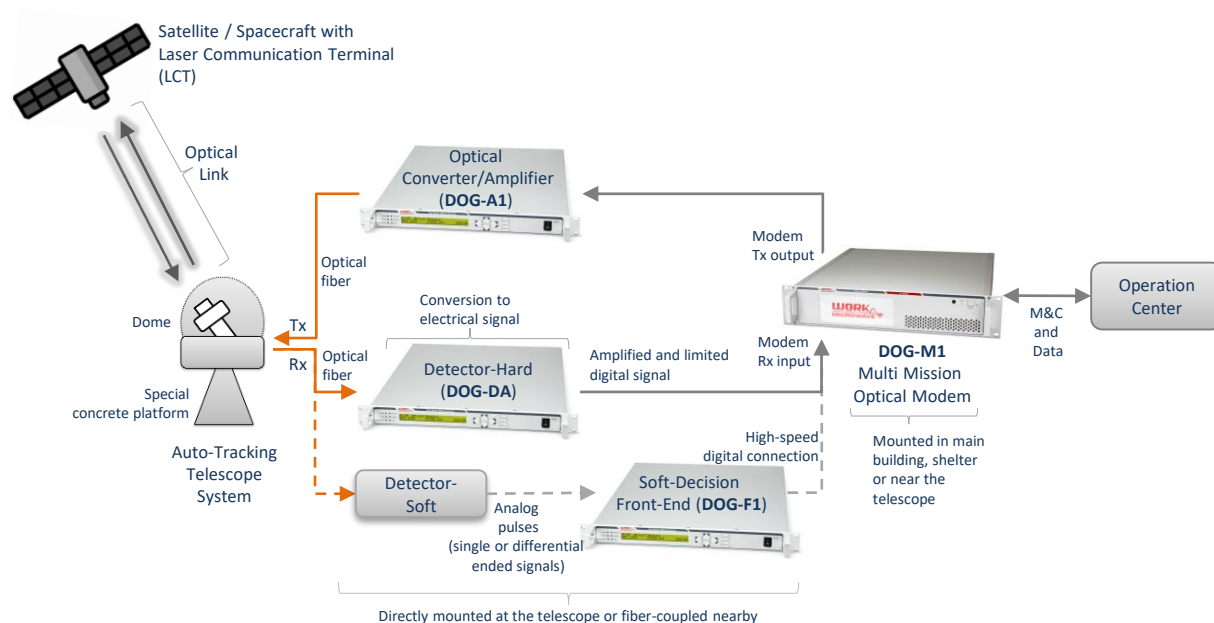
The main components of DOG are:

- multi-mission optical modem supporting both hard-decision and soft-decision decoding,
- optical detector,
- optical amplifier
- telescope sub-system.



As a comparison with classical RF ground stations, WORK Microwave's optical communication engineers created a very **compact and optimized ground station architecture** to eliminate large area need, complexity, extra converters and amplifiers.

The all indoor equipment can be mounted in small rack cabinets.



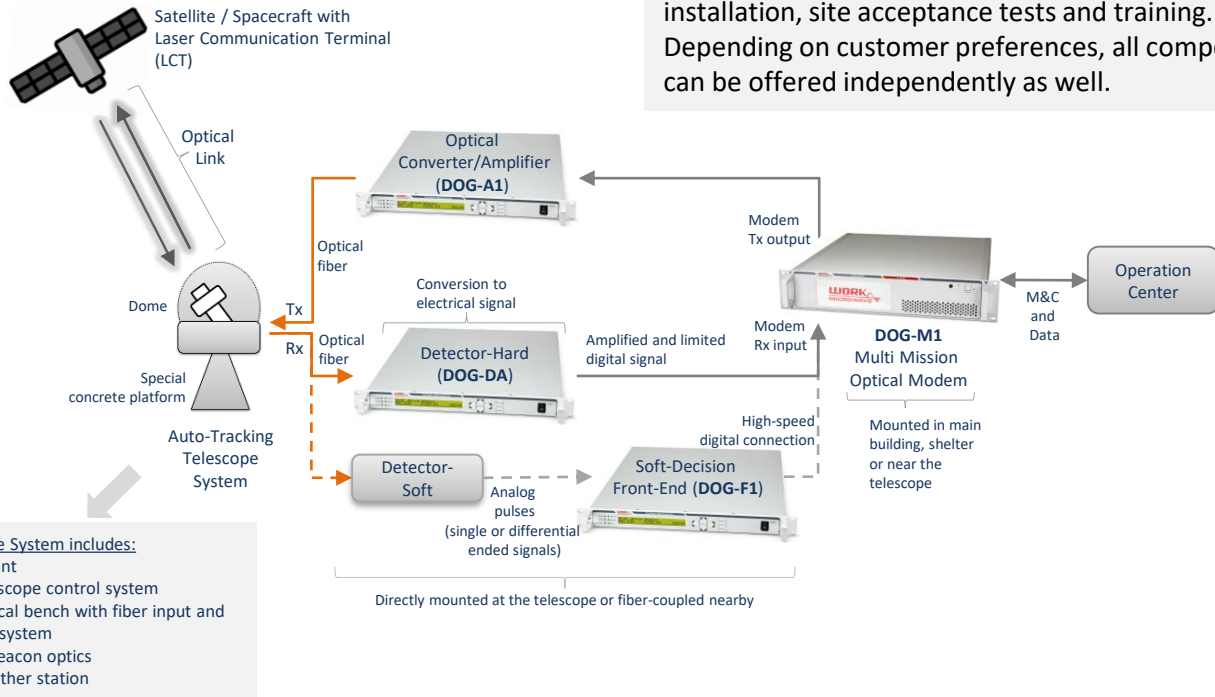
## Turnkey Solution incl. System Integration Services



### Digital Optical Ground Station

#### DOG's System Integration

- Program management
- Customized system design
- Optical link budget analysis
- Site selection
- Site survey
- Soil analysis
- Civil works
- Shelter & system room
- Power distribution
- Weather station
- Installation & Integration
- Site acceptance test
- Training on site



WORK Microwave provides system integration services for the Digital Optical Groundstation (DOG) including program management, customized system design, link budget analysis, site selection, civil works, installation, site acceptance tests and training. Depending on customer preferences, all components can be offered independently as well.

## Site Selection for DOG



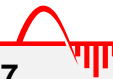
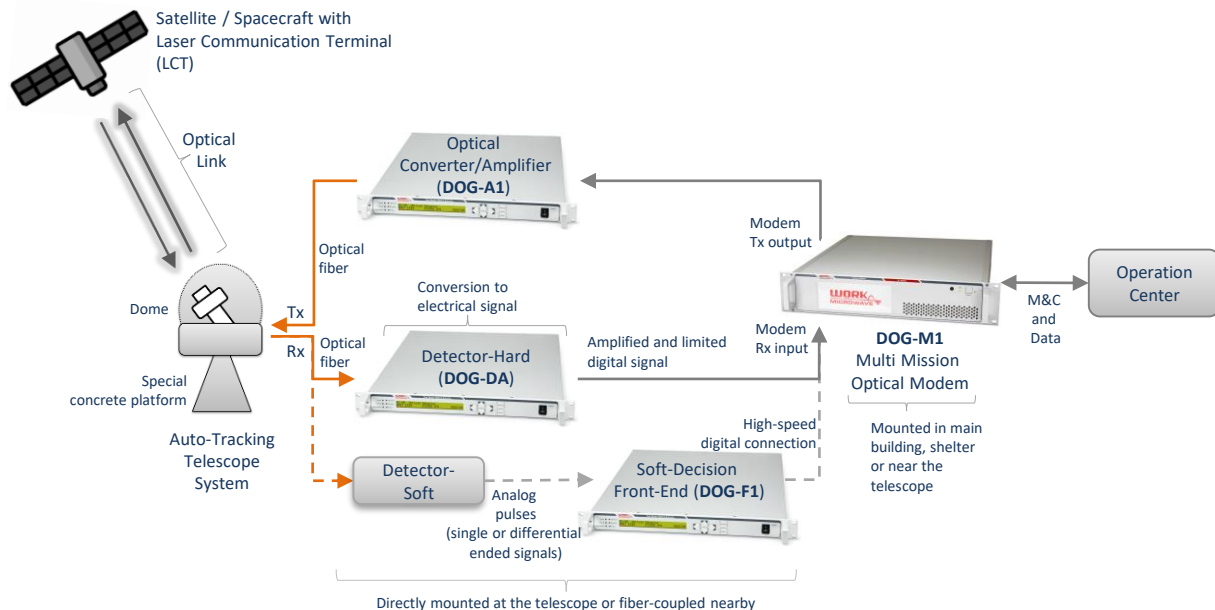
Site selection is more complex and critical process for an optical ground station than a RF ground station. Because free-space optical communication (FSO) signals are very sensitive to clouds, fog and atmospheric turbulence. These weather effects can cause a significant attenuation and even interruptions on both “space to earth” and “earth to space” optical communication links.

As FSO equipment manufacturer and turnkey DOG (Digital Optical Ground Station) provider, WORK Microwave helps you to select the optimal location for installing an optical ground station by doing detailed analysis and simulations on weather conditions according to international meteorological databases.

During site selection, also the conditions like telescope`s line of sight, environmental and natural risks (earthquake, heavy wind, forest fire, flood, landslide, avalanche... etc.), soil features of the ground where the station will be installed on, are considered.



- **One stop-shop solution** to save time, reduce cost and with fast technical support: WORK Microwave offers all components, sub-systems, system integration and logistic services.
- **Customization** depending on requirements and applications: Design might be capable of Rx-only, or Tx/Rx. Also different optical wavelengths, waveforms, bandwidths are possible.
- **Compact solution:** DOG needs minimal space for installation of the entire station and indoor equipment, as optical modem, optical detector and optical amplifiers are designed with built-in modules, converters and amplifiers.
- **High speed and symbol rate:** DOG supports symbol rate up to 10 Gbaud and data rate up to 10 Gbps.
- **Future-ready:** DOG is compliant with both CCSDS (141.0-B, 142.0-B ) and SDA standards and is upgradable for future extensions like HPE (High Photon Efficiency).
- **Highest quality standards:** Like all other WORK Microwave's products and solutions, DOG has a 3 year warranty.

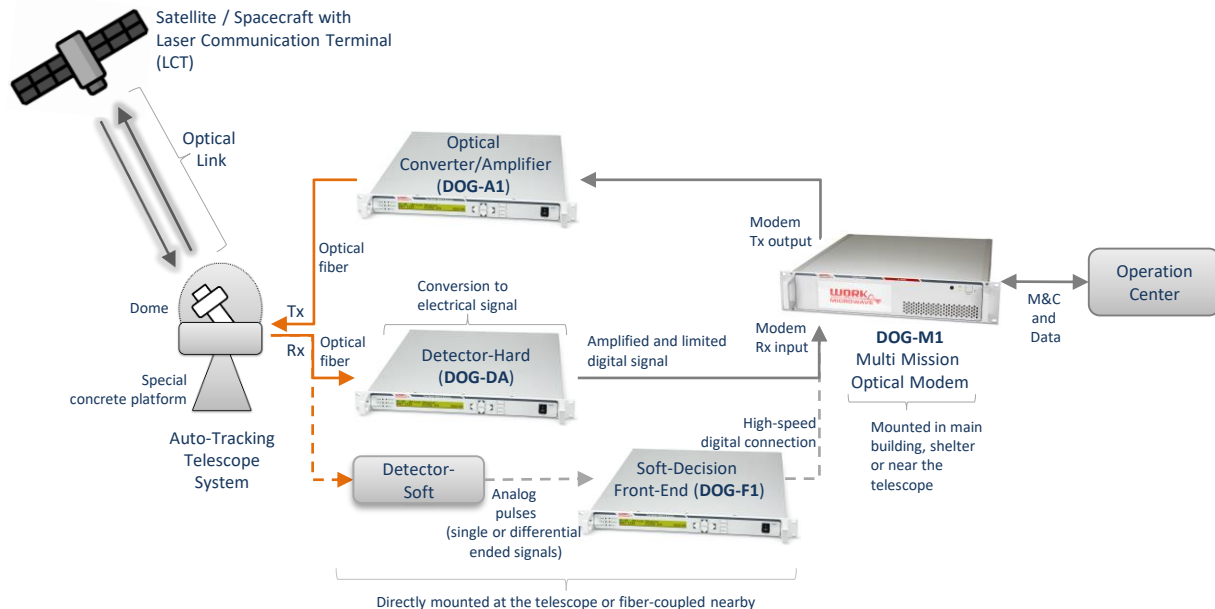


**Earth Observation:** Instead of dealing with increasing bandwidth demands in a crowded and regulated spectrum, optical communication provides more throughput with less effort. Non real-time critical data downlinks can easily leverage geo redundancy in Earth stations to overcome the occasional obstruction of the optical path due to weather conditions.

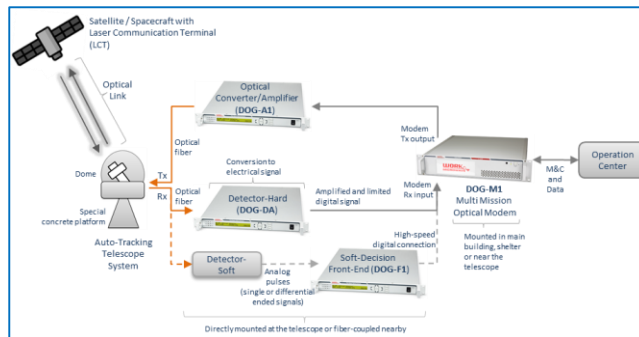
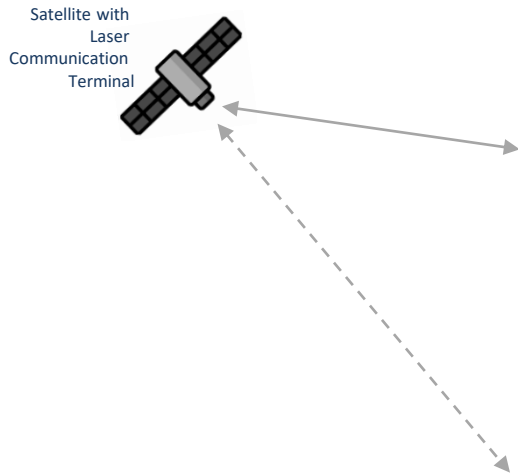
**Military satellite communication:** Due to its strong security capabilities, optical communication is a natural choice as a critical technology for military communication.

**Optical gateway links for communication:** EDRS has paved the way. Increasing bandwidth demand in communication will make optical gateway links a powerful tool in the support of RF infrastructure, be it as overlay system or using geo redundancy the combination of optical and RF communication will provide the throughputs that make satellite systems a prime network option.

**Deep Space data transfer to Earth:** DOG supports commercial and scientific missions transferring data from Deep Space to Earth. WORK Microwave is proud to be part of the ecosystem that will revolutionize the exploration of outer space.



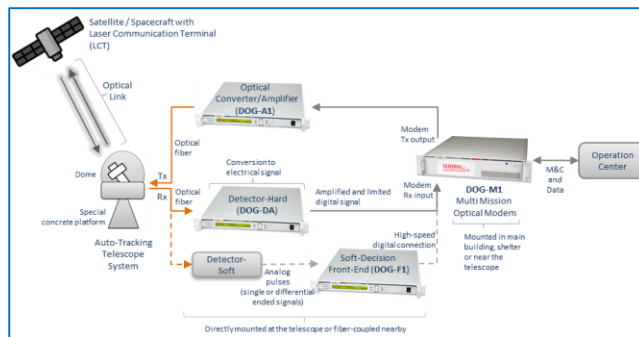




Main station

As optical signals are very sensitive to weather conditions, geographical redundancy can be preferred to increase the link availability.

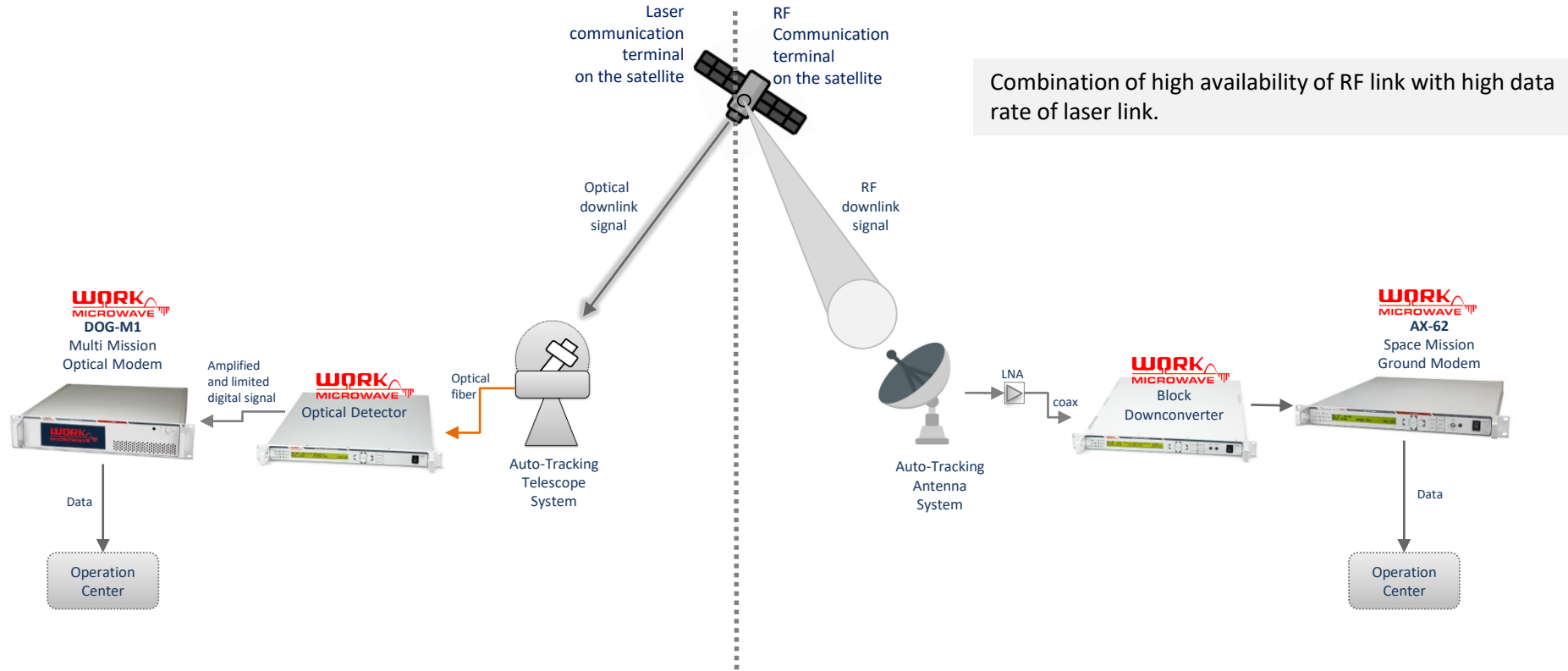
WORK Microwave helps you to find suitable locations for the redundancy, by analysing meteorological conditions and considering the optimal distance between the ground stations.



Redundant station



# Hybrid “Optical & RF” application example





## References & Relevant Experience

The following table shows the specific experience and development activities which are relevant to optical communication between earth and space.

Year	Mission / Project	Subsystem / Product	Work Performed	Relevance
2021 to 2023 (ongoing)	ESA ARTES 4.0	M30 Optical Receive Only Modem	Development of a Customized Optical Receive Only Modem for ESA	Development of an Optical Modem capable of hard decision and soft decision decoding and of a Soft-Decision Front-End unit for respective O3K decoding according to CCSDS 142.0 standard. Technical baseline for DOG-1 modem product.
2020	PIXL-1, KSAT OGS	AR-80-OPT Optical Multi- Mission Receiver	Development of an optical multi- mission receiver	Experimental “fast track” predecessor of ESA’s M30 optical modem, with limited feature set. Relevant experience gained in device structure and hard- decision O3K operation
2017 to 2019	Internal (WORK Microwave)	AX-80 Wideband Modem	Development of a FPGA-based SDR platform capable of sampling full L- band signals and processing of DVB- S2X carriers up to 500 Msps for RX and TX	Soft-decision ADC technology built and proven up to 2.6 Gbps; device processing infrastructure up to 3 Gbps user data rate; Significant amount of customer deployments since 2018
Nov. 2020 (ongoing)	Internal (WORK Microwave)	FSOD Optical Detector	Feasibility study and subsequent product development of optical detectors	Amplified and limited detector for hard-decision signals up to 10 Gbps, resulted already in first detector product; Will allow WORK Microwave to evaluate error behavior from the detector as part of the channel model as well as consider further steps towards a later integration into the modem if desired as part of ground station installations; The FSOD optical detector line was derived from that development and already has been deployed.

### DOG-M1 Multi-Mission Optical Modem

A DOG modem dedicated to support the processing of optical links between space and Earth.



- Proven device infrastructure for commercial operation
- Multi-Mission support
- Hard-Decision and Soft-Decision (de)coding
- Optical On-Off Keying (O3K)
- Support of **CCSDS** 141/142 standards
- Support of **SDA** standard
- Support of **TESAT** specific signals (TOSIRIS, CubeLCT...)
- User data rates up to **10 Gbps**
- O3K symbol rates up to **10 Gsps**
- High-Photon-Efficiency (HPE) future upgradable extension
- Possible remote extension to other proprietary signals

### DOG-DA Free Space Optical Detector

Fibre-coupled Free Space Optical Detector FSOD for the reception of optical free space communication.



### DOG-A1 Free Space Optical Amplifier

Free Space Optical Amplifier FSOA for the transmission of optical free space communication.



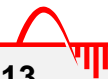
### DOG-CA Electrical-Optical Converter

Electrical optical converter to provide optical signal for outdoor type FSOA units.  
(Can be connected up to 4 amplifiers)



### DOG-F1 Optical Modem Front-End

A DOG digitizer to enhance the DOG-1 Multi-Mission Optical Modem.



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