# MOHA:

# the MIRAS Optical Harness for SMOS


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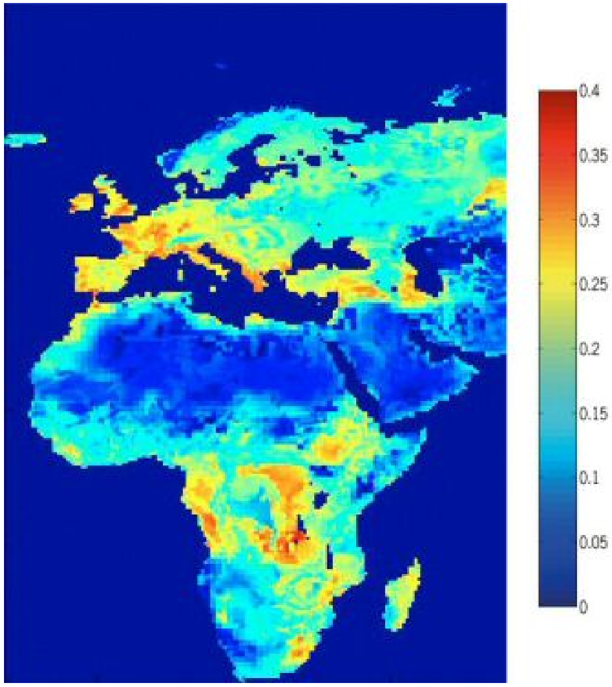
# Outline

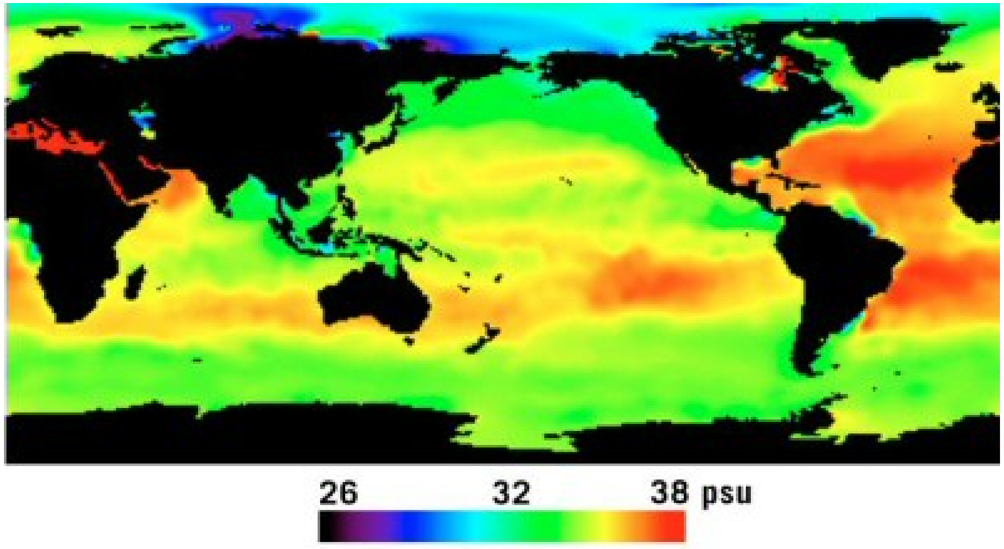
- **The SMOS mission and the MIRAS payload**
- **MOHA – The MIRAS Optical Harness**
  - Function
  - Hardware
- **Challenges and solutions**
- **MOHA status and test results**
- **Conclusion**

## To provide global maps of soil moisture and ocean salinity

- Global soil moisture and ocean salinity data are vital for improving our knowledge of Earth´s water cycle.
- Better forecasts of weather, extreme events, and seasonal climate can be expected.



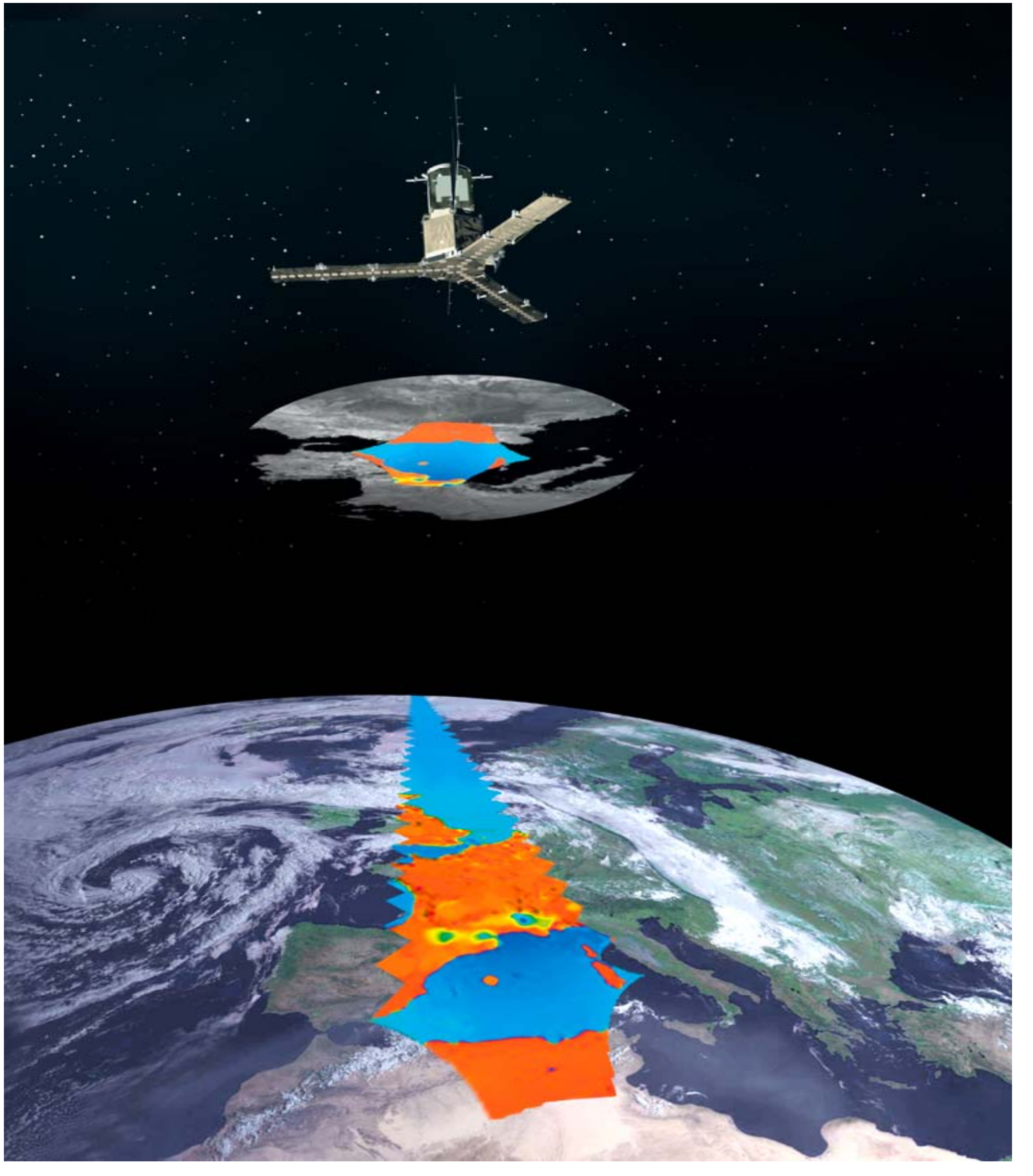

Soil moisture map




Ocean salinity map

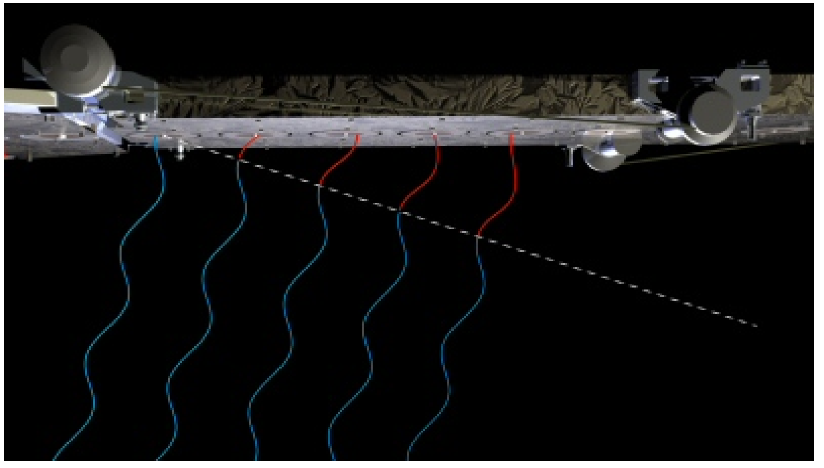
# Measurement Principle

- Moisture and salinity decrease the emissivity of soil and seawater respectively, and thereby affect microwave radiation emitted from the surface of the Earth.
- A two-dimensional 'measurement image' is taken every 1.2 seconds
- As the satellite moves along its orbital path each observed area is seen under various viewing angles
- Due to its polar orbit at 763km, SMOS will achieve global coverage every three days



# SMOS Status

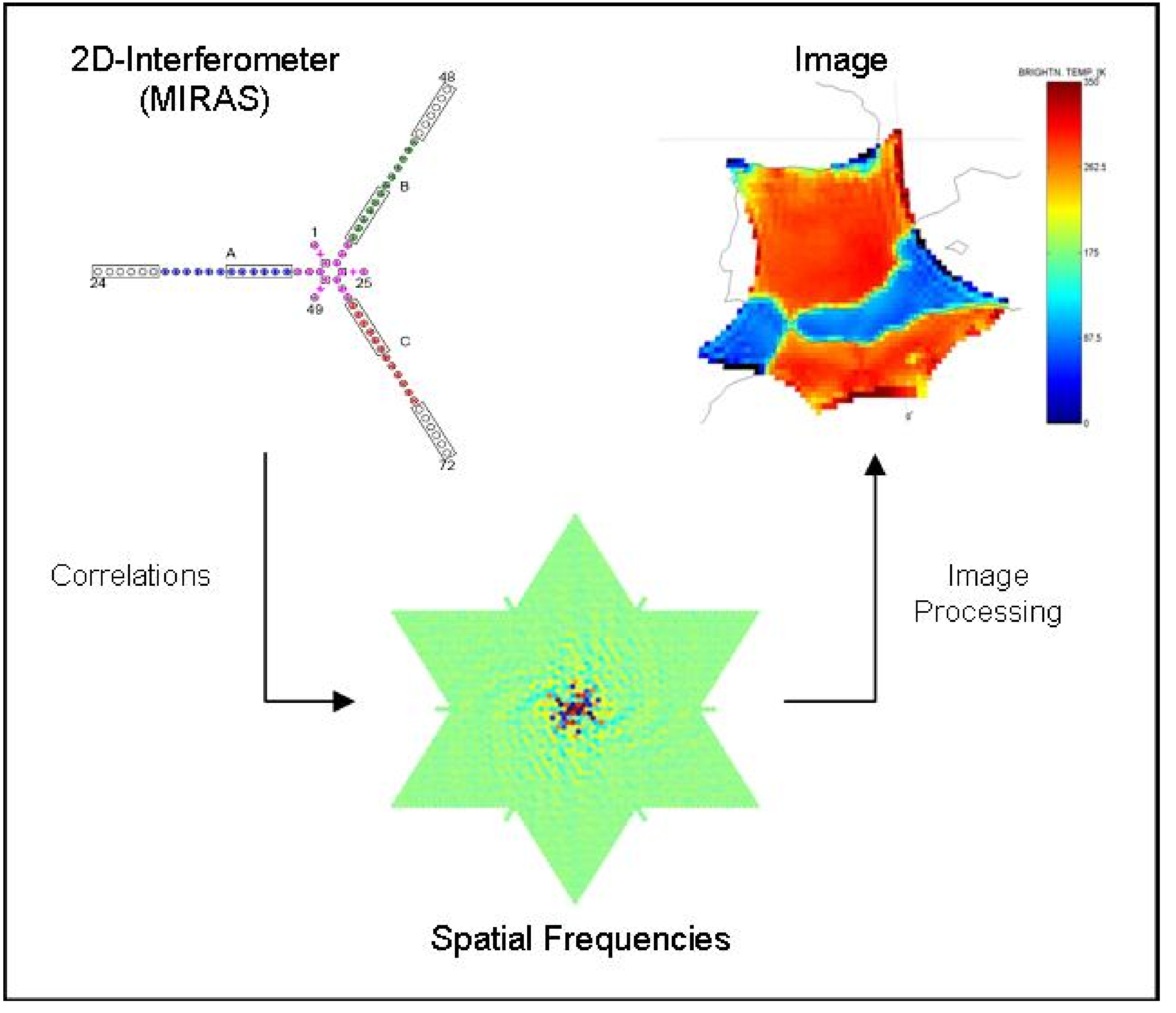
# The MIRAS Payload



- The MIRAS payload: Microwave Imaging Radiometer with Aperture Synthesis
- Exploits the interferometry principle to obtain two-dimensional radiometric images
- Operates between 1400 and 1427 MHz

- 72 small receivers (LICEF) measure the phase difference of the incident thermal radiation
- Observations from all possible combinations of receiver pairs are cross-correlated using a correlator unit (CCU)
- The image is obtained by the two-dimensional Fourier transform of the map of correlation coefficients
- Prime of MIRAS: EADS-CASA Espacio (E)

# Data Processing



# MOHA – the MIRAS Optical Harness

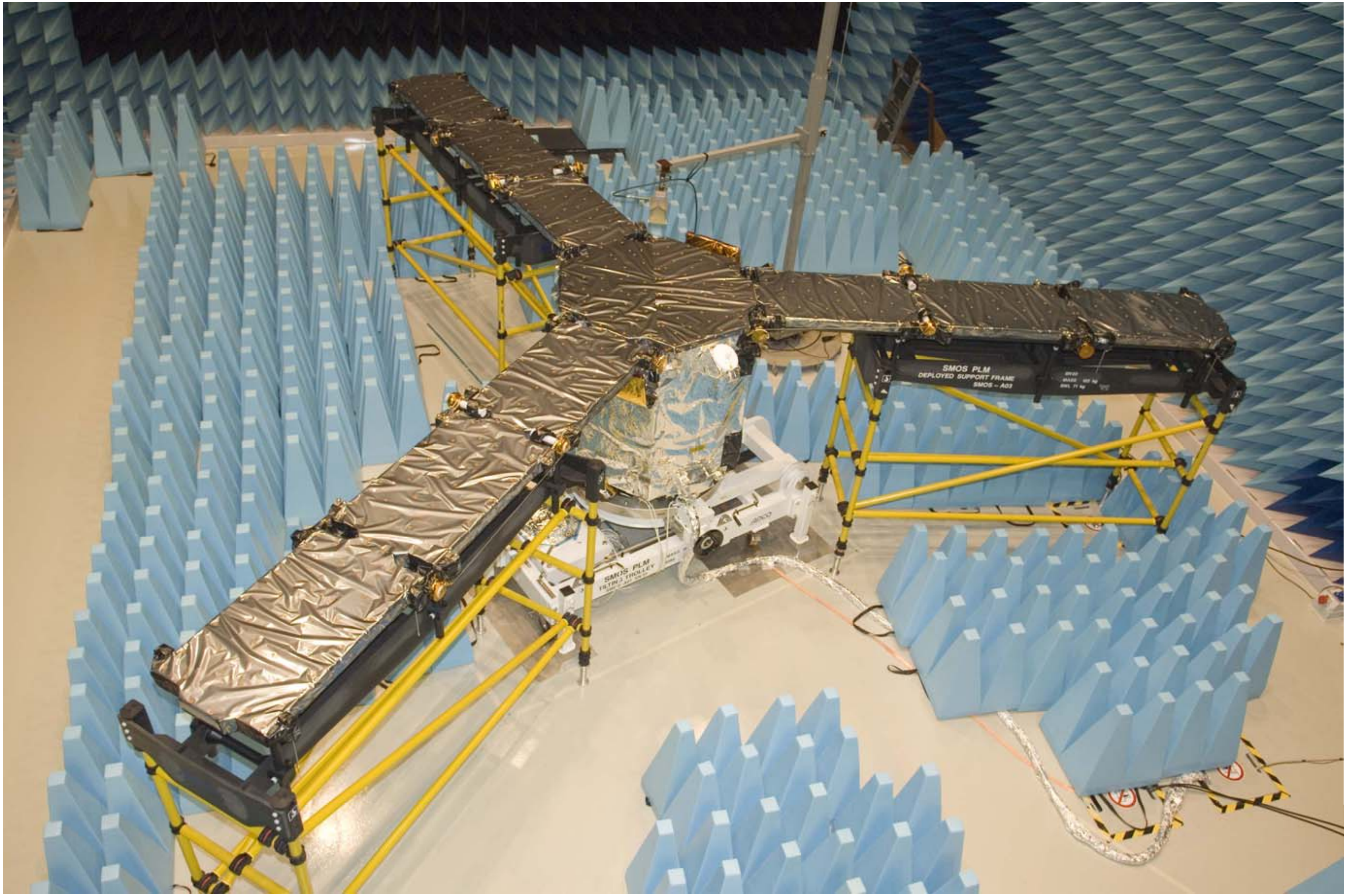
**The basic function of the MOHA Subsystem in SMOS is:**

- **To generate, and to optically disseminate a reference clock signal to 72 LICEF receivers, and to 12 auxiliary units**
- **To transmit the radiation data from the LICEF receivers to the CCU correlator unit, using 72 optical links in parallel**
- **To de-multiplex the data and to deliver it, in parallel, to the correlator via 6x72 = 432 LVDS interfaces**

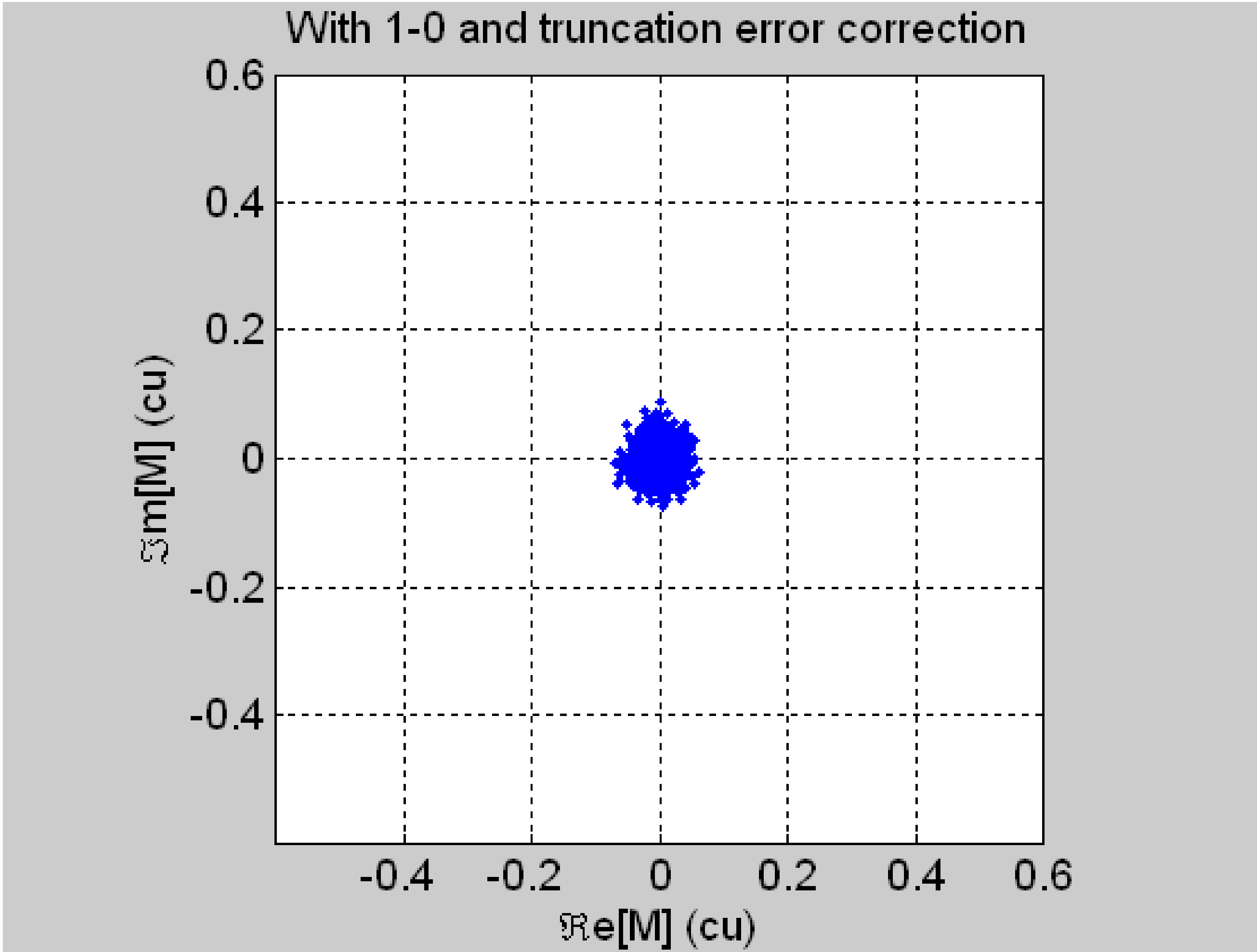
**The reasons for using an optical harness are:**

- **Very low electro-magnetic emission levels**
- **Insensitivity to ground differential voltages**
- **Galvanic isolation**
- **Optical cables are flexible and light-weight**
- **Better phase stability over temperature and if bended**

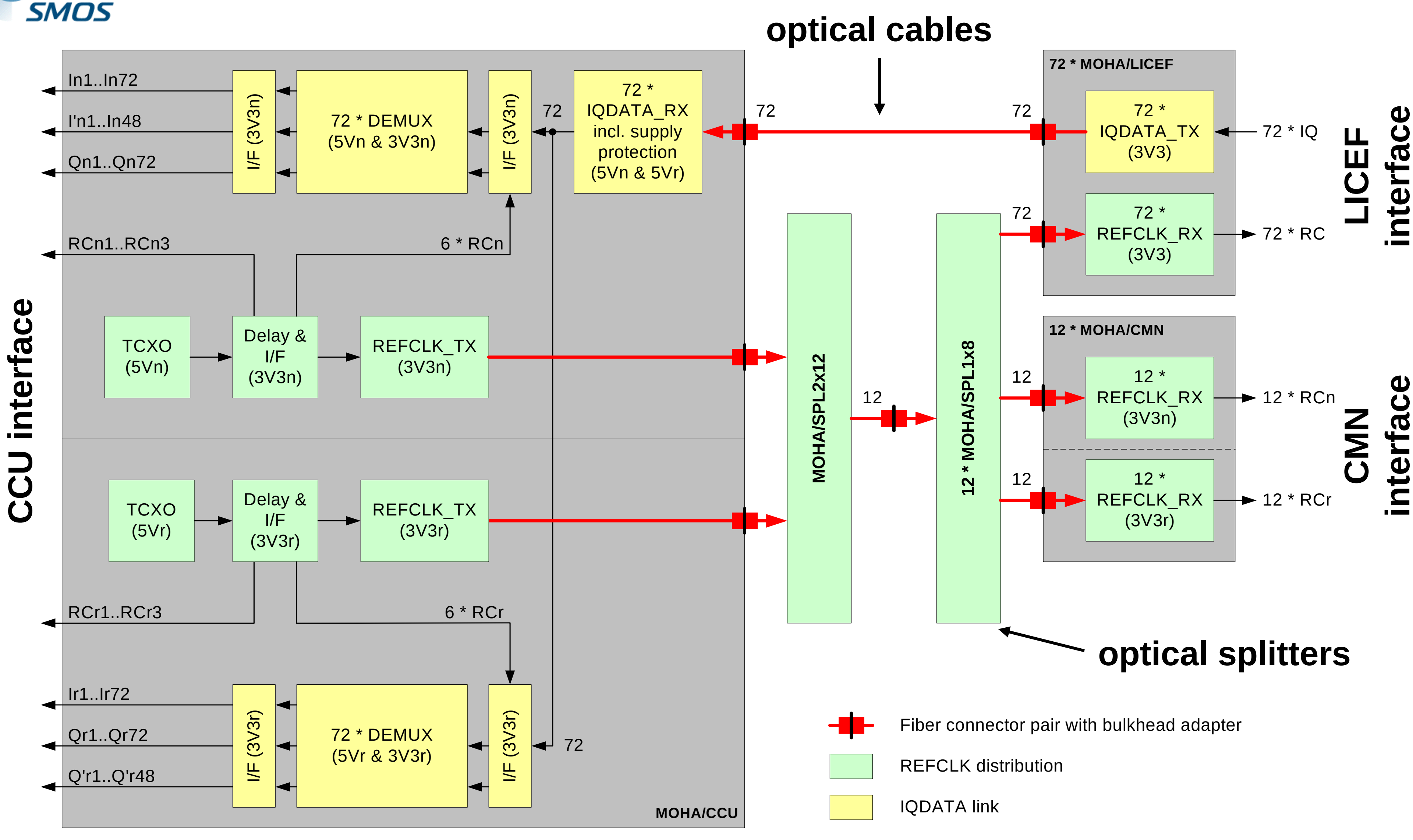
# MIRAS in the Maxwell EMC Chamber



# MIRAS Performances



# MOHA Functional Block Diagram



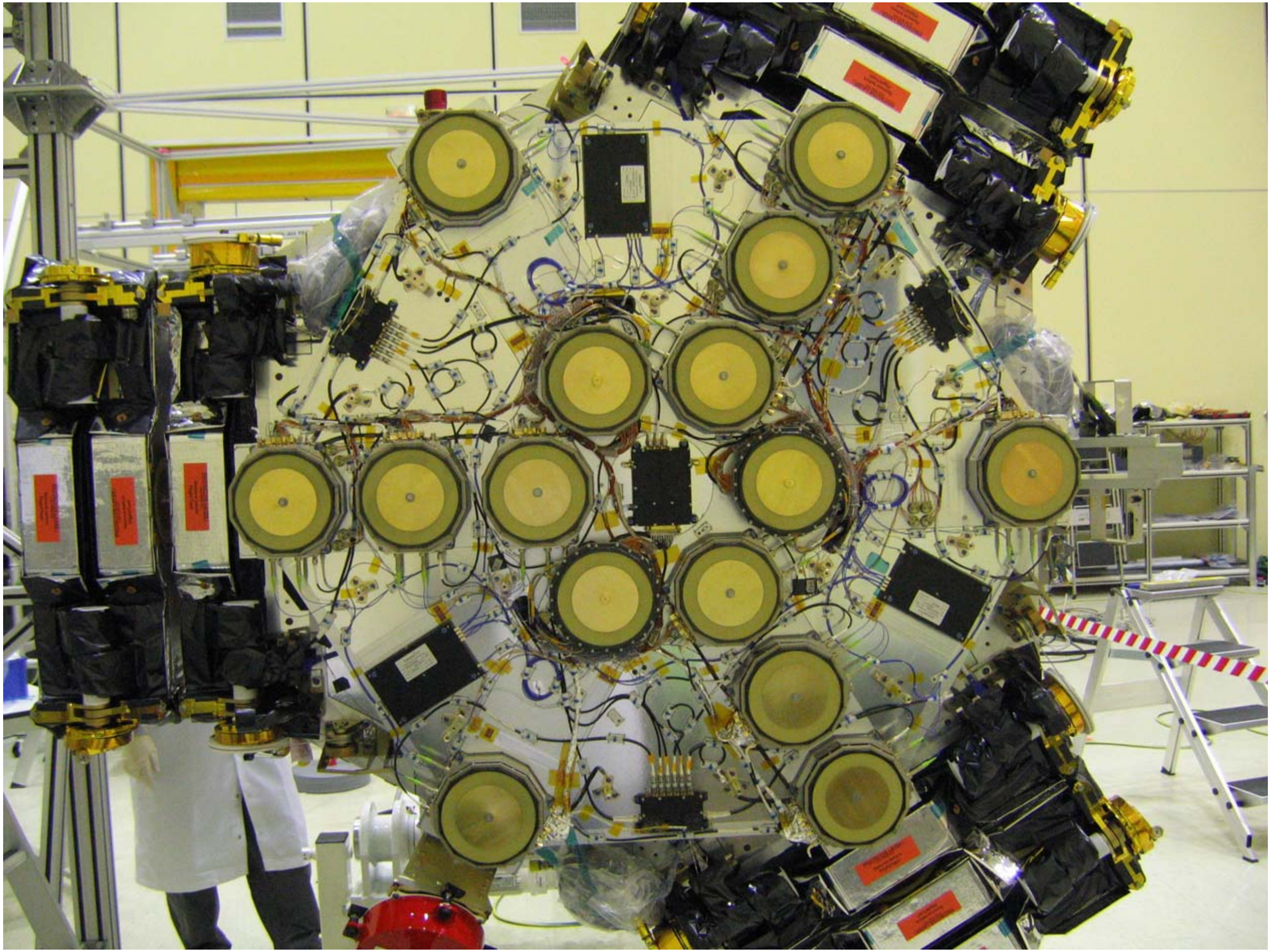
# MOHA Hardware Overview



## The MOHA Flight Model consists of:

- 1 x MOHA/CCU – 2 reference clock transmitters and 72 data receivers / demultiplexers
- 1 x optical 2x12 splitter
- 12 x optical 1x8 splitters, resulting in 96 optical reference clock outputs
- 72 x MOHA/LICEF – 1 reference clock receiver, 1 radiation data transmitter
- 72 x optical data cable (7m)
- 12 x MOHA/CMN – 2 reference clock receivers (nominal and redundant)

# MIRAS Hub



# MOHA Technical Realisation



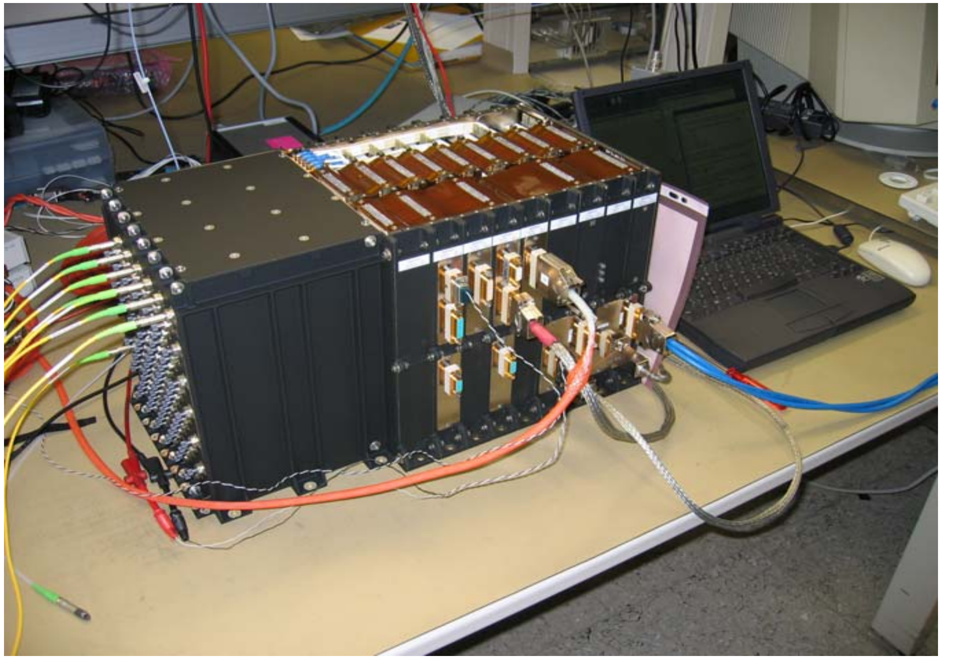
## Basic properties of all optical links:

- Transmission band: 1310nm
- Transmission medium: single-mode optical fibre
- Optical connectors: AVIM
- Optical transmitters:
  semiconductor laser diodes with fibre pigtails
- Optical receivers:
  pin photodiodes / transimpedance amplifiers with fibre pigtails
- Optical splitters: fused fibre couplers
- Reference clock frequency: 55.84MHz
- Data rate per channel: 111.68Mbit/s

# MOHA/CCU

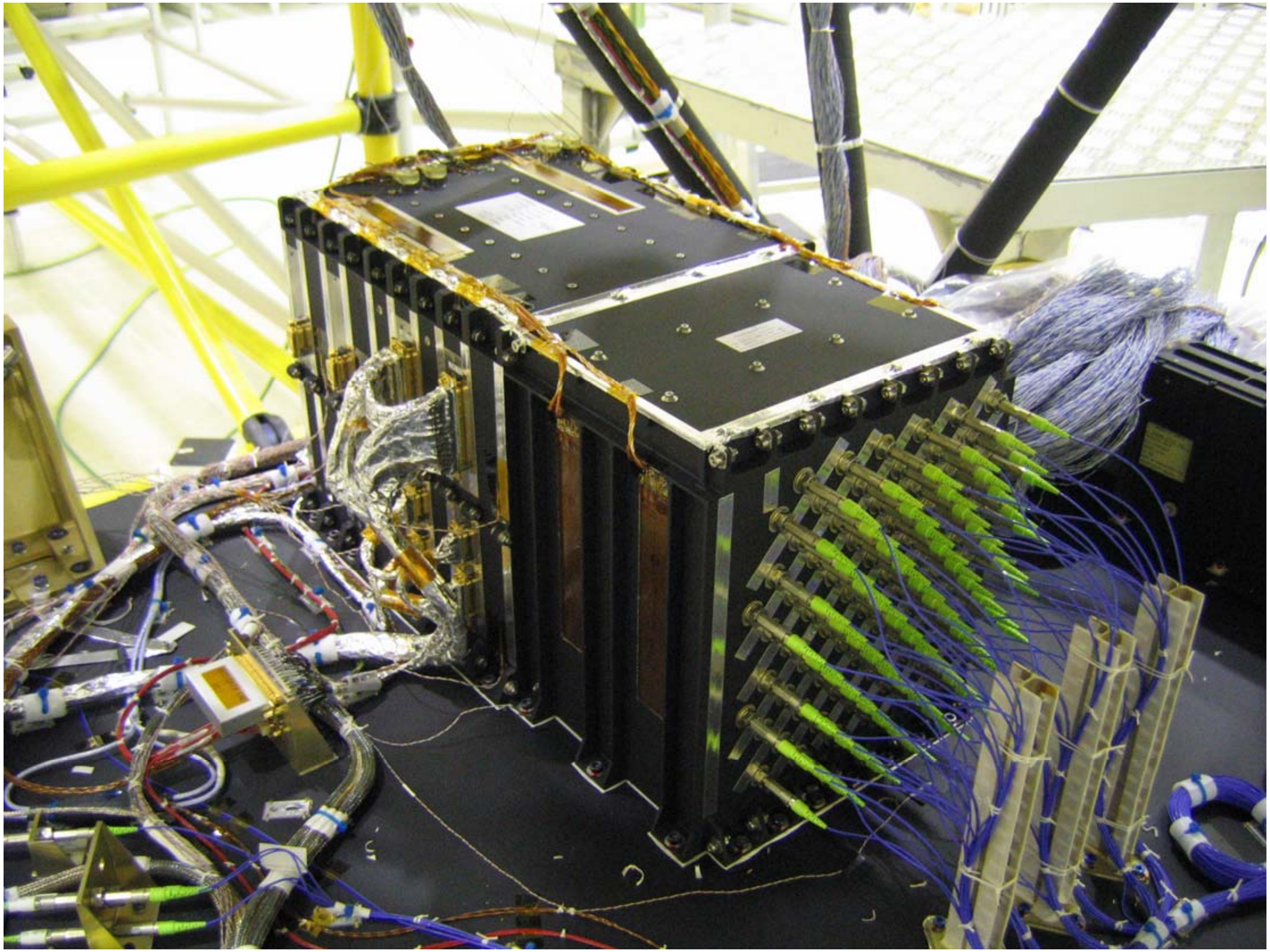
- 1 transmitter module and 6 receiver modules (12 channels each)
- 72 non-redundant optical receivers:
  individual supply cross-strapping and short-circuit protection
- Redundant data recovery and processing by FPGAs
- Power consumption: 17W (0.24W/channel)
- Mass: 6.6kg

MOHA/CCU



MOHA/CCU, integrated with CCU, during functional testing

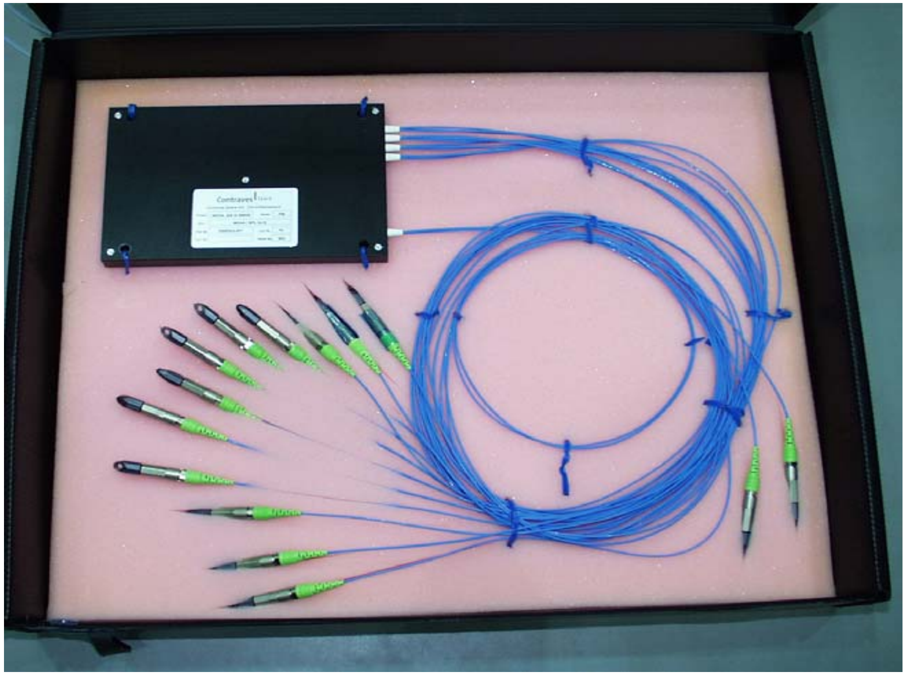
# MOHA/CCU –cont. –



MOHA/CCU and CCU integrated in MIRAS

# Optical Splitters

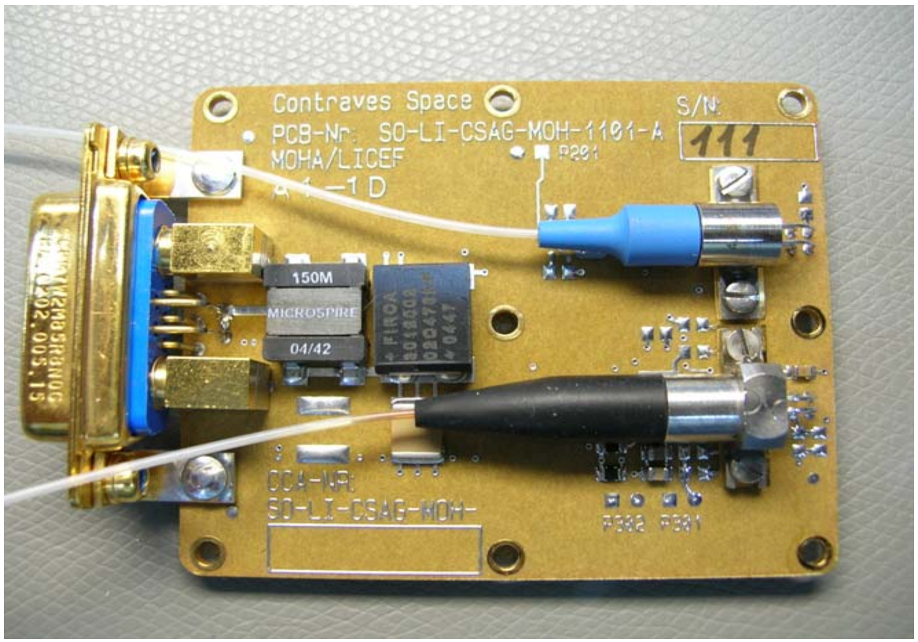
- 1x8 and 2x12 splitters are implemented by cascades of fused 2x2 couplers, interconnected by splices
- 2x12 splitter uses asymmetric couplers
- Aggregate excess loss: <1.3dB
- Clock skew: all fibre lengths (input to output) are within ±10mm
- Mass: 235g/270g



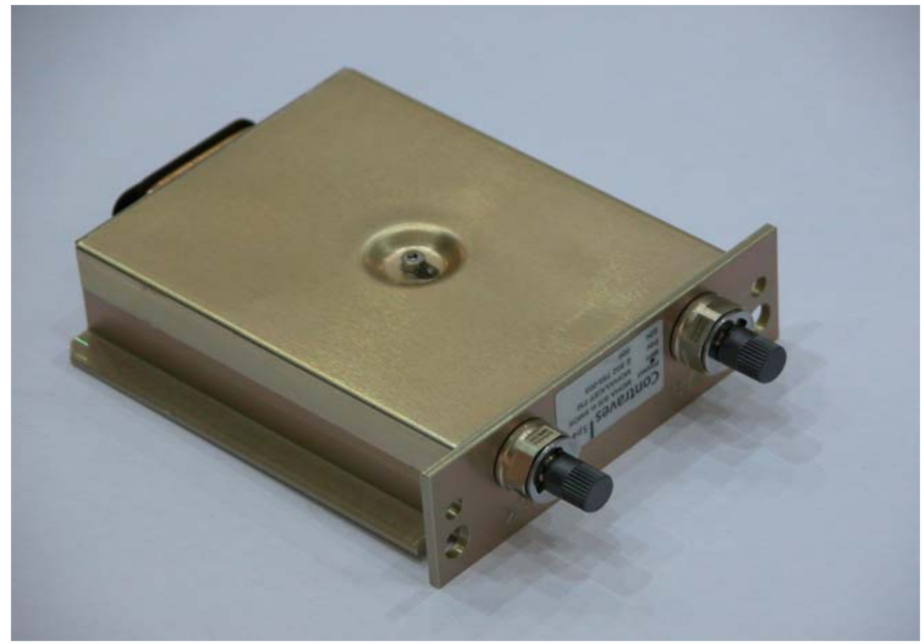
2x12 optical splitter, with fibre pigtails and AVIM connectors

# MOHA/LICEF

- **Worst-case clock skew across all 72 modules: 0.45ns p-p**
- **Nominal optical input power: -20dBm**
- **Jitter at minimum optical input power (-27dBm): <40ps RMS**
- **Envelope: 80x60x20mm$^3$**
- **Power consumption: 0.5W**
- **Mass: 130g**




**MOHA/LICEF circuit card, carrying an optical transmitter and an optical receiver**




**MOHA/LICEF module, ready to be plugged into a LICEF**

## (1) Component qualification

**Suitable fibre-optic and opto-electronic components were not available space-qualified off-the-shelf:**

- **Optical fibre cables**
- **Optical splitters**
- **Optical transmitters**
- **Optical receivers**

**For power consumption and performance reason, also some commercial electrical components had to be used:**

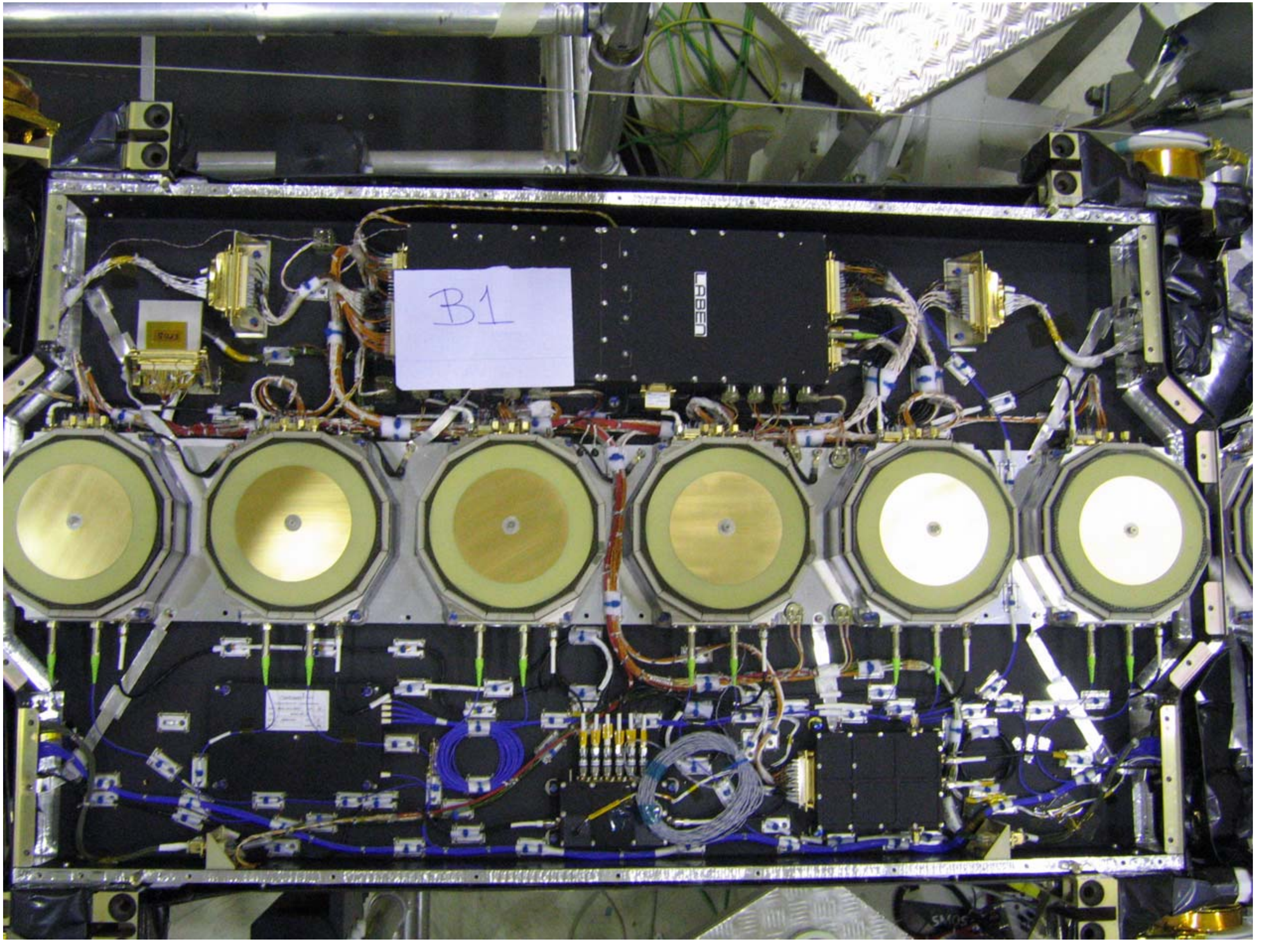
- **Laser drivers**
- **Discriminators**

## (1) Component qualification –cont. –

**The large number of components justified a dedicated campaign consisting of:**

- **Commercial component <u>evaluation testing</u>, to find out – among several candidates – the component most suitable for the application**
- **<u>Qualification testing</u>, to demonstrate that each component can meet its performance requirements for the specified lifetime**
- **Procurement of the flight components and their constituents from a single production lot, in order to eliminate as far as possible any process variations**
- **100% <u>screening and burn-in</u> of the flight components, in order to stabilise their characteristics and to detect early failures**
- **<u>Lot acceptance testing</u> on samples of the flight lot, to ensure that it meets the defined quality requirements**

# MIRAS Arm Segment



# Challenges and Solutions

## (2) Clock skew and data recovery

- **There exist two important timing requirements on the MOHA S/S:**
  - Skew of reference clock distribution: $<\pm 1$ns
  - Skew of reference clock distribution and data transmission: $< \pm 3$ns (round-trip timing to facilitate proper data recovery)
- **In order to achieve these requirements, the delays of all modules are equalised using precise delay measurements and customised fibre cut-back**
- **Also, the parameters of all optical transmitters have to be configured by select-on-test resistors**
- **Consequently, each MOHA/LICEF passes a sequence of approx. 15 test/manufacturing steps**
- **In total, about 1500 separate test/manufacturing activities have to be performed, resulting in a very complex AIT flow**

# MOHA Status and Test Results

- **All flight units and spare/qualification units had been successfully tested and delivered by end of September 2006**

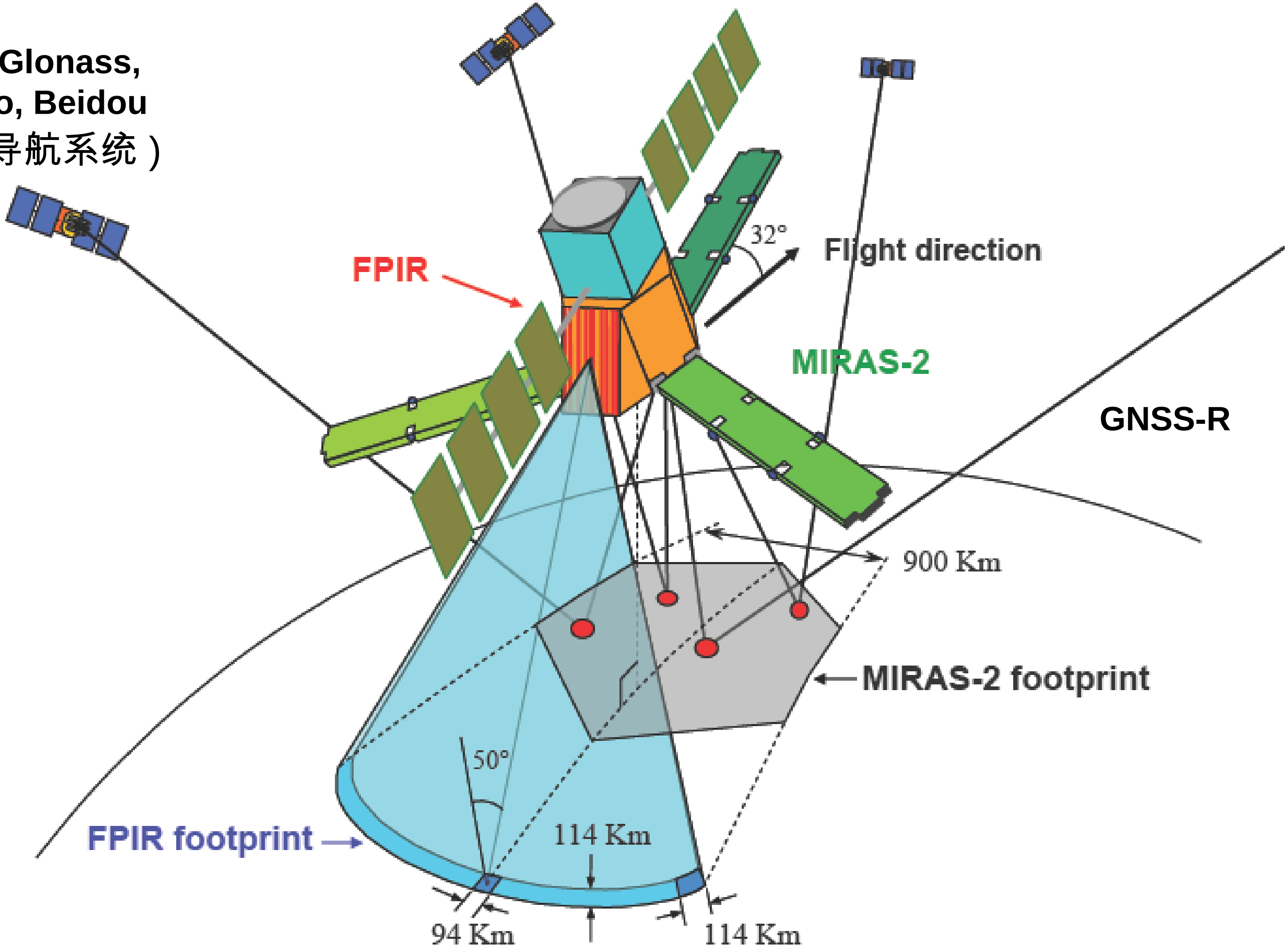
| Parameter | Requirement | Result | Remark |
|---|---|---|---|
| Reference clock distribution: **skew** | < ±1 ns | ±0.15 ns<br>±0.35 ns | nominal<br>worst-case |
| Reference clock distribution: **RMS jitter** | < 50 ps | 12 ps<br>46 ps | nominal<br>worst-case |
| **Bit error probability** of data transmission per channel | $< 10^{-10}$ | $< 10^{-10}$ | 99% confidence (Note 1) |
| MOHA/CCU power consumption | < 20 W | 17 W | |
| MOHA/LICEF power consumption | < 0.75 W | 0.5 W | |

Note 1:

Not a single bit error was detected during subsystem testing of all 72 channels

# Future: SMOSops

GPS, Glonass,
Galileo, Beidou
（北斗导航系统）



# Conclusion

- SMOS is the first European space mission to extensively employ on-board fibre-optic communications
- Very low electro-magnetic emission levels, as well as fibre cable flexibility and phase stability have been the main drivers
- The absence of correlation offsets is by large thanks to MOHA
- Several commercial fibre-optic and electrical components have been successfully qualified for the MIRAS Optical Harness
- For in total more than 100 MOHA modules to be delivered, a special production and test facility has been established and used
- Delivery of the last MOHA flight unit took place end of September 2006
- The launch of SMOS is scheduled for the second half of 2009
- An centralised calibration system being investigated for SMOSops