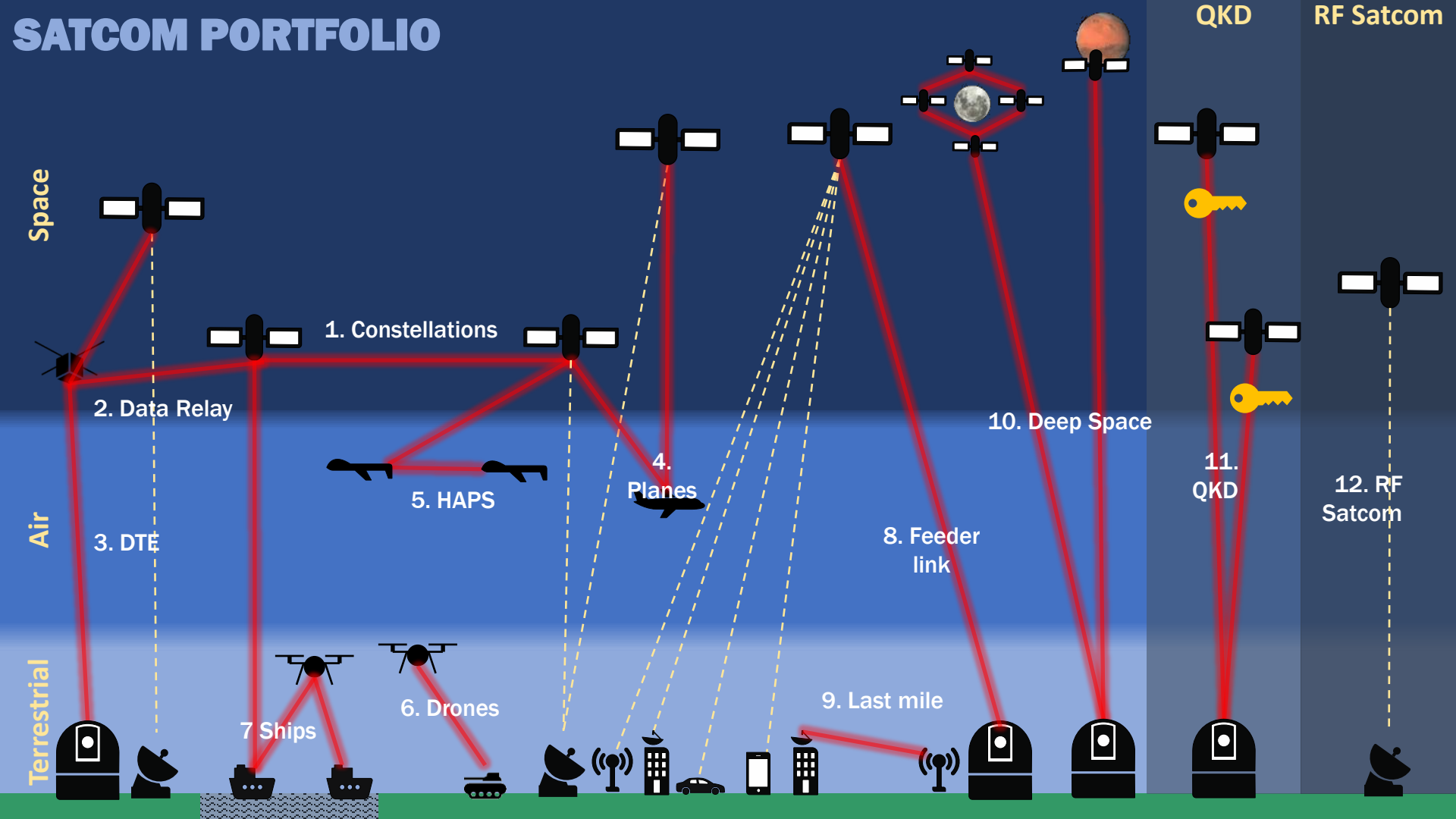
LASER SATCOM AT TNO

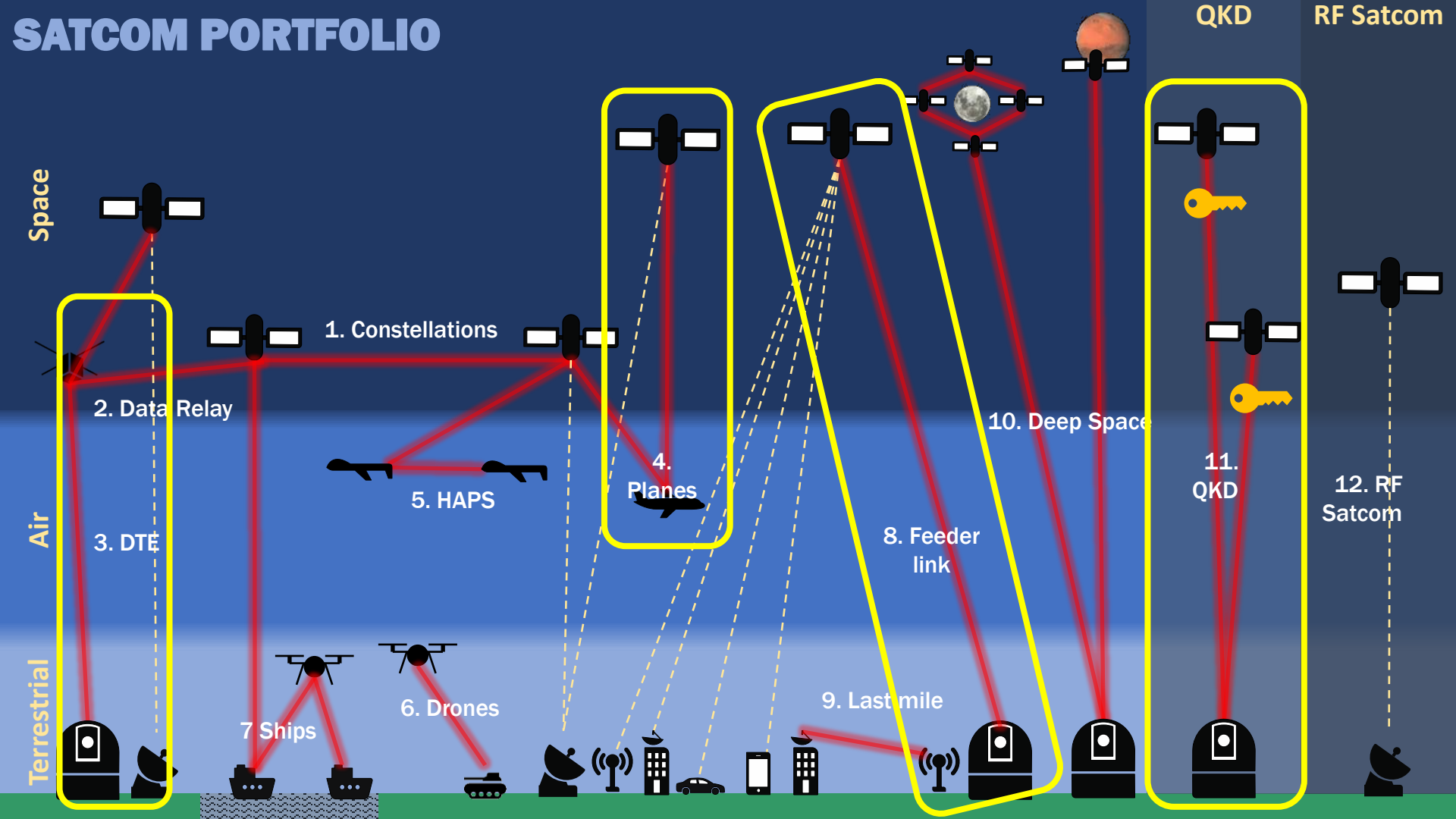
WILL CROWCOMBE

PRINCIPAL SYSTEMS ENGINEER – LASER COMMUNICATION

30 June 2022

Image Credit: NOAA


SATCOM PORTFOLIO
QKD
RF Satcom
Space
Air
Terrestrial
1. Constellations
2. Data Relay
3. DTE
4. Planes
5. HAPS
6. Drones
7 Ships
8. Feeder link
9. Last mile
10. Deep Space
11. QKD
12. RF Satcom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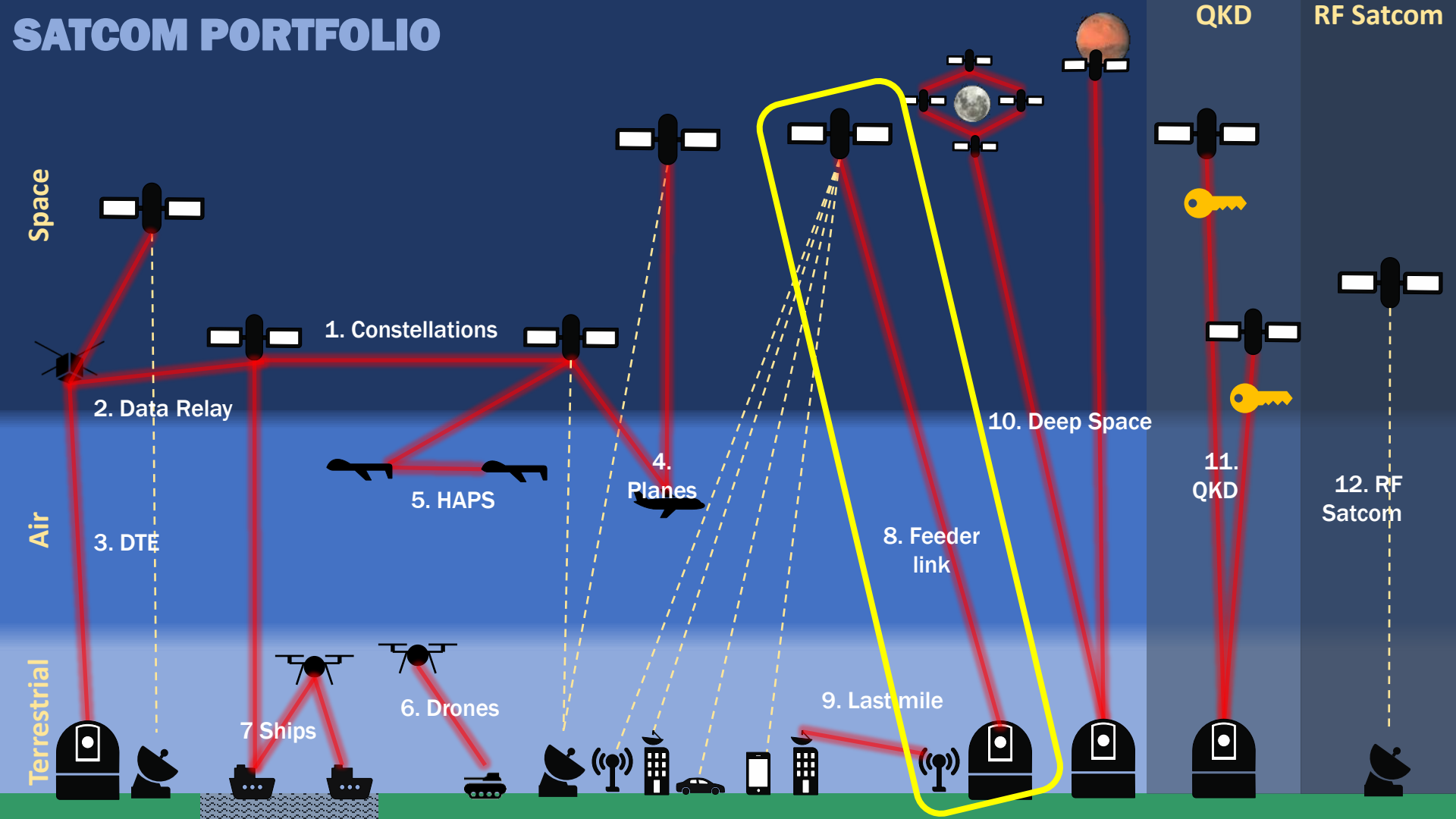
HIGHLIGHTS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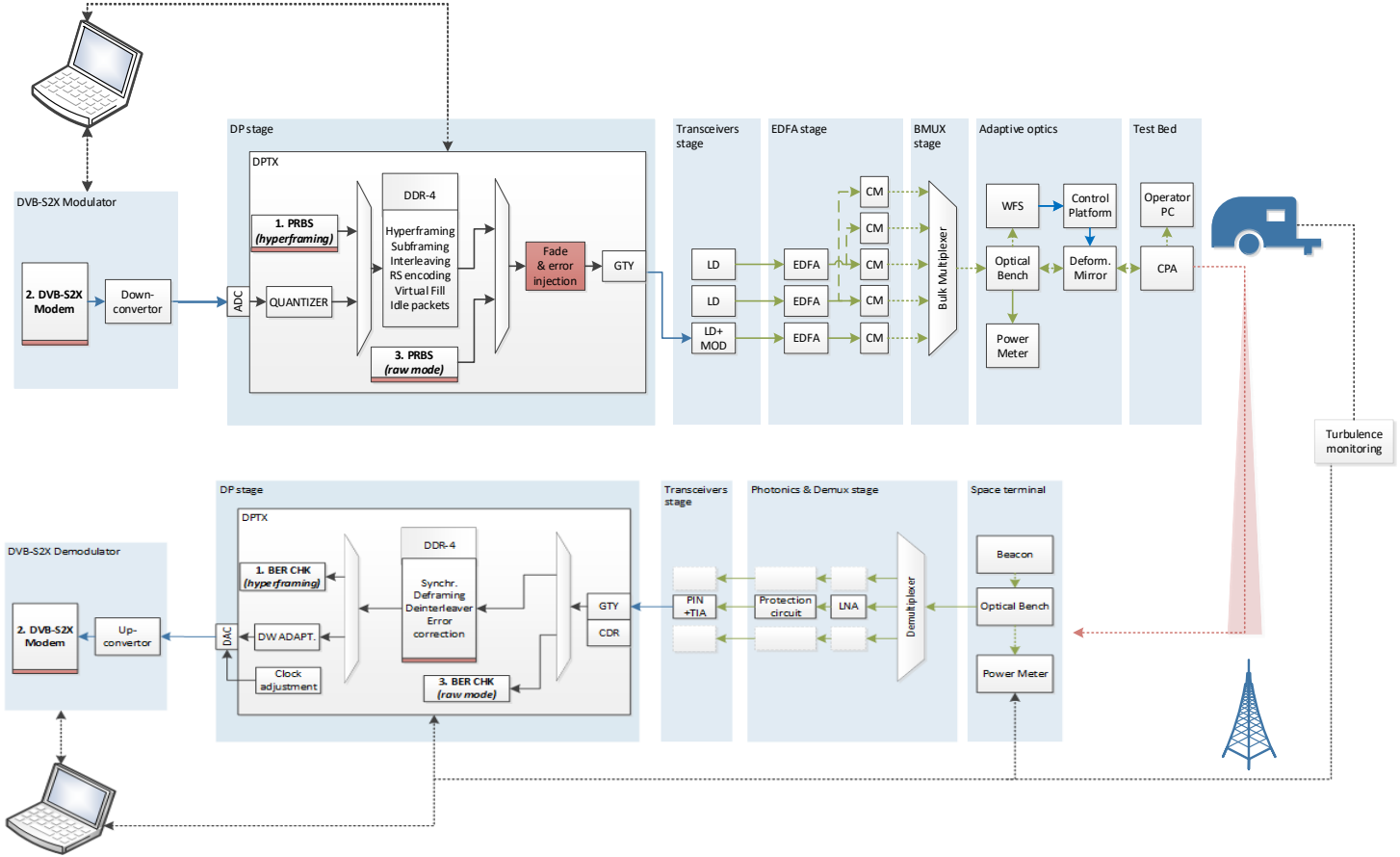
TOMCAT - DEMONSTRATOR TEST SETUP



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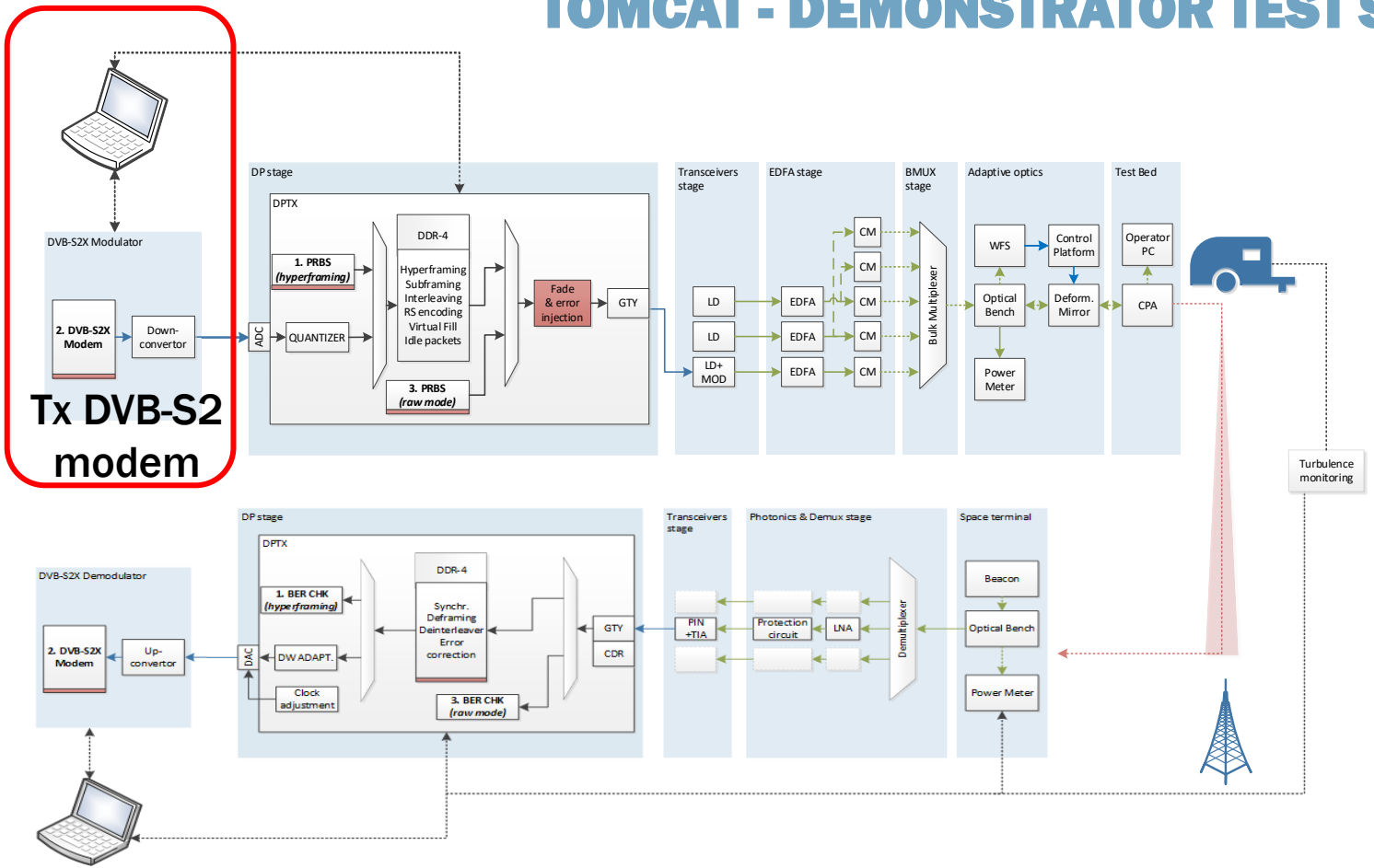

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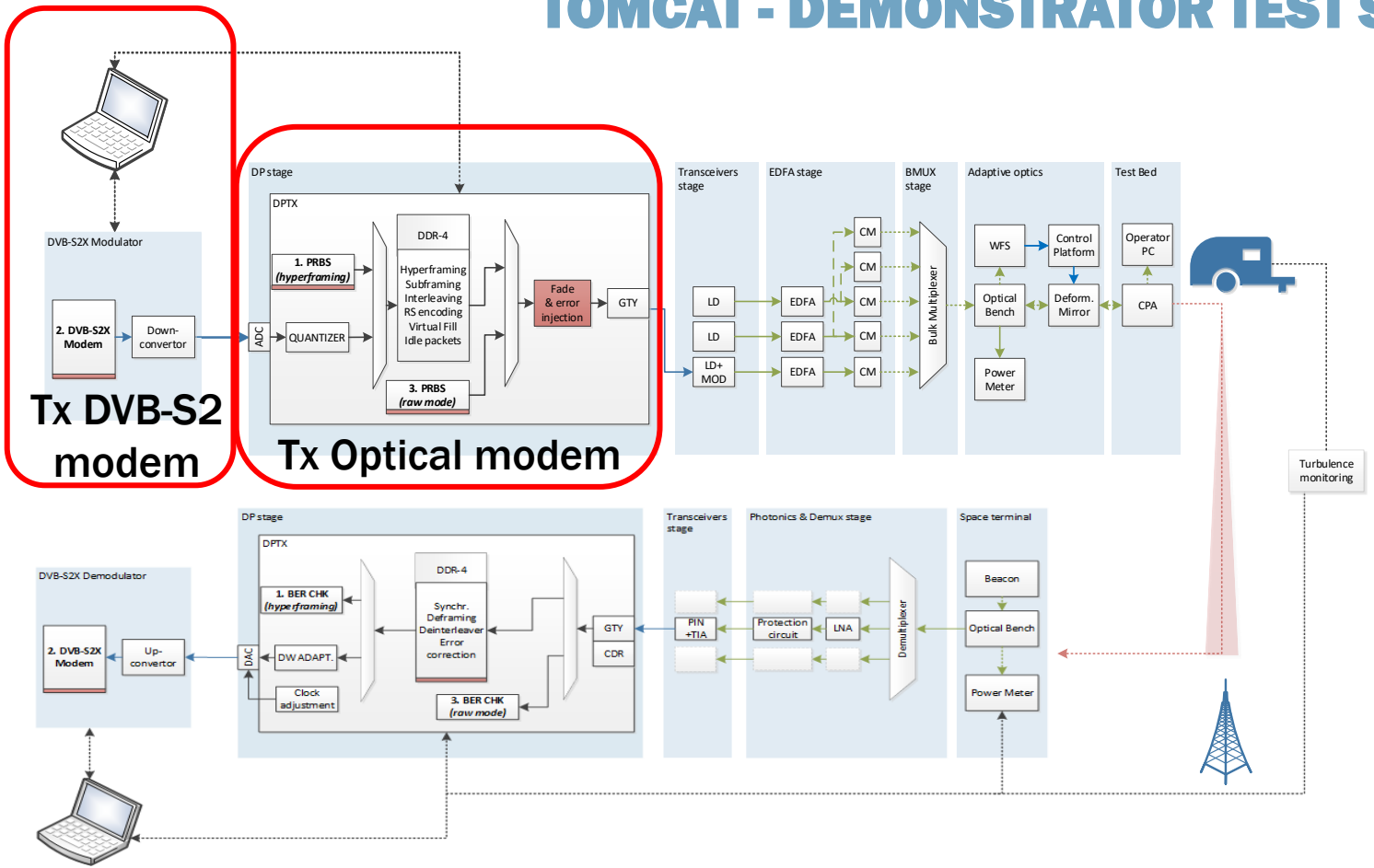

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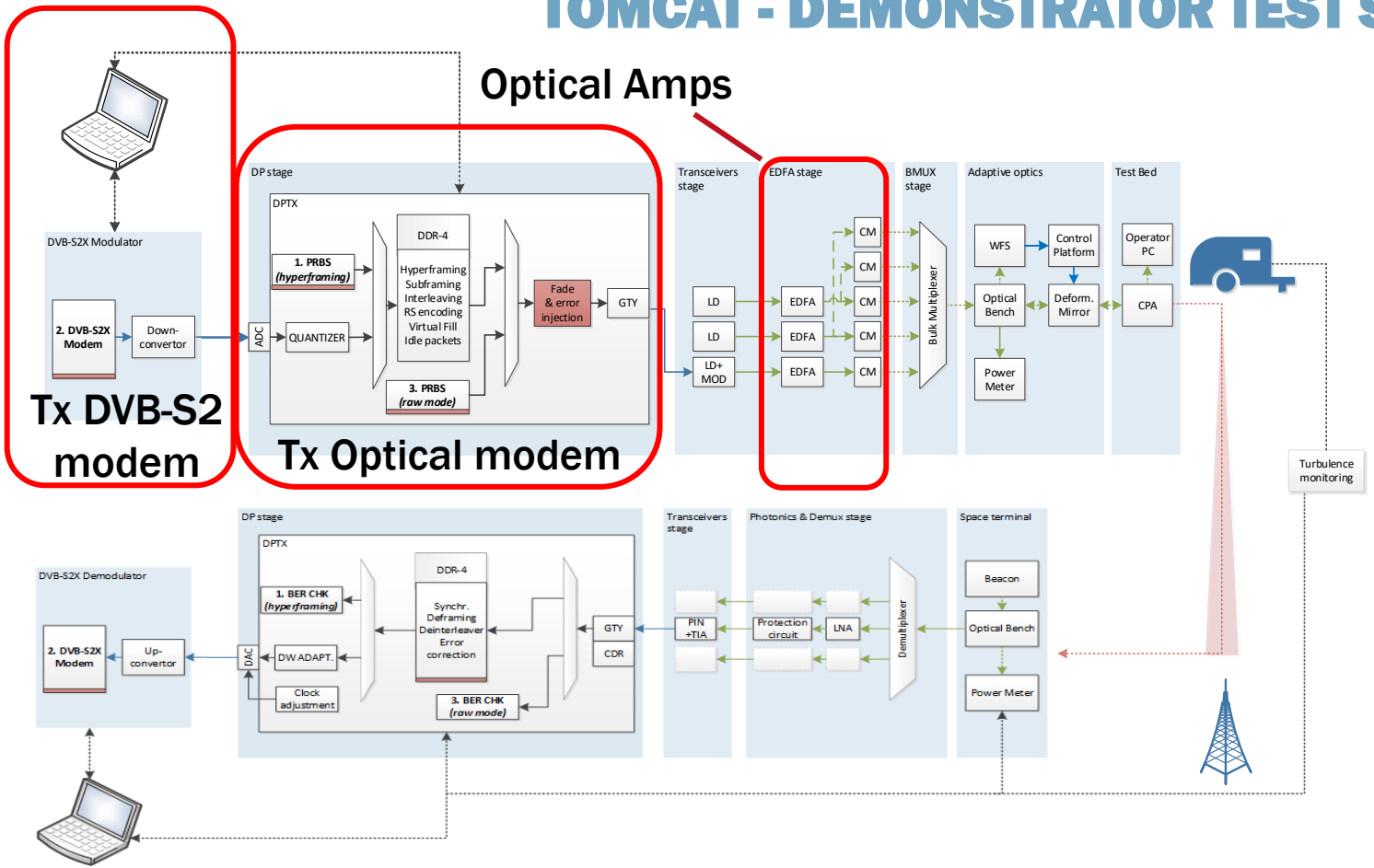

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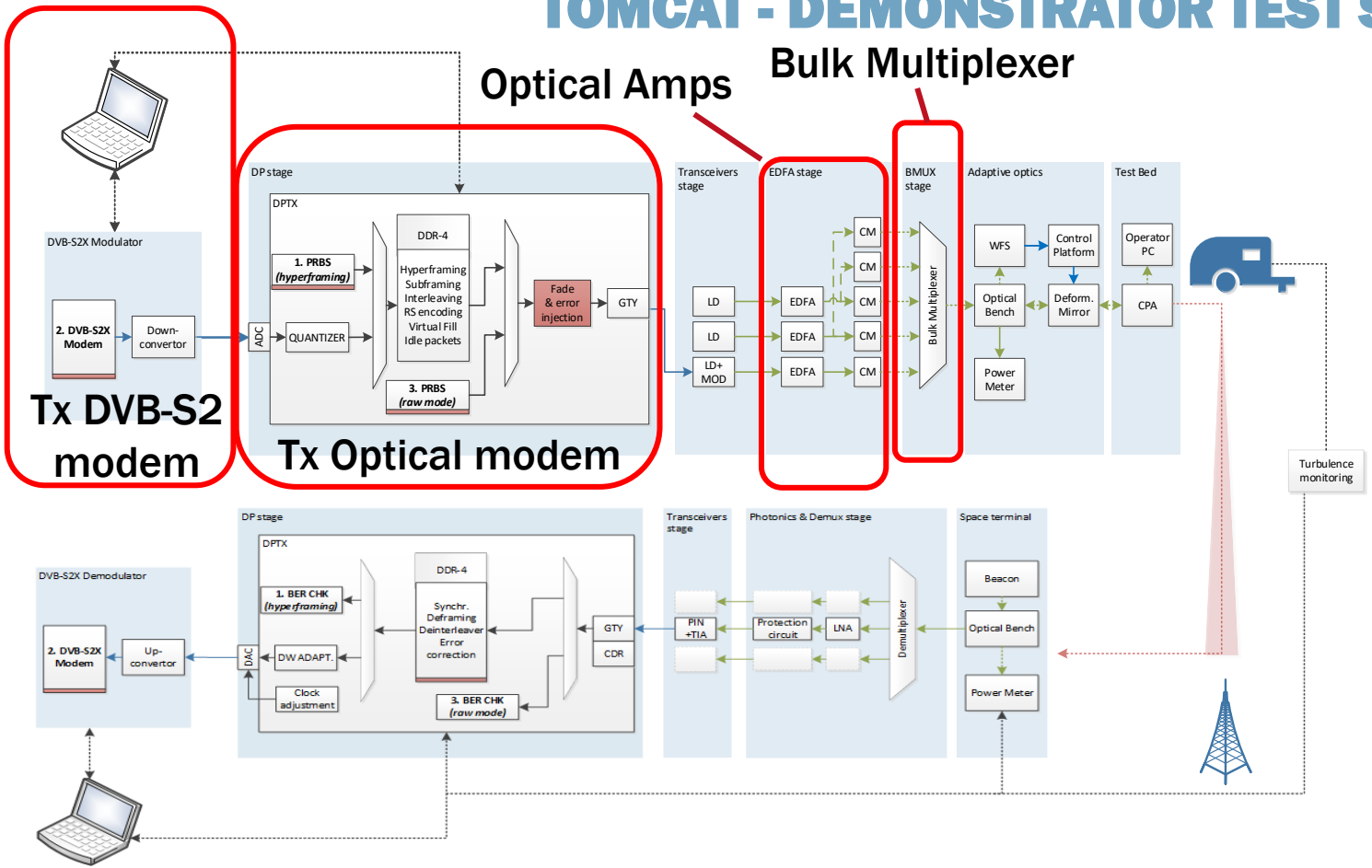

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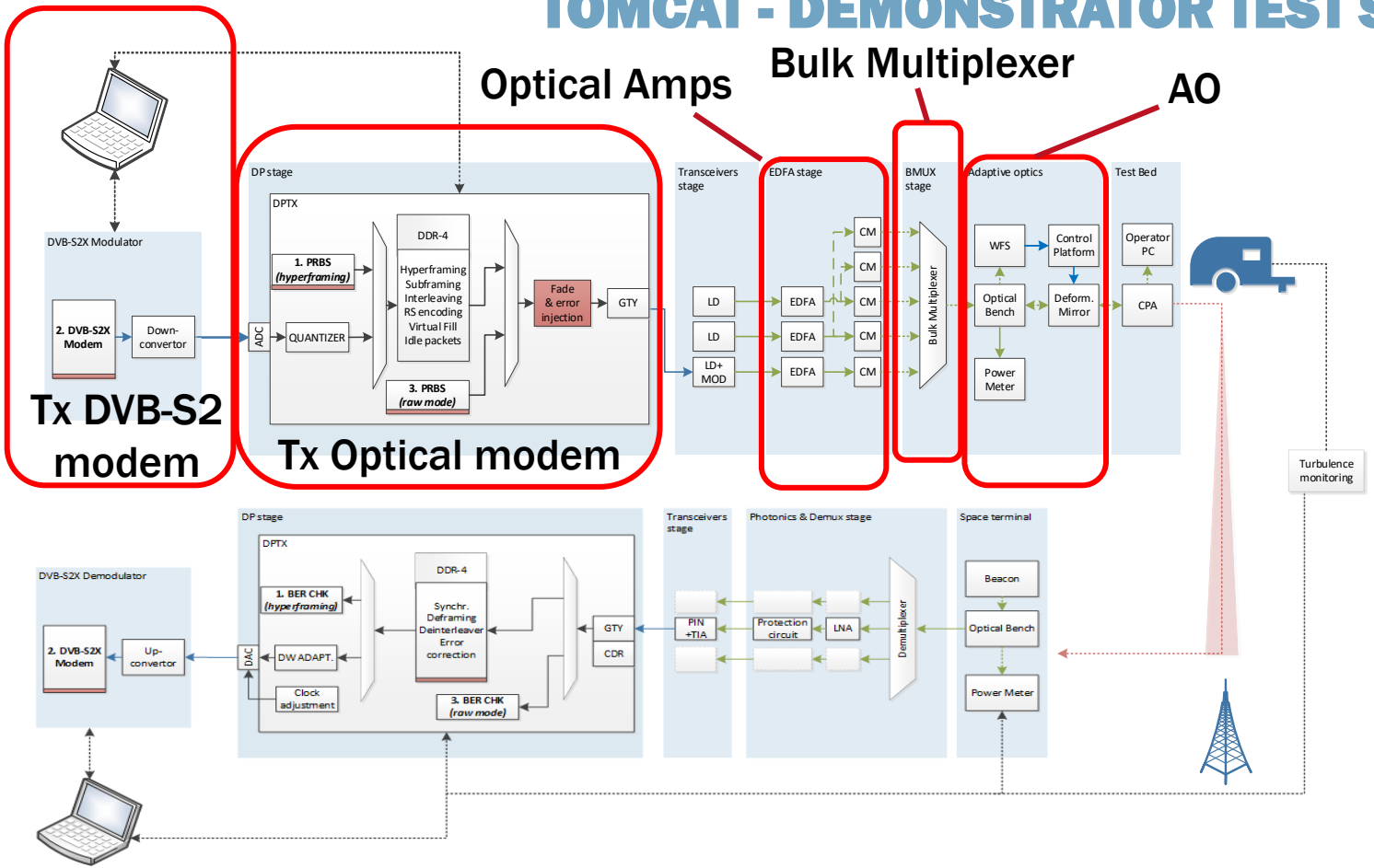

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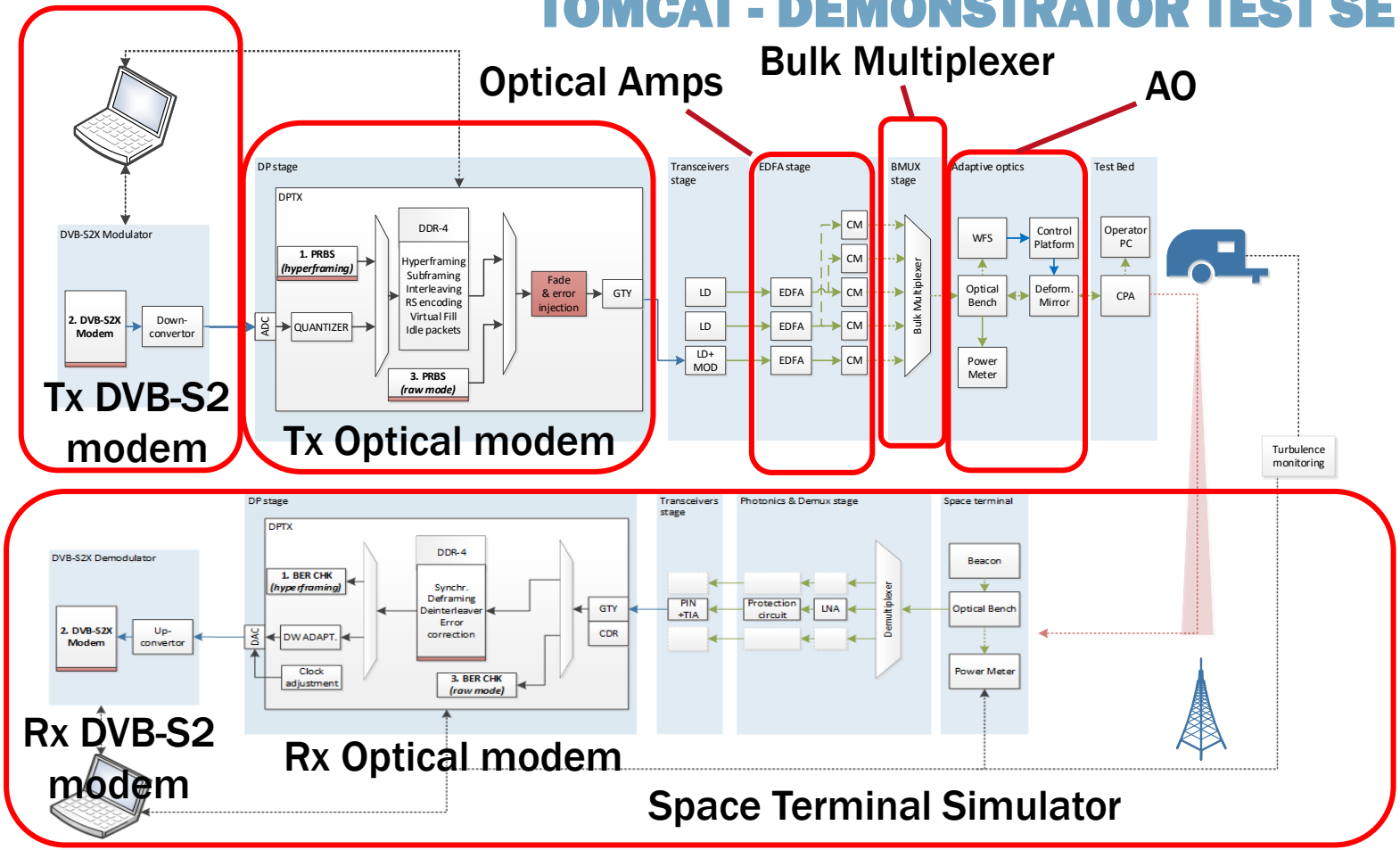
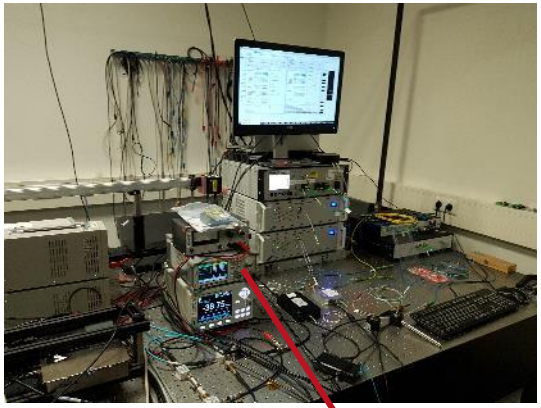


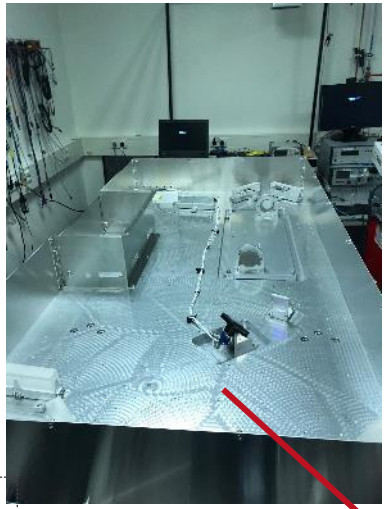
TOMCAT - DEMONSTRATOR

Project with:

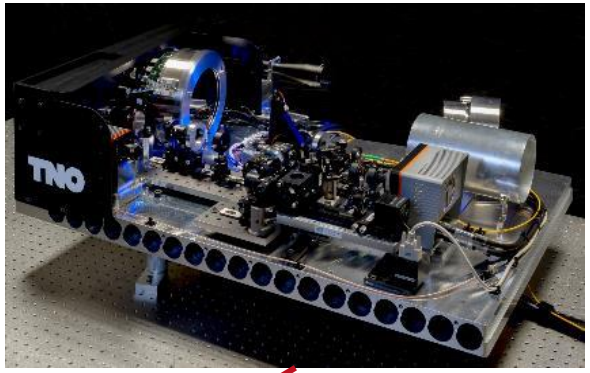
Coms Chain

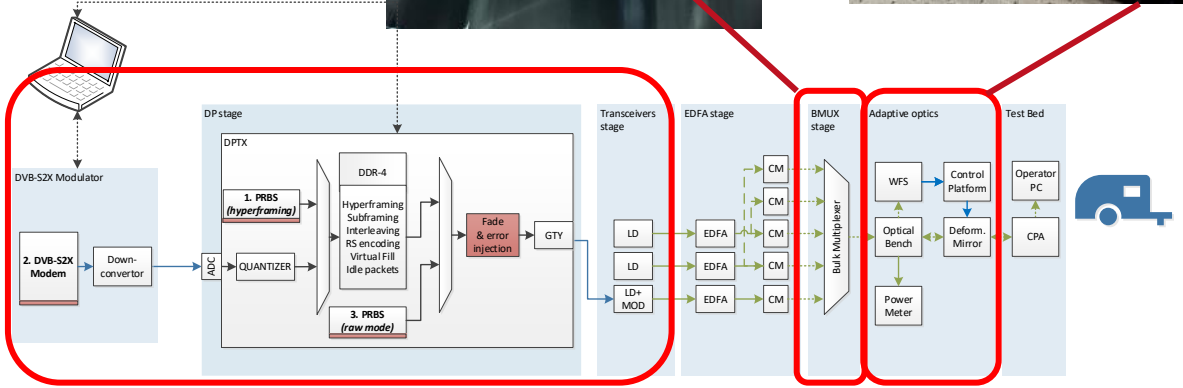


Bulk Multiplexer



AO- OFELIA





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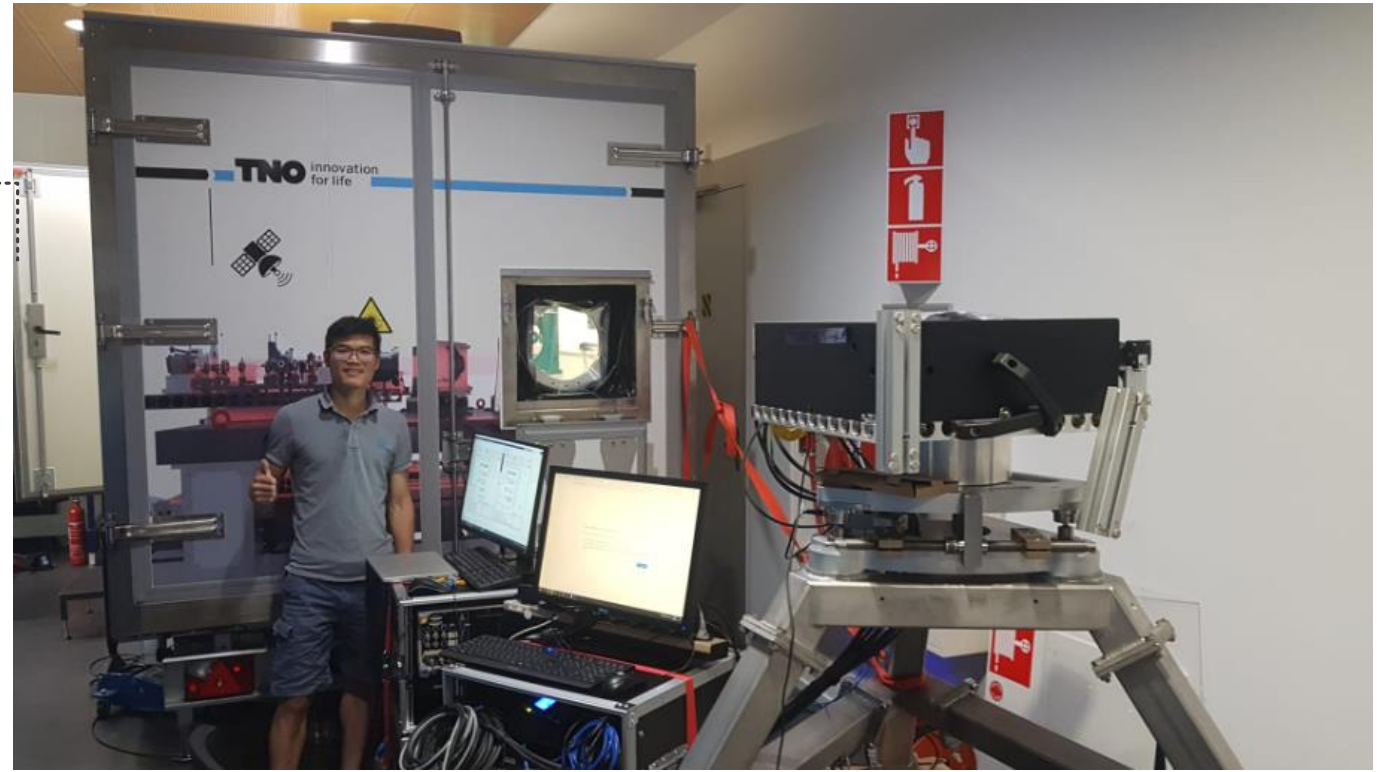
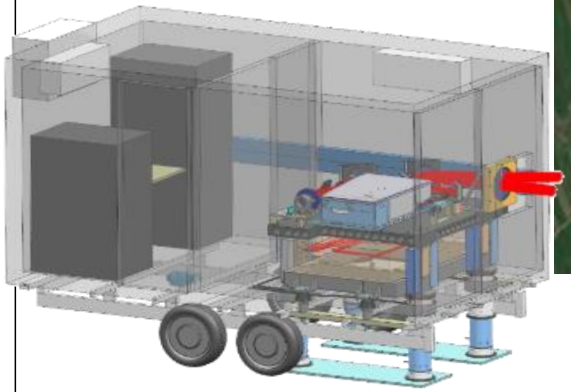


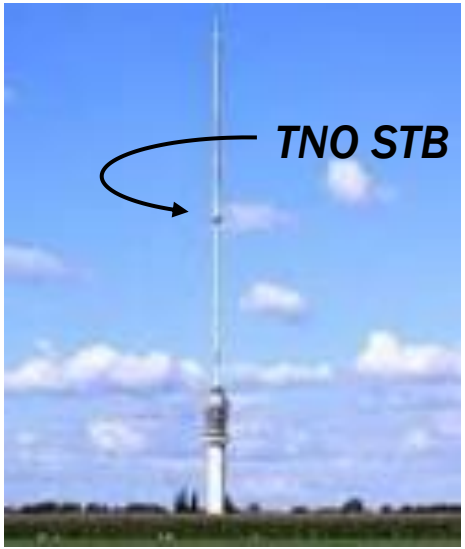
TOMCAT - DEMONSTRATOR

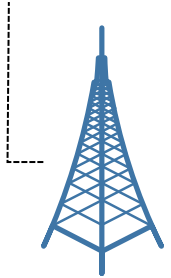
FIELD TEST LOCATION

TOmCAT Demonstrator



Gebrandy Tower



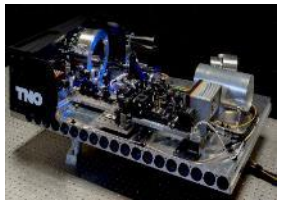


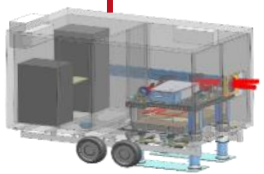
FEEDRLINK OGS ROADMAP

Complete
Ongoing
Planned

Lead: TNO AIRBUS

TOMCAT Phase 1:
Proof of principle





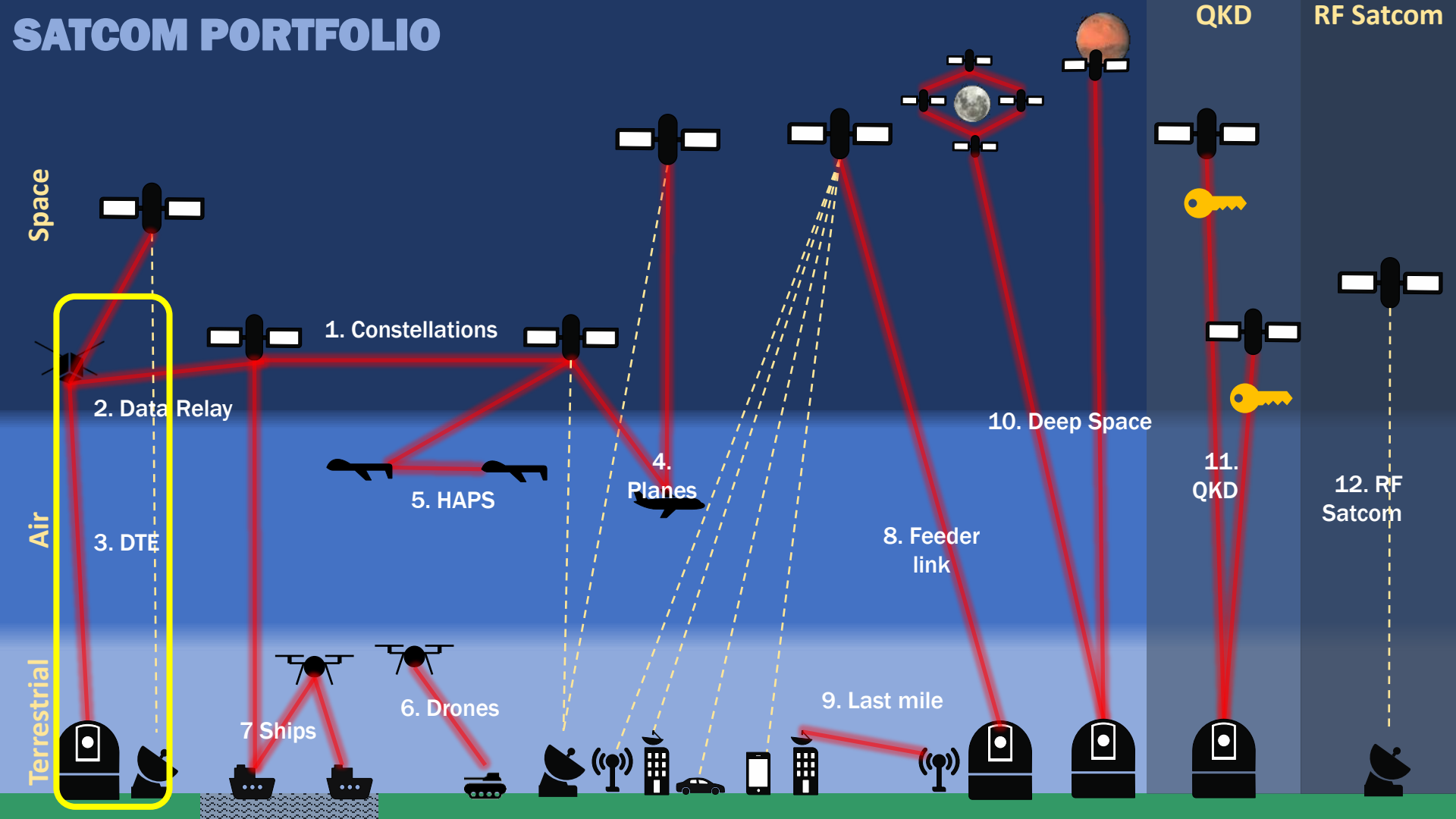
TOMCAT Phase 2: OGS End-2-End Demonstration

IOD Demonstration Phase

Product development

Production

See AIRBUS Roadmap.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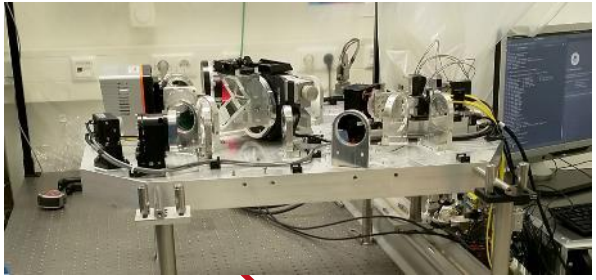
DTE - OGS

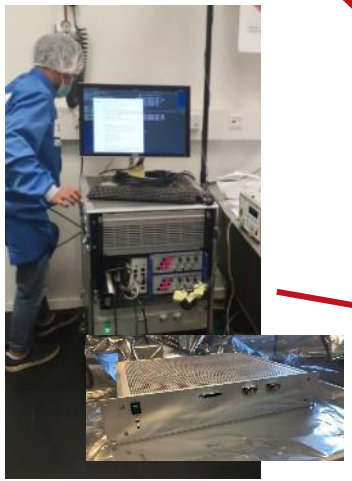
Project with:

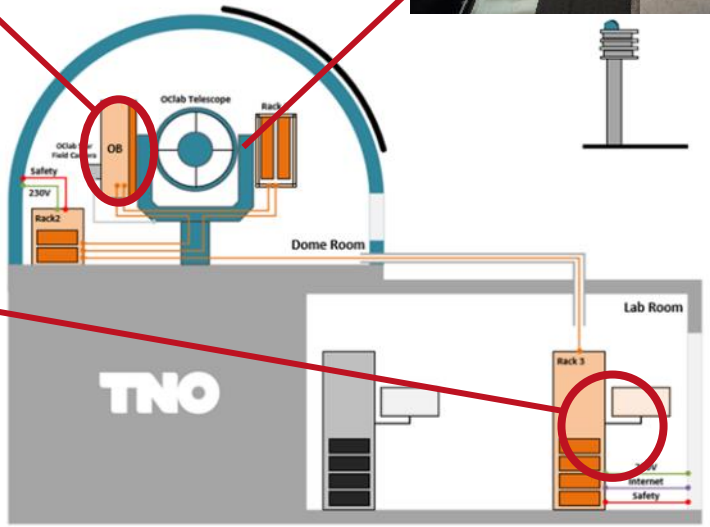
DTE - OGS

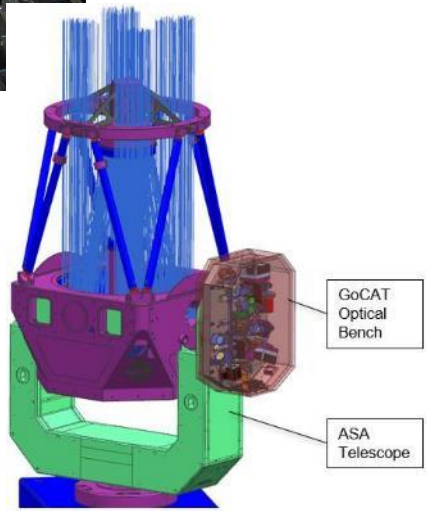
Project with:

TNO AIRBUS CSTS DiGS



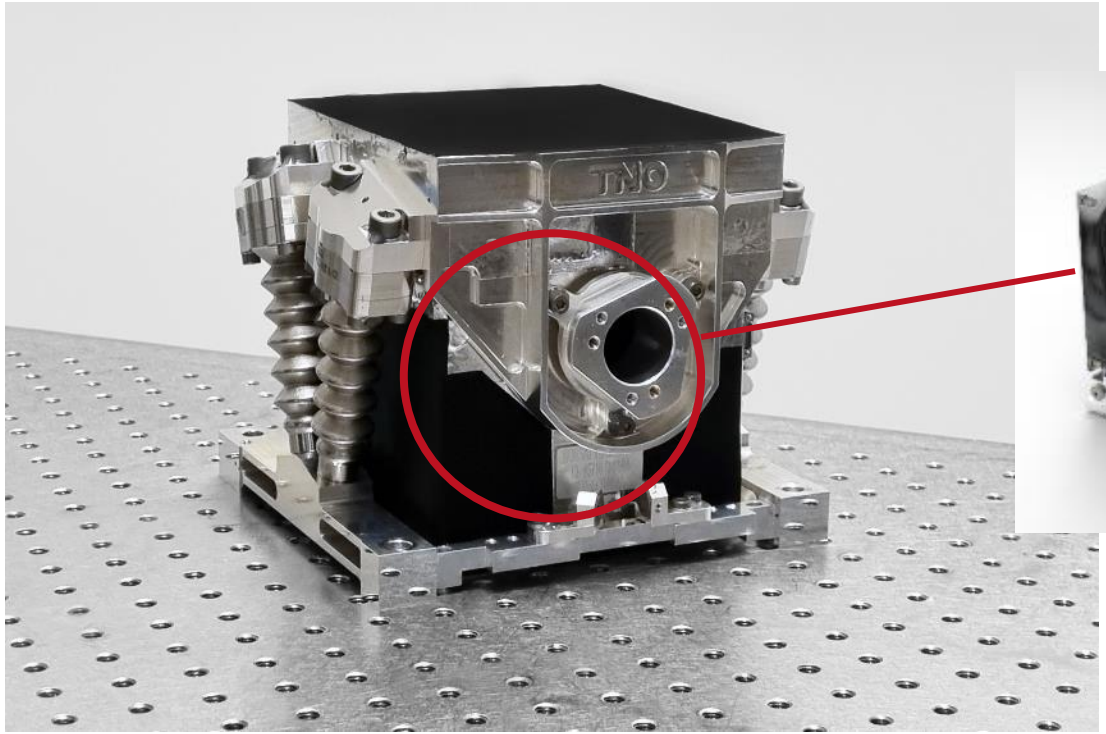






DTE – CUBECAT TERMINAL

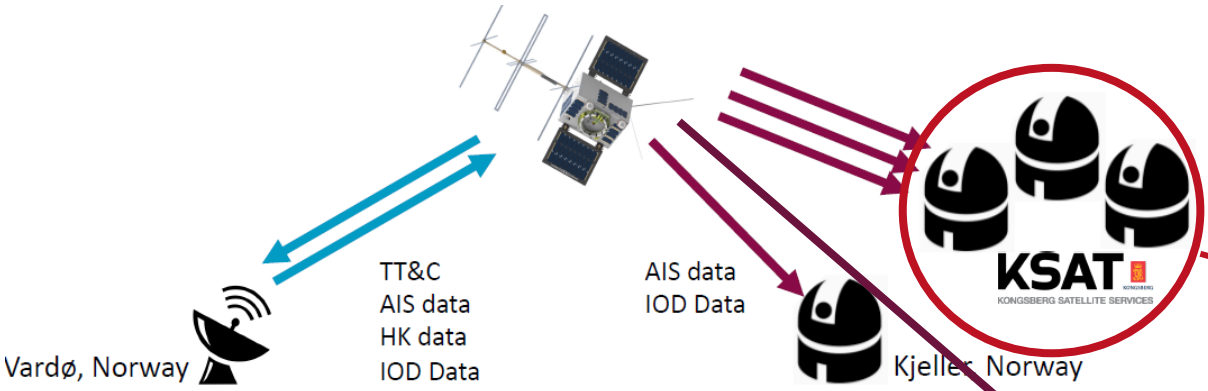
Project with:



DTE – IOD SMALL ON NORSAT-TD

Project with:

DTE – IOD + NUCLEUS NETWORK



Nucleus OGS Network (ESA, DLR, KSAT, TNO)

Primary OGS:

TNO innovation for life

Den Haag OGS

SPACE TECHNOLOGY ROADMAP

Complete
Ongoing
Planned

Entangled source coupling

DCAT

DEMCON

FS
Trk/Qcq/data detector

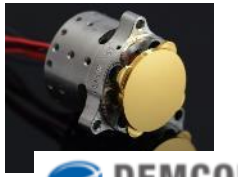
SDA standard interfacing

....

OH ISL

FSO INSTRUMENTS

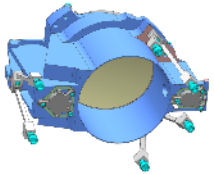
FSM



DEMCON

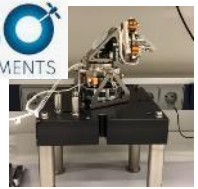
Coherent Transceivers

200mm Telescope



CPA

FSO INSTRUMENTS

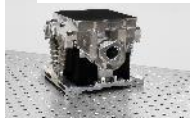


Advanced 03K modem

OB

ThalesAlenia Space

AAC HYPERION



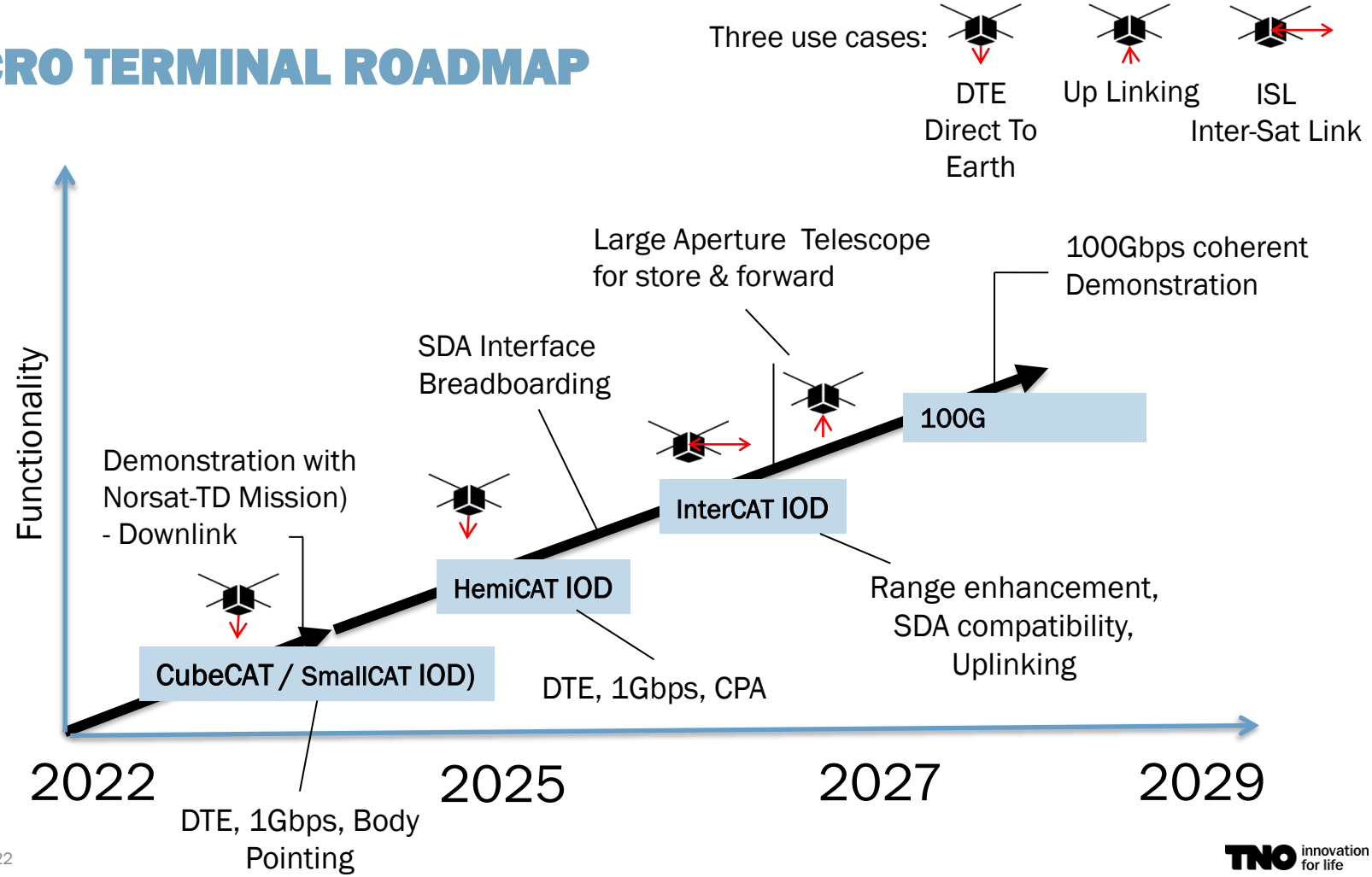
Micro Terminal

03K modem

Ultra fast Quadcell

VTEC LASERS & SENSORS

MICRO TERMINAL ROADMAP

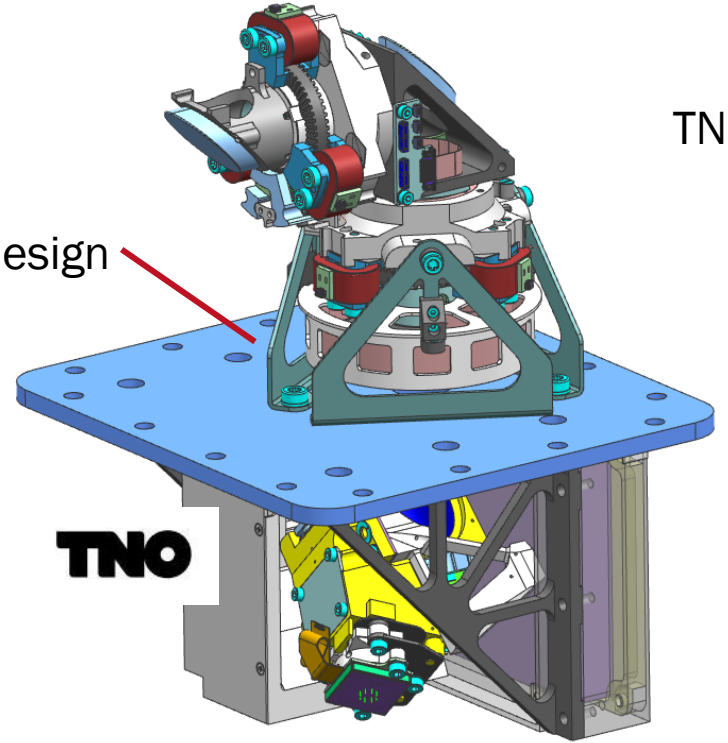


HEMICAT

NEXT GEN MICRO TERMINAL

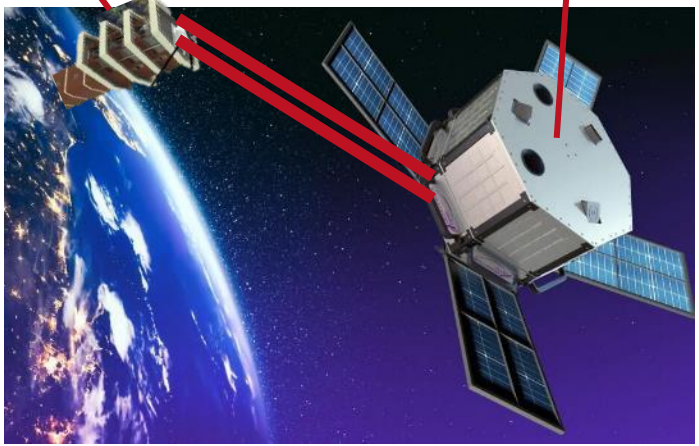
Project with: FSO INSTRUMENTS, SIDUS SPACE, TNO, Raytheon

HemiCAT-
Concept design

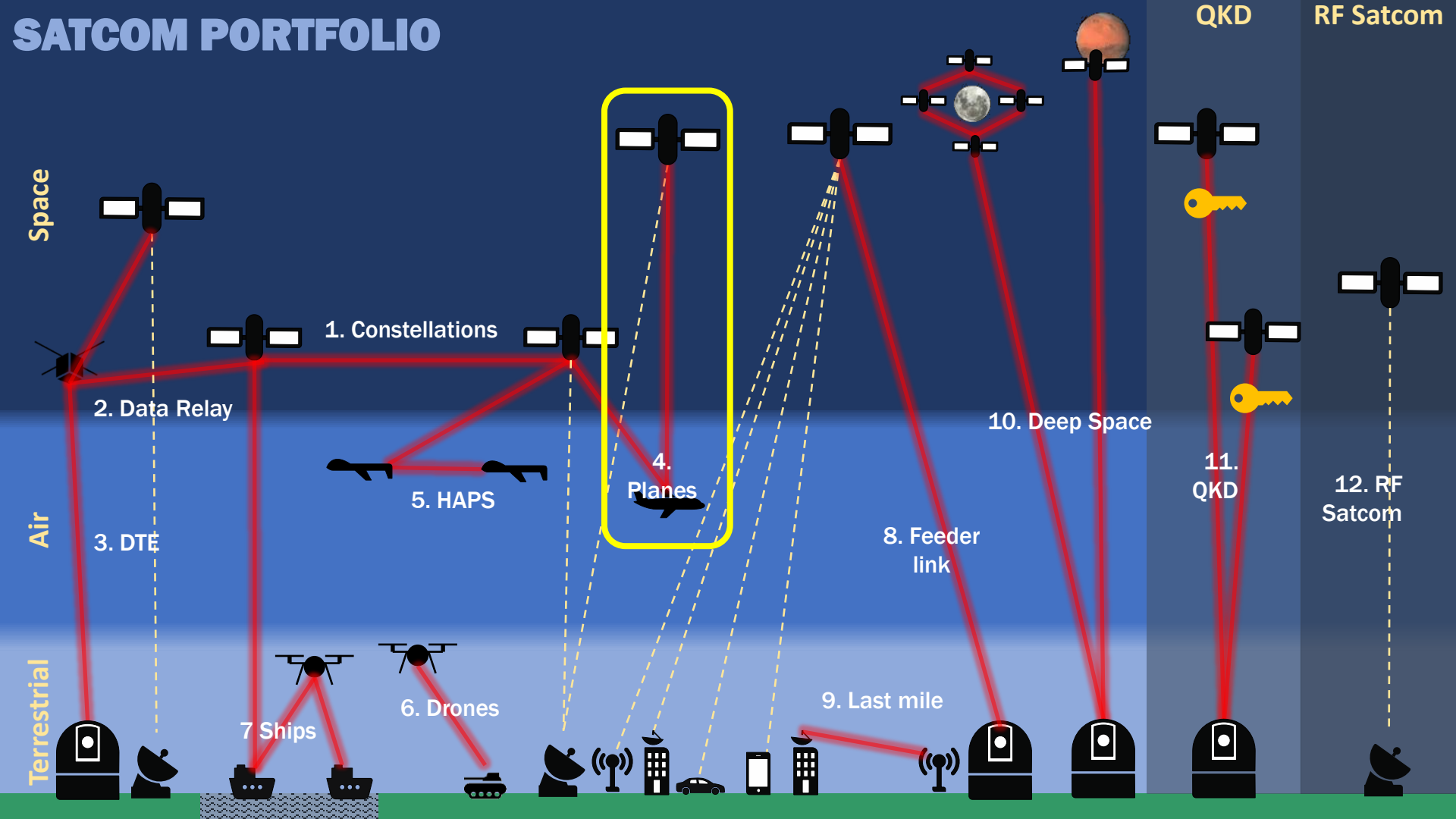


TNO OC Lab OGS

SIDUS Lizziesat



Picture adapted from SIDUS Space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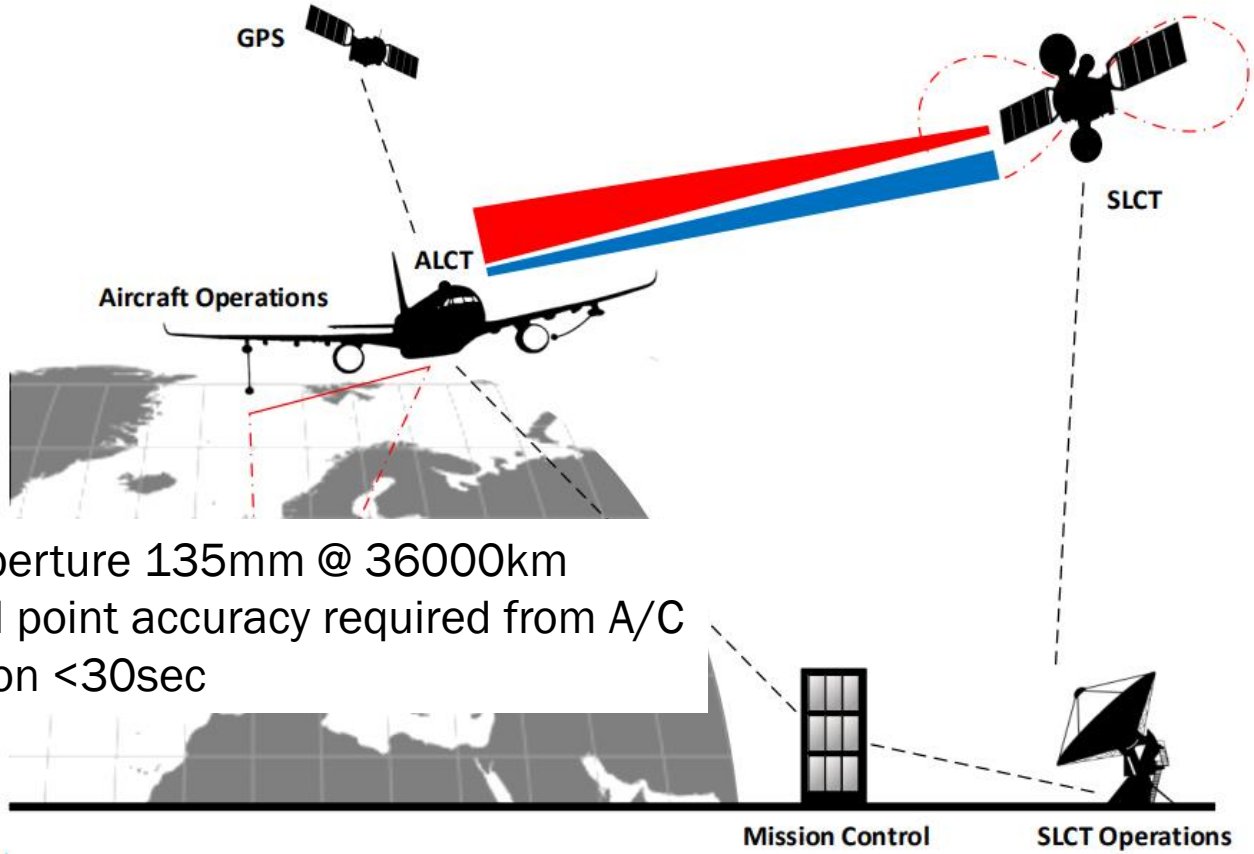
ULTRAAIR

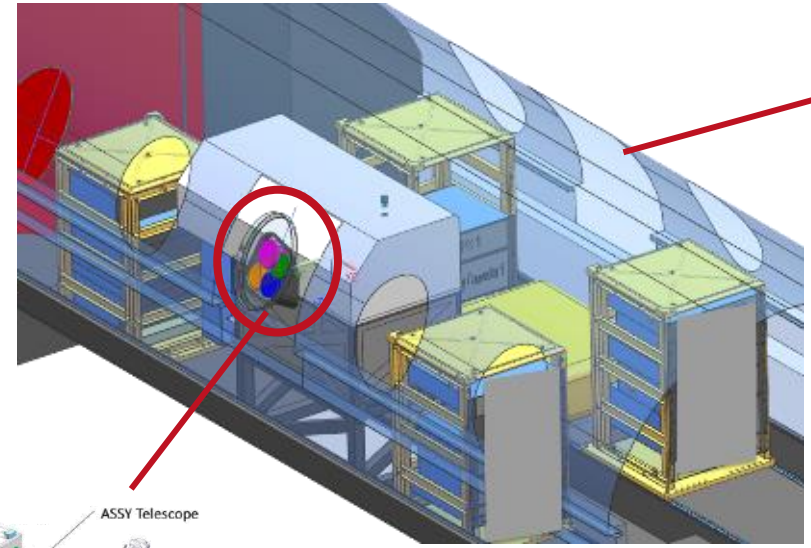
Project with: Netherlands Space Office, esa, TNO, AIRBUS, TESAT

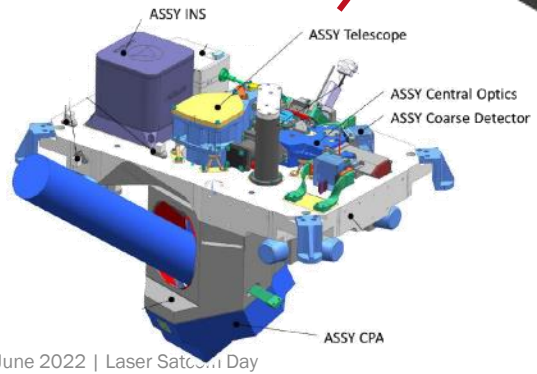


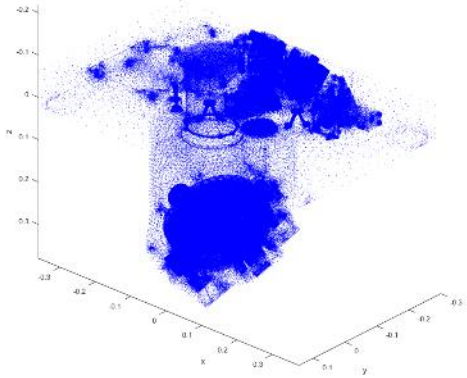
- Target aperture 135mm @ 36000km
- Sub urad point accuracy required from A/C
- Acquisition <30sec

ULTRAAIR

Project with:





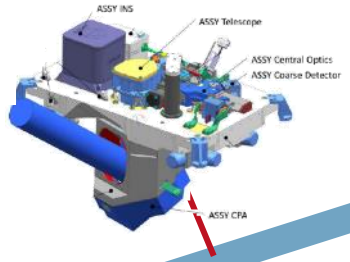


AIRBORNE ROADMAP

Complete
Ongoing
Planned

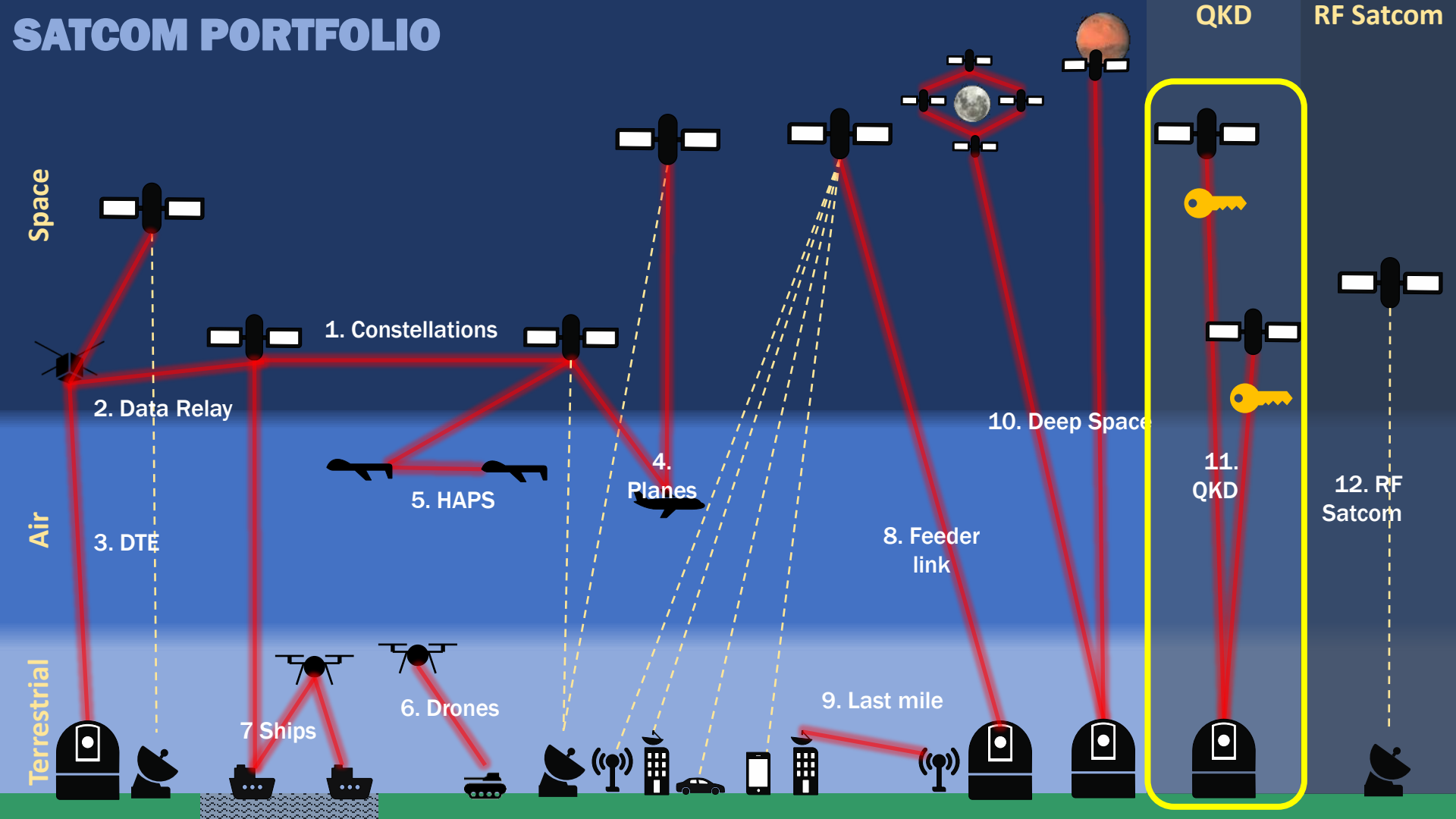
Lead: AIRBUS

- **UltraAIR:** GEO Demonstrator



- Product development (spin offs -> other platforms eg, HAPS, MALE etc, LEO interfacing)
- Production

See AIRBUS Roadmap.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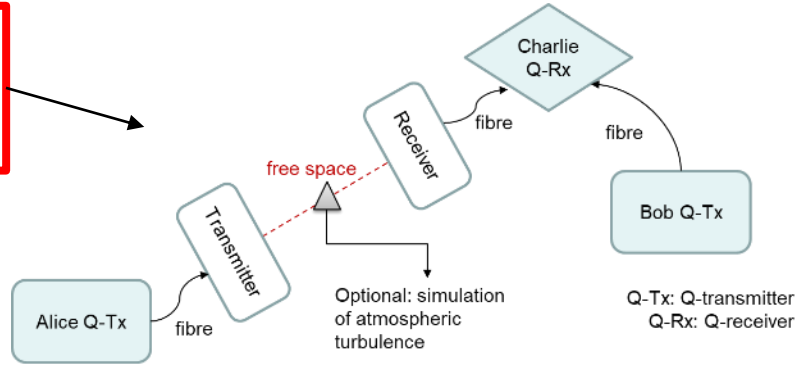
QKD - SEQURE

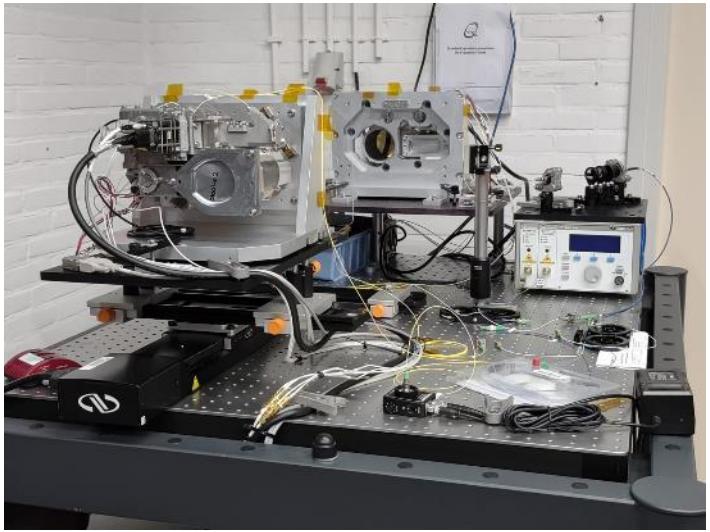
Project with:

TNO TU Delft ABN·AMRO QuTech

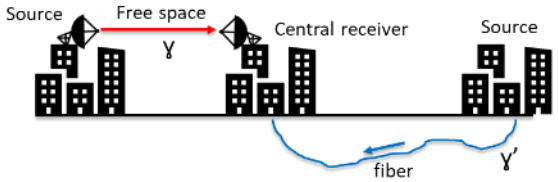
First-ever proof-of-principle of measurement device independent QKD combining free-space and fibre-based quantum channels in lab environment



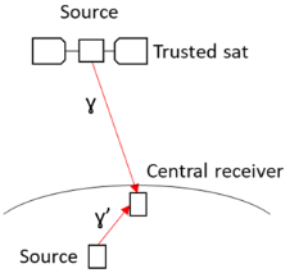
TNO designed and built the optical system for a 3.3km free space quantum channel



1 Ground-based MDI-QKD



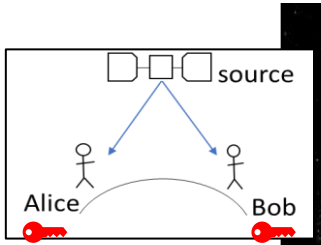
2 MDI-QKD from **GEO or LEO**, satellite acting as source to central receiver on ground

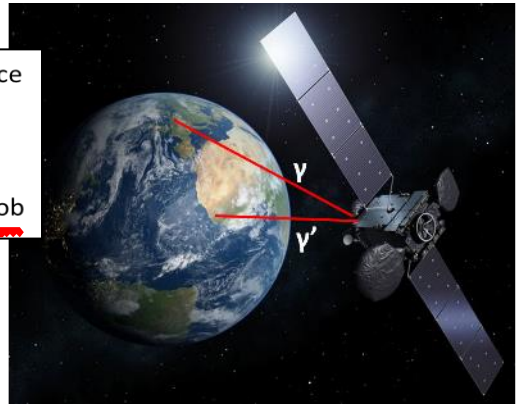


QKD - GEOQKD

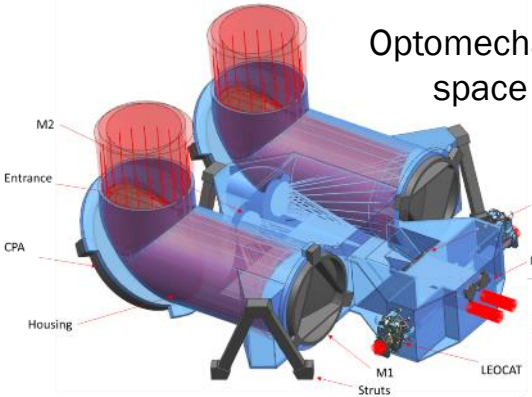
Project with TNO eutelsat CGI

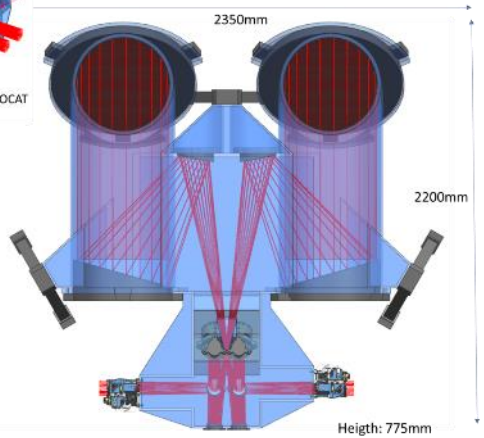
Feasibility and conceptual design study for QKD from a satellite in the geostationary (GEO) orbit





Optomechanical design space segment





Characteristics:

- 2x 0.5m diameter space
- 810nm
- 0.65µrad pointing accuracy
- ~2 to 2.5m diameter ground

Protocol	Total loss	Key per day from GEO	Inherent security
BBM92 trusted (single link)	~41dB	~3 – 10 Mbit	Low
BBM92 untrusted (double link)	~82dB	~10 kbit	High
GEOQKD hybrid solution	~41-82dB	~3 – 10 Mbit	Tuneable

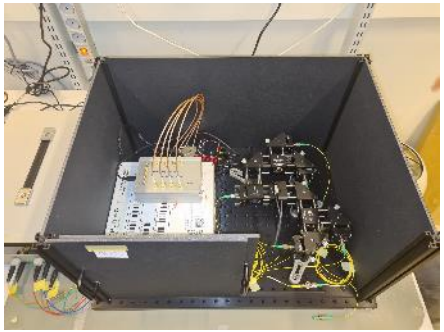
FOLLOWUP GEOQKD PROJECT

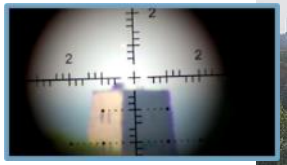
MAIN GOALS

- LAB AND FIELD TEST DEMONSTRATION HYBRID BBM92 (TRUSTED/UNTRUSTED)
- PREPARATION DEMONSTRATOR MISSION

SPECIFIC ACTIVITIES:

- Validate hybrid QKD approach
- Security and vulnerability assessment
- Investigation of ‘beyond QKD’ applications
- Proof-of-concept test of BBM92 over ~2.5km free space from TNO’s Optical Ground Station The Hague
- Define Demonstrator Mission and accommodation study of payload on satellite platform





Project with TNO

EUTELSAT

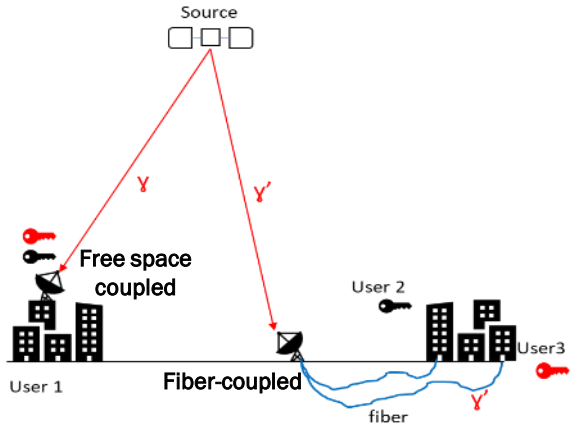
ThalesAlenia Space
a Thales / Leonardo company

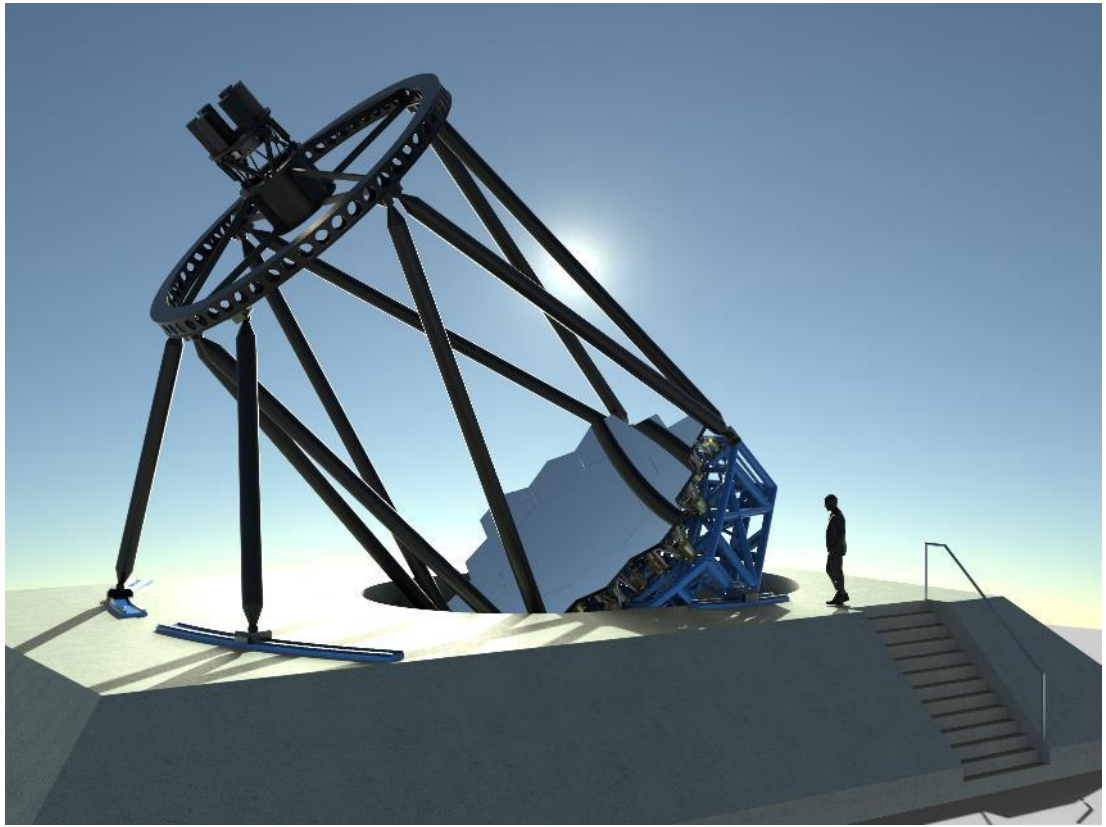
NL Holland High Tech
Global Challenges, Smart Solutions

QKD - GEOQKD GROUND TELESCOPE DESIGN

@1550NM

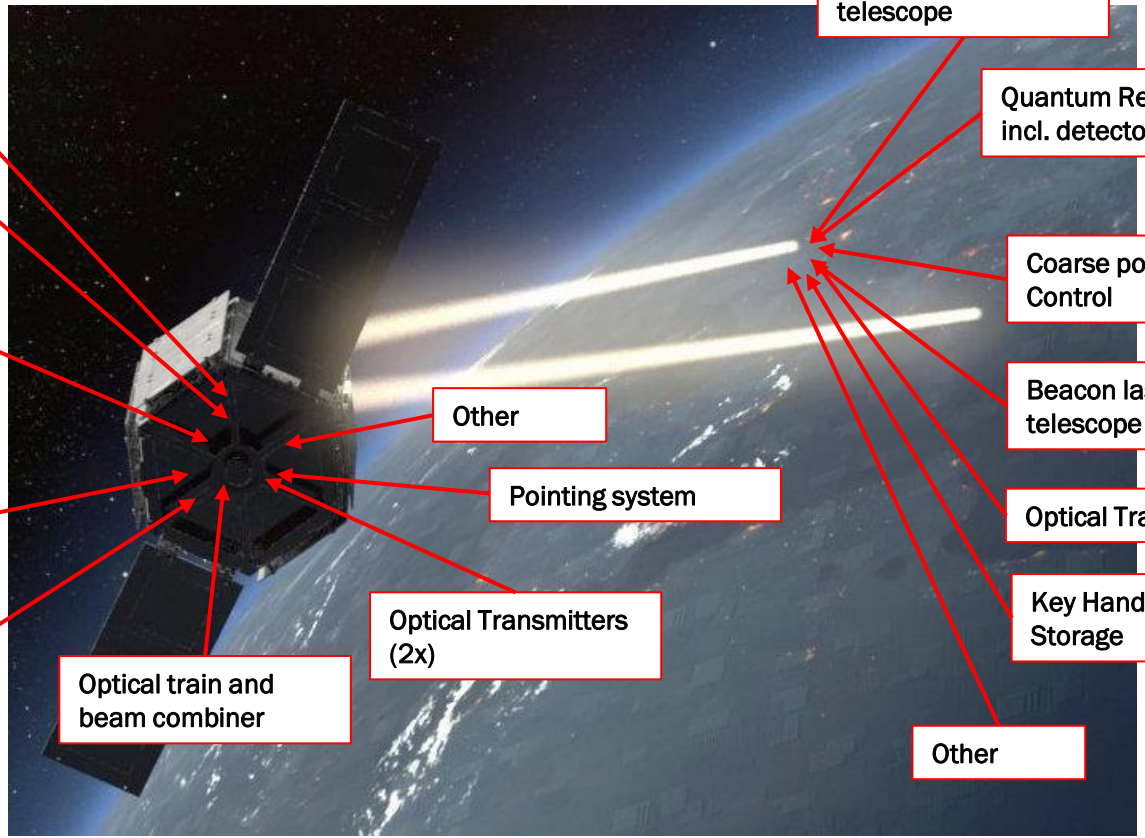
- Could be installed just outside a big city
- Connected to multiple users via optical fiber
- Users have QKD receiver in-house
- No need for user-owned telescope which need to be secured





QKD - CRITICAL SUBSYSTEMS

QKD PAYLOAD



CONCLUSION / TAKE AWAY

- Multiple demonstrators built and tested -> raising the TRL
- Winning the Growth fund at right time -> bridging valley of death
- Challenges ahead -> industrialization, competitive unit prices
- TNO focus:
  - Completing the going demonstrators
  - Supporting industry
  - Next technology wave

- We will only consider ourself successful when we start making product sales in a heathy business environment for industry

CONSORTIUM PARTNERS

THANKS TO OUR PARTNERS!

TNO TEAM MEMBERS

THANKS TO OUR TEAM!

THANK YOU FOR YOUR ATTENTION

FOR MORE INFORMATION: WILL.CROWCOMBE@TNO.NL

TNO innovation for life