Present and future Telecom Payloads: Modern Elements

Berry Smutny

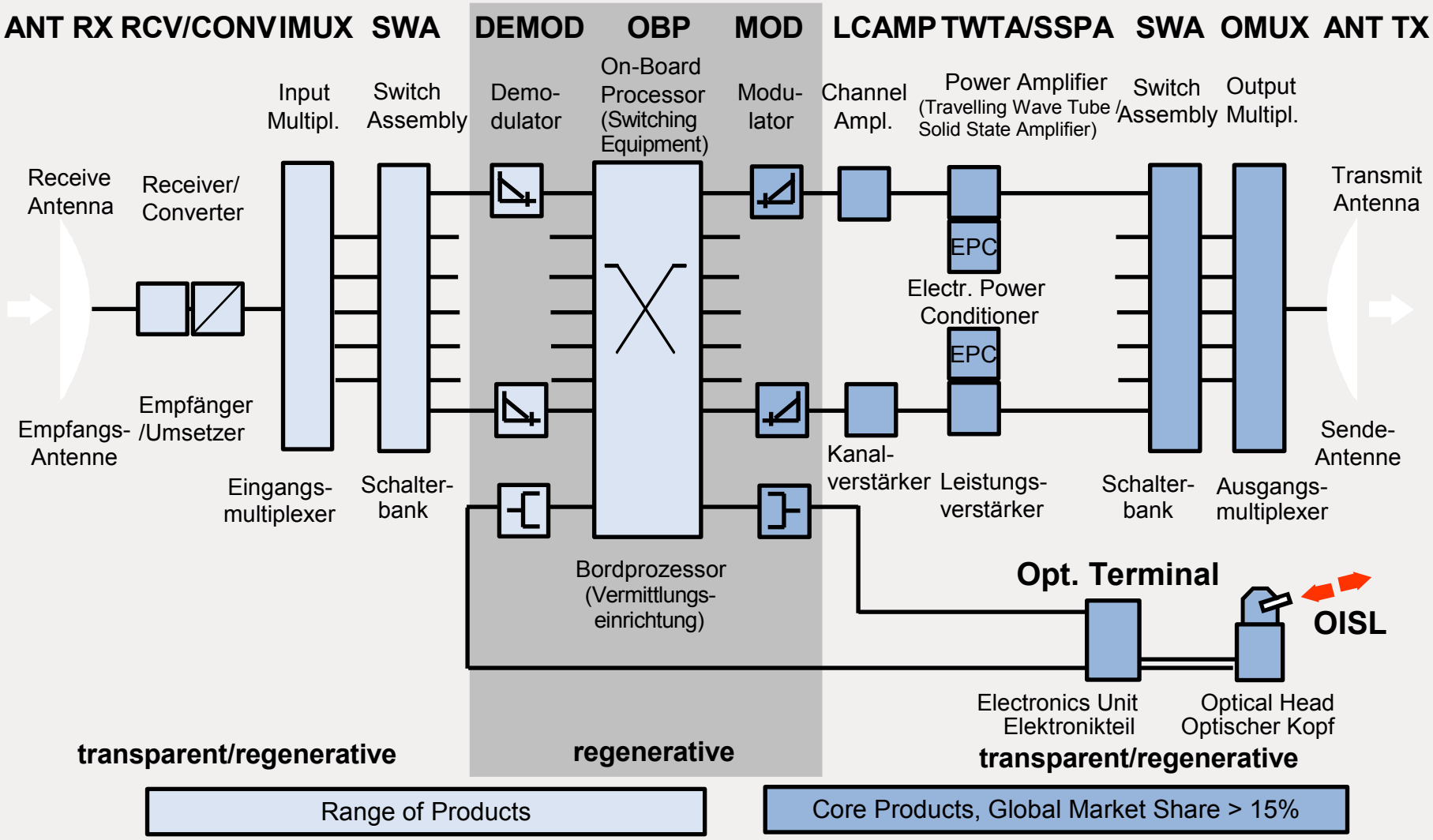
CEO

New Technology Generation for competitive Advantage

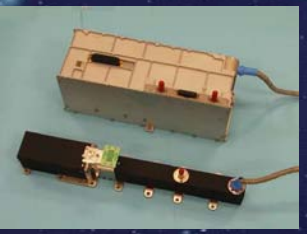
Overview

- Small GEO payloads
  - Market Requirements
  - Payload/Repeater strategy
- New Equipments change payload design philosophy:
  - Flexible Power Amplifiers
  - 3D passive filter solutions
  - V6 Aggregate
- Modern TM/TC concepts
- German programmatic environment
- Data Relay Capability:
  - Programmatic Status
  - Applications

Telecommunication Payload diagram



Participation in Satellite Programs since 1971

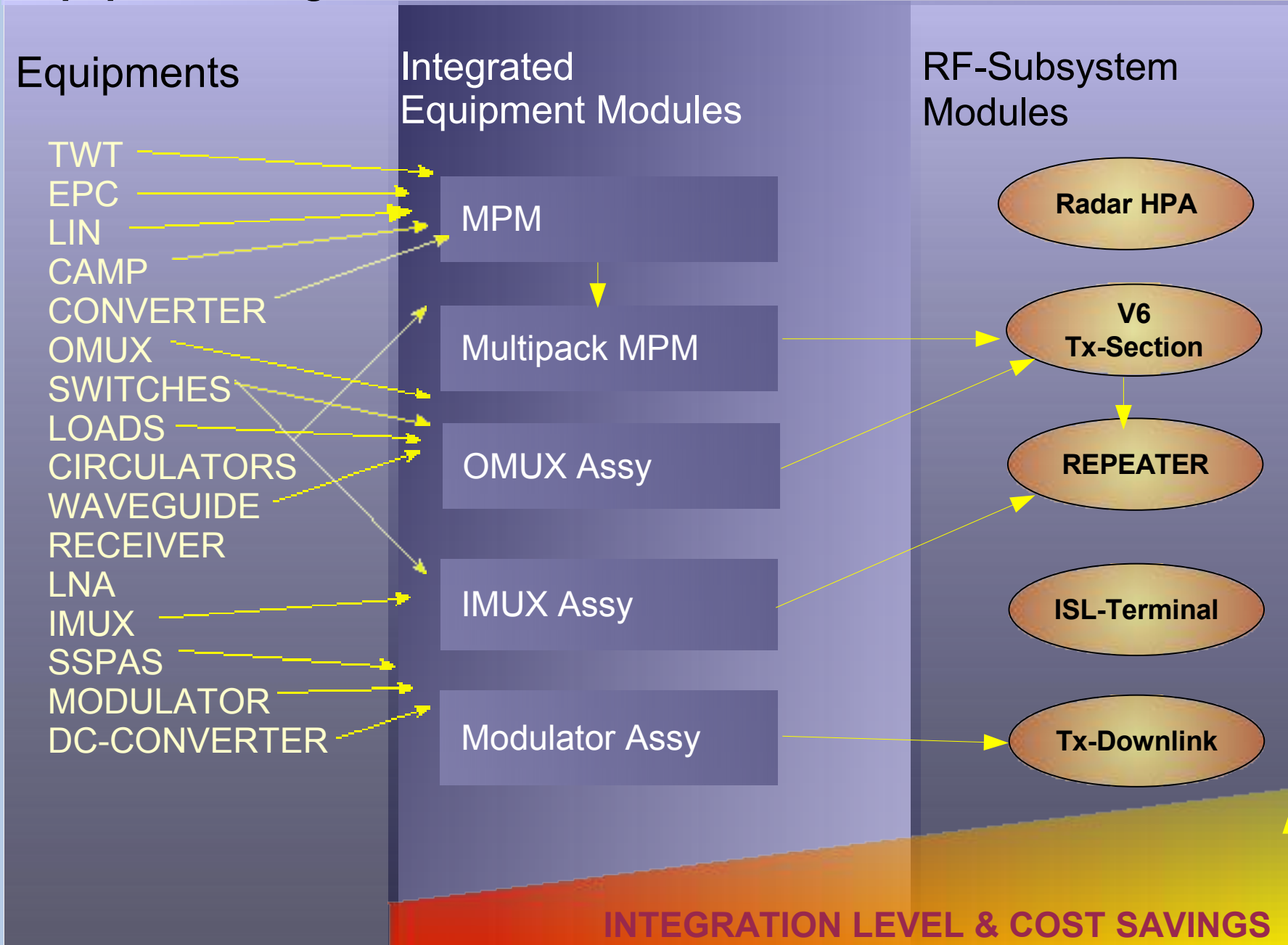


360 Programs in Space.....

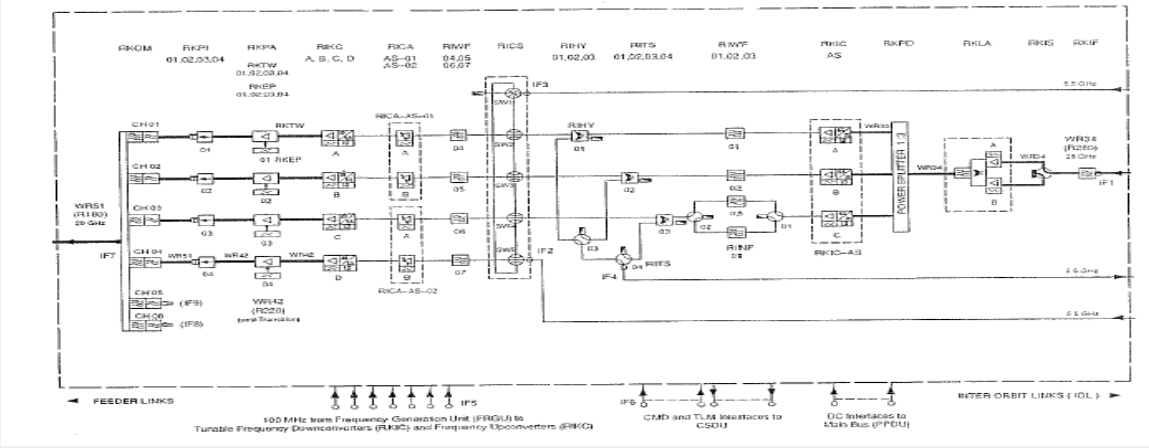
Small GEO payload/repeater market requirements

- Optimize the mission
  - Ka-Band missions
  - Ku/C-Band missions
  - X-Band Missions
- Schedule: <15 months
  - Stringent discriminator
  - Determined by equipments
- Flexibility
  - On Ground
  - In-Orbit
- Costs: Commercial Low-cost approach mandatory
- Compactness: Volume/Mass Benchmarking
- Dual Use: commercial product suitable for military application
- ISL-Link capability (military and Science)
- ITAR free solutions
- Risk Mitigation: In-orbit heritage by pilot missions

Equipment Integration Trends

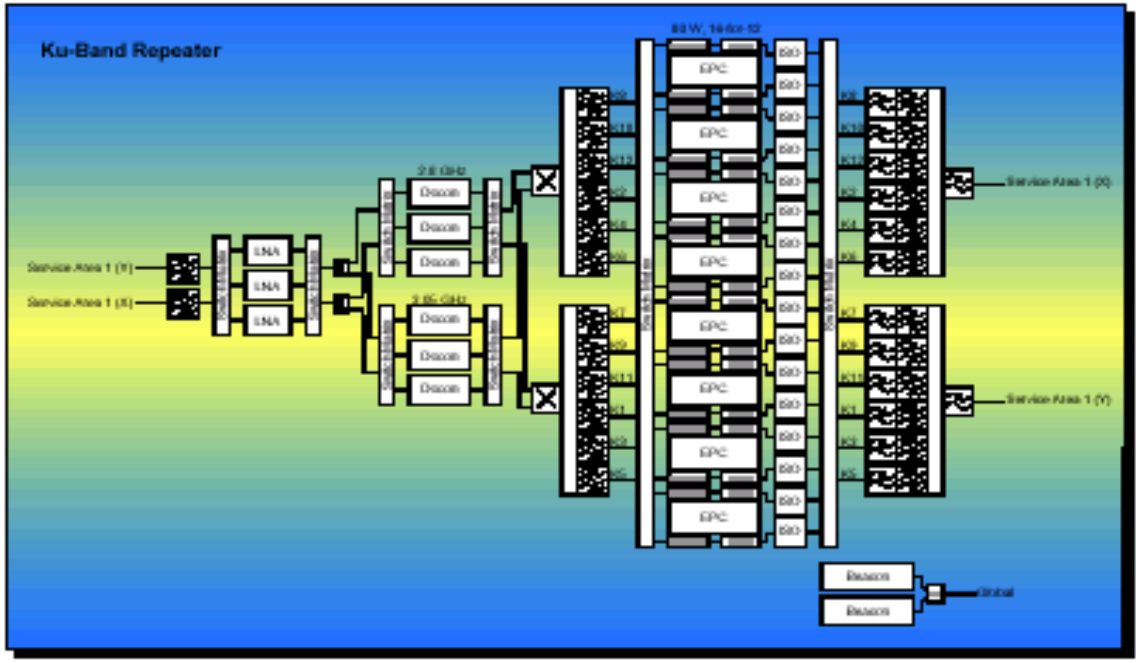


Transparent repeater activities



ARTEMIS Ka-Band 26/20 GHz Repeater

Ku-Band and X-Band repeaters eg SatComBw2



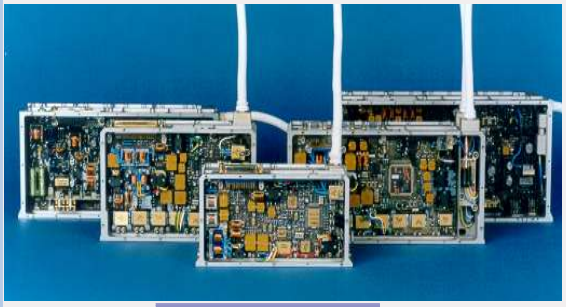
Repeater Strategy

- The analogy to car industry supply chain structure is evident:
  - Tx-Section as the „motor“ of the payload
  - Moving responsibility to the aggregate supplier (BMW-principle)
  - Cost and schedule reduction can only be achieved by aggregation of payload integration
  - Modularity mandatory in order to serve many missions
- Small GEO Platforms have less mounting area
  - GO to the 3rd Dimension
  - Utilize the Volume with high density
- Low-Risk solutions for digital/analogue Hybrids
  - Small GEOs are smaller risk for new innovative technologies

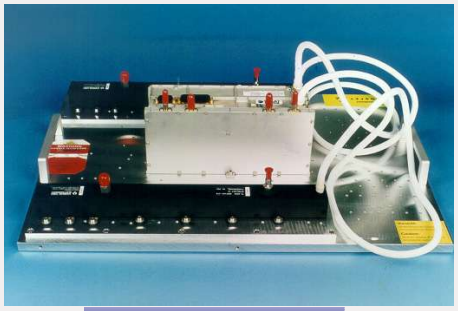
* Intelligence has to equalize disadvantages of the small GEO concept
* Modularity by in-orbit tunability enables schedule reductions
* Equipment technology determines the payload capability

▶ **Aggregation** and **flexibility** are key parameters to competitiveness

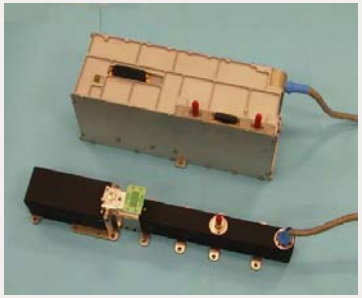
Product Line Active Products



EPC



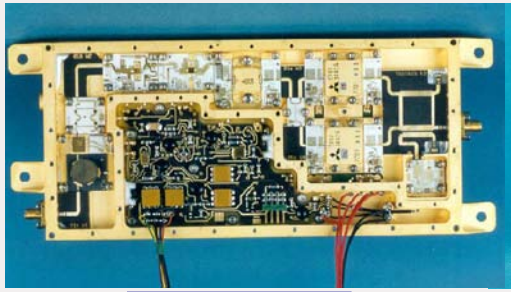
DUAL MPM (L)



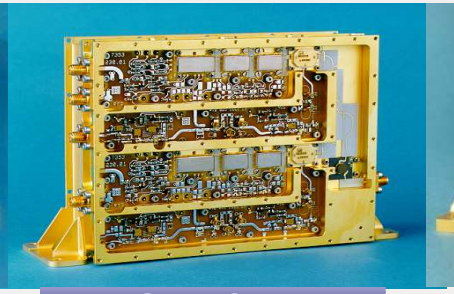
MPM (LC)

Product Scope

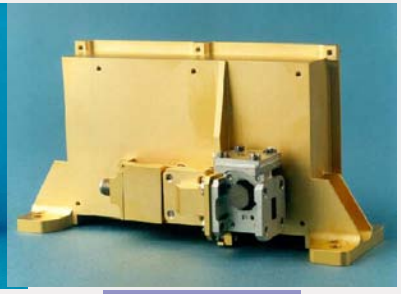
- EPCs/TWTAs
- Linearizers
- Channel Amplifiers
- MPMs (LC-TWTAs)
- SSPAs
- Up/Downconverters
- Low Noise Amplifiers
- Receivers
- DC/DC Converters
- RADAR TWTAs



SSPA



UP/DOWN Converter

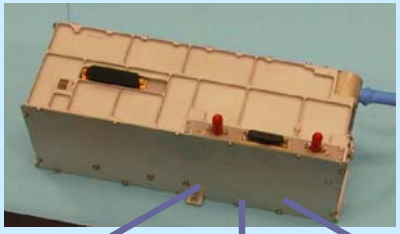


LNA

- All assembly, integration and testing is conducted in Backnang
- Linearizers and Channel Amplifiers typically integrated in EPC
- TWTAs qualified for NASA, ESA, Intelsat, Eutelsat and Inmarsat
- Lifetime in orbit of over 15 years
- Accumulated 66 million operating hours in space
- Frequencies range from 1.5GHz up to 60GHz
- RF output ranges from 10W to 450W

DC/DC Converter

Modular MPM Design

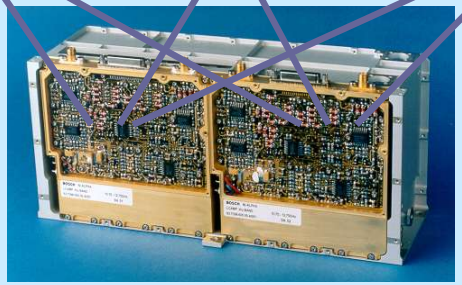


Single EPC
- ATC
- ATC-M
- ATC-L

LIN (L)

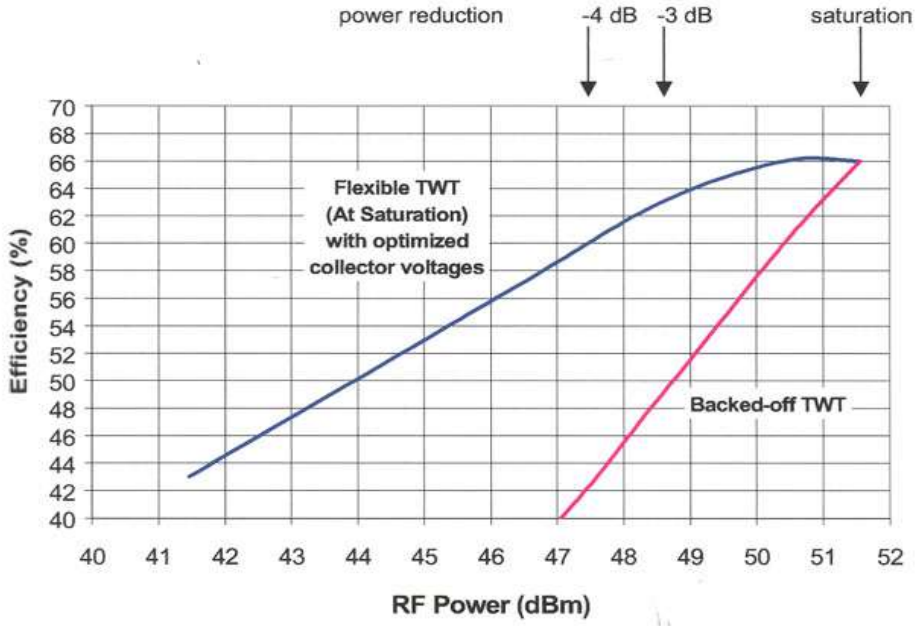
CAMP (C)

L-CAMP (LC)



Dual EPC

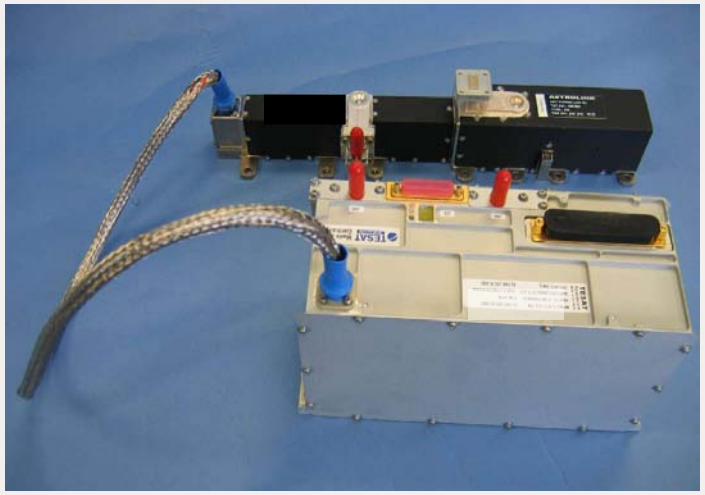
- MPM (LC) consists of TWT and EPC with integrated linearized Channel Amplifier
- Adjusting saturated RF output power of 3 to 4 dB with constant RF input power and constant efficiency



Flexible Microwave Power Module Ka-Band

Technical Characteristics:

Frequency range:	17.8 - 20.2 GHz
Operational BW:	500 MHz (800 MHz optional)
RF output power:	60 - 120W (e.g. in 4 steps)
Transition time:	~ 15 msec /step
DC input voltage:	50 / 70 / 100 V
Efficiency MPM:	> 60 % (at Pout max.)
Dynamic range:	30 dB (1 dB steps)
Mass:	
EPC + LCAMP:	XXXX g
TWT (CC):	XXX g

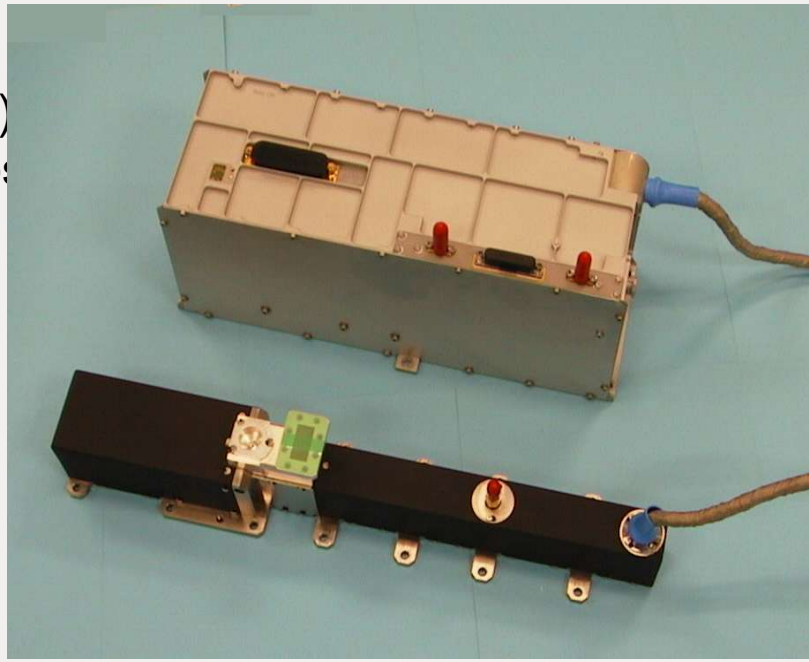


Status: EM by end 2006
FM contract signed
FM deliveries 2007

Flexible Microwave Power Module Ku-Band

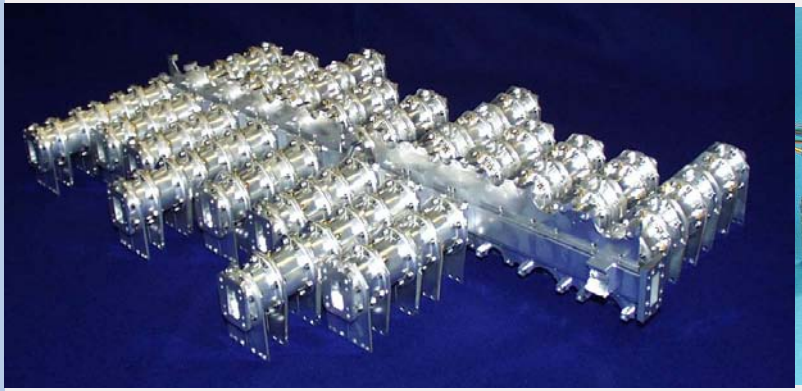
Technical Characteristics:

Frequency range:	10.75 - 12.75 GHz
Operational BW:	500 MHz (1GHz optional)
RF output power:	60 - 150 W (e.g. in 32 steps
Transition time:	~ 15 msec/step
DC input voltage:	50 - 100 V (regulated)
Efficiency MPM:	> 60 % (at Pout max.)
Dynamic range:	30 dB (1dB steps)
Mass:	
EPC + LCAMP:	XXXX g
TWT (CC):	XXX g



Status: EM 3rd Quarter 2006
FM release 4th Quarter 2006

Product Line RF Passive Modules



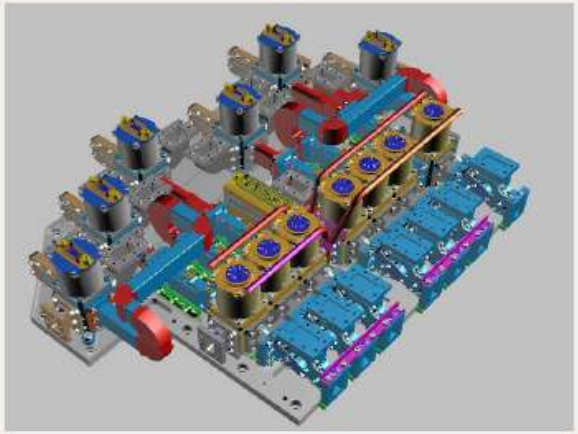
Product Scope

- Invar OMUX all Bands
- Ka-Band Invar Imux
- Ku-Band Alu OMUX
- Ku-Band dielectrical Imux
- OMUX Assemblies
- RF Waveguide Switches
- RF Loads
- RF Diplexers
- RF Circulators
- Waveguide Assemblies

- All manufacturing, assembly and integration as well as high power and multipaction tests are performed in Backnang
- Focus on Ku-band (12/14GHz) and Ka-band (20/30GHz) filter products and “wave guide” technology. Tesat-Spacecom produces for the “high-end” segment of the filter market
- Tesat Switches operate in a range of 4-40GHz for satellite redundancy switch matrices

MINIMUX

Output Switch Matrix Assemblies



New Product ECOMUX

3D OMUX – Motivation & Advantages

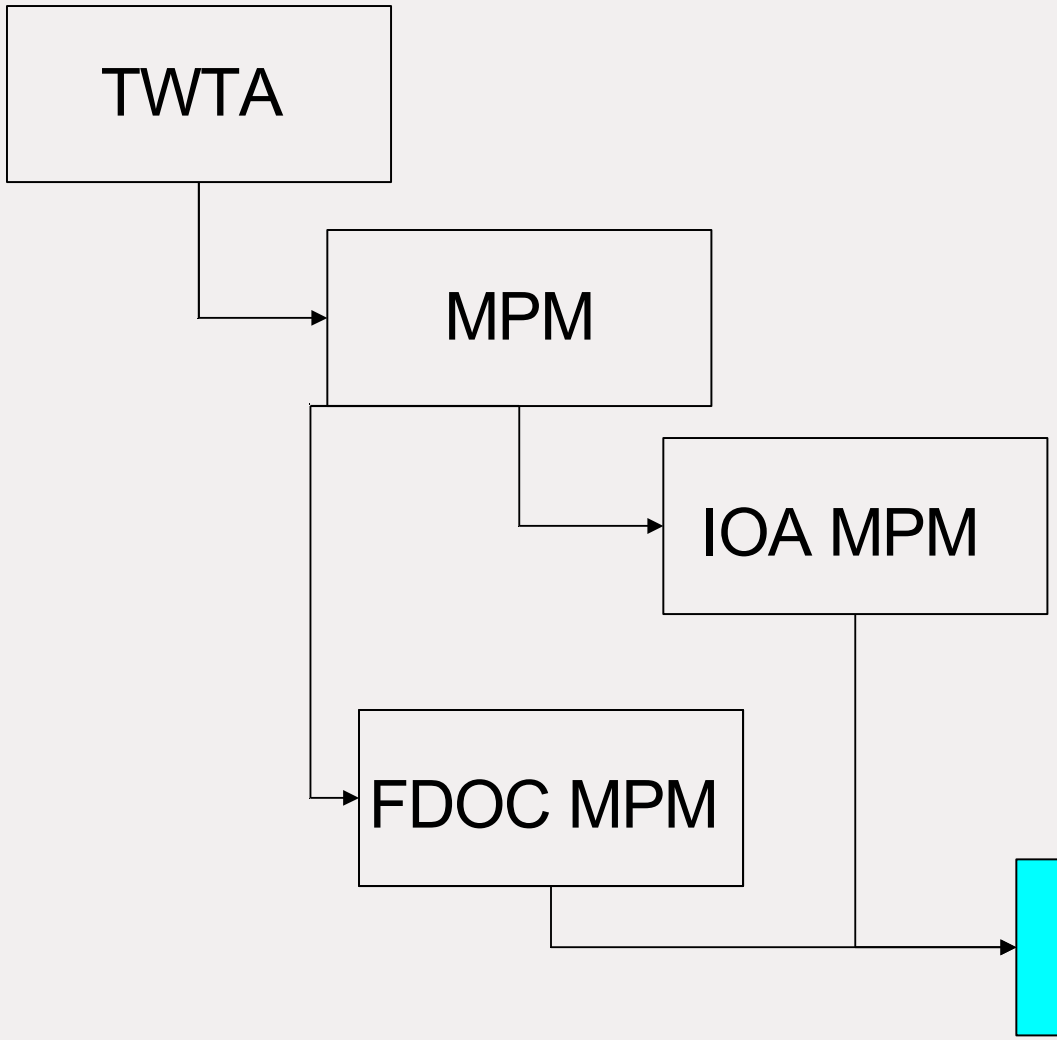
- ***Basic needs:*** More selectivity and more flexibility for payloads
- ***Result:*** Higher numbers of switches and filters relative to no. of amplifiers.
- ***Observation:*** Area for multiplexers and switch networks was growing in the last 5 years but size of the payload panel is limited for most satellite types.
- Main Advantages of the 3D-OMUX design
  - reduced foot print
  - higher integrated equipment
  - more simple equipment interfaces
  - in most cases complete output network

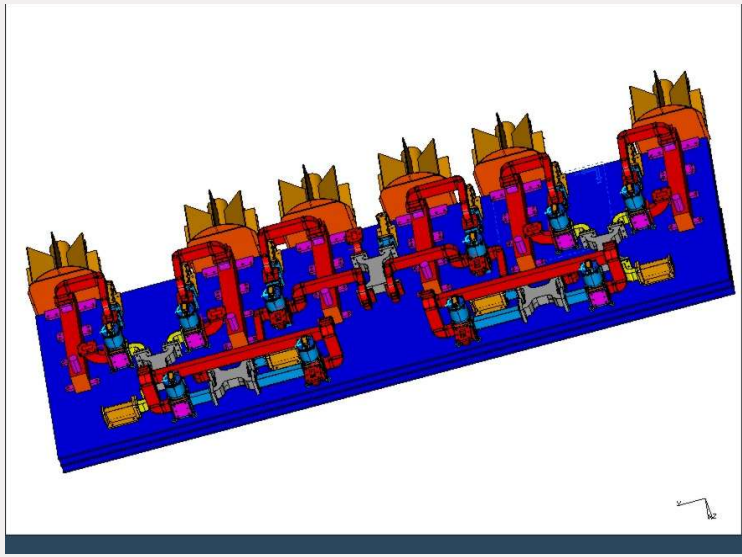
→ for small satellites the use of more complex output networks possible

→ better and earlier prediction for payload performance

→ shorter and less risky AIT for the satellite

V6 MPM Power Aggregate – Integration Strategy





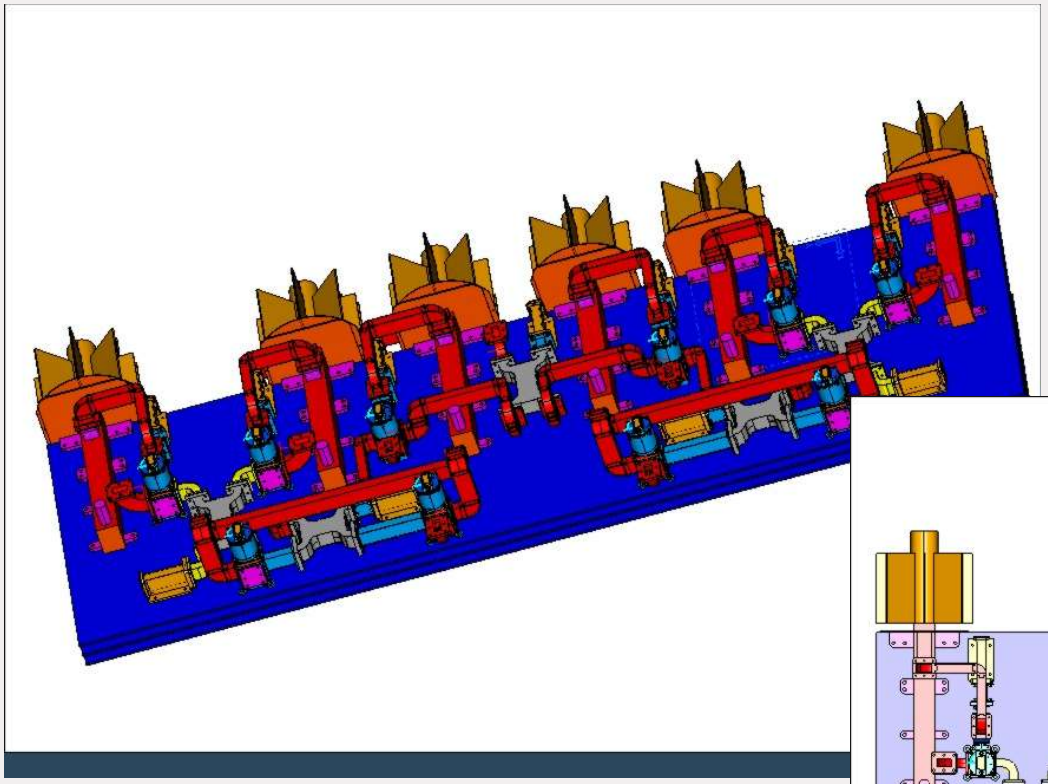
V6 – Basic Philosophy and Features

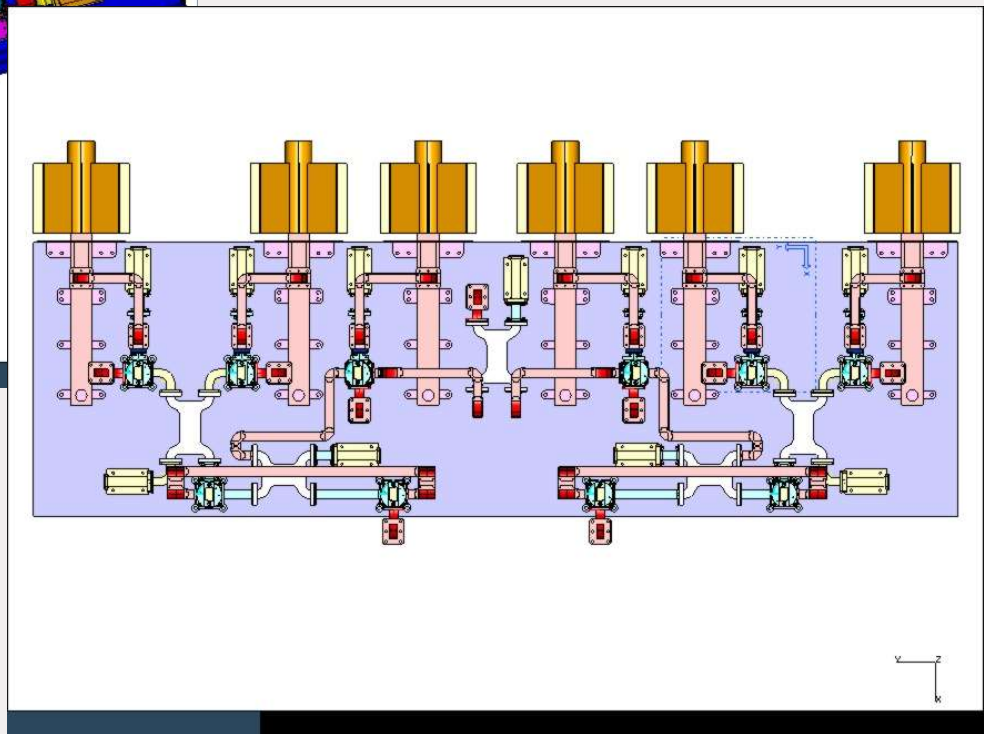
- Flexibility
  - Use of IOA MPMs RF Power
  - Power Combining possible
  - Active phase adjustment of the MPM channels
- Standard module
  - One Mechanical Interface
  - One Thermal interface
  - One TM/TC interface

AIT effort on Satellite-Level
  - Mechanical integration simple
    (One Plate instead of > 50 Components)
  - V6 is delivered by Tesat completely tuned and tested

- Management effort
  - One Module to be managed
- Risk-Mitigation
  - one specification with clear interfaces
  - No extra margins
- Mounting space
  - Extremely dense Packaging in Assembly possible
  - Critical parameter mounting area minimised by 3D design

V6 – 2D Sketch of Output Network and TWTs for 6 TWT Assembly





Optical TM/TC -- Motivation

Example: 12-Channel Ku Band Repeater

"Classical" TM/TC

DC-Harness: 10,5 kg + Mounting material

Gesamt	Pro MPM
260 TC-Signale	10 TC-Signale
370 TM-Signale	9 TM-Signale
630 Einzelsignale	19 Einzelsignale

Optical TM/TC

⇨ One (two fibers to each Unit)

⇨ Mass 4 g/meter
10 g/Connector
=> 200 m fiber plus 100 Connectors
results in 1800 g

⇨ Each signal created and distributed individually via PLIU	⇨ All Signals over one (two) fibers
⇨ High complexity of harness	⇨ Low Complexity of harness
⇨ High hardware cost	⇨ Low Hardware cost (Use of-existing standards possible)
⇨ High mass	⇨ Low mass
⇨ High EMC-sensitivity	⇨ No EMC-sensitivity
⇨ Harness problems difficult to handle exchange	⇨ Harness problems eaysy to handle by fiber
⇨ Different standards of satellite primes only adapatbele via hardware changes	⇨ Adaptation to Standards via Software possible
⇨ Low data rates, hardwaredriven	⇨ High data rates und Ilexibility in CAN Bus

Optical TM/TC
Results of Tesat studies, e.g within Euro SkyWay

Advantages of optical harness versus copper harness

- No EMC Problems
- Lower harness mass
- Easy to integrate
  - “Safe-to-Mate” procedure to integrate electrical interfaces
  - Lower risk to damage fiber optical connections
  - No grounding loops
- Scalable to higher data rates without changing the network architecture and the cabling

COMEG NG

Leuchtturm-Vision

Flaggschiff deutscher Raumfahrttechnologie

Wettbewerbsfähige Plug-In Satellitentechnologie für den zukünftigen kommerziellen Markt 2007-2012

Systemparameter

- Digitaler interoperabler Router
- 40 % unter aktuellem Marktpreis
- Leistung: 4500 W
- Masse: < 2000 kg
- Lieferzeit: < 14 Monate

Aktueller GEO Markt

Digitale Flexible Gläserne Nutzlast

- Flexibel konfigurierbare Mikrowellengeräte
- Interoperabilität durch optische Vernetzung
- Digitaler Router mit voller Kompatibilität zu transparenten Standardsatelliten

NL und Geräte für aktuellen GEO Markt

„Low Cost and Mass“ Buskonzept

- Neuartiges AOCS (neue Sensorik)
- Ionenantriebe und GaAs Solarzellen
- Neuer Busrechner (COTS)
- leichter Kabelbaum
- Neues Struktur- und Thermalkonzept

Geräte für aktuellen GEO und LEO Markt

Hochleistungs - Bodensegment

- HW / SW abgestimmt auf die Verwendung mit Plug-In Satelliten und Satellitenclustern
- Betriebskostenoptimiertes Bodensegment
- Sehr niedrige Beschaffungskosten

Systeme für rural und nomadic IP-Service Markt

Weg

Marktfähige Produkte durch anwendungsorientierte Entwicklung innovativer Systeme und Kombination der besten Ressourcen in der deutschen Industrie und Wissenschaft

- Erschliessung neuer Märkte
  - Aufbau zukunftsträchtiger Kompetenzen
  - Langfristig tragfähige industrielle Strukturen
  - Weniger externe Ab -hängigkeit (ITAR Regularien)

Optical Data relays with Laser Communication Terminals

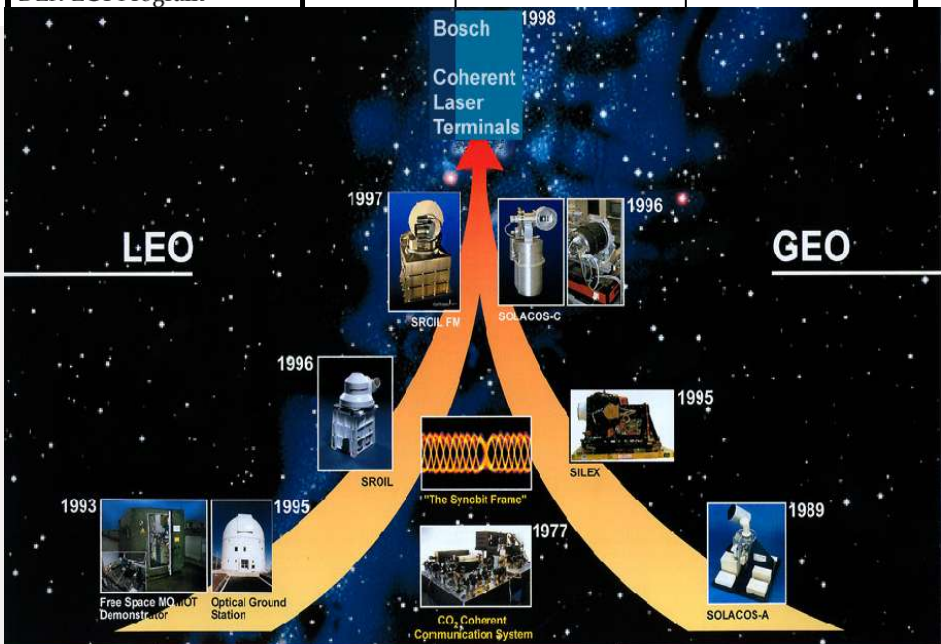
- Optical Data Relays are key strategic technology
  - MilSatCom and BMD need mandatory high data rate ISLs
  - Science missions and Reconnaissance are limited by downlink data rate
  - In Long term optical down links will complement microwave spectrum
  - Commercial GEO-LCT application will come as slow as satellite providers compete on this subject...
- Germany No. 1 in laser communication terminals
  - SILEX, SROIL, DLR-LCT, Teledesic and LCTSX paced the way
  - Continous investments pays off
- Optical Laserlinks are digital by default!
  - Analogue optical com is technically not reasonable
  - Interfaces from digital data to bent-pipe payloads have to built and verified
  - DLR starts program (ODA) for die AD Interface
  - ARTES-11 would be an attractive opportunity...

The 30 years of European coherent laser crosslinks for space.

- Started with the CO_2 ESA program 77
  - Batelle Institute, Frankfurt
  - Breadboard
- SOLACOS and Nd:Host 1989
  - ESA and DLR studies (Dornier)
  - EM with Syncbit and fibre actuators
- Optical Ground Station in Spain (ESA)
- SROIL ESA program 1996
  - BPSK homodyne EM from Contraves
- DLR-LCT, KTV Medis DLR 1997
  - 2 QM terminals Tesat
- Teledesic, Celestri 1997-1999
  - Motorola and Tesat
  - Qualification of cohernt terminal
  - Contract of 500 terminals
- LCTSX DLR 2002
  - Flight contract for 2 FM terminals
  - 2006 Launch and verification

German OISL Programs European OISL Programs

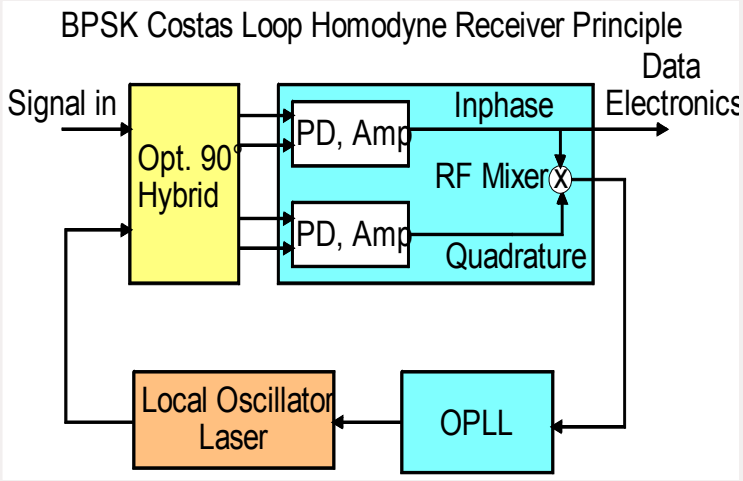
Project	70s	80s	90s
Coherent CO2			
SILEX			
Intelsat Optical Link			
Nd:YAG System Study			
SOUT			
Optical Ground Station			
High Power Laser Diode			
SOLACOS			
Mini Terminal Study			
ISL Oblique Mirror			
SROIL			
DLR-LCT Program			

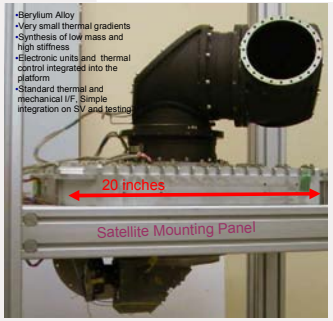


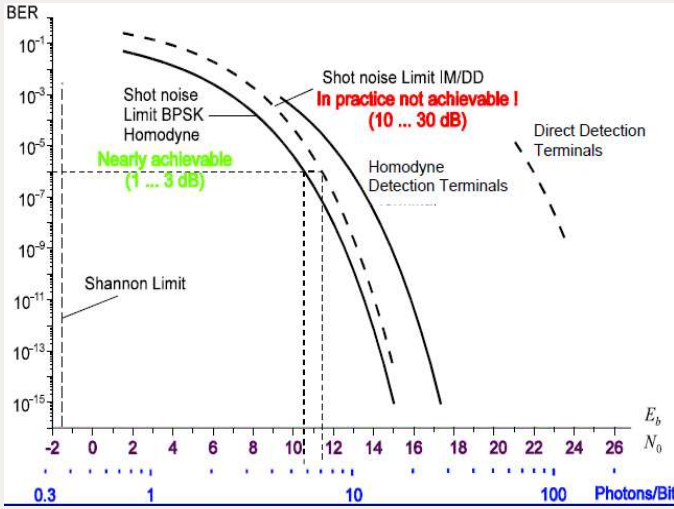
German Laser Communication Terminal Key Design Features

The Coherent Transceiver:

- Costas Loop Detection
- Monochrome System
- Com & Track Immune to Sun
- Beacon-less Acquisition
- No pixel sensors, all 4Q
- Scalable output power
- Hemispheric pointing
- Self diagnosis



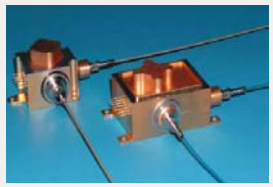




The Optics:

- No optical bench, simplistic design
- Carl Zeiss Telescope
- No optical filters

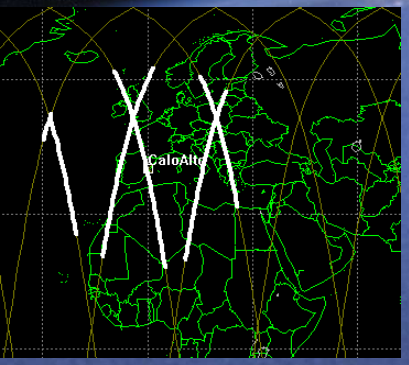
The Laser Source

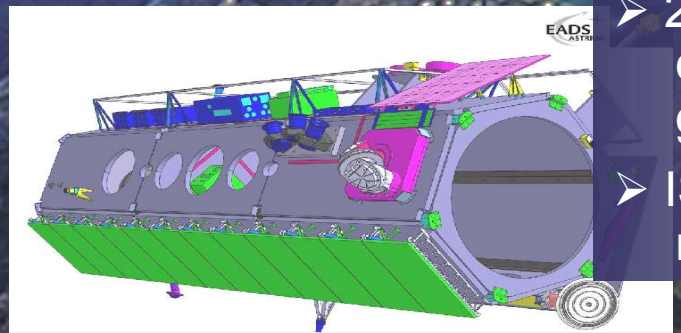


- Frequency of 281.000.000.000.000 Hz with 0,4 Hz Stability
- Space qualified cooperation with the US, utilized for ESA and NASA mission

The German TerraSAR LCTSX programme

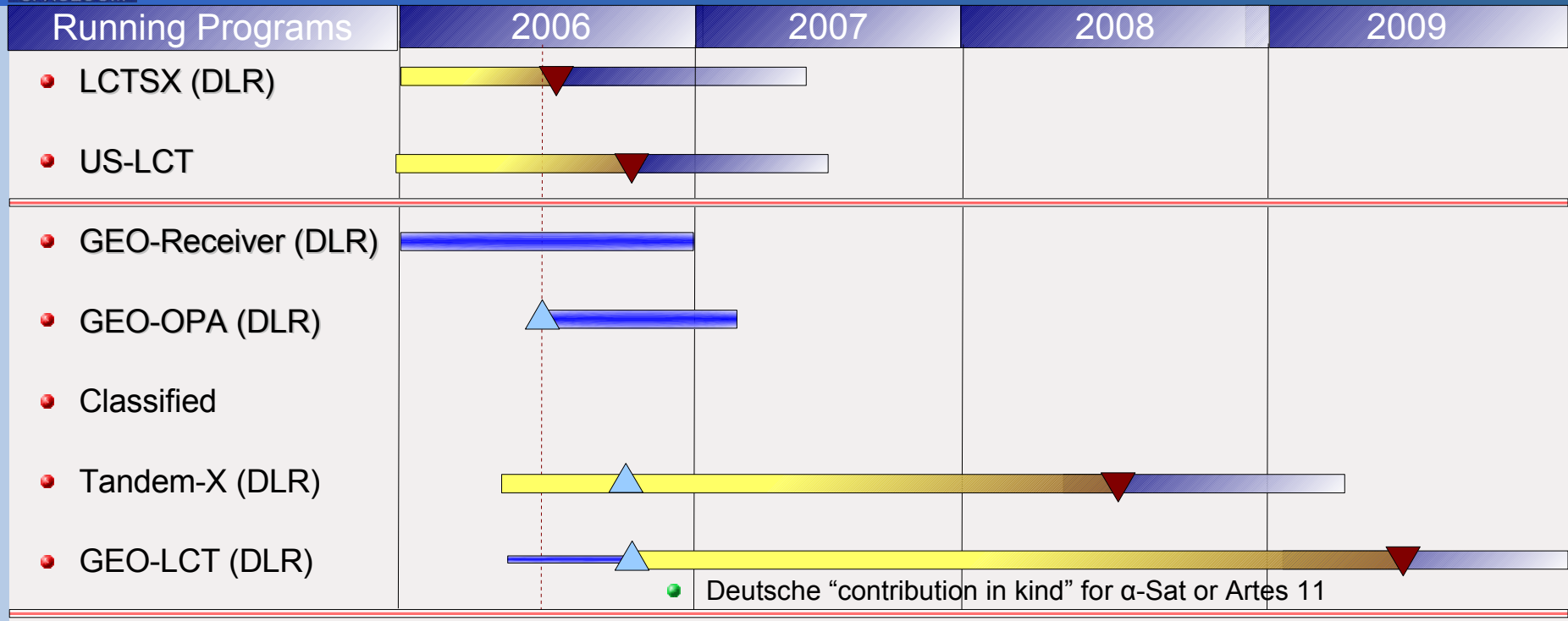
LCTSX



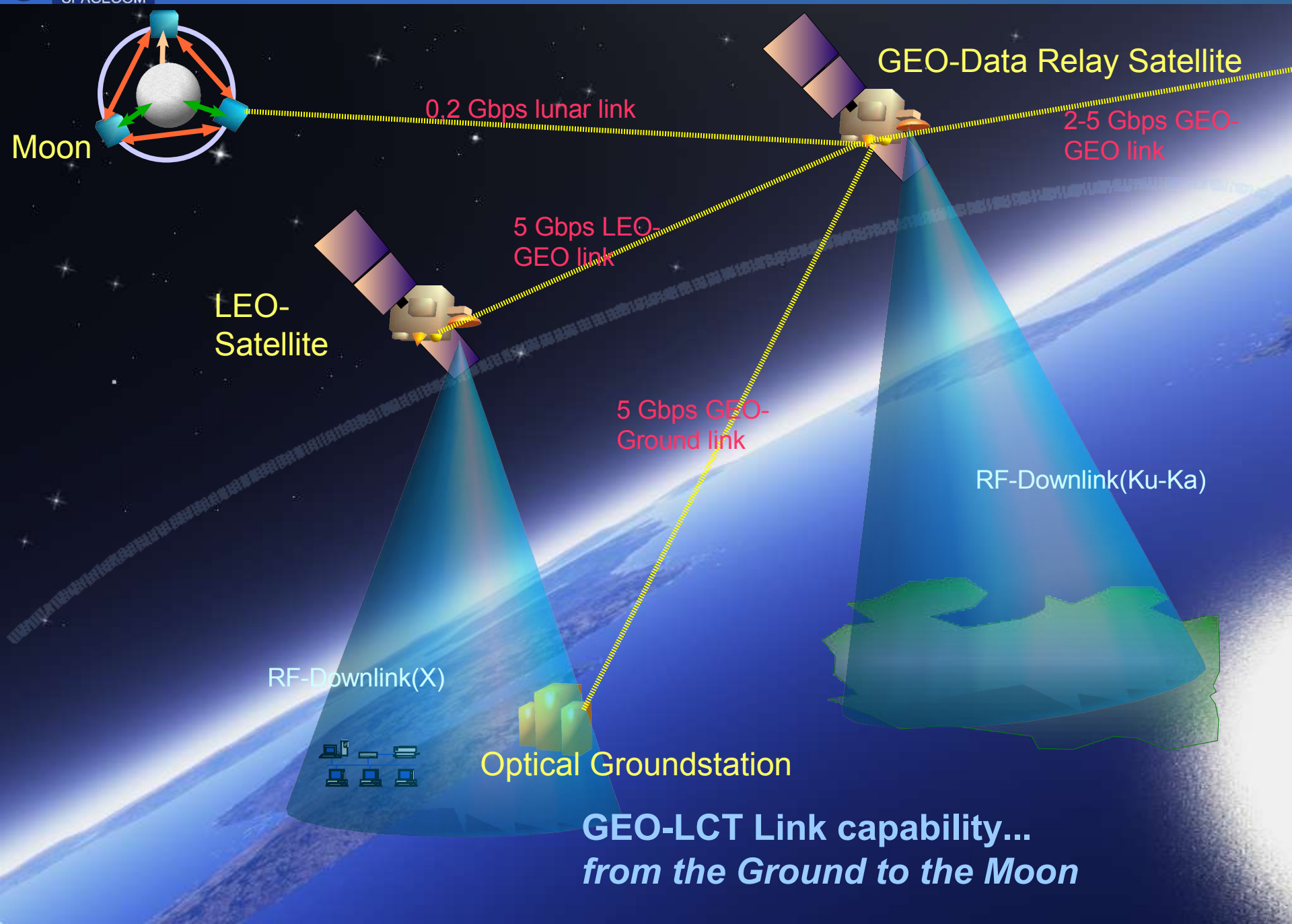


- Delivery of 2 flight models 5500 Mbps Data rate laser crosslink terminals to the German Space Agency for launch in Q3/06
- Verification of terminal No. 1 on the German satellite TerraSAR with a optical ground station in Spain Q1/2007 ; Experimental datalink for SAR-data
- 2005 Island-to-Island (Teneriffa) coherent link demonstration in October 05 with mobile ground station and ESA optical ground station
- ISL verification in 2007 with Terminal No. 2 mounted on US satellite

LEO LCT Integrated System Test on TerraSAR Satellite



- LEO-LEO ISL Terminals
  - LCTSX delivered, launch October 06, verification until Mid of 2007
  - US-LCT to be delivered End of September, Launch April 07
- GEO-LEO ISL Terminals
  - Tandem-X LCT and GEO-LCT programm started 1st of June 2006,delivery date is Mid of 2008. Nominal Data rate is 1-2 Gbps.
  - Both Terminals are capable for LEO-LEO, LEO-GEO, GEO-GEO and GEO to Ground links



GEO-LCT Link capability...

from the Ground to the Moon