ATM-Workshop, Berlin, June 19, 2002

COMED ATM Payload Demonstrator

B. Hespeler
Tesat-Spacecom
71522 Backnang, Germany

Table of Contents

GEO - Broadband Satellite Systems

Services:

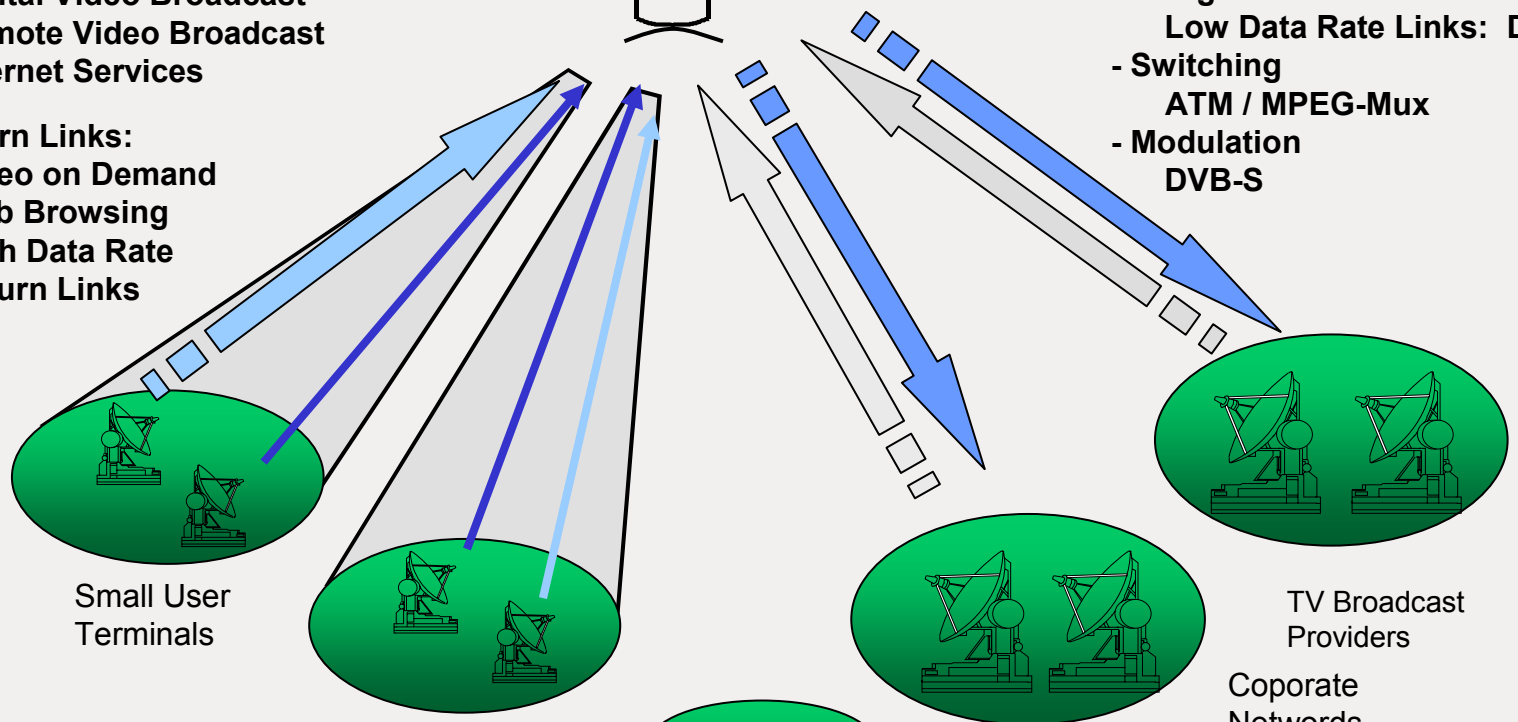
Forward Links:
- **Digital Video Broadcast**
- **Remote Video Broadcast**
- **Internet Services**

Return Links:
- **Video on Demand**
- **Web Browsing**
- **High Data Rate Return Links**

Communication Satellite

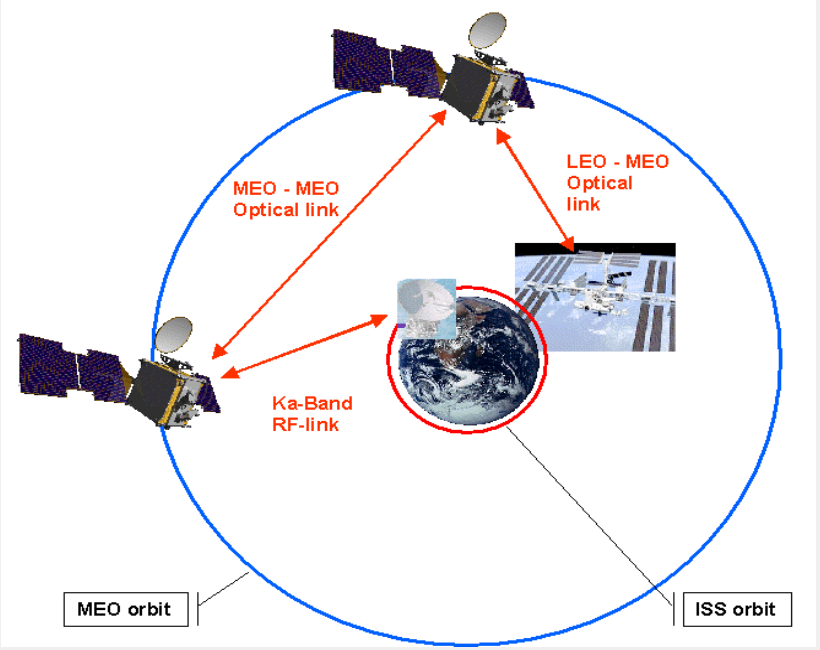
On-Board Functions:

- **Demodulation**
  - **High Data Rate Links: DVB-S**
  - **Low Data Rate Links: DVB-RCS**
- **Switching**
  - **ATM / MPEG-Mux**
- **Modulation**
  - **DVB-S**

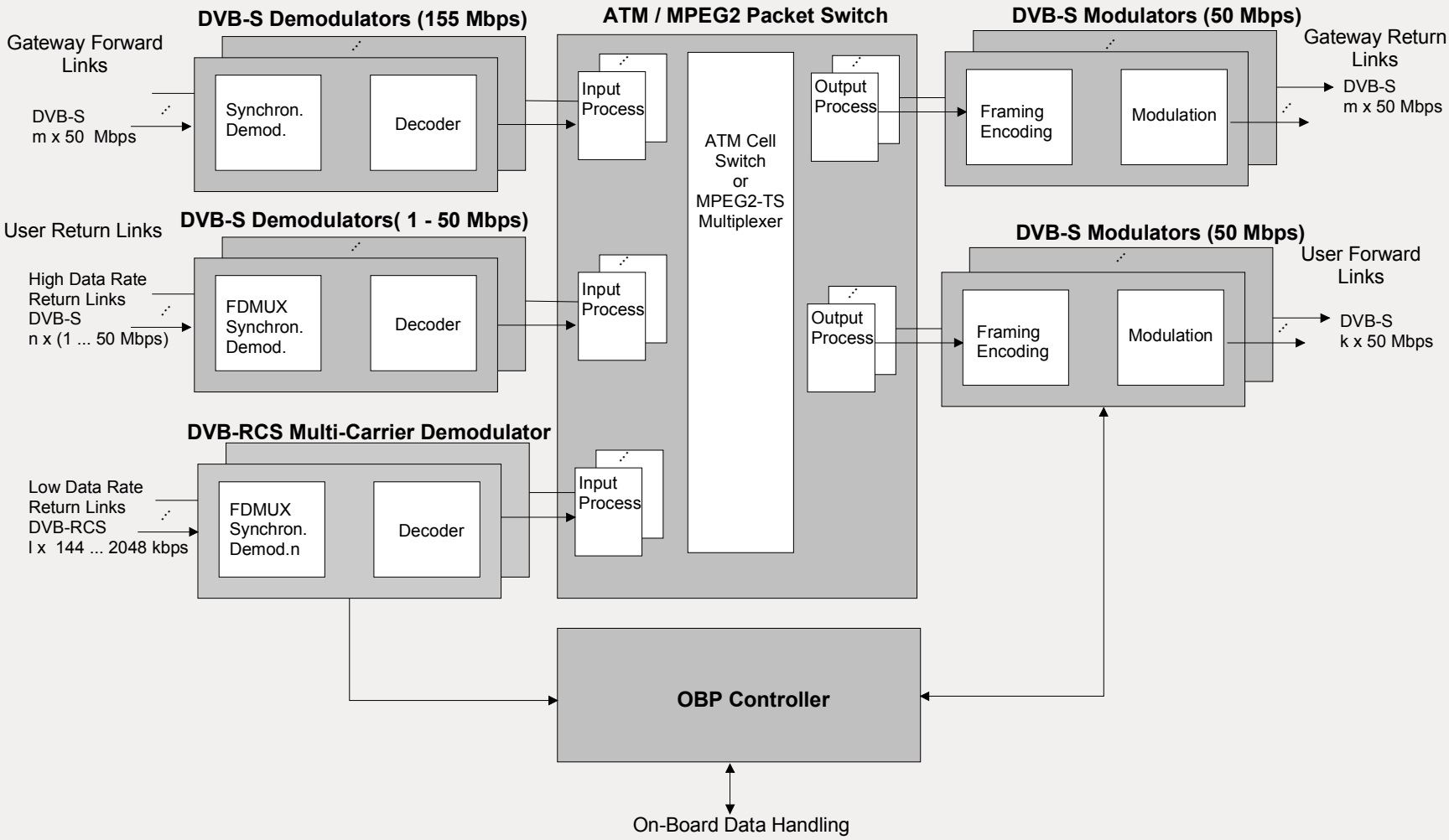


MEO - Communication Satellite Systems

Services:	Symmetrical Links between Fixed Ground Stations or Vehicels, e.g. Leased Lines at 155 Mbps (STM-1)
Switching Scheme:	ATM, Quasi-Static Connections
Transmission Waveform:	DVB-S
Intersatellite Links:	Optical
Throughput :	1 - 5 Gbps
Example:	MEDIS



Reference Architecture of On-Board Processing Payload



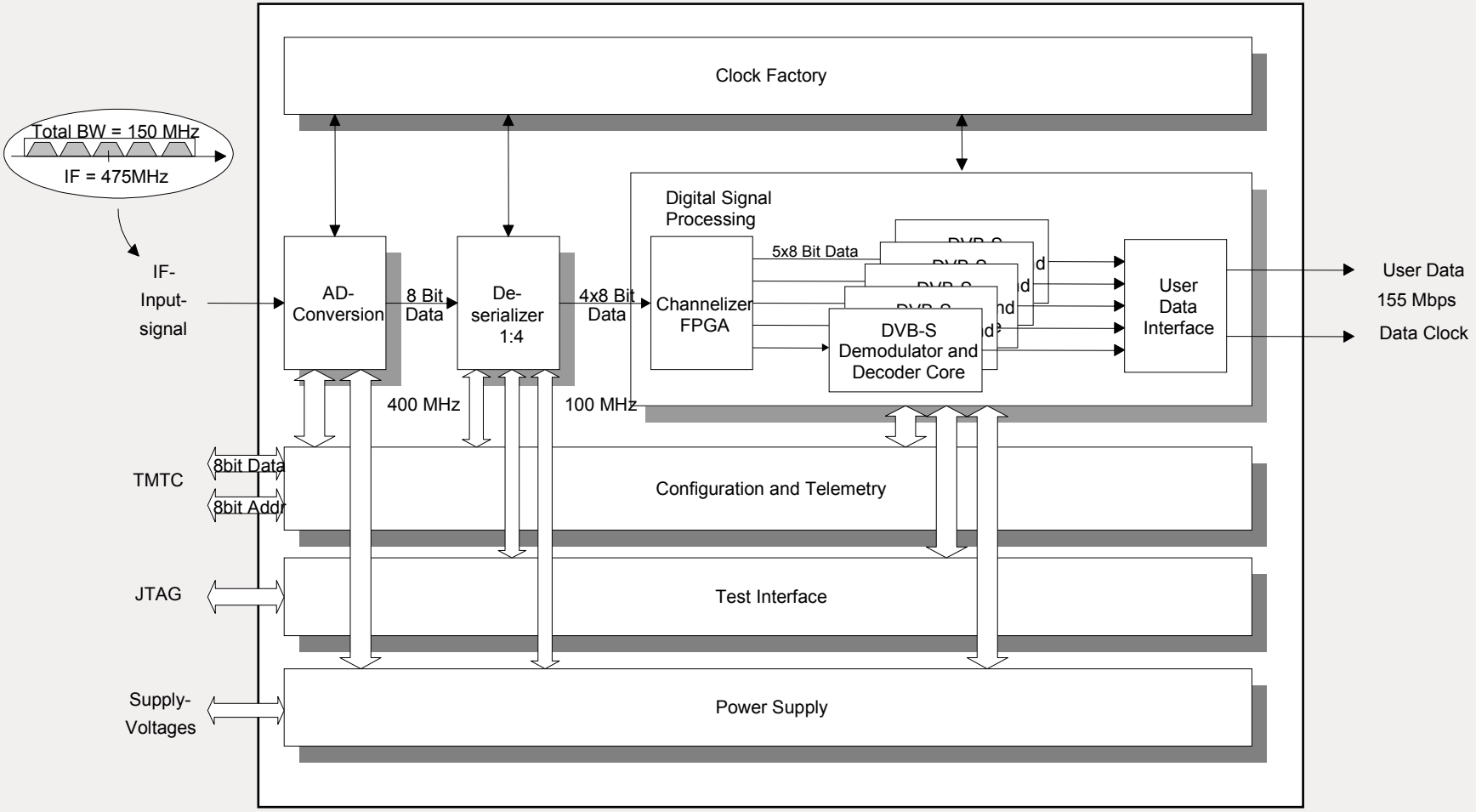
COMED ATM Payload Demonstrator - Rationale and Objectives

- Attractive Applications of On-Board Processing Payloads in the Field of Broadband GEO Systems and MEO Systems
- Support of German Satellite Industry Necessary to Compete
- Tesat-Spacecom and German DLR Initiated the COMED Program with the Following Objectives:
  - ⇨ Development of the Basic Technology for On-Board Demodulators and Switches
  - ⇨ On-Ground Demonstration of Technology and Capability at Tesat
  - ⇨ In-Orbit Verification Envisaged

Characteristics Of DVB-S Demodulator

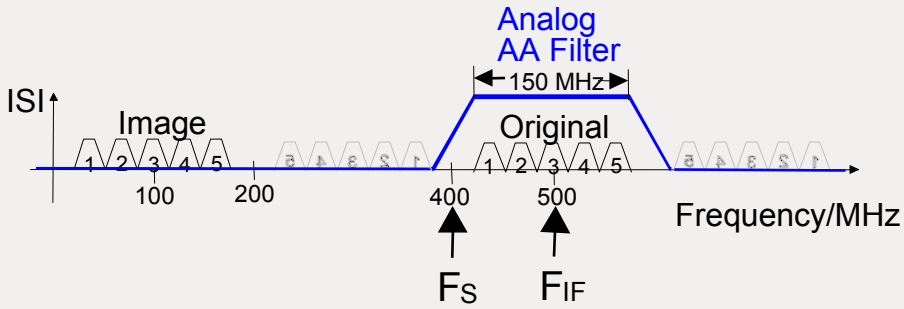
Parameter	Value	Unit
Transmission Standard	DVB-S	-
Modulation Scheme	QPSK	-
Decoding	Reed-Solomon + Viterbi	-
Synchronisation	Carrier Frequency and Phase Clock Frequency and Phase	-
Input IF Frequency	0 ... 475	MHz
Number of Carriers	1 ... 5	-
Carrier Bandwidth	1 ... 50	MHz
Total Input Bandwidth	Max. 200	MHz
User Data Rates per Carrier	1 ... 100	Mbps
Overall Data Rate	Max. 200	Mbps
Eb/N0 @ BER = 10^{-10}	7.5	dB
Power Consumption	15 (155 Mbps Version)	W
Mass	3 (155 Mbps Version)	kg
Status	DVB-S Demodulator ASIC under Development, EM in Q4/2002	-

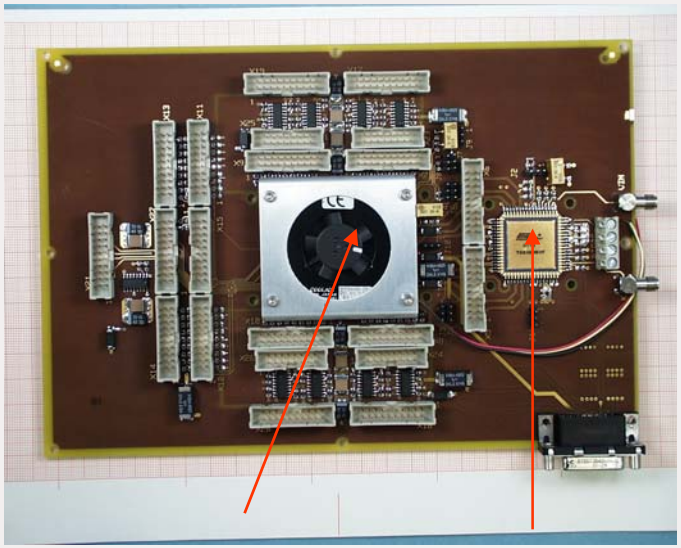
Architecture of On-Board DVB-S Demodulator (155 Mbps)



Broadband Analog-to-Digital Interface

Functions:	A/D-Conversion, Deserializer 1:2:4:8
Sampling Scheme	Bandpass-Sampling
A/D-Wordlength	8 bit
Effective Wordlength	7 bit
Input Frequency	up to 1.5 GHz
Sampling Rate	up to 1 Gsps
Power Consumption	10 W
Technology	Space Qual. A/D-Converter
Status	Breadboard Verified



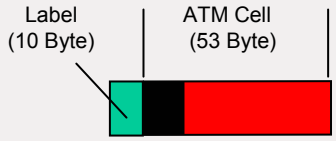


Deserializer (with Active Cooler)

A/D-Converter

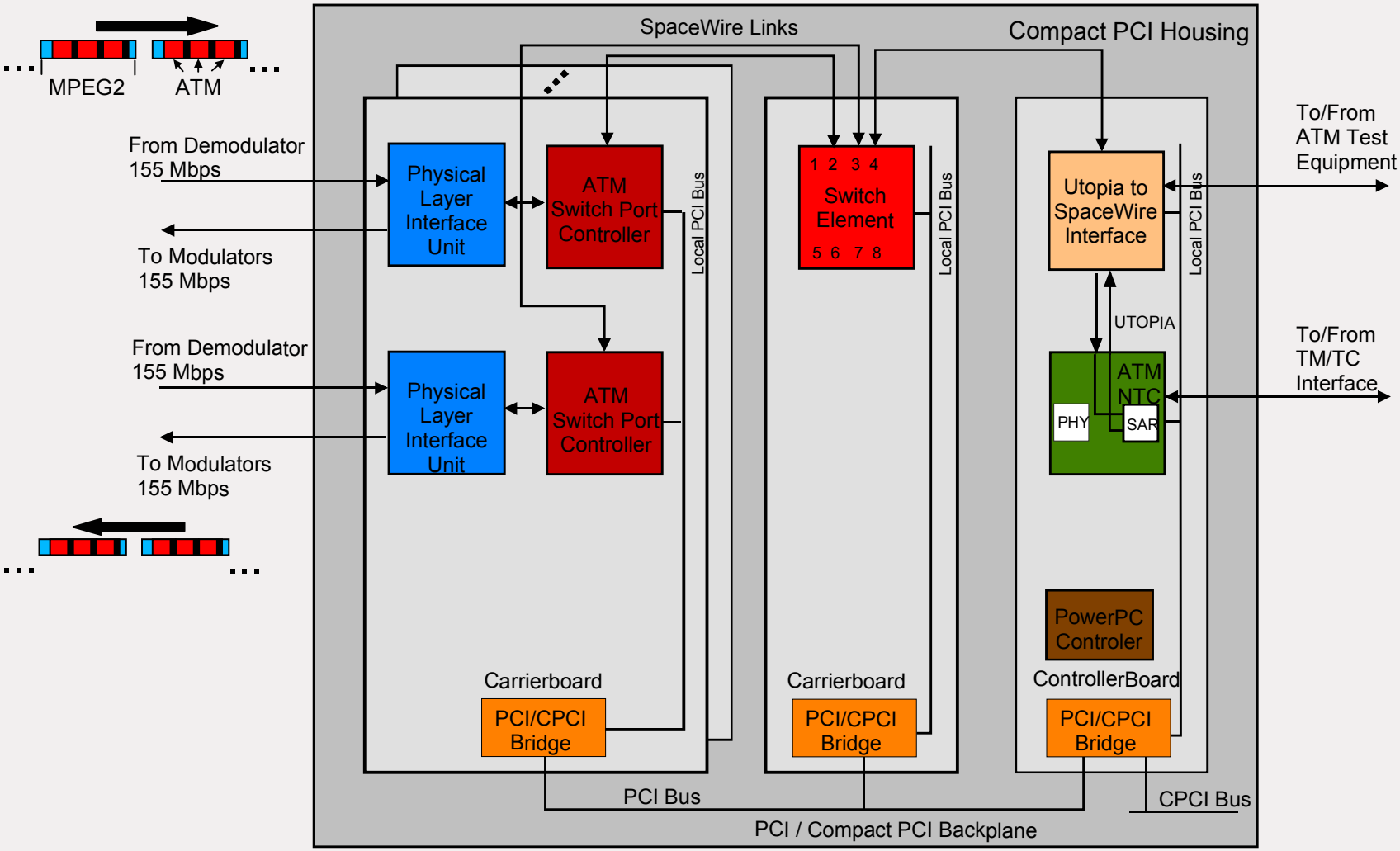
On-Board ATM Switch - Design Trade-Offs

- Requirements
  - ⇨ Switching Scheme Independent of Transmission Protocol
  - ⇨ Support Various Transmission Protocols: ATM, MPEG-Mux, IP, MPLS
  - ⇨ Scalability (Throughput 1.2 Gbps ... 10 Gbps)
  - ⇨ Support Quasi Static Connections



- Technical Solution
  - ⇨ Use Internal Label Switching (Insertion of 10 Byte Header)
  - ⇨ Separate Application Specific Functions and Generic Functions
    - ➔ Physical Layer Interface Unit (to Interface to Mod./Demod.)
    - ➔ Port Controller (to Adapt to Switching Scheme)
    - ➔ Generic Switch Element (to Perform Switching)
  - ⇨ High Speed Data Interfaces to Interconnect Functional Blocks
  - ⇨ Configuration of Links (VCI/VPI) through Controller Interface

Architecture of ATM-Switch Demonstrator (1.2 Gbps)



FPGA Developments

ATM Switch Element

- 8 x8 Switch Matrix, 1,2 Gbps Throughput, Internal Packet Format
- Supports Various Packet Formats (MPLS, ATM, IP, MPEG2)
- Status: Verified in Target System

ATM Switch Port Controller

- Adaption of ATM Cells to Internal Packet Format
- Status: Verified in Target System

Utopia to SpaceWire Interface

- Adaption of SpaceWire Interface to Utopia Interfaces
- Status: Verified in Target System

Physical Layer Interface Unit

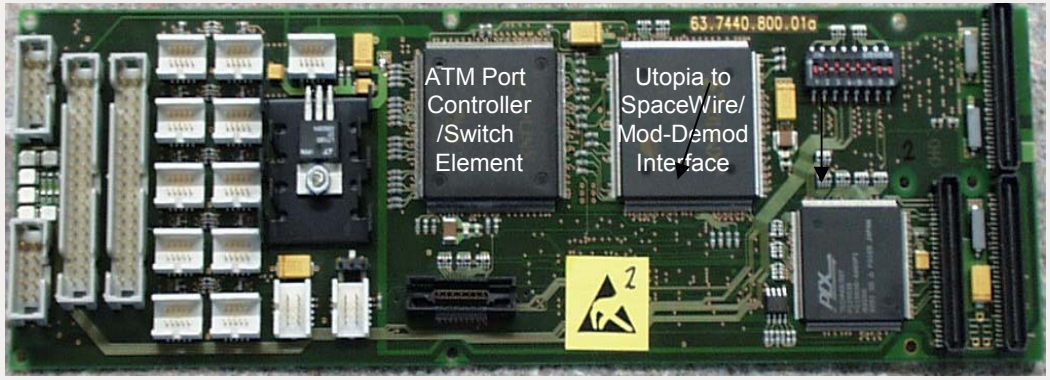
- Interface to Demodulator/Modulator
- Status: Verified in Target System

- All FPGAs Realised with Xilinx Virtex II
- Design Is Compatible to Space Qualified ASICs

ATM-Switch - Hardware

User Data Interfaces

SpaceWire 8 x 155 Mbps



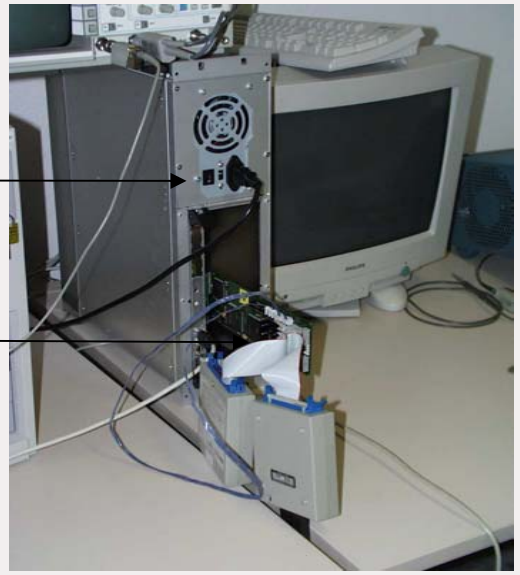
Configuration & Monitoring

PCI Bus Interface

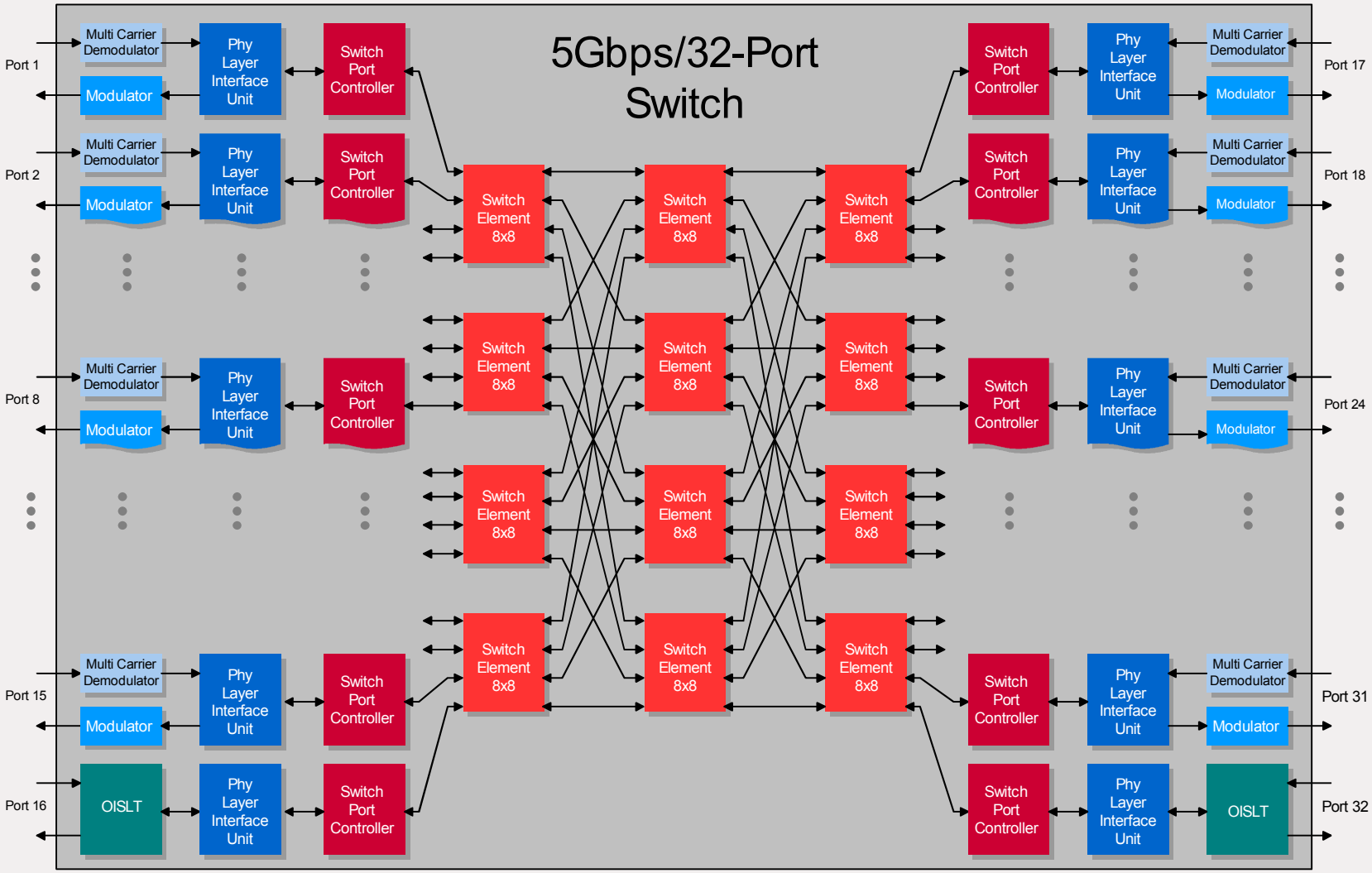
Univeral ATM Switch Board (FPGA Based)

Compact PCI Unit

Univeral ATM Switch Board



Architecture of On-Board ATM-Switch (5 Gbps)



OBP-Controller Software

Embedded Software:

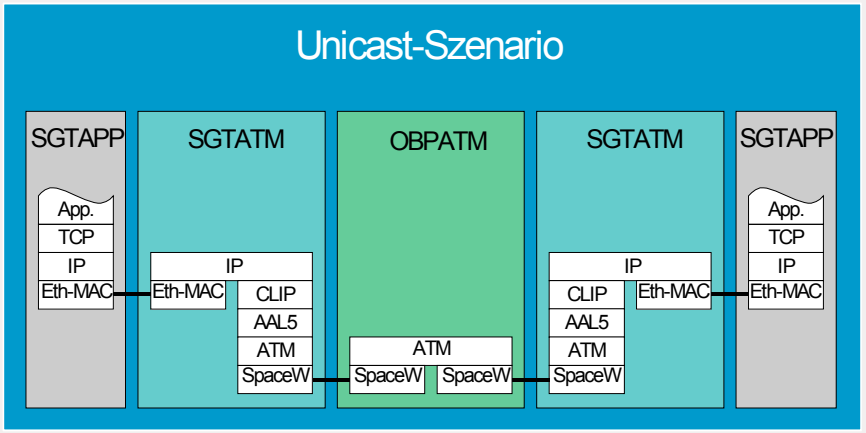
- Control and Configuration of Switch and Demod
- TM/TC Interface
- Power PC, Vx-Works, C

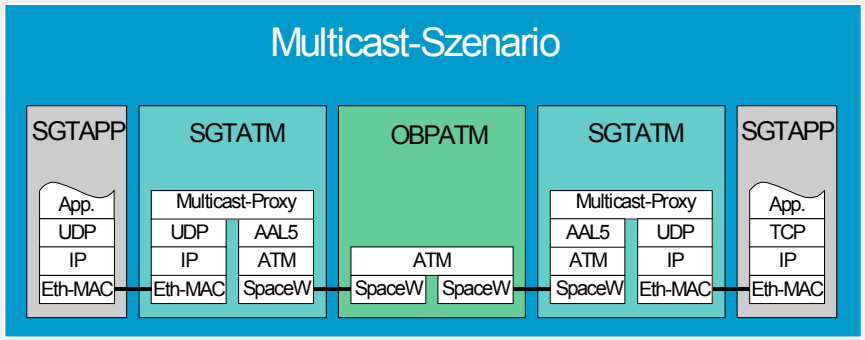
Satellite Ground Terminals:

- IP-Applications
- Linux PC

Control Station:

- Configuration of OBP (Link Management)
- Graphical User Interface
- Windows NT, Java





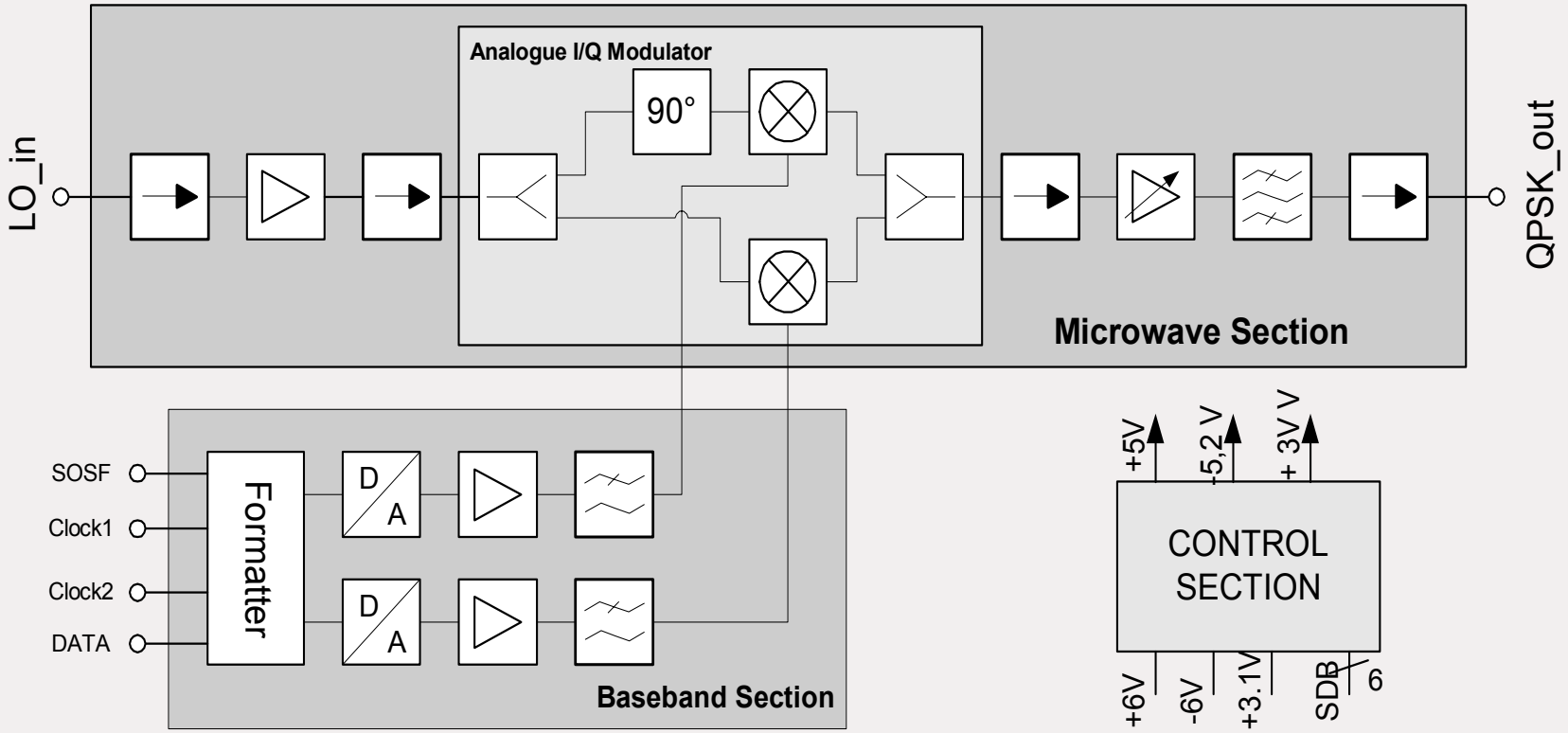
Characteristics of On-Board ATM-Switch

Parameter	Value	Unit
Switching Architecture	Shared Memory, Label Switching	-
Supported Transmission Protocols/Formats	IP, ATM, MPLS, MPEG2	-
Switch Matrices	8 x 8, 16 x 16, 32 x 32	-
Data Interfaces (SpaceWire)	155	Mbps
Throughput of Single Switch Element	1.2	Gbps
Max. Throughput (4 Level Cascade)	10	Gbps
Status	FPGA Based Demonstator Successfully Tested, Concept and Parts Transferable to Space Qualified Hardware	-

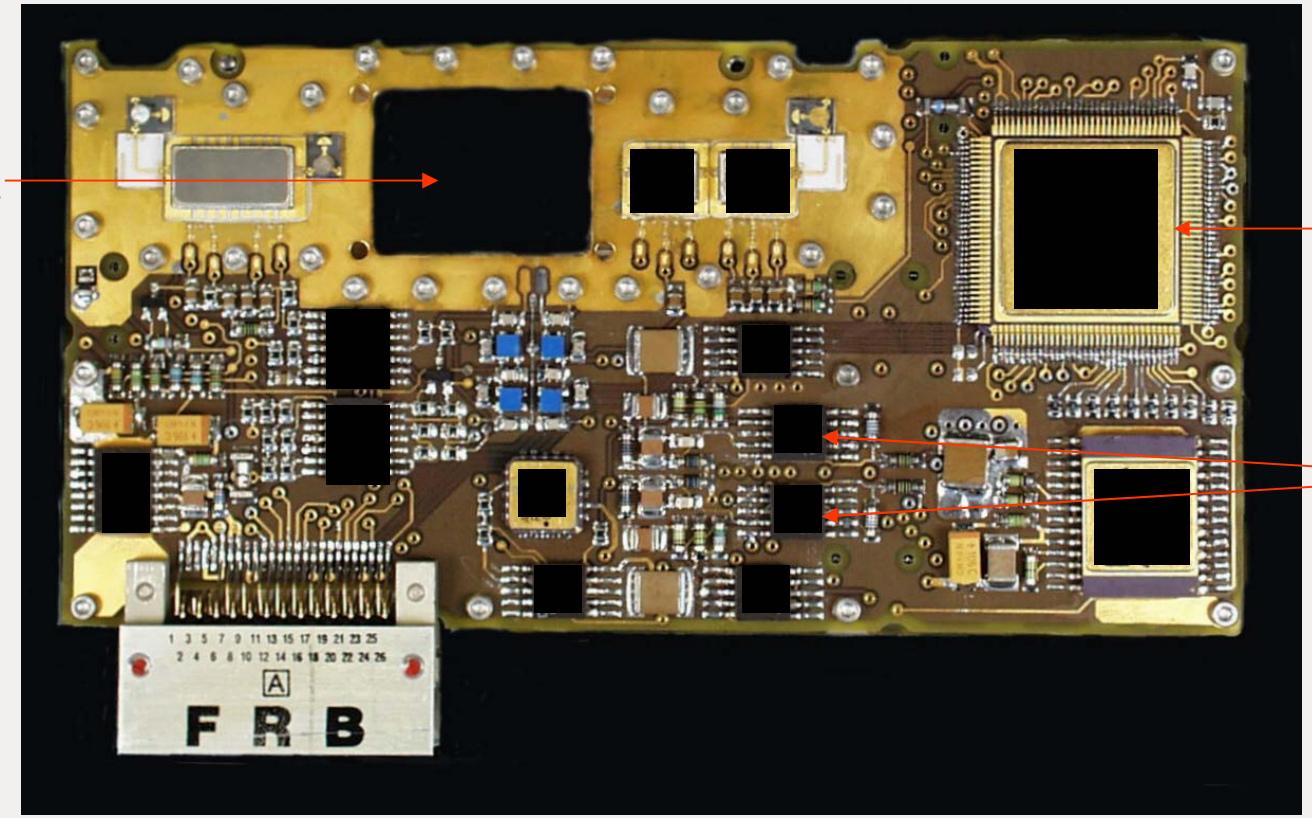
Characteristics of On-Board DVB-S Modulator

Parameter	Value	Unit
Operating Freq. Range	17.7 ... 20.2	GHz
Modulation Scheme	QPSK	-
Formatting and Coding	According to DVB-S Std.	-
Transmission Data Rate	Up to 70	Mbps
Carrier Suppression	> 30	dB
Single Sideband Suppression	> 30	dB
RF Output Power	-20 ... 0 in Steps of 0.5 dB	dBm
Amplutide Accuracy	0.2	dB
Phase Accuray	3	Deg.
Size	142 x 86 x 15	mm^3
Mass	250	g
Power Consumption	4	W
Temperature Range	-20 ... + 60	°C
Status	EQM Successfully Tested	-

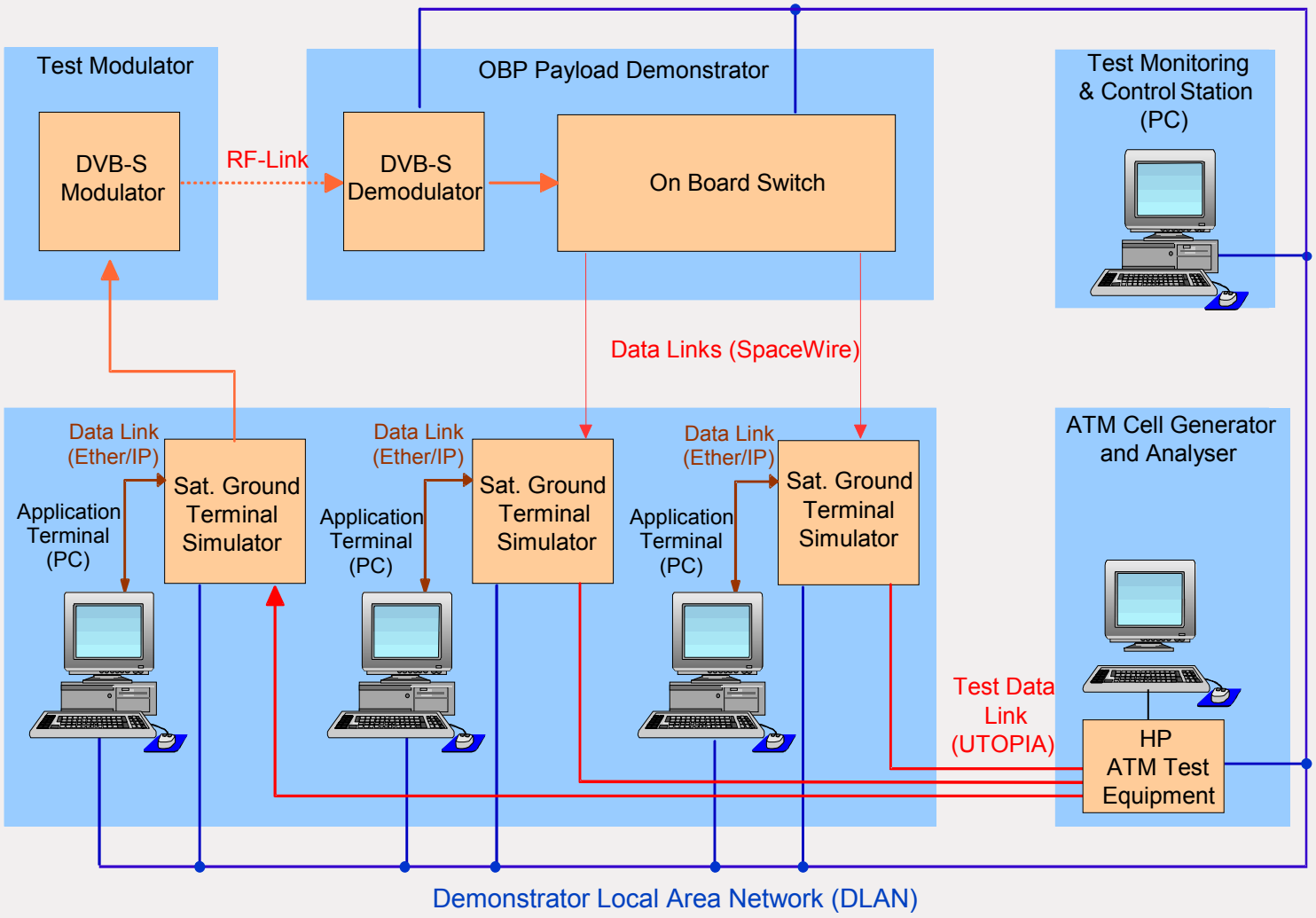
Block Diagram of On-Board DVB-S Modulator



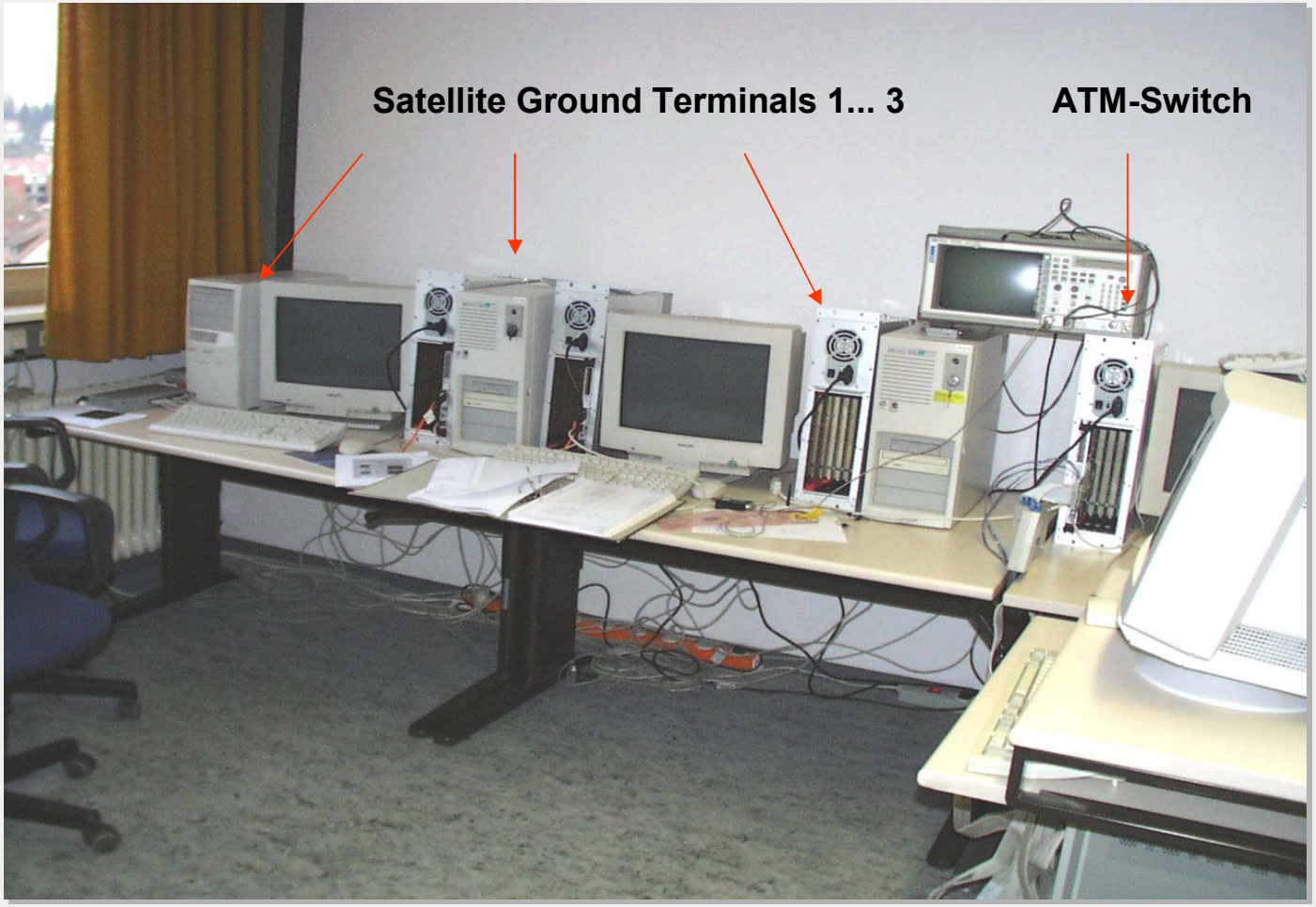
On-Board DVB-S Modulator - EQM



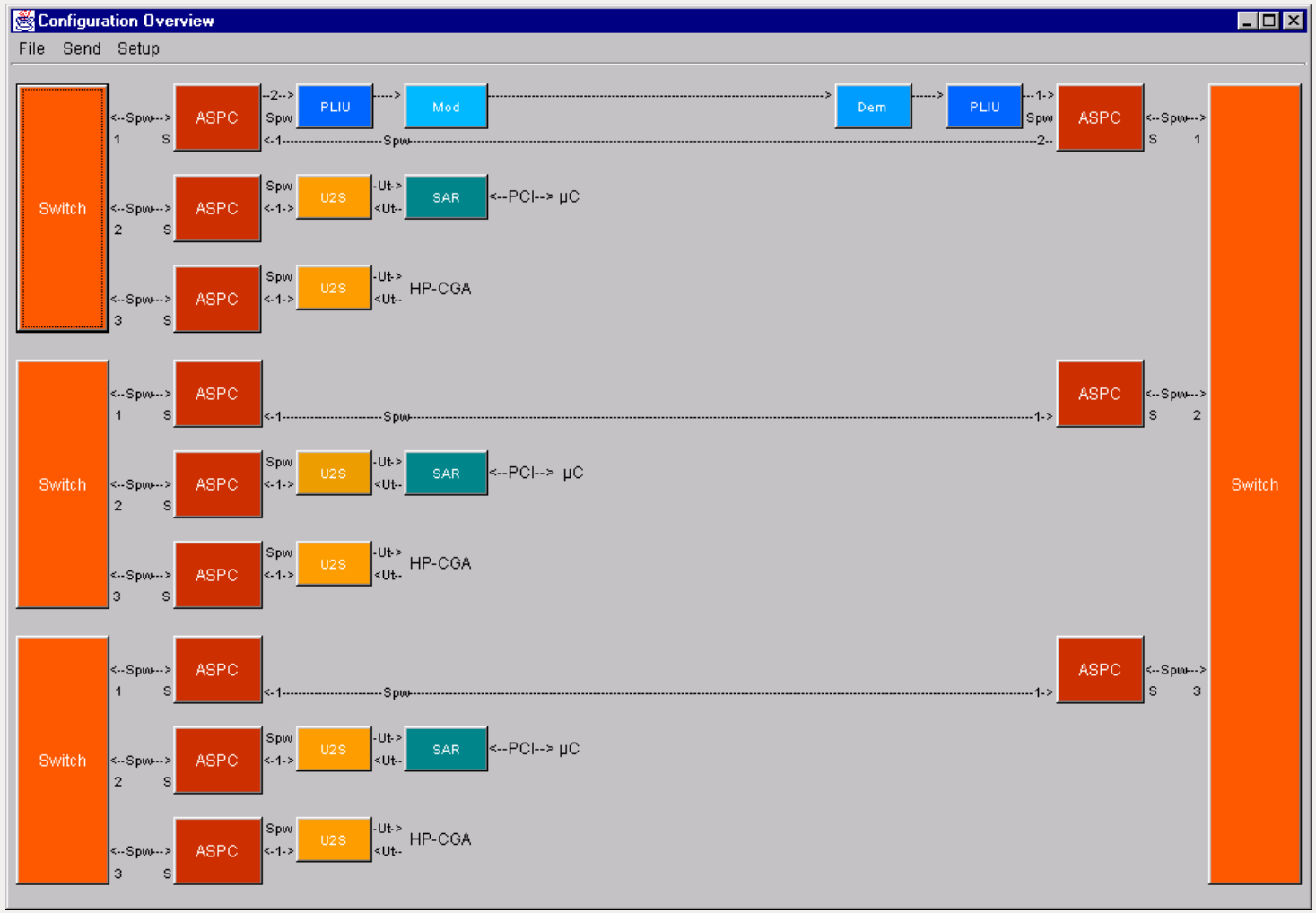
Overview of COMED OBP Payload Demonstrator



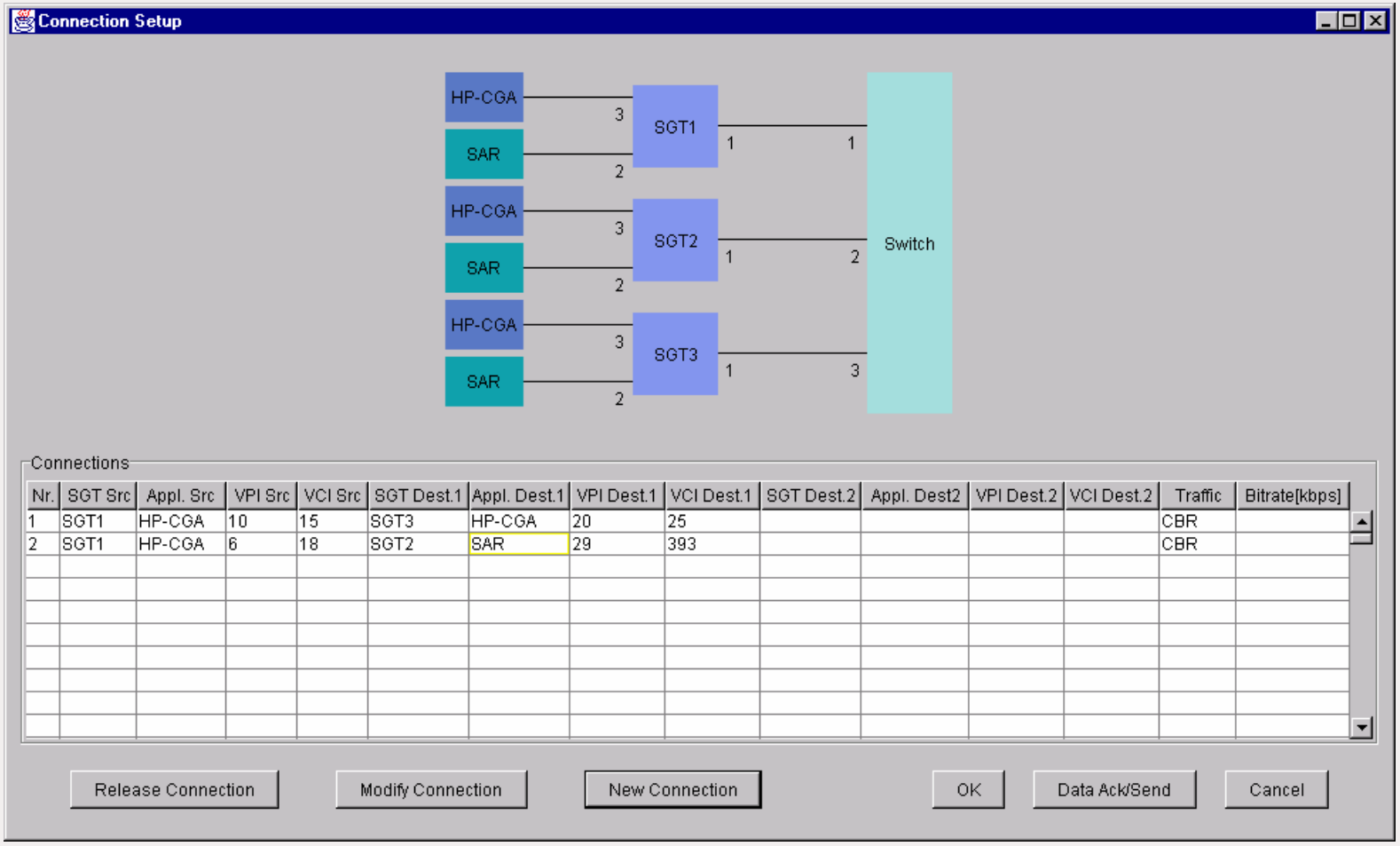
COMED ATM Payload Demonstrator



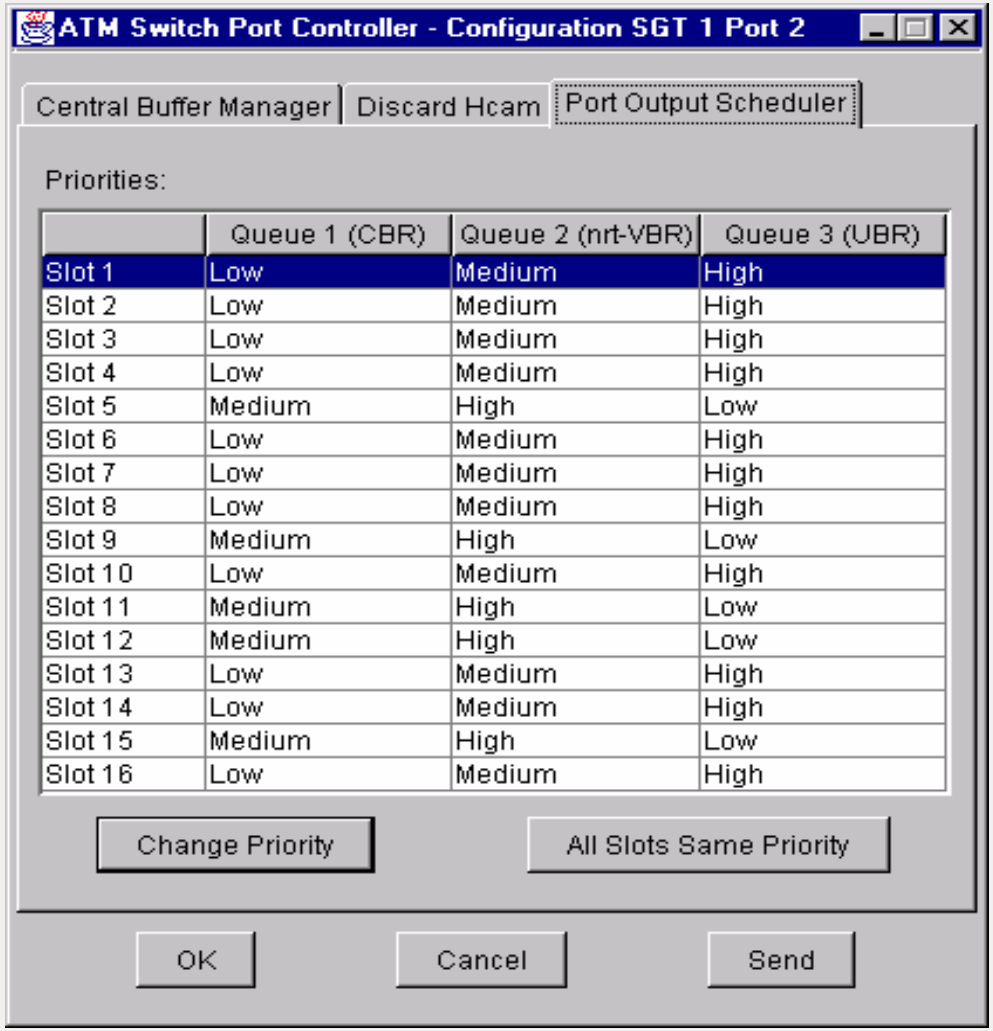
Configuration of Demonstrator



Configuration of Connections



Configuration of ATM Switch Port Controller



	Queue 1 (CBR)	Queue 2 (nrt-VBR)	Queue 3 (UBR)
Slot 1	Low	Medium	High
Slot 2	Low	Medium	High
Slot 3	Low	Medium	High
Slot 4	Low	Medium	High
Slot 5	Medium	High	Low
Slot 6	Low	Medium	High
Slot 7	Low	Medium	High
Slot 8	Low	Medium	High
Slot 9	Medium	High	Low
Slot 10	Low	Medium	High
Slot 11	Medium	High	Low
Slot 12	Medium	High	Low
Slot 13	Low	Medium	High
Slot 14	Low	Medium	High
Slot 15	Medium	High	Low
Slot 16	Low	Medium	High

COMED OBP Payload Demonstrator

- Analysis of Switching Characteristics under Various Application and Load Conditions
  - ⇨ Throughput
  - ⇨ Cell Loss Rate
  - ⇨ Back Pressure Mechanism
- Characterisation of End-to End Data Transmission
  - ⇨ Bit Error Rate
  - ⇨ Quality of Service (Jitter) etc.
- Demonstration of Unicast and Broadcast Applications
- Demonstration of IP-Applications (IP-Radio, MP3 Streaming)
- Demonstration of Complete DVB-S / ATM Based Communication System with Real Hardware Suited to be Transferred to Space Qualified Technology

Conclusion

- On-Board Equipment under Development at Tesat-Spacecom
  - ⇨ DVB-S Demodulator
  - ⇨ ATM-Switch
  - ⇨ DVB-S Modulator
- Attractive Technical Solutions Available
  - ⇨ Flexibility in Data Rates, Carrier Frequency, Transmission Protocolls
  - ⇨ Excellent Performance
  - ⇨ Concepts Providing Minimum Mass and Power
- Functions Verified through COMED ATM Payload Demonstrator
- Transfer to Space Qualified Hardware Feasible

➔ **Prepared to Deliver Flight Hardware**