ATM-Sat: ATM-Based Multimedia Communication via LEO-Satellites

Projektübersicht

Dr. E. Lutz, Dr. H. Bischl

DLR Oberpfaffenhofen

Projektdaten

- Projektdauer: Juli 1999 - Juni 2002
- Projektpartner:
  - DLR Oberpfaffenhofen, Institut für Kommunikation und Navigation Abteilung Digitale Netze (DN) - Projektleitung
  - DLR Oberpfaffenhofen, Institut für Kommunikation und Navigation, Abteilung Navigations- und Leitsysteme (NL)
  - GMD FOKUS Berlin, Competence Center for Advanced Network Technologies and Systems (CATS)
  - Bosch SatCom GmbH Backnang, Space Communication Systems
- ATM-Sat wird finanziert aus dem Strategiefonds der Helmholtz-Gemeinschaft

Projektziele

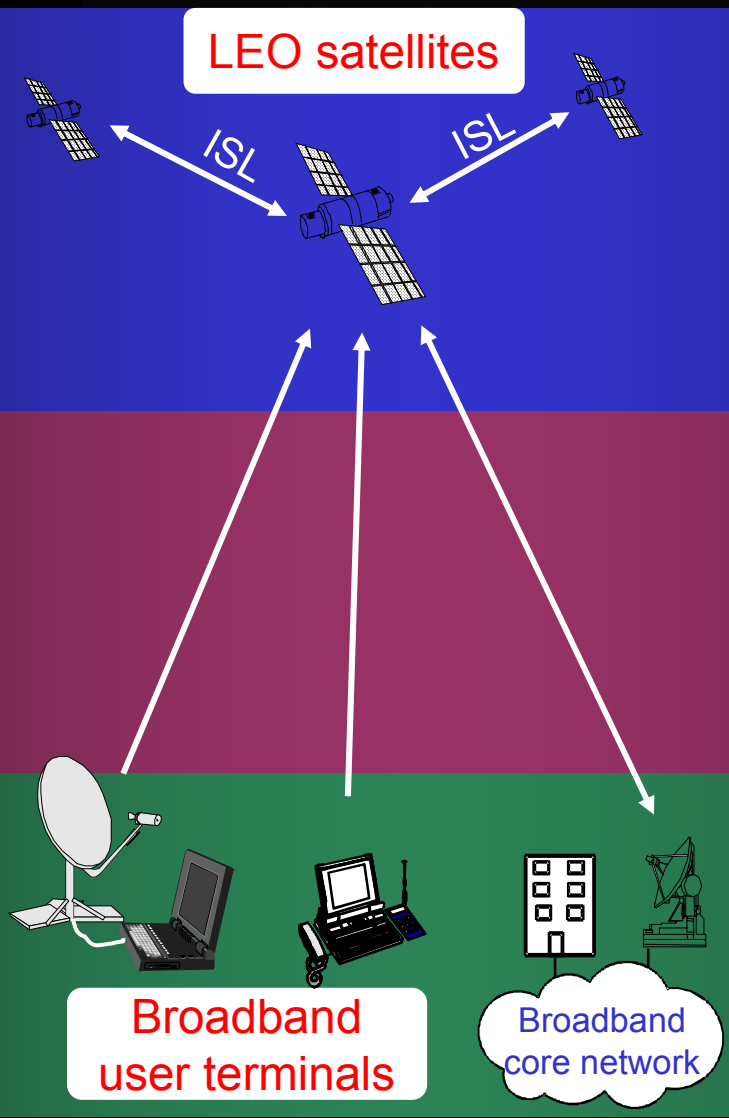
- *ATM-Sat will develop the concept and the communication technology for a multimedia satellite system with:*
  - *Low Earth Orbit satellites → and GEO satellites*
  - *intersatellite links*
  - *on-board ATM switching*
  - *fixed and mobile terminals*
  - *reenforced consideration of internet-based services*
- *ATM-Sat will verify the developed communication technology with a demonstrator*
- *ATM-Sat will provide support to the German space and communications industry in acquiring the future market of multimedia satellite communication*

System Characteristics

- *LEO satellites*
- *intersatellite links*
- *dynamic network topology*

- *shared medium*
- *limited bandwidth*
- *propagation delay*
- *bit errors*

- *fixed, portable, and mobile terminals*
- *multiservice scenario*



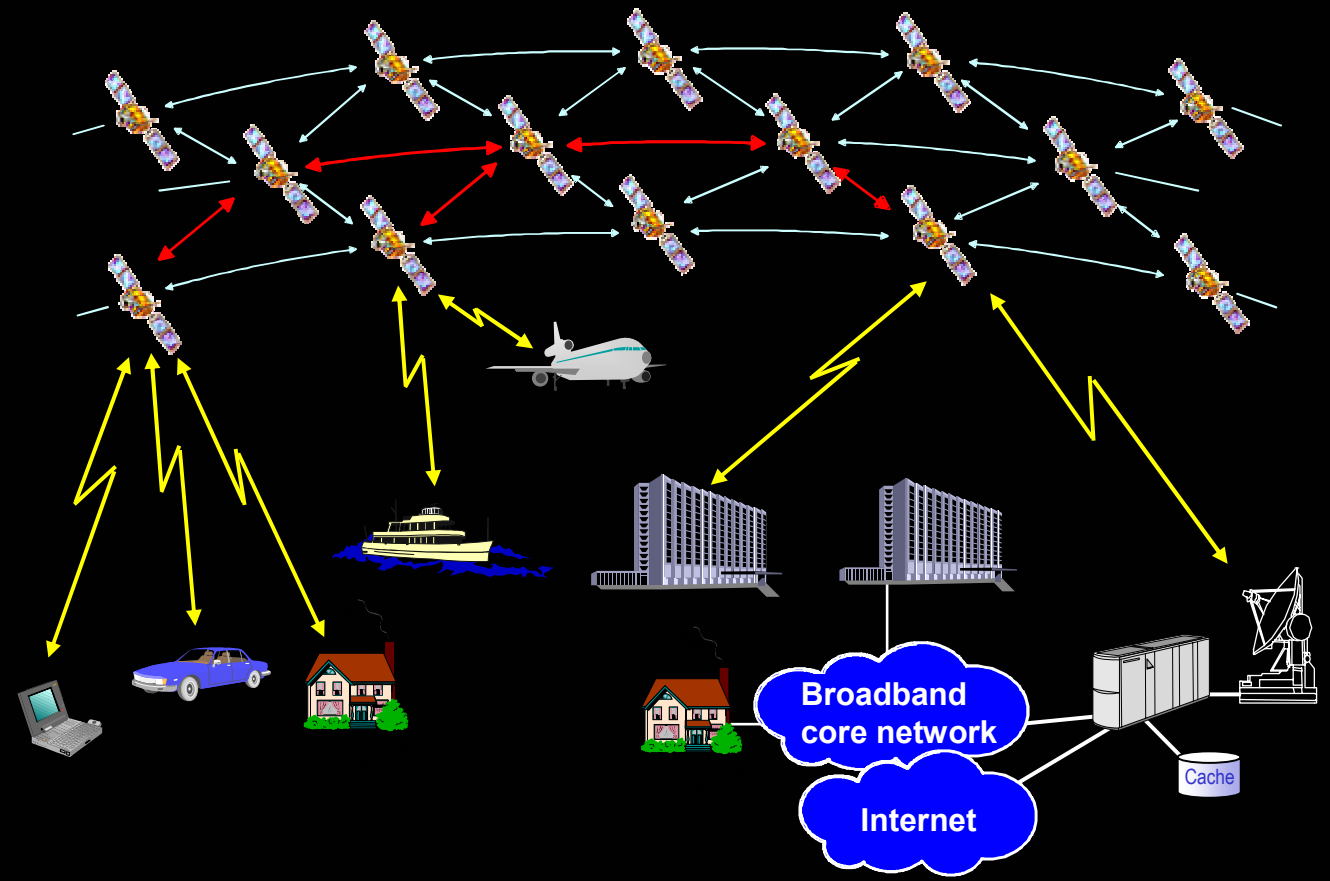
ATM-Sat R&D

- *system and protocol architecture (DLR, GMD)*
- *on-board processing (Bosch)*
- *ISL routing scheme (DLR)*
- *radio & ATM resource (DLR) management*
- *multiple access protocol (DLR)*
- *error control (DLR)*
- *transmission scheme (DLR)*

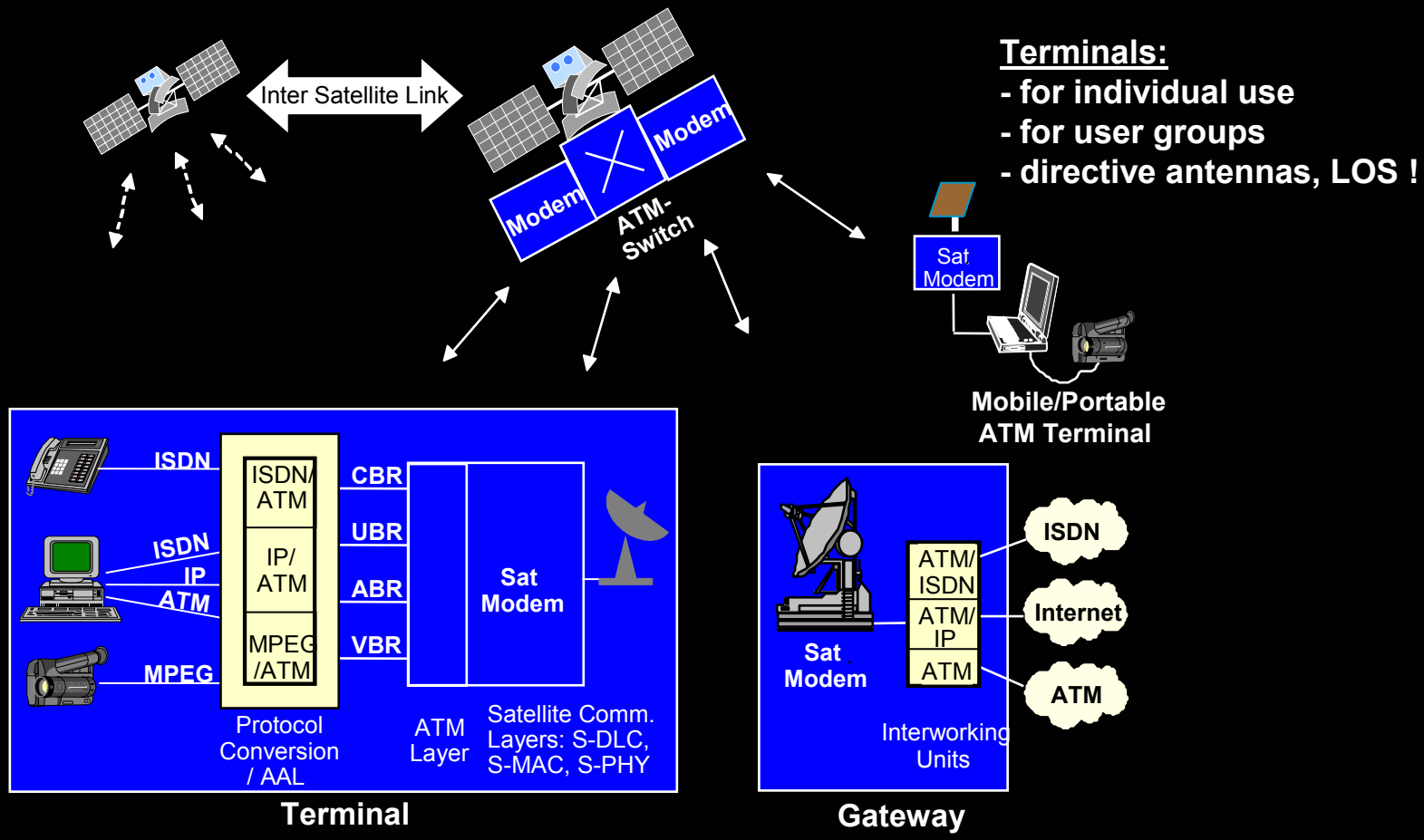
- support all traffic classes !
- meet QoS requirements !
- optimize bandwidth utilization !

- *mobility management and handover (GMD)*
- *IP over satellite-ATM (GMD, DLR)*
- *active intelligent antennas (DLR)*

Systemkonzept eines ISL-basierten breitbandigen LEO Satellitensystems für die Multimediakommunikation



Systemkonzept / Anwendungszenarium für das Zielsystem



Dienste und Anwendungen (Auswahl)

	Standard	Bit rate	Mapping ATM services
Voice	LD-CELP, ADPCM, SB-ADPCM, PCM	16 - 64 kbit/s	CBR
CD quality audio	MPEG-1 audio (MP3)	32 - 224 kbit/s	CBR
	MPEG audio FFT	384 kbit/s	CBR
Video conferencing and video telephony	H.261	p*64 kbit/s, p=1, 2, ..., 30	CBR, rt-VBR, nrt-VBR
	JPEG	1, ..., 2 (5) Mbit/s	CBR, nrt-VBR
	MJPEG	1, ..., 2 (10) Mbit/s	CBR, nrt-VBR
Broadcast TV quality video	MPEG-2	2, 4, 6, to > 20 Mbit/s	CBR, rt-VBR, nrt-VBR
Multimedia applications	MPEG-4	64 kbit/s, ..., 2 (4) Mbit/s	CBR, rt-VBR
Web browsing, file transfer, IP over ATM		p*16 kbit/s, p=1, 2, ...	UBR, UBR with MCR, ABR
Network interconnection		p*16 kbit/s, p=1, 2, ...	UBR, UBR with MCR, CBR, nrt-VBR, ABR

Einige Systemparameter

- *Terminal data rate:* *uplink: 16 kbit/s, 32 kbit/s, ..., 2 Mbit/s*
  downlink: 16 kbit/s up to 32 Mbit/s
- *Satellite switch capacity: 5 Gbit/s - 10 Gbit/s*
- *Spotbeams per satellite: 100 - 300*
- *Carriers per satellite: 150 - 300*
- *Maximum number of carriers per spotbeam: 30 - 60*
- *Maximum number of downlink channels (16 kbit/s) per carrier: 2000*

  ⇒ Unidirectional downlink channels (16 kbit/s) per satellite: 300000 - 600000
  ⇒ Bidirectional channels (16 kbit/s) per satellite: 150000 - 300000

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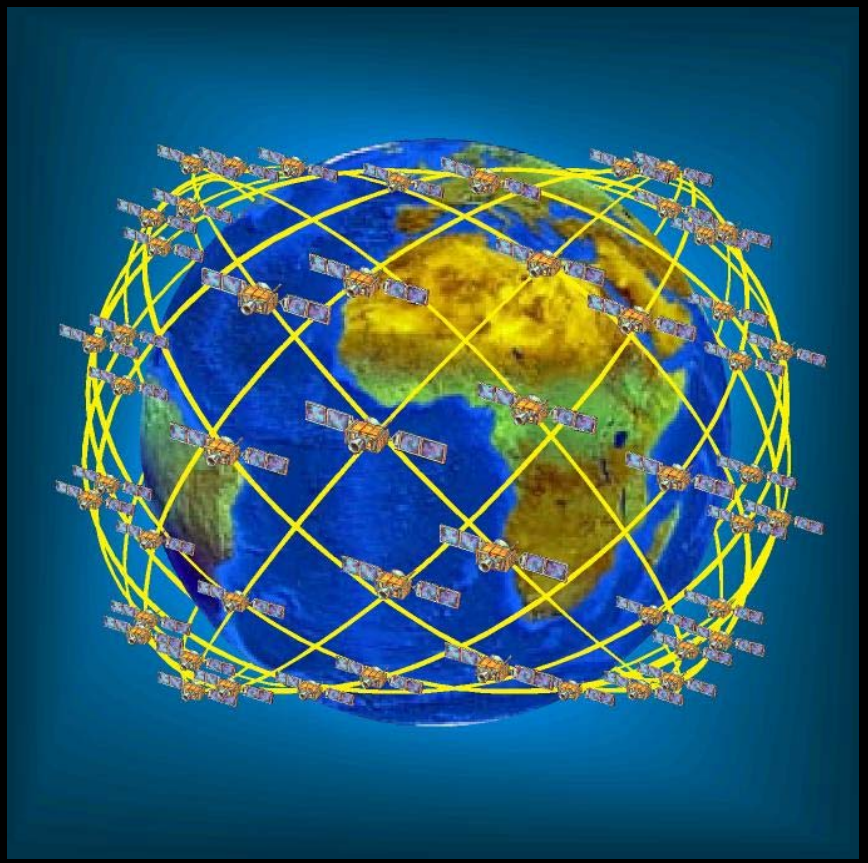
Satellitenkonstellation

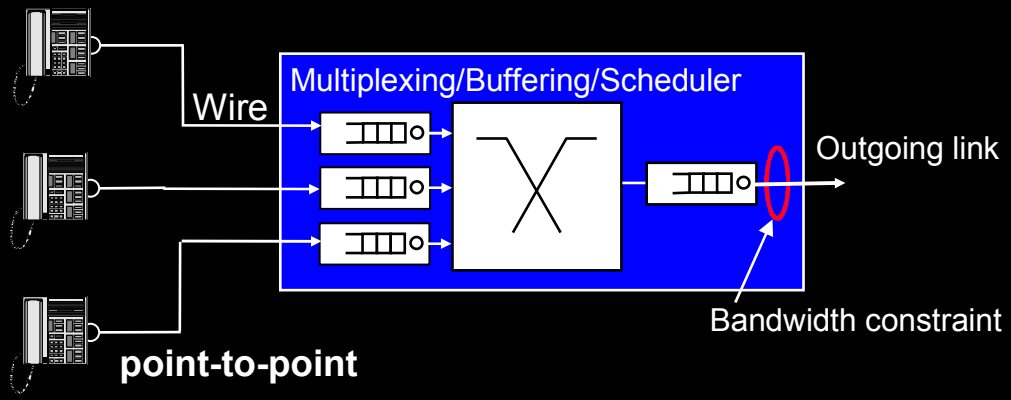
Satelliten: *72 (12*6)*
Orbits: *12*
Orbithöhe: 1350 km
Orbitperiode: *112.7 min*
Inklination:47°
Phasung: *25°*
ISLs: *ja*
Minimale Elevation: 20°-30°

⇒ *Ø Footprint: 4200 - 3200 km*



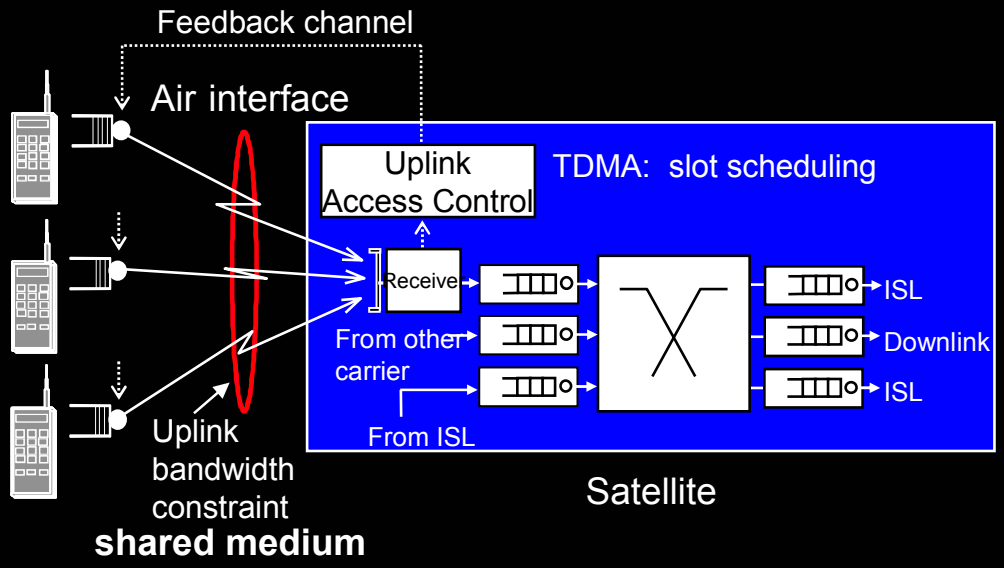
ATM in fixed and radio networks

Fixed Network



Only one terminal per ATM switch port

Radio (ATM-Sat) Network



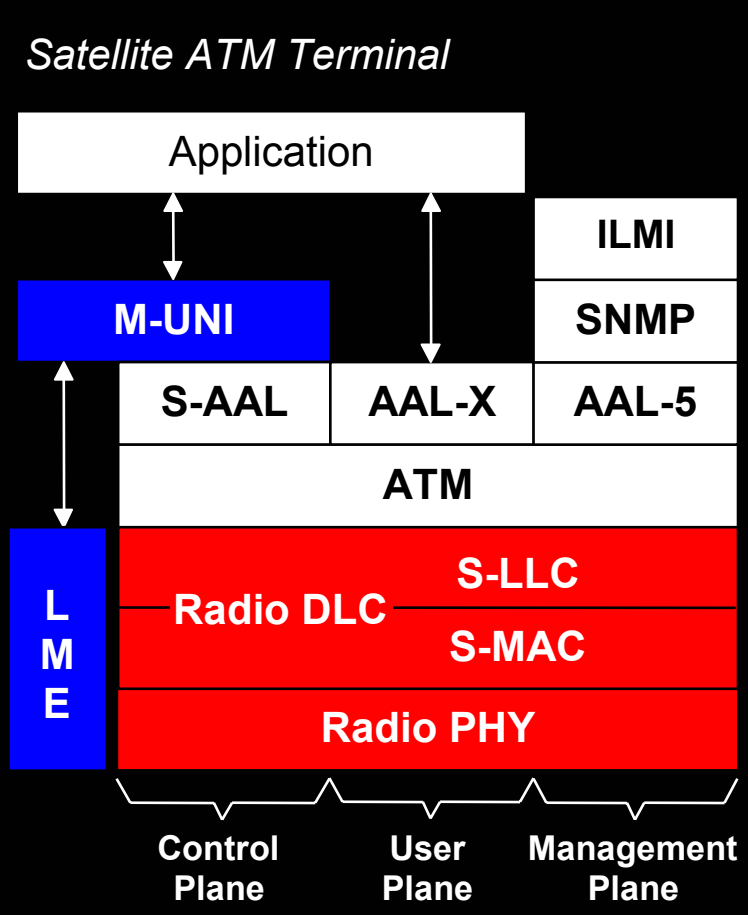
Problems:

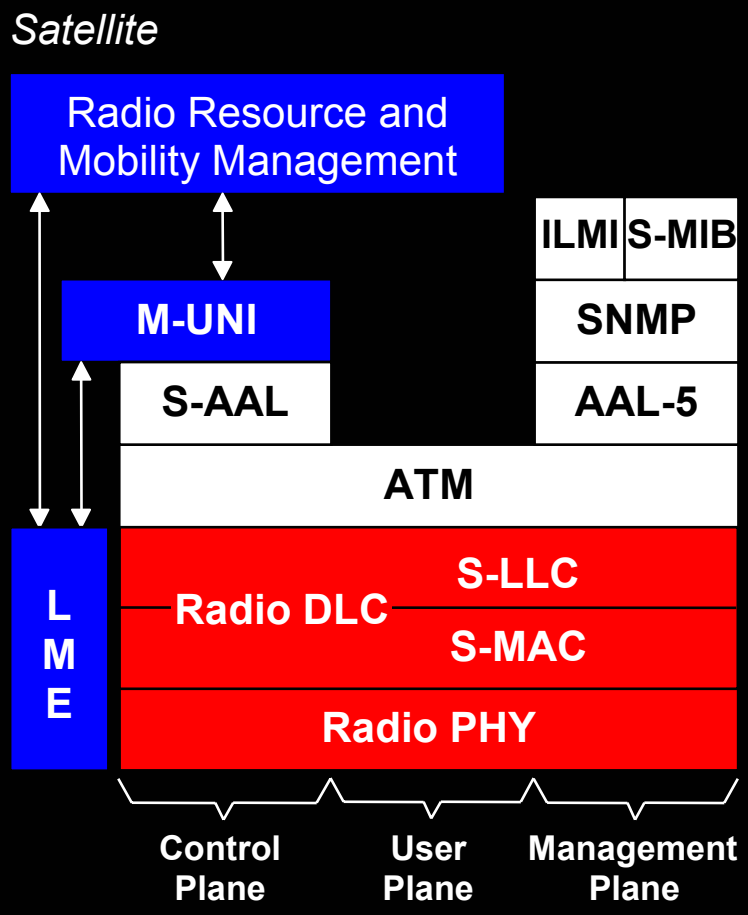
More than one terminal per ATM switch port !

TDMA: scheduling
delay
hard limitation

CDMA: complexity, back-off
power control

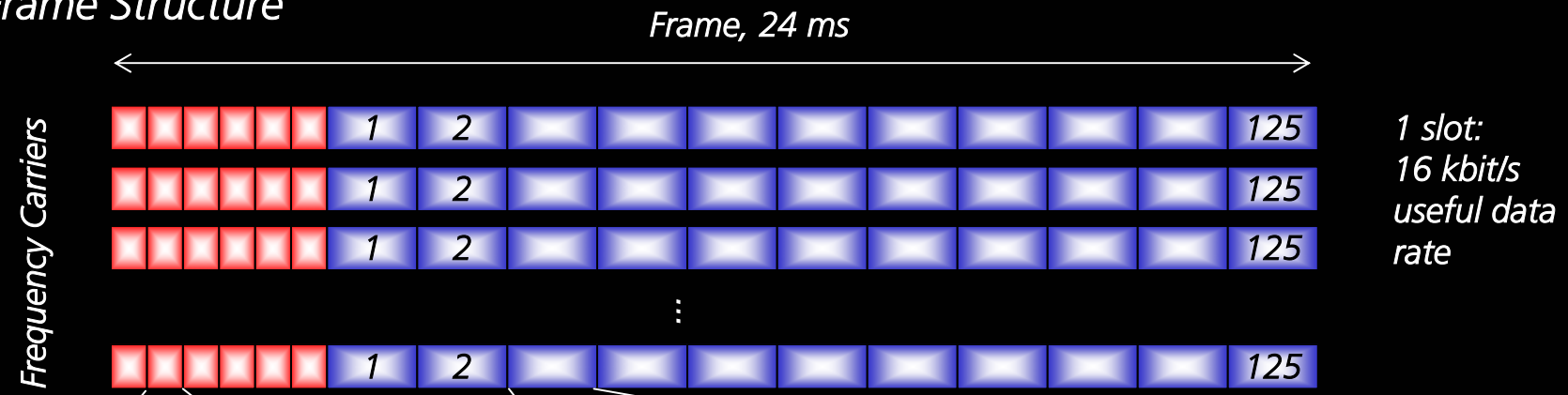
ATM-Sat Protokollarchitektur





MF-TDMA Frame

Uplink Frame Structure



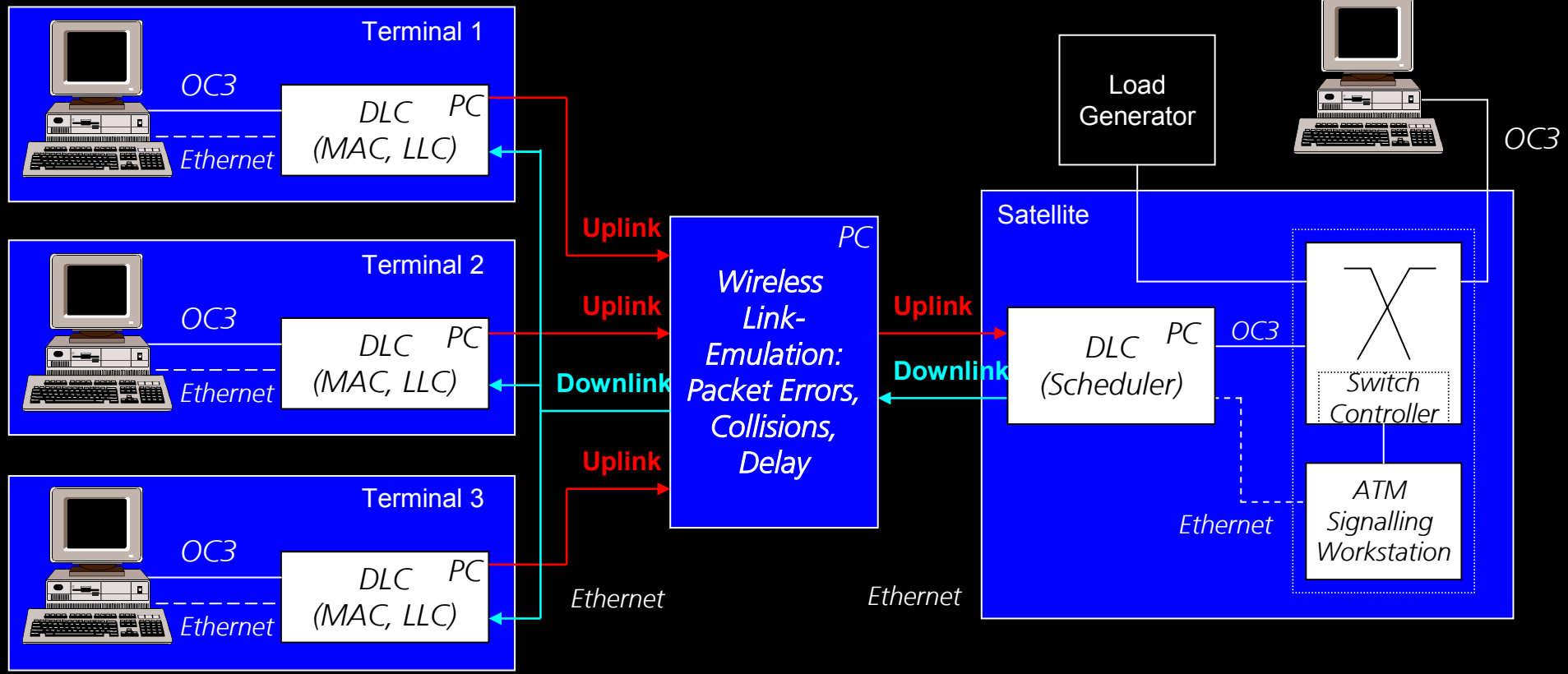
CTRLPACKET (15 Byte):

- Out-Band Signalling
- RS(15,11) Code

FULLPACKET (80 Byte):

- In-Band Signalling
- One ATM-Cell per packet
- RS(80,64) Code

ATM-Sat Demonstrator (MAC)



Uplink bit rate: *≈ 3 Mbit/s*
Downlink bit rate: *up to / more than 32 Mbit/s*

ATM-Sat Demonstrator (MAC)

Planned Demonstrations (selection)

- *MAC protocol, priority scheduling*
- *Connection setup and release, more than one connection per terminal*
- *Video (MPEG1, MJPEG) and audio applications with CBR or UBR*
- *Web browsing with UBR or UBR with MCR*
- *Network interconnection ?*

Planned Experiments and Measurements (selection)

- *Influence of radio channel (cell loss, delay) on end application, performance of error control*
- *Efficiency of scheduling algorithm (statistics of slot usage, ...)*

Warum aktive intelligente Antennen?

Breitbandige Multimediakommunikation über Satellit

Hohe Kanalbitrate

Koexistenz verschiedener Satellitensysteme im gleichen Frequenzband

LEO-Satelliten

Richtantenne im Terminal notwendig

Mobile Terminals

Richtantenne muß schnell schwenkbar sein

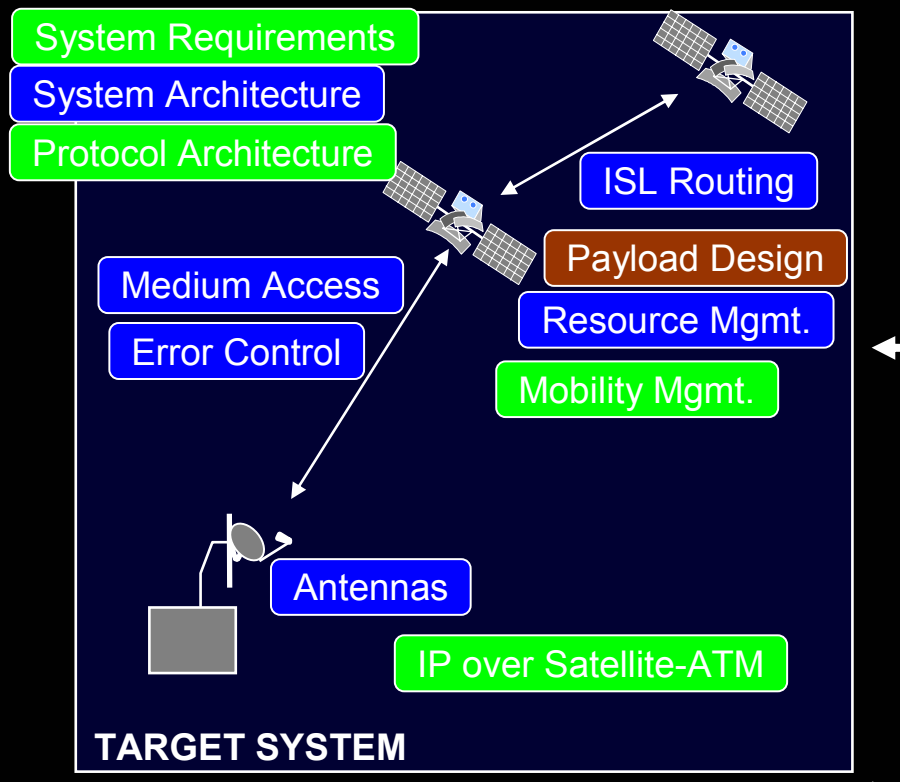
Entwicklung aktiver intelligenter Antennen

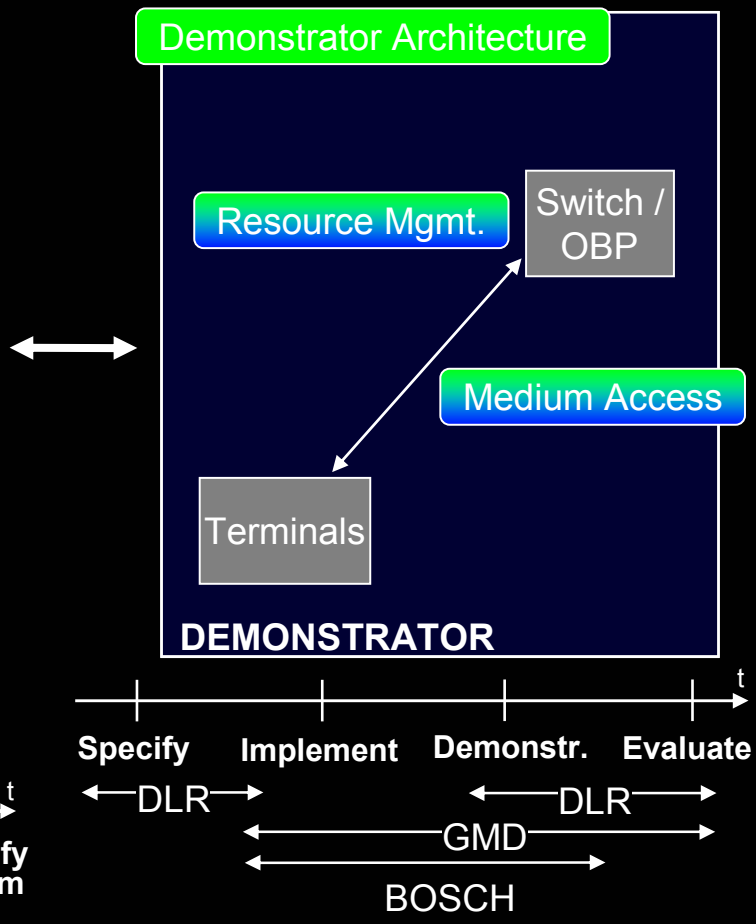
Zusammenfassung

- ATM-Sat entwickelt eine Systemarchitektur für die ATM-Übertragung über LEO-Satelliten
- ATM-Sat entwickelt die Protokollarchitektur, Fehlersicherung, Medium Access Control (MAC), Ressourcenmanagement, ISL Routing und Verfahren für IP over Satellite-ATM
- ATM-Sat entwickelt und realisiert einen LLC/MAC-Demonstrator für ATM über Satellit (Priority Scheduling, Radio Resource Management)
- ATM-Sat führt End-zu-End Demonstrationen und Performance-Messungen am Demonstrator durch
- ATM-Sat macht Untersuchungen zu aktiven intelligenten Antennen und entwickelt und realisiert dazu auch einen Demonstrator

Zusätzliche Folien

ATM-Sat R&D Objectives





DLR
GMD
Bosch

Warum ATM?

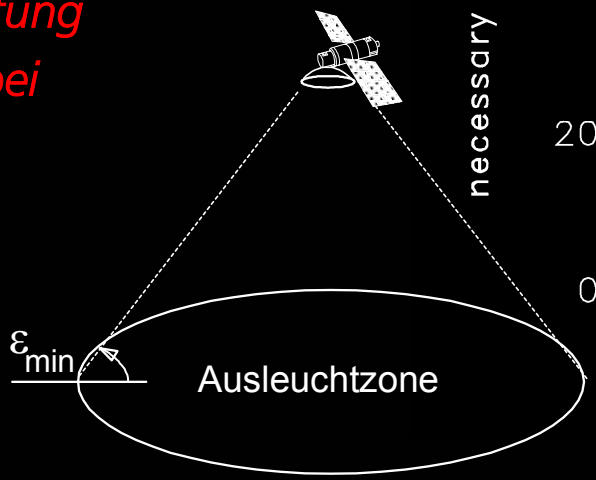
new broadband satellite networks, partly with ISLs

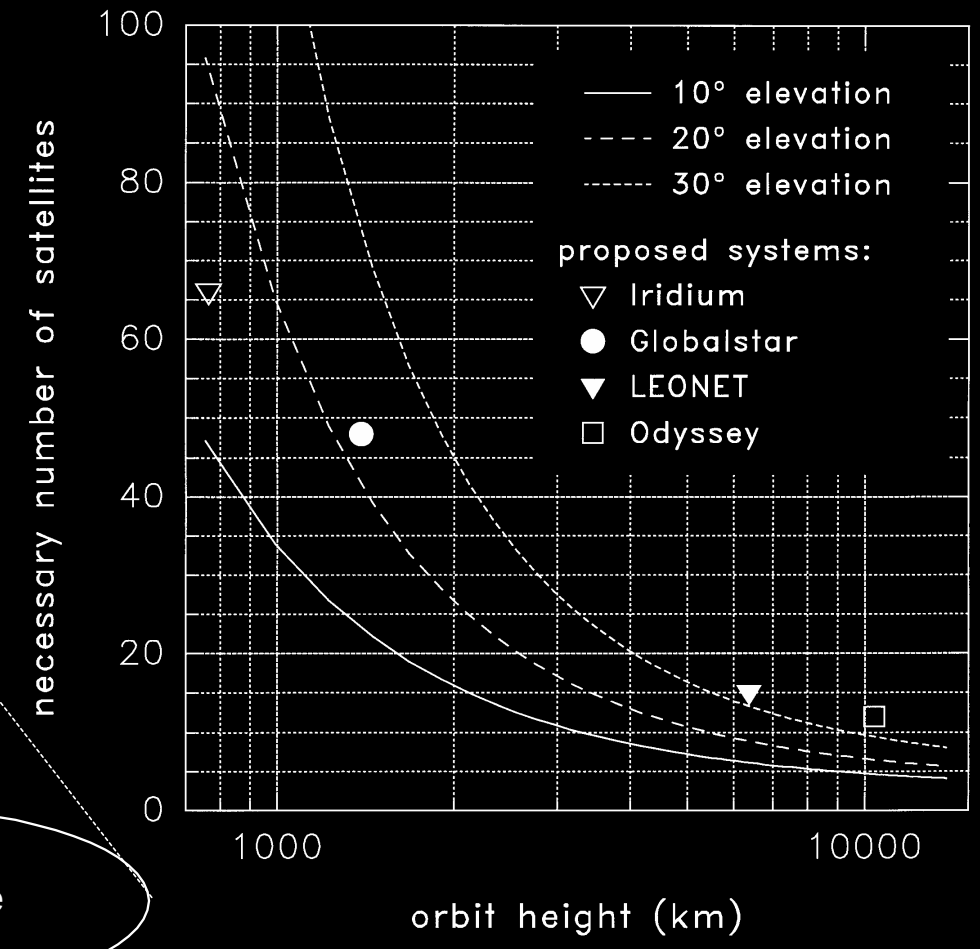
ATM advantages → ATM in fixed broadband core networks, LANs → ATM in satellite networks for fixed, portable, and mobile communication

Systemarchitektur

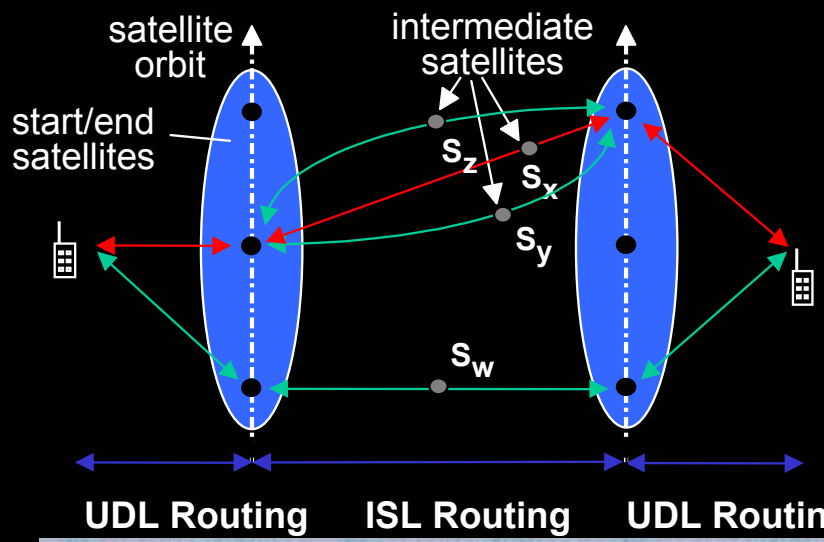
Vor- und Nachteile kleiner minimaler Elevationswinkel (ε_{min}):

+ große Ausleuchtzone (Footprint)
⇒ wenig Satelliten erforderlich
- mehr Abschattungen
- höhere Freiraumdämpfung
- höhere Regendämpfung
- erhöhter Aufwand bei aktiver intelligenter Terminalantenne (Schwenkbereich)

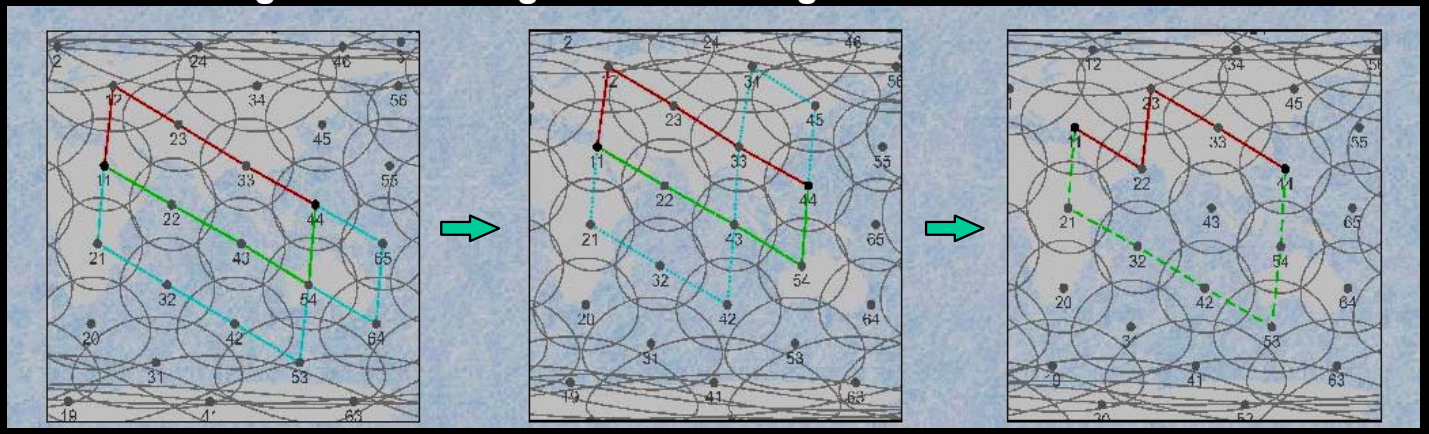




ATM-Based ISL Routing



- multiservice routing scheme
- integration of UDL/ISL routing
- integration of routing with CAC
- combined routing/dimensioning problem



ATM-Sat Protokollarchitektur - DLC Layer

- *DLC Layer unterscheidet die verschiedenen ATM-Verbindungen anhand der VPI/VCI-Werte der ATM-Zellen*
- *Beim Verbindungsaufbau müssen dem DLC Layer die VPI/VCI-Werte mit den Verkehrsparametern (ATM-Dienstkategorie, PCR, ...) vom UNI (über LME) mitgeteilt werden*
- *DLC Layer muß bei der CAC beteiligt sein (über LME)*
- *Beispiele:*
  - *CBR-Dienst: feste periodische Allokierung von Zeitschlitzen während der gesamten Verbindung entsprechend der PCR*
  - *UBR-Dienst: dynamische Allokierung von Zeitschlitzen entsprechend dem Verkehrsaufkommen (round robin)*
  - *UBR-Dienst mit MCR: feste Allokierung von Zeitschlitzen entsprechend der MCR, dynamische Allokierung weiterer Zeitschlitze entsprechend dem Verkehrsaufkommen*

Fehlersicherung

Terminal

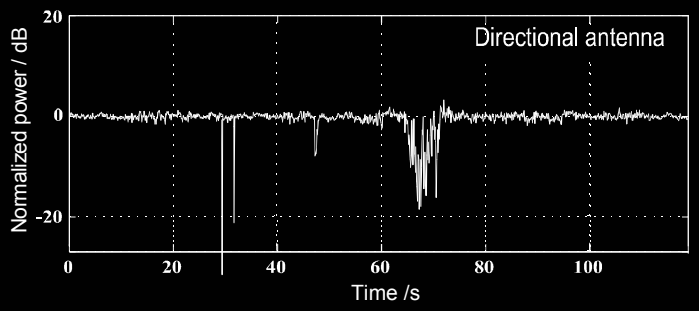
	AAL
	ATM
ARQ, FEC	S-LLC
	S-MAC
FEC	S-PHY

ATM Service Category	*Error Control Method*
CBR, rt-VBR	(adaptive) FEC
nrt-VBR	limited ARQ, (adaptive) FEC
ABR	ARQ, (adaptive) FEC, hybrid ARQ
UBR	not mandatory, ARQ, (adaptive) FEC

Satellite

ATM	
S-LLC	ARQ, FEC
S-MAC	
S-PHY	FEC

Error-prone Satellite-Channel



channel modelling,
rain attenuation