Ground Segment

Application	Application
Presentation	
Session	
Transport	Transport
Network	Internet
Data Link	Network Interface
Physical Layer	Physical
The Ground segment: Architecture, technology, equipment	

Ground terminals

Classification

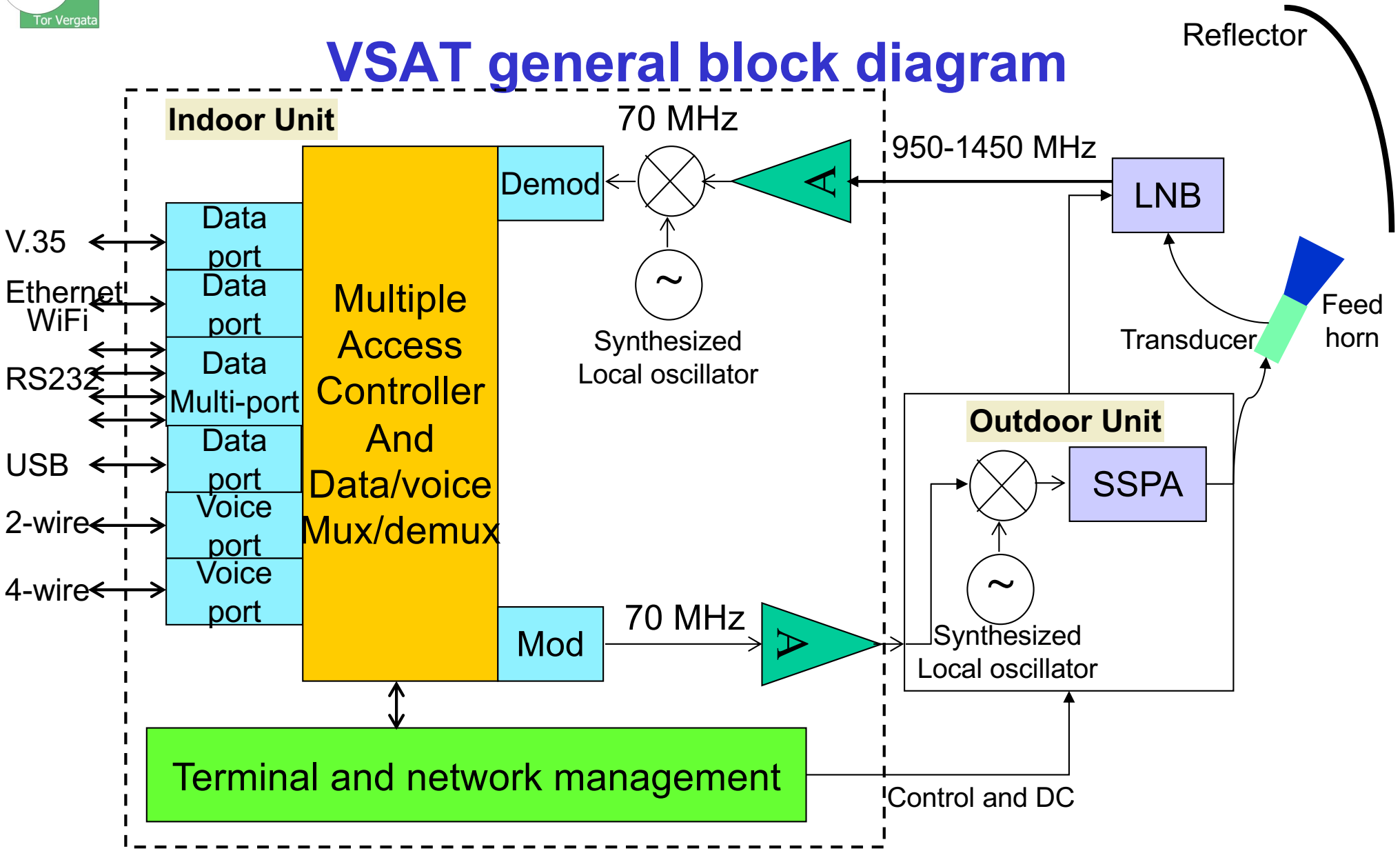
- Network stations
  - Gateways
  - Hub
    - NCC functionality
- User terminals
  - VSAT like
    - Fixed
    - Transportable
  - Personal

General configuration

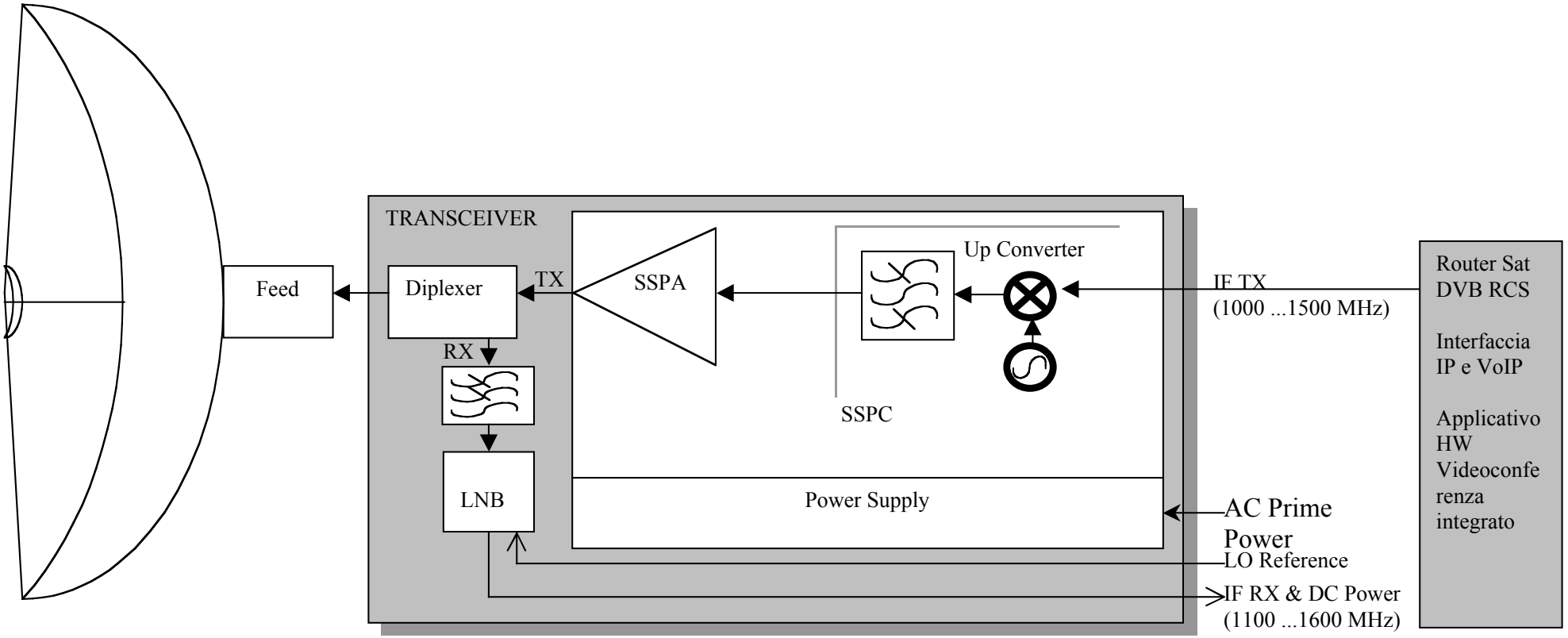
- RF section
- Baseband section

This section deals mainly with VSAT like terminals but some concepts are general

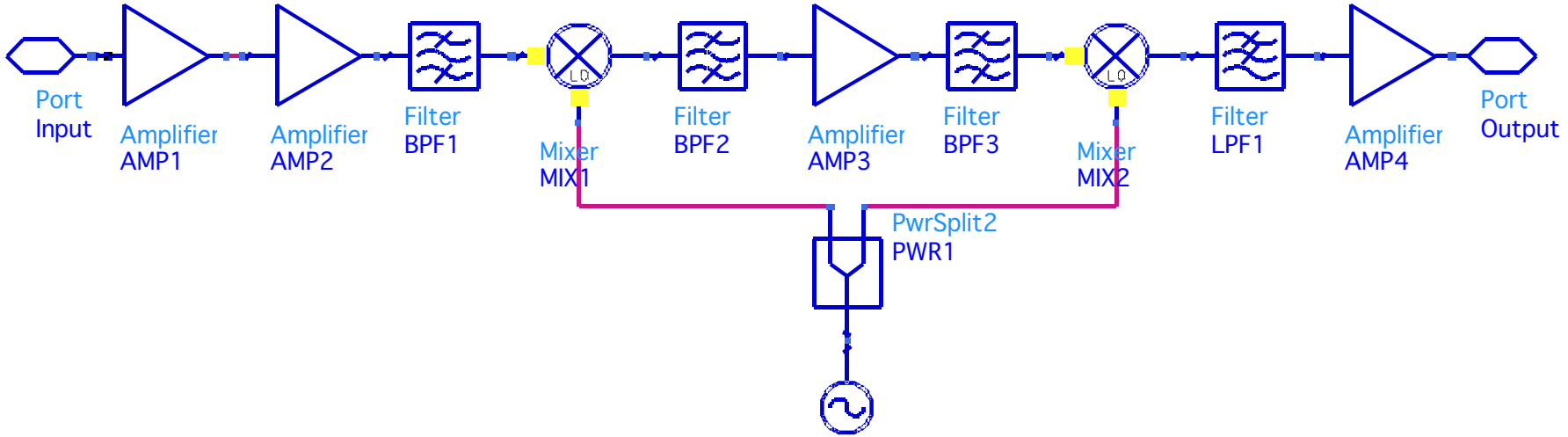
VSAT general block diagram



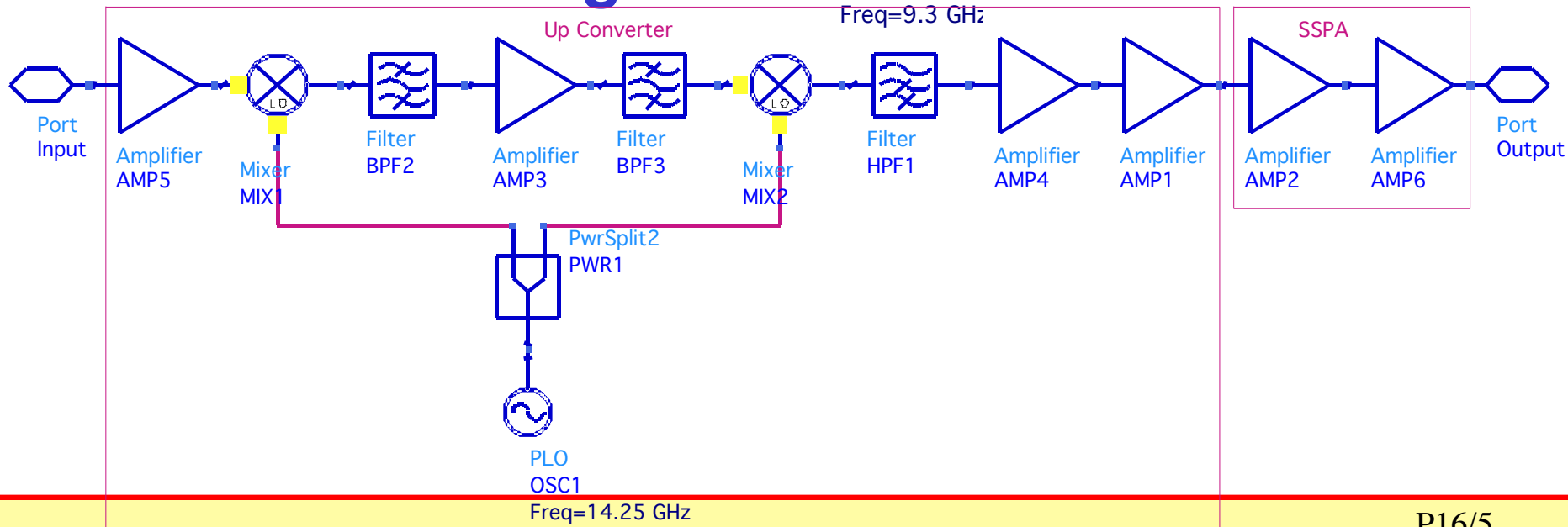
VSAT outdoor unit (ODU)



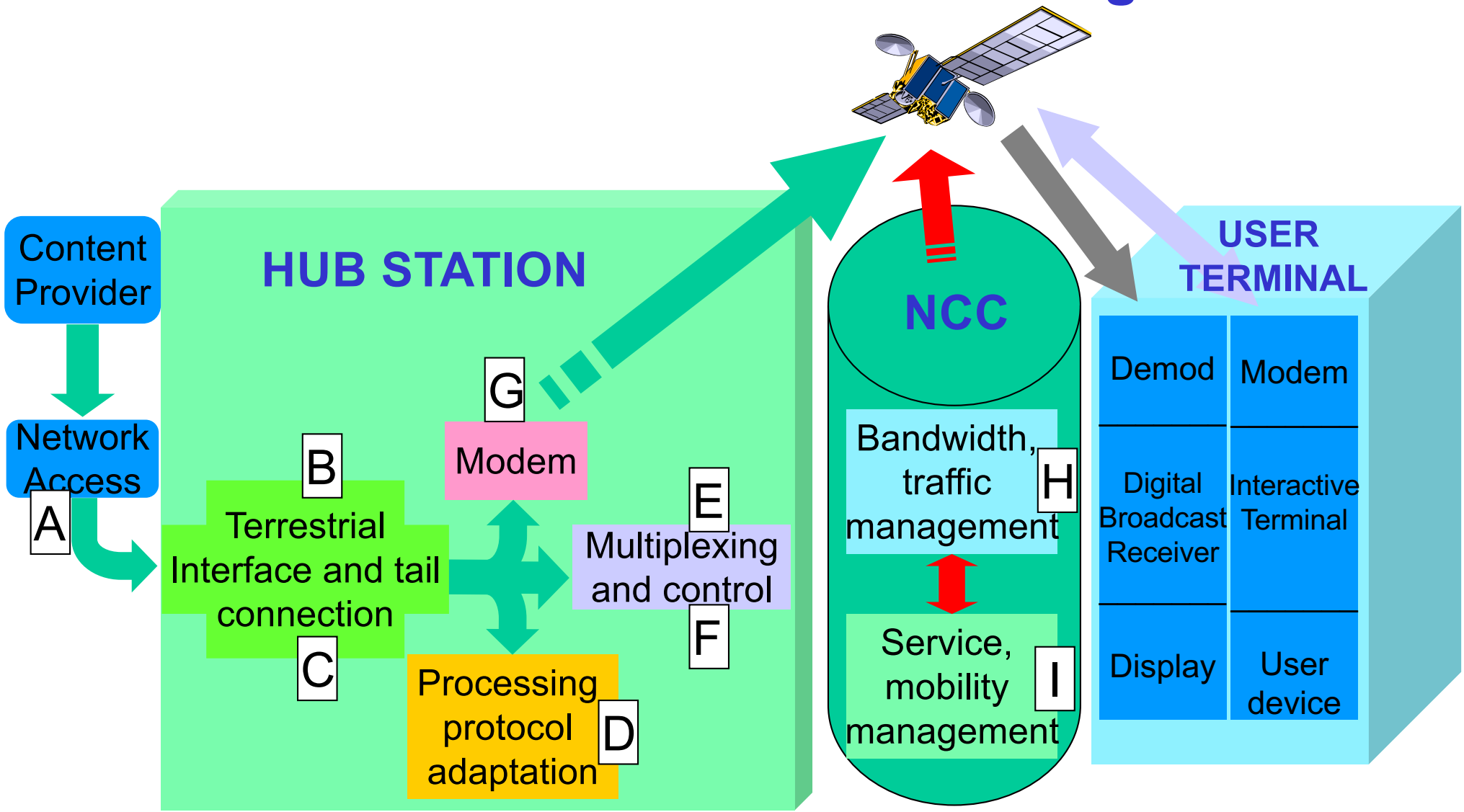
LNB block diagram



SSPA block diagram



Baseband Architecture block diagram



Baseband Architecture functionality

Function	Requirement	EI	Description
User interface or access to content	Deliver a standard application to the user	A	Defined by selected standard for the particular application
Backhaul circuits	Connect between user interface (or content source) and Earth station	B	Typically a terrestrial transmission line using cable, fiber, or local microwave
Terrestrial interface	Interface from backhaul circuit to the BB equipment of the Earth station	C	Port cards or connectors that comply with the selected standard (in A)
Information processing	Compression, encryption, protocol conversion, etc, based on unique constraints of the baseband architecture	D	Data processing or specialized protocol conversion equipment
Multiplexing	Combining two or more information channels into a single data stream	E	Multiplex equipment-fixed time slot, statistical or packet multiplex
Multiple access processing and control	Assign and allocate data for efficient transfer via the satellite network	F	Baseband multiple access equipment
Modulation and demodulation	Encode and transfer data streams between the baseband equipment and the RF terminal	G	Modem equipment
Bandwidth management	Engineer and optimize the flow of the network traffic	H	Network Control elements
Service management	Coordinate application delivery, information supply and conditional access for users	I	Service management elements

User Interface and Access to Content

- Specific user interface
  - Voice
  - Data
  - Videoconferencing
- Source of content
  - TV programs
  - Web pages
  - Radio programes
- User interface
  - RS-232
  - RJ-11
  - V.35
  - Ethernet
  - USB

Backhaul Circuits

- To provide the last mile link between the Earth station and the user or source of content
- The distance can be in the order of kilometers
- If station and user co-located the backhaul circuit replaced by a piece of cable
- Owned, leased, shared, rent
  - Twisted-pair cable
  - Coaxial cable
  - Fiber optic cable (single or multi mode)
  - Line of site microwave (point to point or multipoint)

Terrestrial interface

- Not peculiar for satellite Earth stations
- Standard arrangements
  - Conventional termination
- Alternative
  - Directly on the baseband equipment (port cards)
  - Reduced amount of rack space
  - Backhaul circuit cannot be tested or reconnected without disrupting the operation of the baseband equipment

Information processing for the Baseband Equipment

- Functions
  - Digital compression
  - Encryption
  - Protocol conversion (e.g. spoofing)
- Equipment
  - Specialized digital electronics
  - Local processor with custom software
  - IP router like (with proper configuration)
  - Server with operating systems (Unix, Windows NT)

Multiplexing or Packet Routing

- Typical multiplexing functions
- Broadcast: MPEG2 TS
- Packet switching
- ATM

Multiple Access Processing and Control

- FDMA
  - Simple control
  - Multiplexed information directly connected to the modem
- TDMA
  - Stringent requirements in terms of network timing
- CDMA
  - Simple control assuming orthogonality

Modulation and Demodulation

- Modulator and demodulator may be separated due to multiple access attributes
- VSAT star network (TDMA scheme)
  - Hub transmits a continuous TDM stream on the forward link
  - VSAT transmits in TDMA burst format at lower data rate (4:1)
  - One outroute modulator (continuous TDM)
  - Multiple inroute demodulators (each in burst mode)
- FDMA
  - Combined modem if uplink and downlink bandwidth are the same
  - Continuous carrier transmission

Bandwidth Management

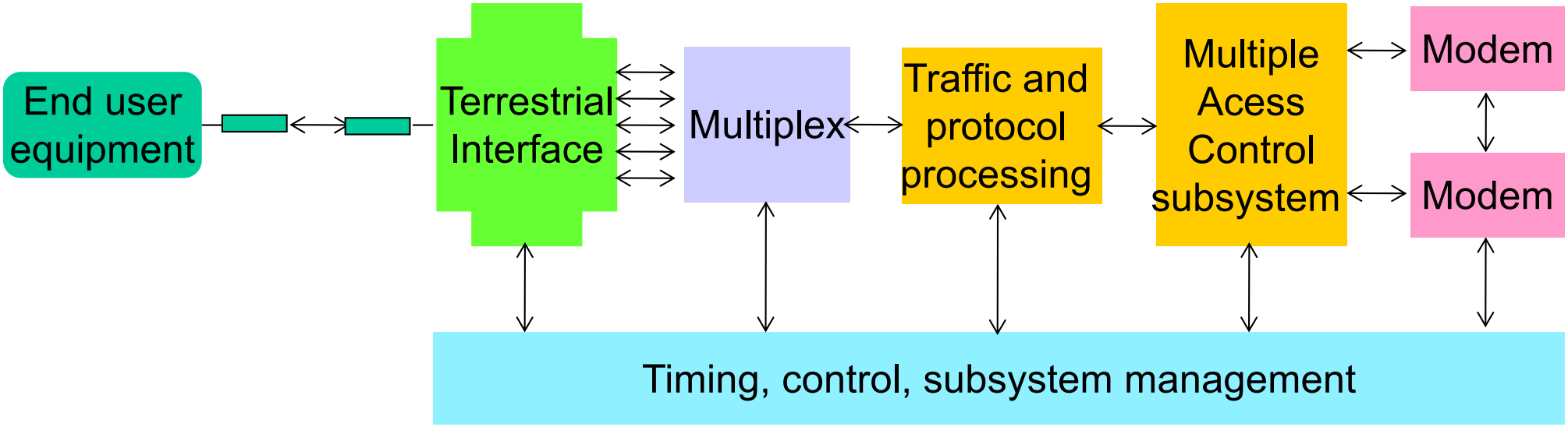
- Traffic control
- Capacity assignment and optimization
- Coordination

Service Management

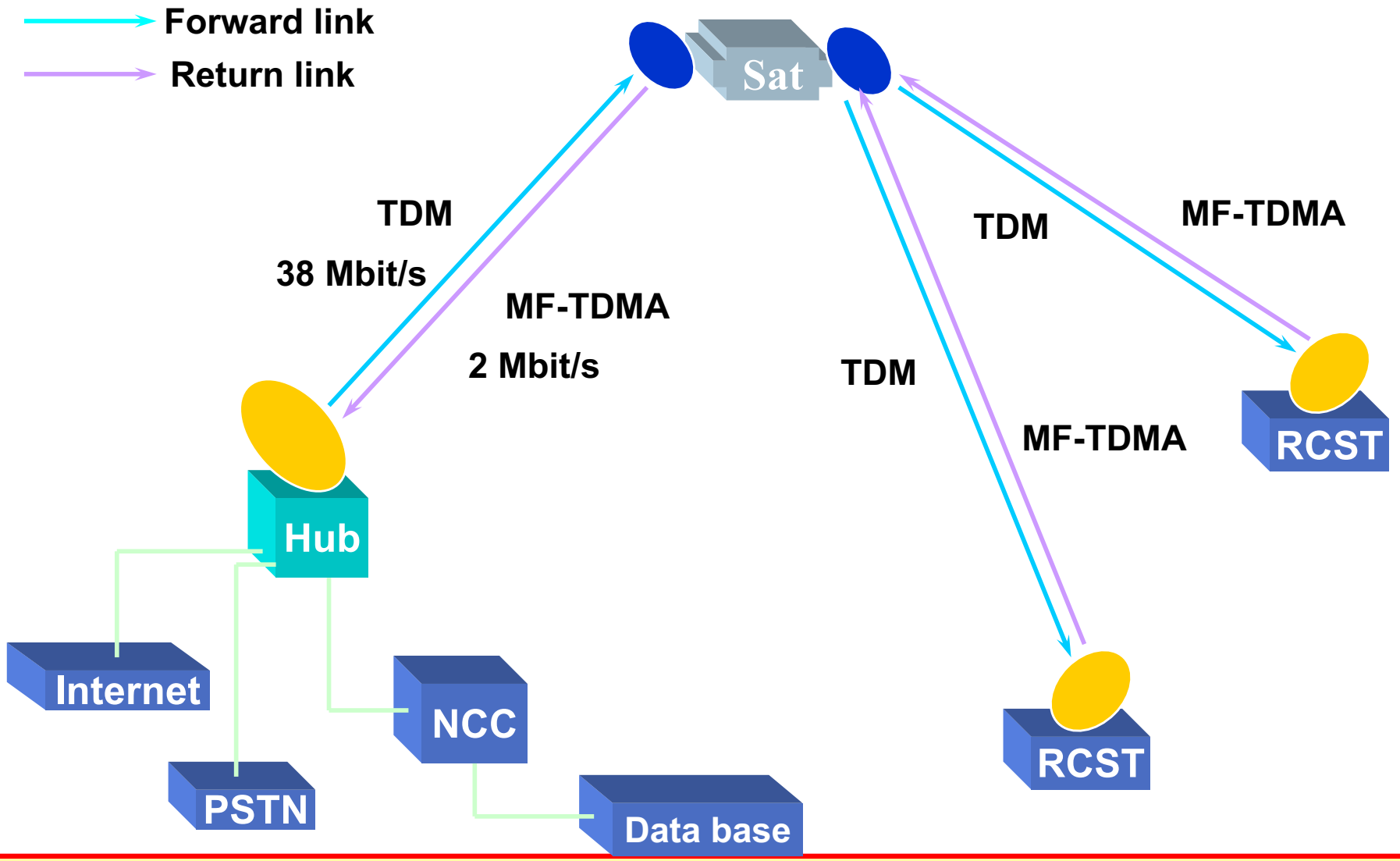
Baseband and Modem Equipment

- Network monitor and control
- The set of service management functions tied to
  - Nature of business structure
  - Regulatory environment
  - Competition

Baseband subsystem (Hub)



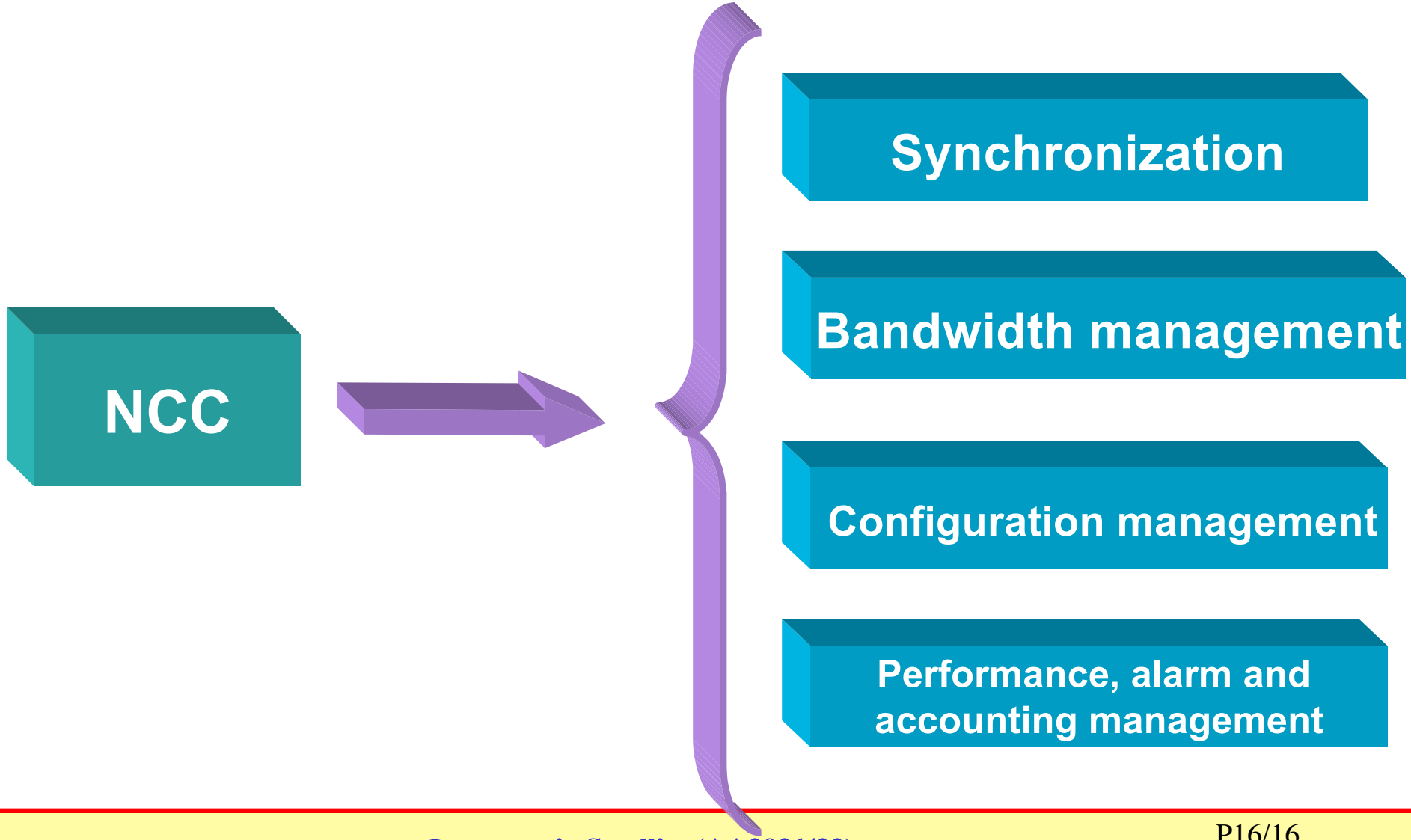
DVB RCS standard scenario



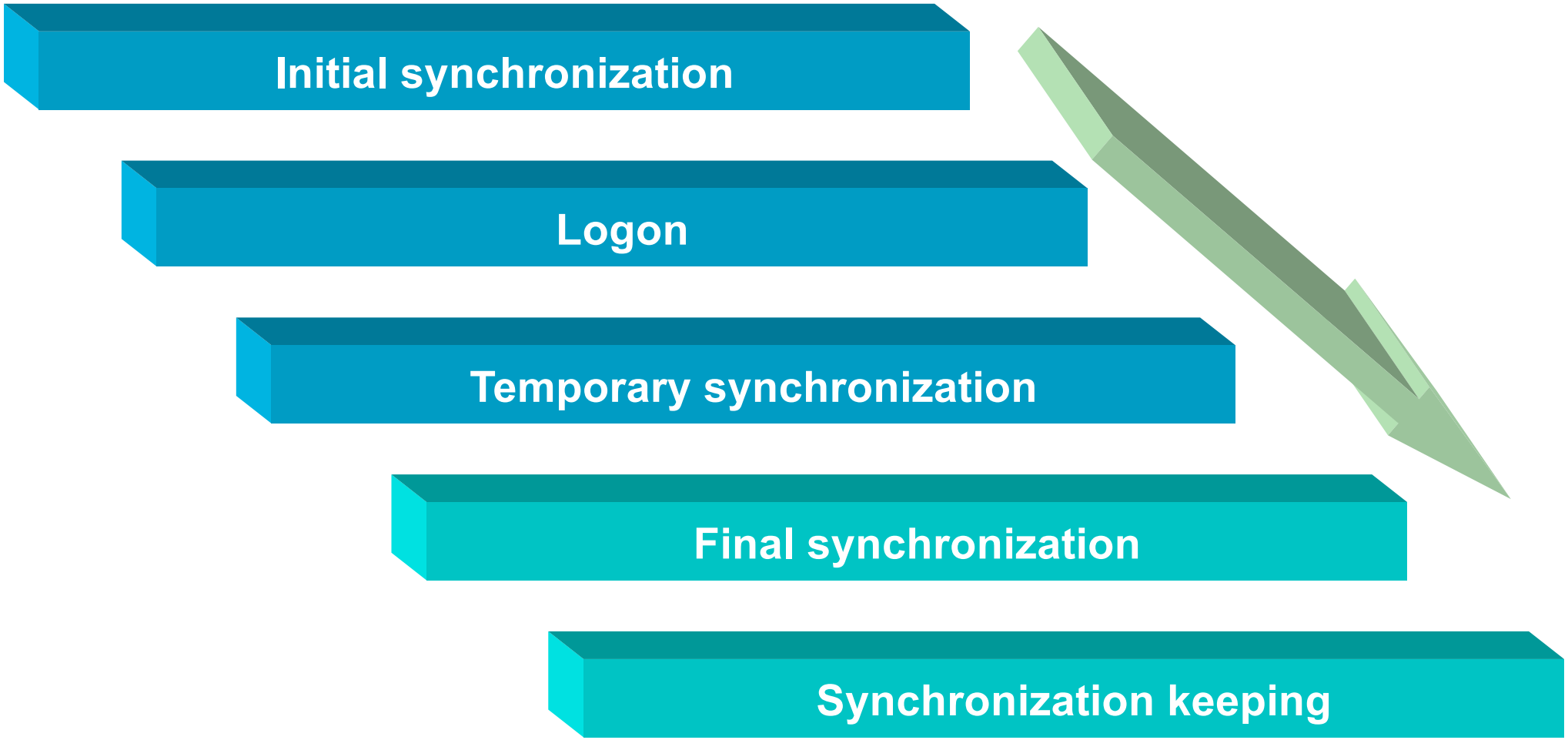
Network Control Center (NCC) functionalities

- User configuration management
- Network synchronization and acquisition control
- Damage management
- Accounting
- Alarm and performance management
- Whole capacity management
- Data base management
- Communication channel allocation to terminals real time management
- Resource BoD management
- User terminal access to network control
- Frequency, time and power errors correction

DVB RCS NCC functionalities



Synchronization procedures



Sinchronization phases

The access to the system and the terminal synchronization is achieved through:

1) **Preliminary synchronization:** RCST receives information concerning system technical and administrative characteristics
2) **Logon**: RCST requires initial access to the network and receives initial logon to NCC information
3) **Approximate synchronization acquisition**: initial synchronization acquisition concerning physical parameters (correcting frequency, time and power)
4) **Optimized synchronization**: RCST completes the physical synchronization
5) **Synchronization keeping**: RCST keeps the synchronization during the entire session.

RCST is not allowed to send burst until the synchronization is not completed.

Initial and final procedures

- Session: Time interval between RCST entrance to and exit from the network
  - **Logon**: allows RCST to access to the satellite network
  - **Logoff**: allows RCST to exit from the satellite network.

Initial synchronization procedure

- At the beginning RCST through a set of messages sent by NCC receives all the information concerning the technical and administrative characteristics of the system it is going to accede, necessary to correctly execute all the operations during the whole session: Network Clock Reference (NCR) synchronization, to initialize the internal clock.

Logon

- After having received all the information concerning the satellite interactive network structure, RCST is ready to start logon to be admitted to the system and ready to send its own packets.
- RCST sends a logon request in a time interval such as CSC using a random access Slotted-Aloha like. The request includes the RCST MAC address and a field showing the terminal capacity.
- In case of no collisions, NCC replies to RCST
- ***NCC checks that transmission resources are available and that administrative aspects are satisfied*** *(valid account, fee paid, etc.)*

Synchronization acquisition

- RCST, after having achieved the access to the network and the authorization to go ahead, starts the phase to acquire time and frequency synchronization and power optimization using NCR, transmitted in the forward link, as reference.
- ***NCC performs frequency, time and power errors measurements and sends these information to the correction center.***

Synchronization keeping

- RCST receives, at regular intervals, the Burst Time Plan (BTP) from NCC. BTP, inside the signalling of the forward channel, includes information about the structure of the superframes (SCT), frames (FCT) and tile intervals (TCT). Finally, RCST receives also the TIM broadcast message.

NCR = Network Clock Reference SCT = Superframe Composition Table
FCT = Frame Composition Table TCT = Time-slot Composition Table
TIM = Terminal Information Message

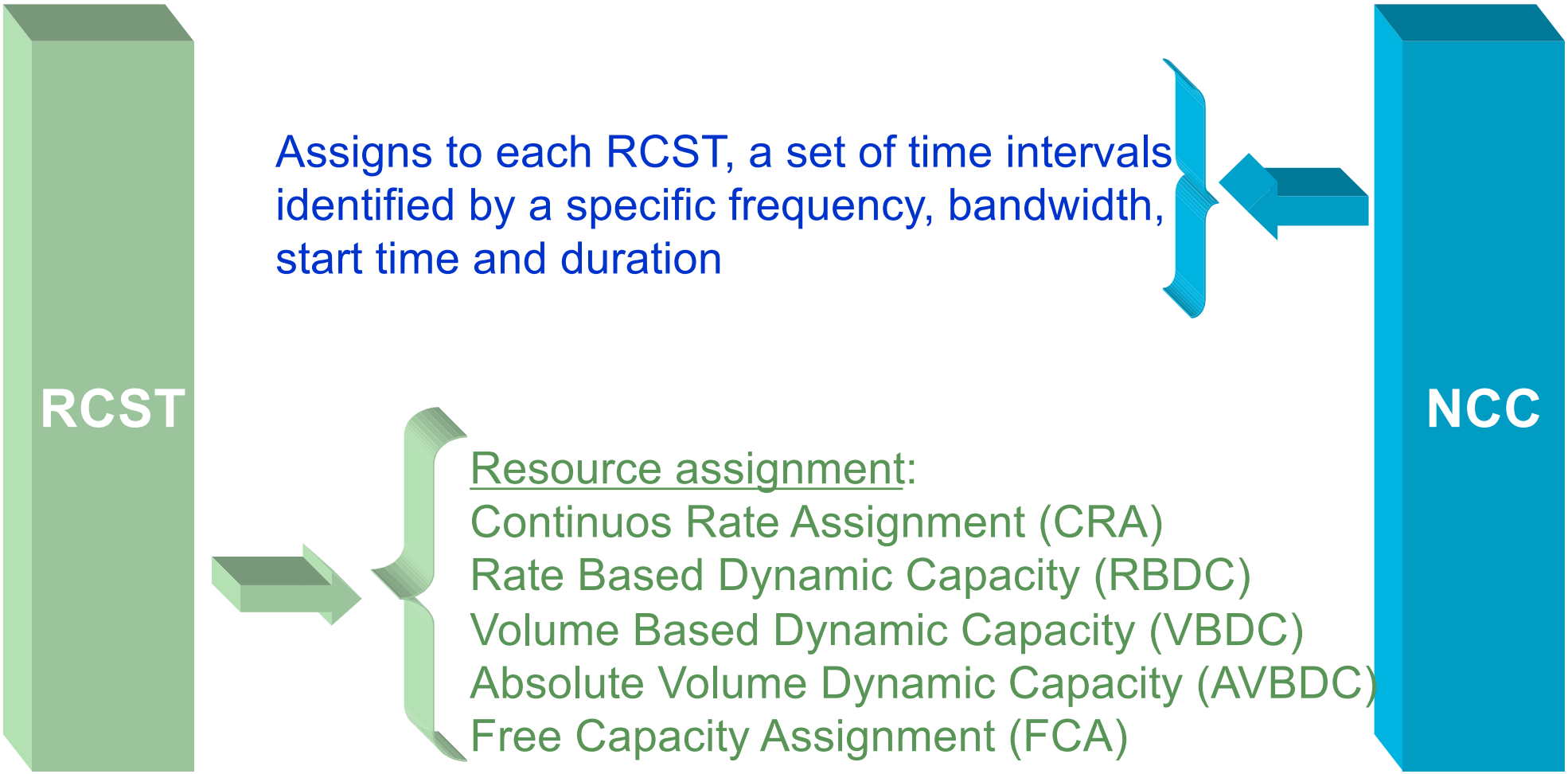
Network syncronization

- RCST, as soon as it is on, receives general information (SI Tables) of the network from the NCC which monitors and controls the correct system working conditions.
- Messages from NCC are inserted in the MPEG2-TS in private fields and transmitted in the forward channel
- Both NCC messages and data can be transmitted together
- NCC checks all the transmissions performed by a RCST
- Before starting transmission RCST must be accepted in the system through the logon, exchanging data with NCC
- After logon ends, NCC sends to RCST a set of tables including the Terminal Burst Time Plan (TBTP) that allows RCST to transmit data in dedicated time intervals, for assigned frequency slots and determined power level
- RCST starts transmitting MPEG2-TS packets
- RCST exits from the network through a logoff procedure if the transmission is finished or if NCC decides in this way.

RCST synchronization through NCC

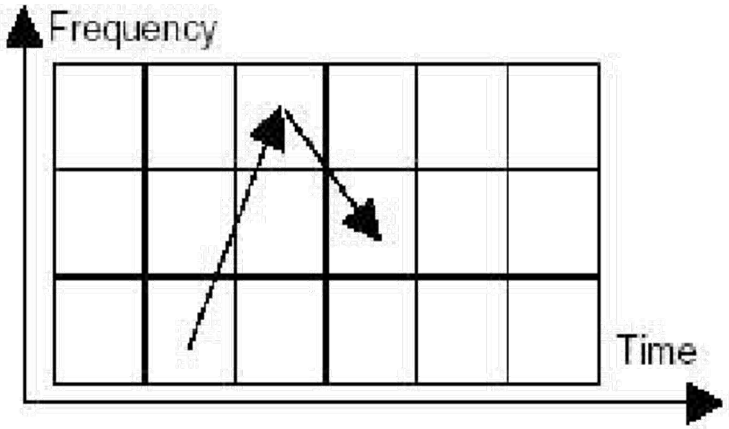
- An efficient TDMA system is necessary to get good synchronization among signals, so that interference among users is minimized and capacity is maximized.
- NCC compensates frequency shift errors of both the satellite and the RCST, thus achieving synchronization of all the RCST of the whole interactive network.
- In this way, technical constraints on the RCTS are relaxed.
- The Network Clock Reference (NCR) signal, transmitted in the forward channel in a field of the MPEG-2 TS, provides to RCTSs a reference frequency of the NCC clock.
  - RCSTs achieve the central frequency, start time and burst duration. The bursts are transmitted according to Burst Time Plan (BTP) received in the forward link. The BTP is expressed in terms of central frequency and absolute start time (provided by NCR) of the superframes. The start of a superframe is always a value provided by the local NCR counter to a RCTS, taken as reference for all the other allocations of bursts present in the superframe. RCSTs recover the absolute NCC reference clock value and compare it with the NCR value provided in the NCR, thus achieving the network synchronization.

Bandwidth management



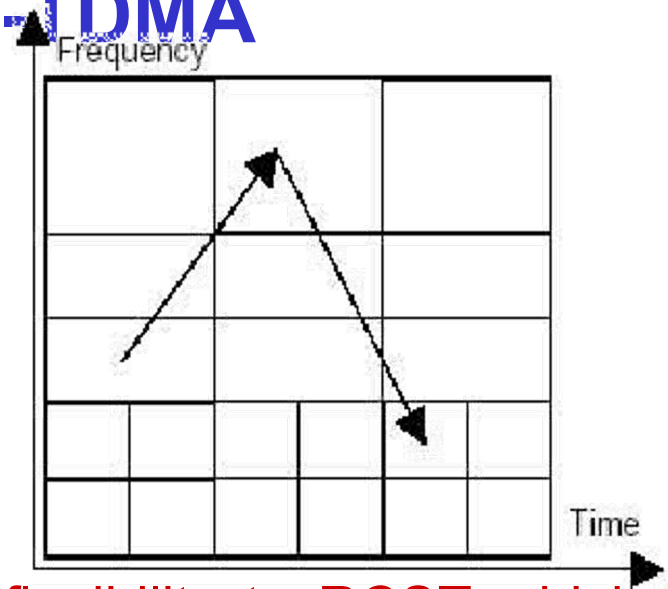
Static and dynamic MF-TDMA

Fixed MF-TDMA



- Bandwidth and duration units assigned to RCSTs are fixed (arrows show a typical sequence of capacity units assigned by a NCC to a RCST).

Dynamic MF-TDMA



- Provides flexibility to RCST which can vary capacity assignment amount.
- Other than frequency and burst duration the RCTS can vary the bit and coding rate for different bursts.
- The advantage is to get a greater flexibility and a more efficient adaptation to to the requirements of a multimedia network.

Dynamic MF-TDMA (frequency hopping)

- Frequency hopping is exploited in adjacent time intervals
- RCSTs have a specific set of frequencies available in different time intervals.
- RCST informs the NCC of this interval in a CSC burst during logon. The frequency hopping capability for specific equipment is decided in the terminal design phase and typically is 20 MHz (± 10 MHz around the central frequency).

Return channel capacity segmentation

- Time intervals are numbered so that NCC can assign them univocally to each RCST.
- Terminals can get available resources under control of NCC
- For each superframe the time interval allocation is communicated to RCST through the TBTP table sent by NCC
- RCST reads TBTP message from NCC to extract the assignment number and the allocations of the respective time interval for the following transmissions on the return channel.

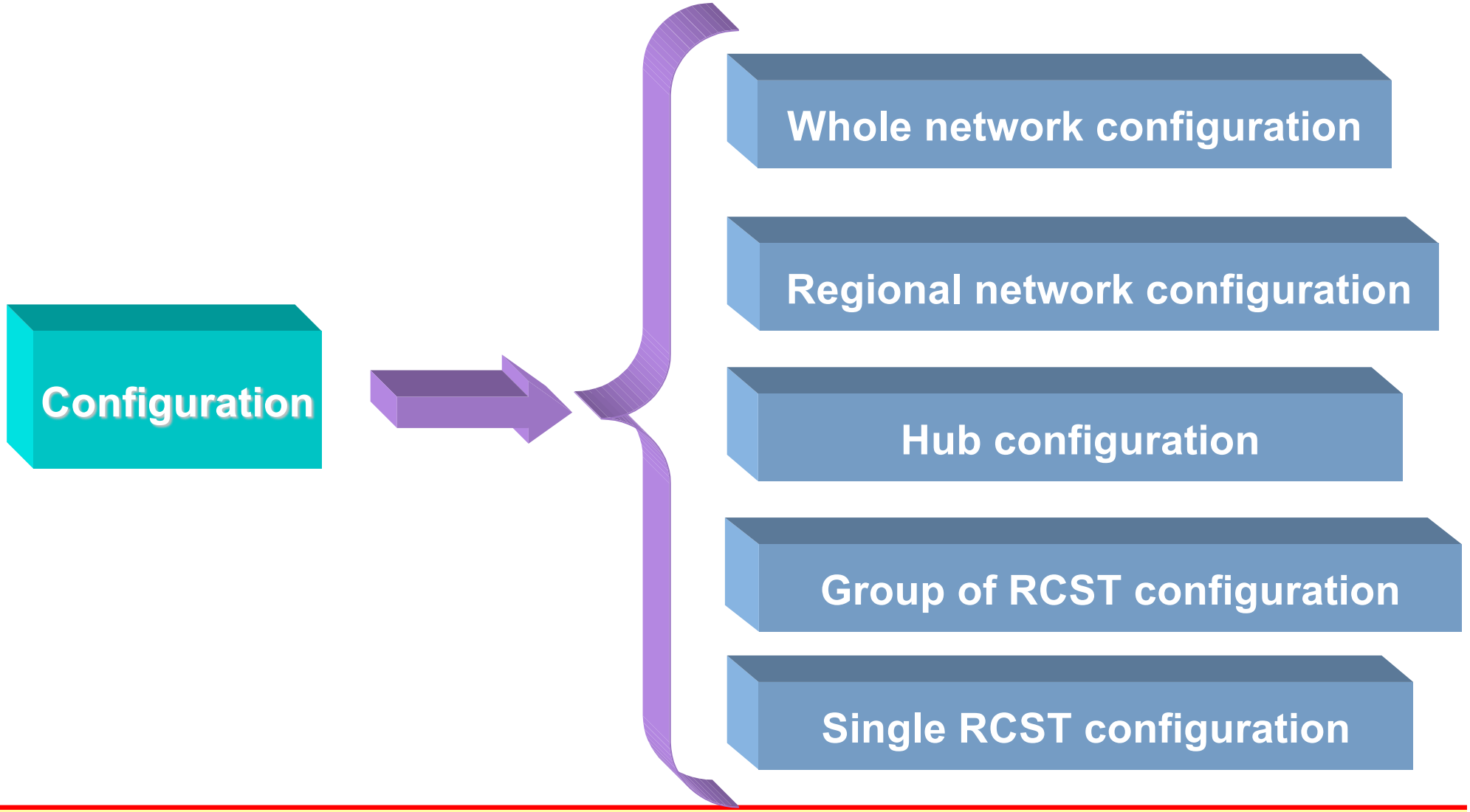
NCC: management and control

- NCC coordinates, through the messages that allow the RCST to accede the network:
  - User calls identification
  - RCST power optimization
  - Logon
- RCST is allowed to transmit requests to receive payloads only after having correctly received control messages from NCC on the forward channel.

Feeder

- Transmits signals on the forward channel, compliant with DVB-S standard, over which user data and control/time signals are multiplexed.

System configuration



RCST address

- In the forward channel RCSTs are univocally identified through a physical address Medium Access Control (MAC) and a logical address.

MAC address

- Physical address of 48 bits stored in a non volatile memory
- Unique physical identifier of the single terminal
- Inserted in the CSC burst transmitted by the terminal
- Used also to encapsulate IP datagram in MPEG2-TS frame
- Two MAC addresses:
  1) MAC unicast
  2) MAC Broadcast

Logical

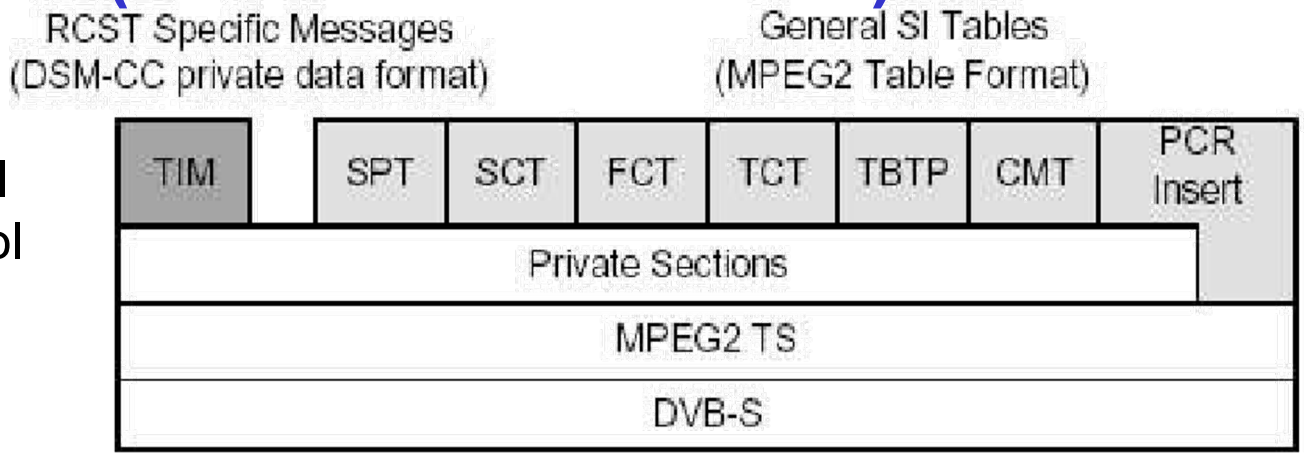
- Composed of two fields: Group_ID, Logon_ID, assigned to RCST during logon, Used for l'indirizzamento until logoff ends
  - Group_ID (8 bits) corresponds to a group of RCSTs
  - Logon_ID (16 bits) corresponds to a RCST in a group idenfified by Group_ID.

Signalling in the forward link

- Signalling on the forward link is based on tables as Service Information (SI) which contain:
  - Information concerning the network structure
  - Specific messages to each RCST
  - Fields for private data as defined in the DVB-SI standard
  - Special TS packets (with Program Clock Reference, PCR)
  - Descriptors for standard DVB_SI tables

SI tables (Service Information)

Forward channel signalling protocol



- *SI tables* structured in 6 types are broadcasted to usrs, in private sections of the flow generated in the forward channel

SI tables (Service Information)(2)

SCT	describes the partition of the whole capacity in frames and superframes
FCT	describes the partition of the frame in time-slot, TS (containing the duration, number of TS, start time and frequency of each TS)
TCT	provides information about properties of time slots
STP	contains empirical data of the satellite required to update burst position at regular intervals
CMT	provides frequency, time and amplitude corrections
TBTP	sent by NCC to a group of RCSTs identified by Group_ID, or to a single RCST according its Logon_ID. TBTP allows TS to be allocated one by one or also continuously defining the number of TS to allocate
TIM	sent by NCC to a RCST through the MAC address (uni-cast) or to all the terminals through the MAC address (broadcast). It contains information concerning terminal configuration (forward channel) and is utilized also for handover
PCR	allows to insert the NCR value in the MPEG2-TS on the forward link to synchronize RCSTs in the return channel

Signalling on the return channel

- NCC manages the RCST synchronization through a message exchange using specific time slots
- ACQ and SYNC: special bursts containing information dedicated to NCC to let it correctly measure time, frequency and power for each RCST

Burst Time Plan (BTP)

- Sent to all the RCSTs which experienced problems using TBTP.
- It contains information that allow the terminals to know when they can transmit data bursts
- RCSTs send Capacity Request (CR) messages to NCC to request capacity based on the traffic volume to be transmitted.

Alarms, accounting and performance

PERFORMANCE
Network elements current status check
System performance statistics management

PERFORMANCE
ALARMS
ACCOUNTING

ALARMS
Active system alarms check
Statistics of occurred alarms management

ACCOUNTING
User accounting management. Each account contains: source RCST, destination Hub and number of transmitted segments

VSAT Indoor Unit (IDU) vendors

- AAE Systems, Inc. – Eclipse
- Advantech Wireless - DVB-RCS
- Comtech EF Data - Advanced VSAT Solution
- Comtech EF Data – SkyWire
- Elbit (Shiron) – InterSKY
- Gilat Satellite Networks
  - SkyEdge II-c
  - SkyEdge II
  - SkyEdge
- Hughes
  - HN System
  - HX System
  - Spaceway 3
  - JUPITER System
- iDirect - Evolution & Velocity
- NanoTronix – OpenRCS
- ND SatCom
  - SKYWAN 5G
  - SKYWAN 7000
- Newtec - Sat3Play
- PolarSat
  - VSATPlus 3
  - VSATPlus II
  - FlexiDAMA/SkyIP
- Romantis – UHP
- SatPath – SkySwitch
- STM (EMC) – SatLink
- Thales Alenia Space – SpaceGate
- TSAT TSAT3000
- ViaSat
  - LinkStarS2A
  - SurfBeam 2
  - ArcLight
  - SLQ
  - LinkWay

Viasat LinkStar

- Satellite two way communication system for broadband-on-demand, for multiple services Internet Protocol (IP) compliant
- Low cost VSAT (Very Small Aperture Terminal)
- Star topology
- The network is divided in regional areas each equipped with a pair Hub/RNCC (Regional NCC)
- A LinkStar NCC can manage up to 10 RNCC each able to support up to 10000 RCST (total 100000 RCST)
- DVB compliant

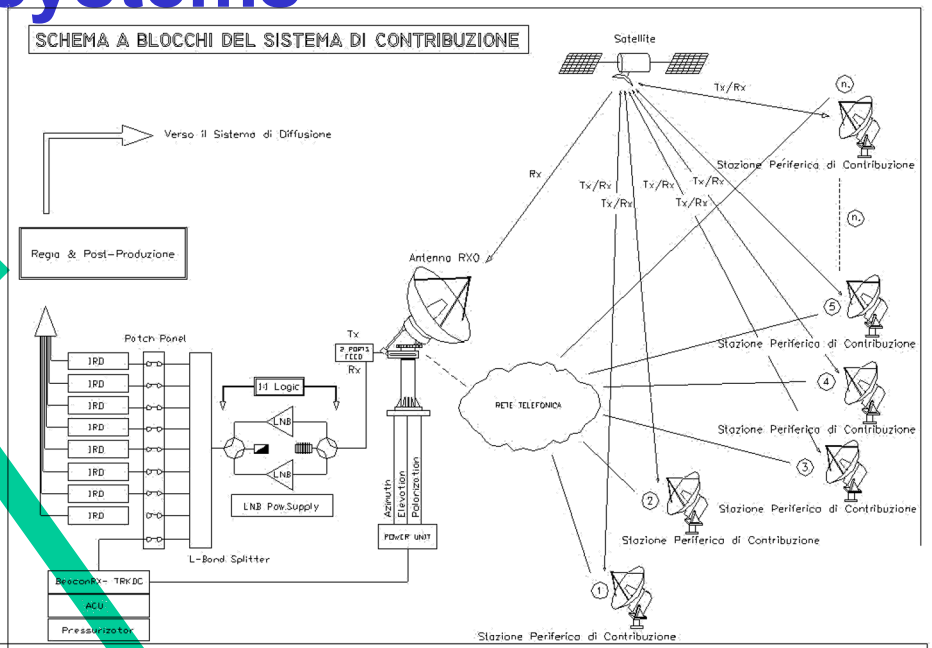
Viasat Linkway

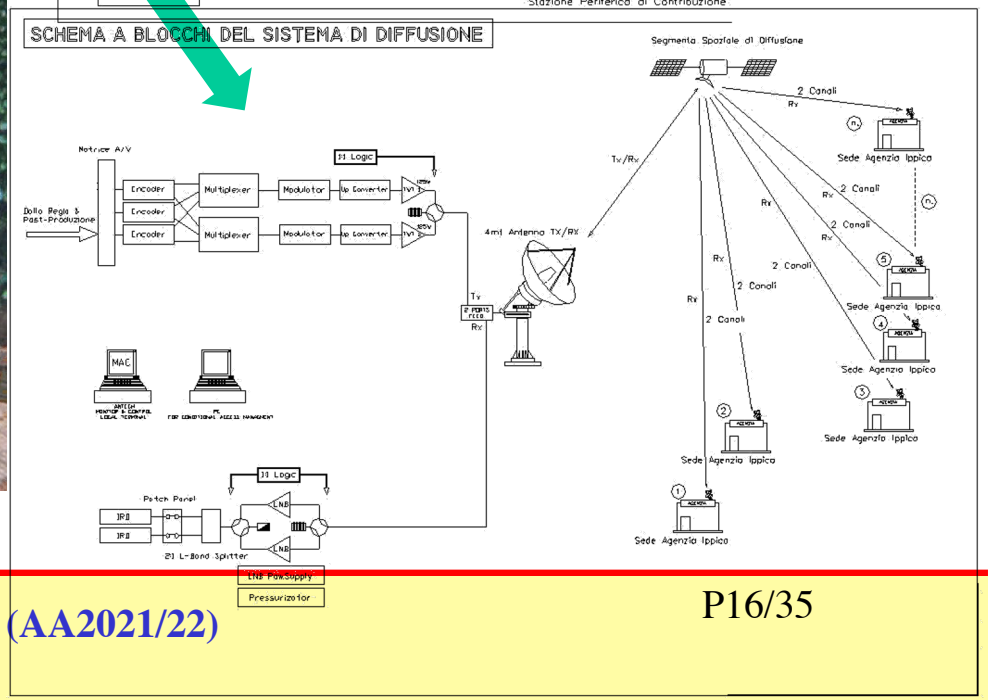
- Multicarrier mode, multi-rate and TDMA
- Fixed and dynamic band allocation
- Star, mesh and virtual star topologies supported
- Standard user interface for circuit and packet switching
- Management and control implemented through the communication between NCC and MRT (Master Reference Terminal)

TV Satellite systems

System architecture

- Contribution subsystem
  - Mobile and DSNG contribution
  - Fixed contribution
  - Not necessary for DSNG or contribution reversal
- Distribution subsystem

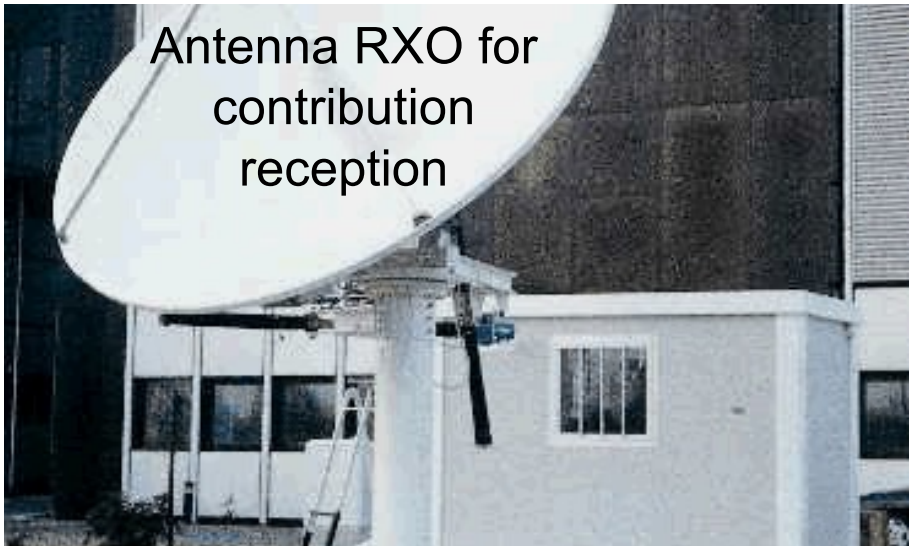




TV Satellite systems (2)

- Applications
  - TV channels broadcasting "Direct To Home";
  - Program distribution for terrestrial TV networks;
  - Video contribution reversal to the production centre from remote location
  - DSNG (Digital Satellite News Gathering) services
- Characteristics of fixed contribution stations
  - Antenna 1.8 - 2.4 m diameter;
  - HPA 8 - 125 W;
  - SCPC;
  - Bit rate 2 - 4 Msys/s;
  - DVB MPEG-2 4.2.0
- Characteristics of digital distribution platforms
  - Antenna 4.5 - 7.5 m;
  - HPA 400 W - 2.4 kW;
  - MCPC;
  - Bit rate 27.5 Msys/s;
  - DVB MPEG-2 4.2.0;
  - Ku 13.75 - 14.50 GHz; K 17.3 - 18.1 GHz; C 5.85 - 6.65 GHz
- Characteristics of mobile or DSNG contribution stations
  - Antenna 1.2 - 1.5 m diameter with automatic steering;
  - HPA 125 - 400 W;
  - SCPC or, rarely, 2 channels MCPC;
  - Bit rate 5 - 12.8 Msys/s;
  - DVB MPEG-2 4.2.0 or 4.2.2 (for sport events needing post-production);
  - Ku band 13.75 … 14.50 GHz.
- Characteristics of contribution receiving stations
  - Antenna 3 - 4.5 m;
  - Tracking of satellites in inclined orbit;
  - Multiple SCPC reception;
  - Bit rate 2 - 4 Msys/s;
  - DVB MPEG-2 4.2.0 ;
  - Ku band 10.75 … 12.75 GHz.

TV Satellite systems (3)

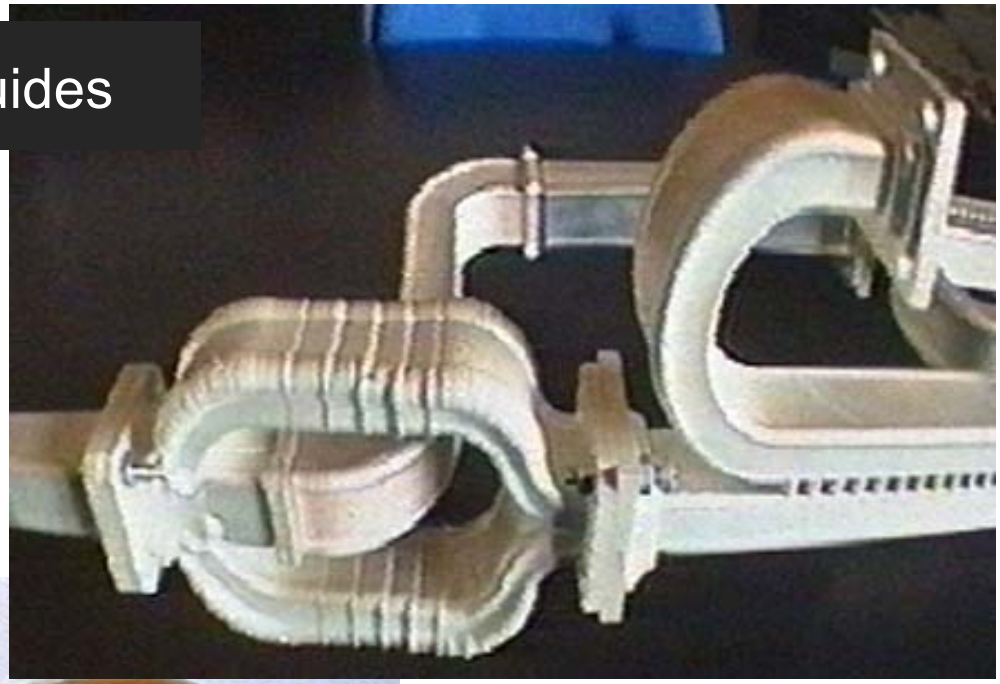


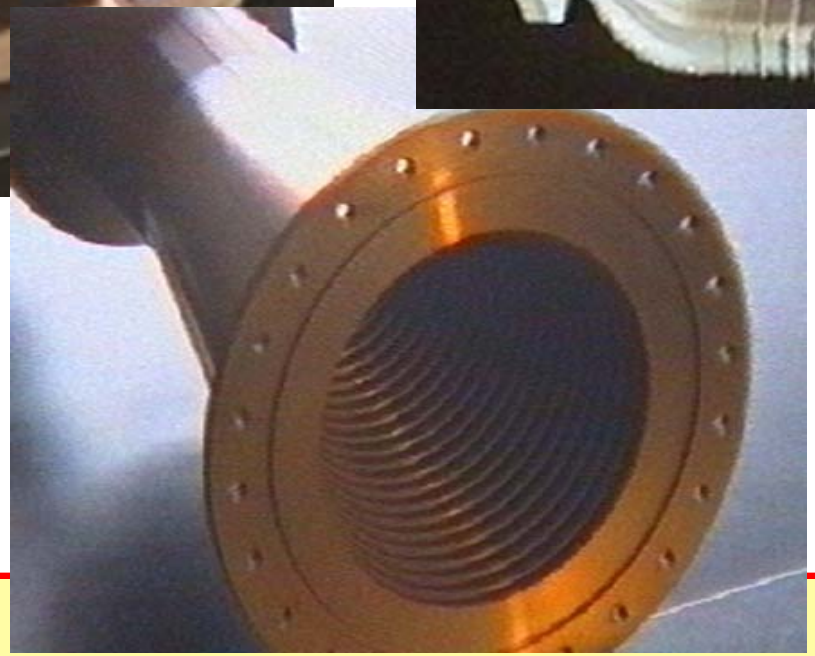
HRT Platform

Stream Platform

Antenna Feed

Waveguides





Corrugated Horn