



**INEO**  
GDF SVEZ

## New trends in satellite communications

## Presentation summary

- INEO E&S Aeronautical Export Department
- Satellite access analysis
- Anticipating the future

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- **INEO E&S aeronautical export department**
- **Satellite access analysis**
- **Anticipating the future**

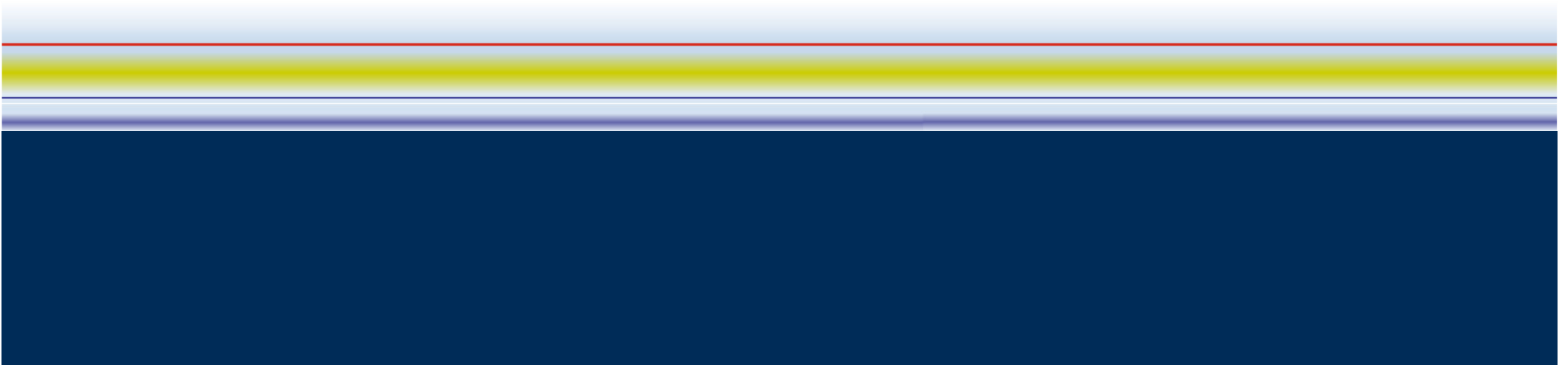


# INEO E&S Aeronautical Export Department

→ INEO E&S designs, builds, installs and maintain  
Information and Communication Systems

# INEO E&S

At a glance



# Skills – Fields of activities

## Infrastructures

- Power stations
- Solar power systems
- Secured electrical distribution
- Airfield lighting
- Monitoring & Control
- Navigational Aids (VOR-ILS-DME-NDB-DF)



## Air Traffic Control

- Voice Communication Switching System (VCSS)
- Meteorological Systems
- AFTN / AMHS switch
- Aeronautical Information Systems (AIS)
- Time Synchronisation
- Recording Systems
- ATIS / D-ATIS
- Integrated Consoles
- 3D tower simulators

## Communication Systems

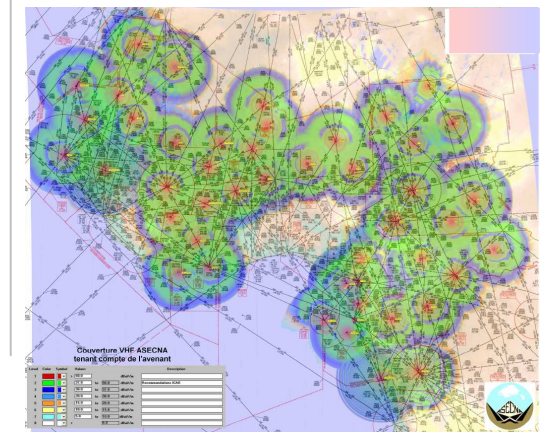
- VHF, HF, MW, V-Sat Communications
- LAN / WAN Networks
- Secured optical fiber networks (data collection around the runway)
- Remote VHF stations
- Monitoring & Control



# Scope of work

## Aeronautical System Integrator

- > Project Management
- > Engineering / Detailed design
- > Equipment procurement
- > Integration
- > Overseas Transport
- > Installation and Commissioning
- > Training
- > Maintenance

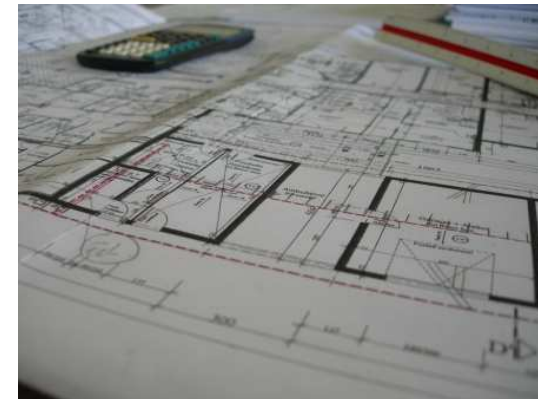


# The strength of an expertise dedicated to the customer



A multidisciplinary technical expertise for the benefits of the customer:

- Pool of Aeronautical Experts
- Pool of Telecommunications Experts
- Software development engineers
- Design department
- Integration facilities
- Partnerships with strategic suppliers



INEO E&S develops its own products dedicated to the Air Traffic Control world:



**Concerto Voice  
Communication Switch**



**3D Tower simulator**



**Voice@net Voice  
Communication Switch  
Simulator**

# Reference – Telecommunication Project



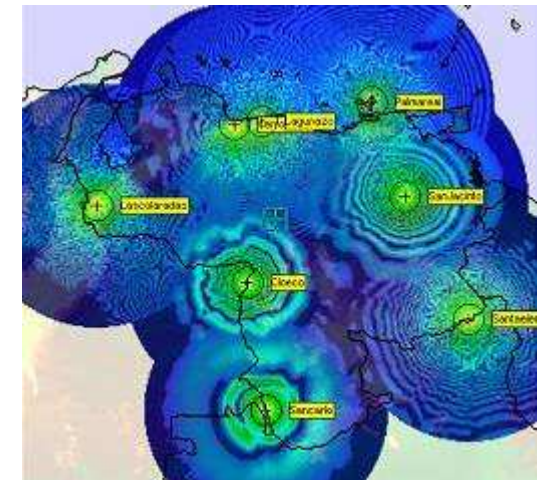
## VHF coverage and VSAT network for INAC (Venezuela)

International Civil Aviation Organization (ICAO)

Date: 2006 - 2007

**Supply, installation, commissioning, training of the technical staff of the civil aviation in order to implement a VSAT network of 29 stations and 8 VHF stations**

- VHF radio coverage studies, design of the VSAT network and of the microwave links
- Interconnection of the VSAT system with the Radar, VHF, AFTN, ATN and ATS/DS voice switch
- Monitoring and control of all active equipment from two geographically separated centers
- Turnkey solution including the provision of space segment and operation of the network



## TDMA based solution using SkyWAN modem

- > Meshed network
- > Low bandwidth consumption

## Frame Relay network with Memotec product

- > Reliable product
- > Well suited to Aeronautical networks

## An evolutive network:

- > Upgrade to 31 stations in 2008
- > RADAR Broadcast
- > Integration of AMHS in 2010



# Reference – Telecommunication Project

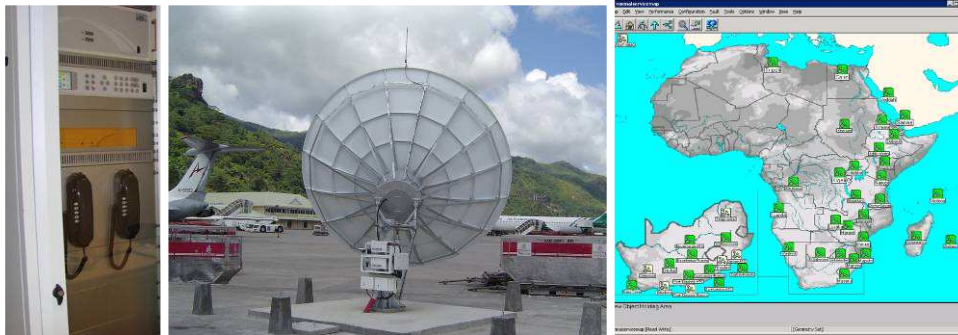
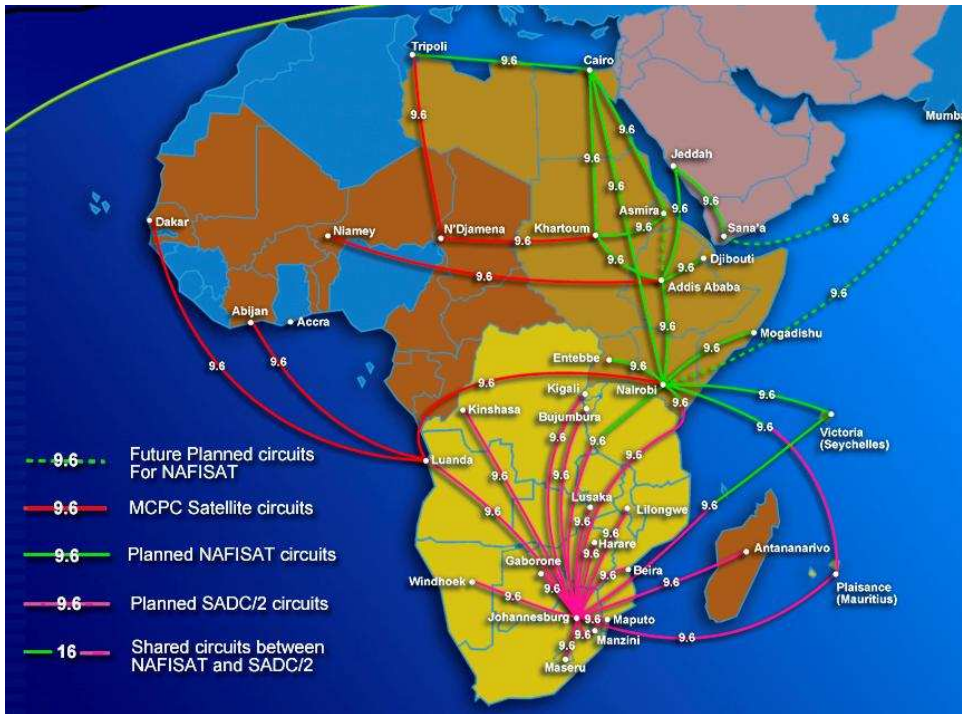
## Aeronautical VSAT networks in Africa: SADC-2 / NAFISAT / IVSAT

**ATNS**

**Date:** 2006 - 2008

### Renewal of the VSAT network for SADC and NAFISAT countries as well as ATNS domestic network (IVSAT)

- Turnkey VSAT network including 43 stations in 28 countries for fixed services (SADC and NAFISAT) as well as mobile services (IVSAT)
- Interconnection with AFISNET (ASECNA)
- On demand bandwidth allocation
- Monitoring and control on each site with two centralized centers (Nairobi and Johannesburg)
- Seamless integration with the Radar system, VHF, AFTN, ATN and ATS/DS



# Reference – Telecommunication Project

## Peruvian VSAT project

**CORPAC**

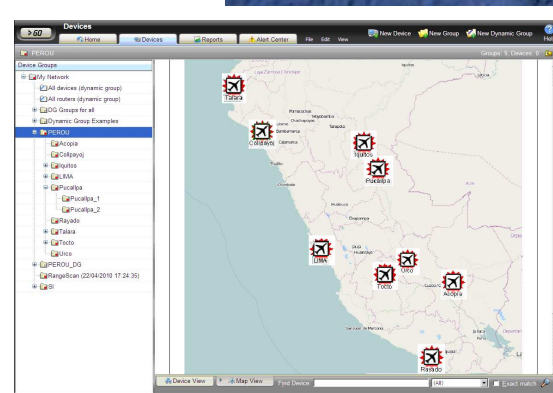
**Date: 2009 - 2011**

### Customer objective

- VSAT network for the new RADAR system
- Migration of existing services
- 8 stations across the country

### INEO Solutions

- Turnkey solution including studies, VSAT stations and space segment allocation
- Fully hardware-redundant system
- Main link through satellite, backup link through existing REDAP network (terrestrial)



## Presentation summary

- INEO E&S Aeronautical Export Department
- **Satellite access analysis**
- Anticipating the future



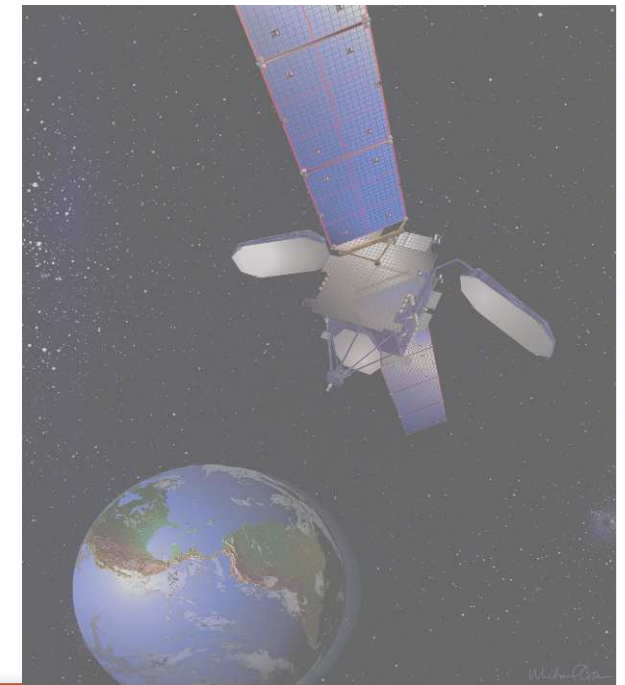
# Satellite access analysis

## Incident of ANIK E2 on January 20<sup>th</sup> 1994

On January 20<sup>th</sup>, 1994, Telesat Canada's Anik E2 satellite experienced an attitude control failure due to a solar storm. Anik E2 began tumbling uncontrollably. The satellite was eventually recovered using a unique ground-based determination and control system.

Anik E2 resumed service on August 1st, 1994, about six months after the solar flare.

- Satellite was back into business using a innovative technique based on ground loop control (GLACS)
- Enhanced satellite availability improvements

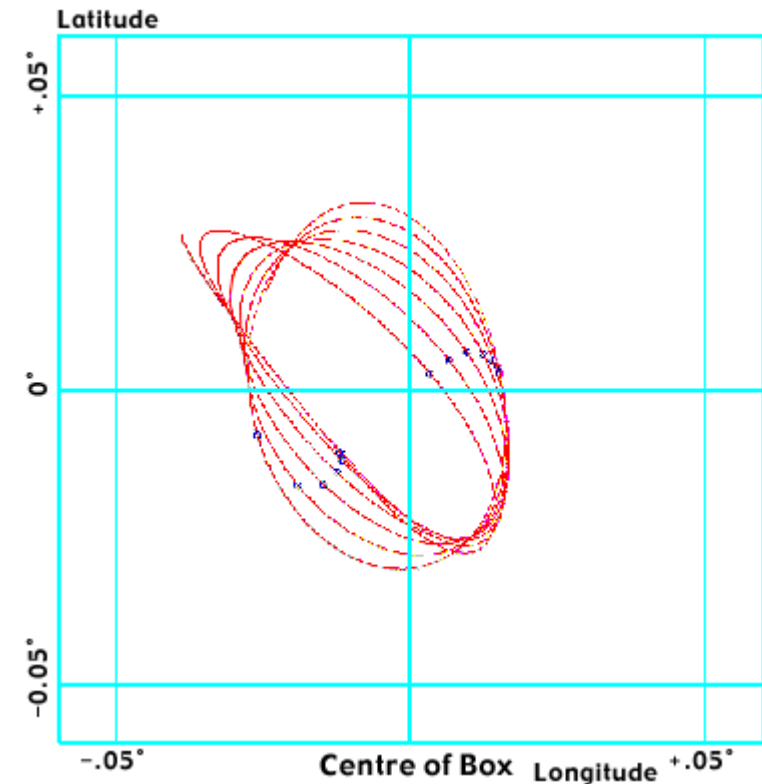


- **Attitude control is mainly computed inside the satellite**
  - Position sensors for Three-axis regulation
  - Phase comparison techniques to obtain the Round Trip Time (distance estimation)
- **Telecontrol, Tracking and Command (TT&C) link with earth operation center.**
  - Communication link in Payload band (C, Ku or Ka).
  - Backup link in S-band using an on-board low-gain antenna



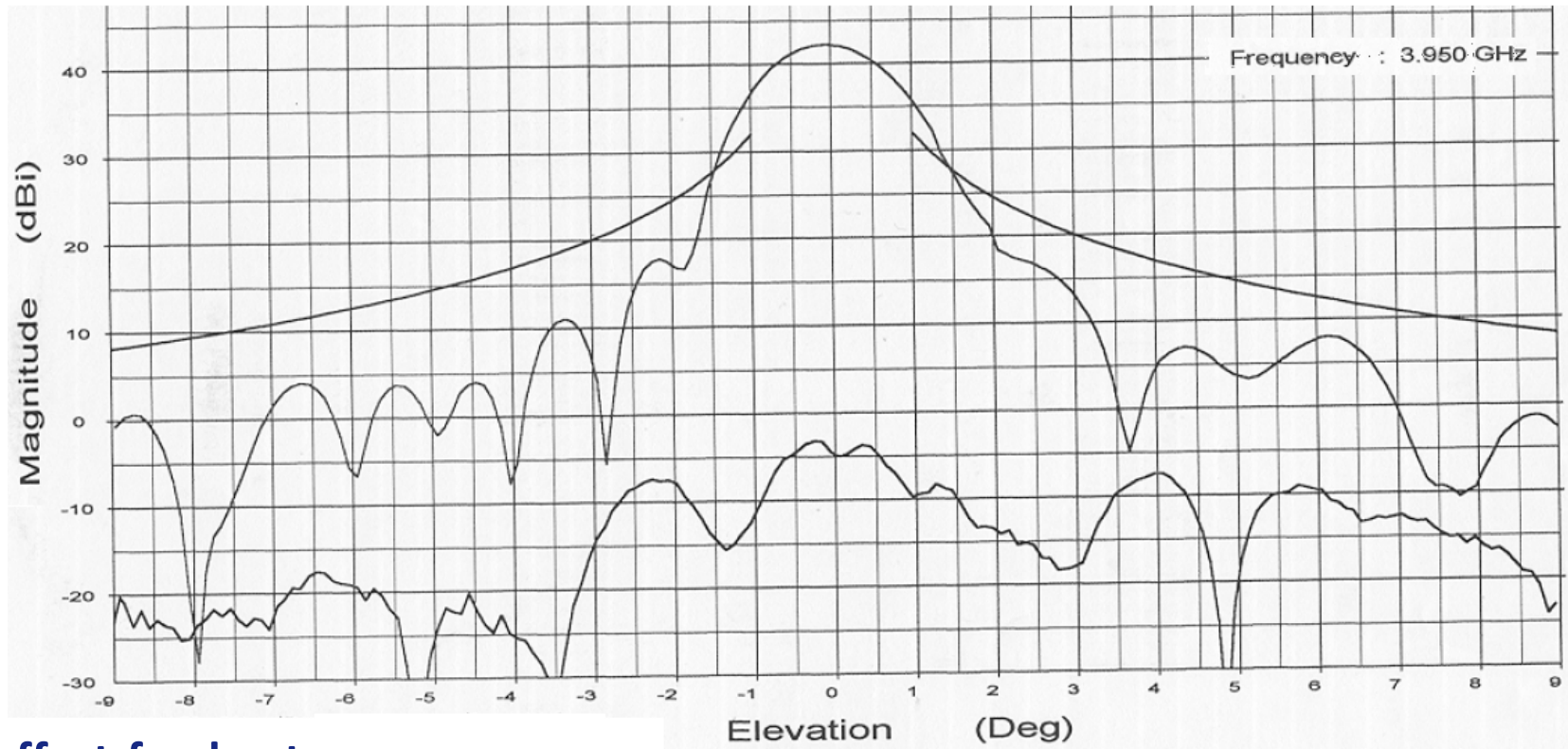
# Satellite orbit variations

- Satellite's orbit is never perfect, the latitude and longitude vary with time.
- Centre of Box predicts are used to point ground antennas at the satellites in orbit.



Path of the satellite over a one-week period. Each day, there are two points where the satellite comes closest to the centre of the station keeping box.

# 3.8m C-Band antenna pattern



**3.8m C-band offset-feed antenna.  
Pattern given at 3.950 GHz.**

**0.05° variation is minimal: # 0.3 dB (linear approximation)**

## Incident of ANIK F1 May 10 th 2011

“ [...] Anik F1 suffered an unanticipated and unforeseeable attitude disturbance which caused a loss of earth lock. [...] the attitude disturbance was caused by a high acceleration imparted on the spacecraft (which was beyond the control system to handle), which in turn was caused by a ruptured heat pipe on the south west deployable radiator.[...] ”

David Wendling

Vice President,Space and Network Engineering TELESAT

- Shows the progress accomplished since 1994: 1 day of service perturbation
- Satellite communication still can have troubles
- Telesat has one of the biggest availability: more than 99.97% (99.989 % in 2004)

## Presentation summary

- INEO E&S Aeronautical Export Department
- Satellite access analysis
- Anticipating the future



## Anticipating the future

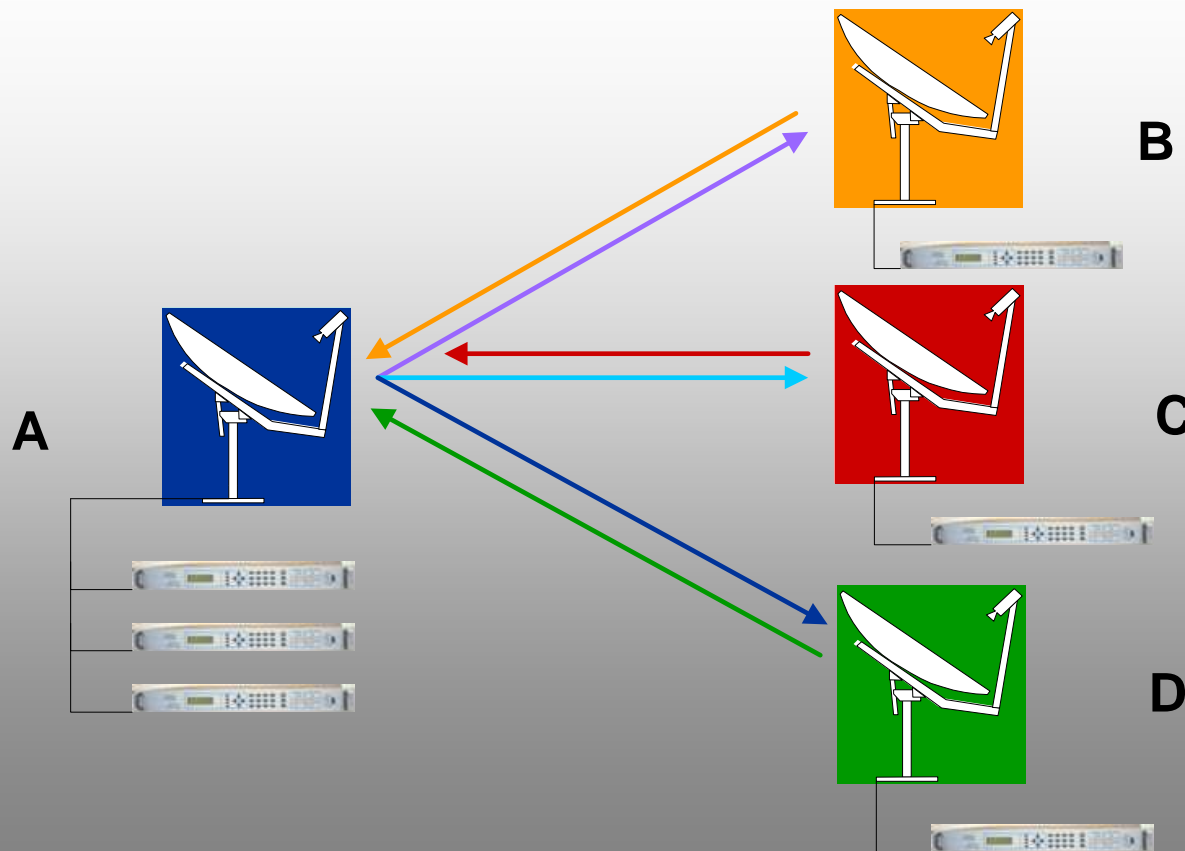
→ Satellite technologies & IP features

## Presentation summary

- INEO E&S aeronautical export department
- Satellite access analysis
- **Anticipating the future**
  - Satellite access: the TDMA hegemony ?
  - The IP convergence

**Satellite Access :**  
**the TDMA hegemony ?**

# Point to Point - SCPC

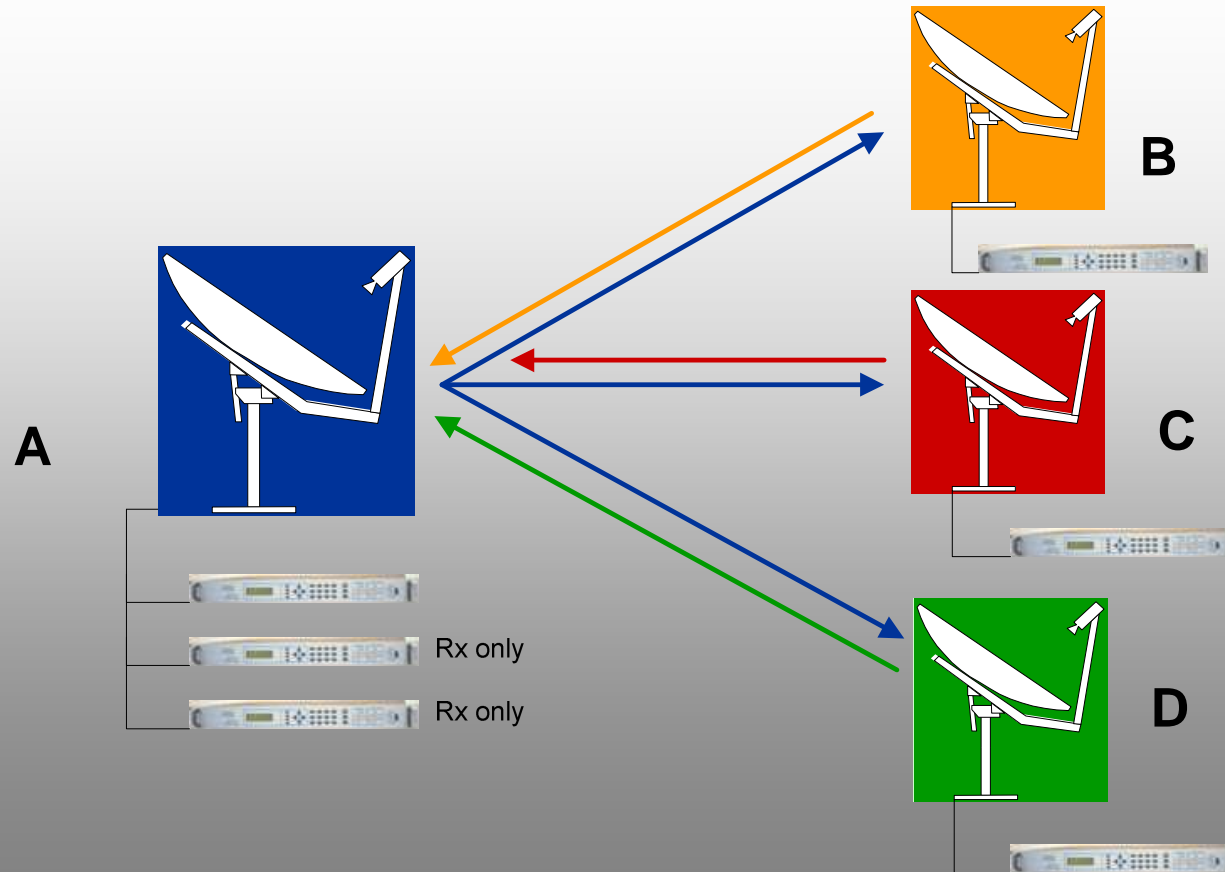
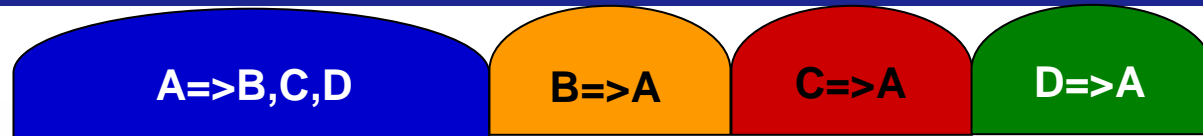


- One carrier per link
- Each carrier only contains information for remote site
- Hubless connections (Point to Point)
- One pair of modem per connection

➤ **Well suited for:**

- Networks with a high percentage of permanent circuits
- High availability and robustness
- Small meshed networks or large hybrid networks

# Point to Multipoint - MCPC

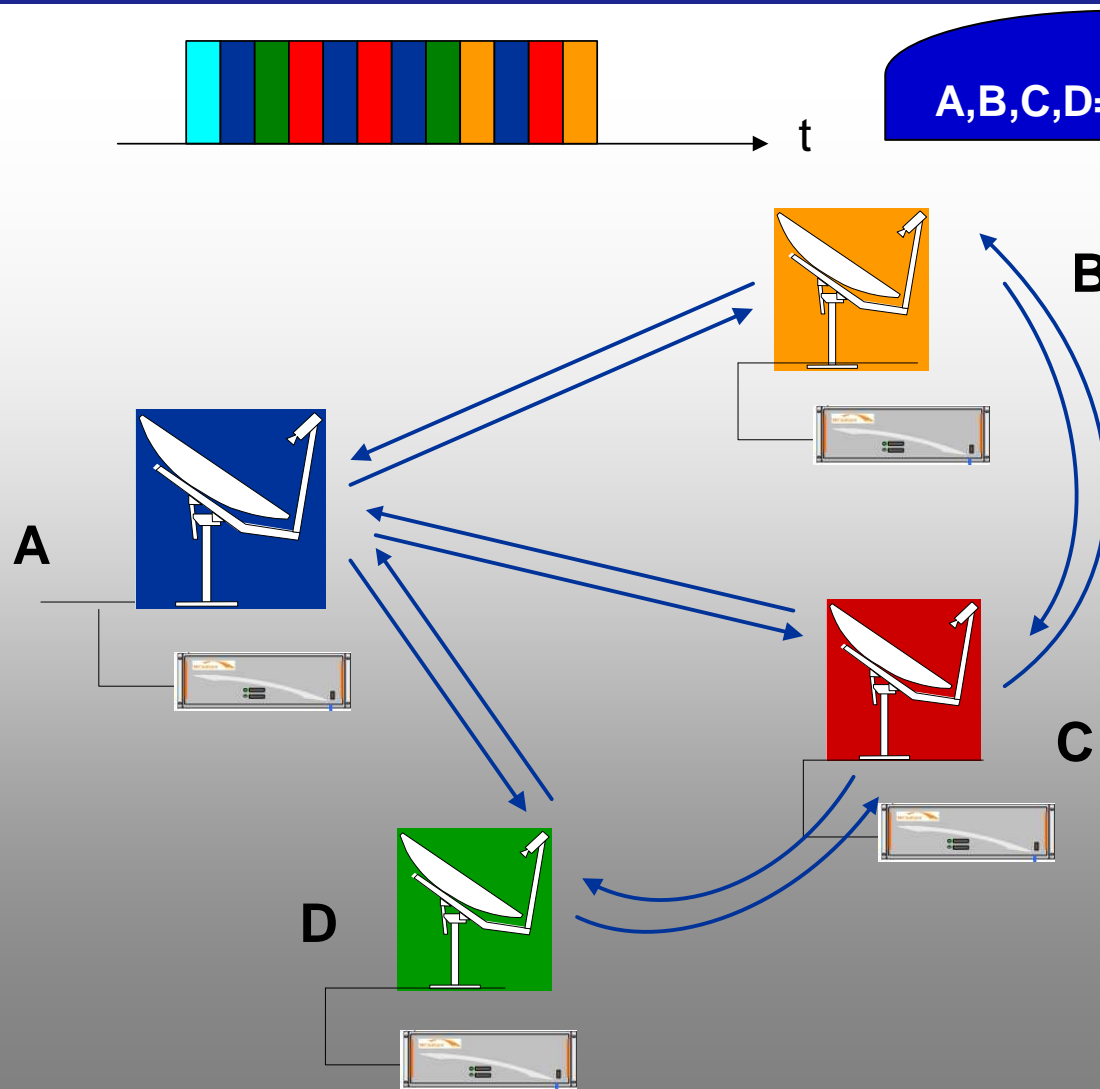


- One carrier per station
- Each carrier contains information for different remote sites

➤ **Well suited for:**

- Networks with a majority of permanent circuits
- Star/Hybrid topologies (Star with some meshed links)
- High availability and robustness
- Asymmetric traffic

# TDMA



- One carrier shared by a large number of stations
- Frequency hopping : Multi Carrier
- Time divided in slots.
- Synchronisation stations (one main, one stand by)

➤ **Well suited for:**

- Networks with a high percentage of DAMA circuits
- Full Mesh topologies with a large number of sites
- Flexibility

Bandwidth can be allocated permanently (**PAMA**) or on demand (**DAMA**)

## PAMA Services:

- Radar
- VHF



**Low JITTER**  
**No BW request**

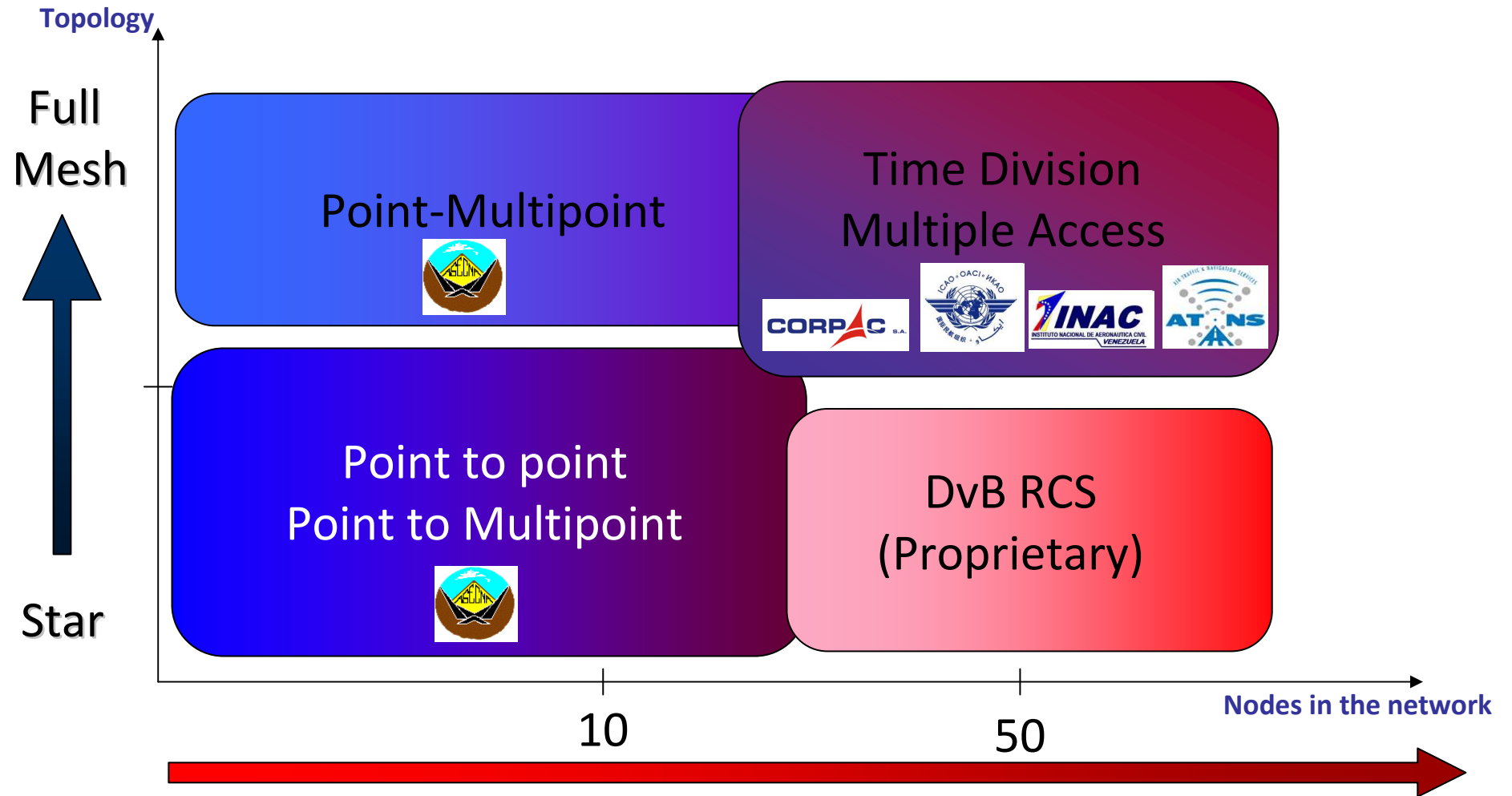
## DAMA Services

- AFTN, AMHS
- ATS/DS
- RCMS (VOR, Radar, VHF, etc)
- M&C



**BW on demand**  
**PAMA on demand for real time**  
**(low jitter)**

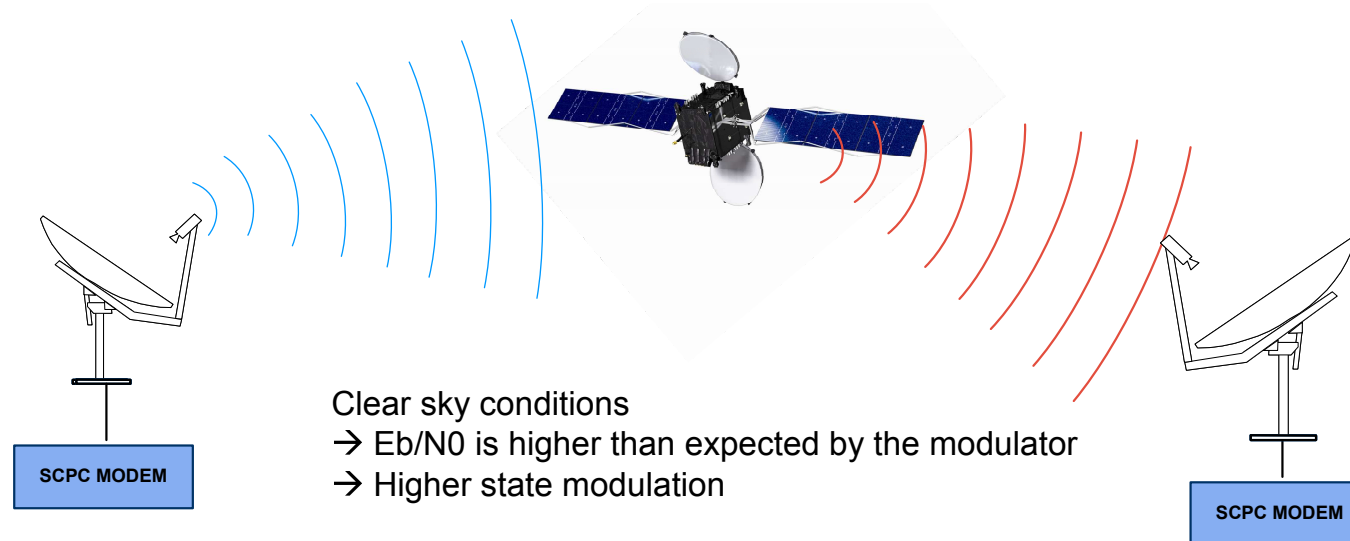
# VSAT Technologies



Three S/MCPC technical improvements have been developed:

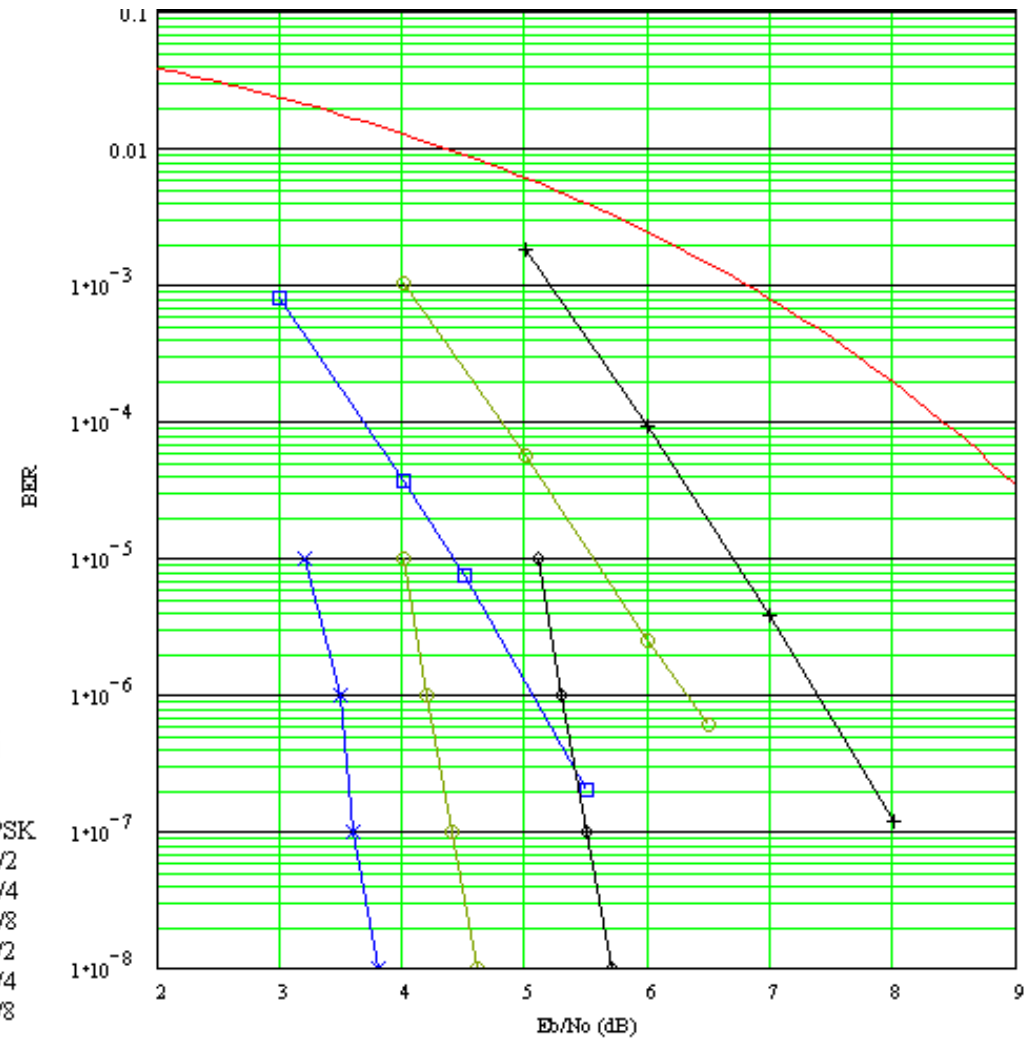
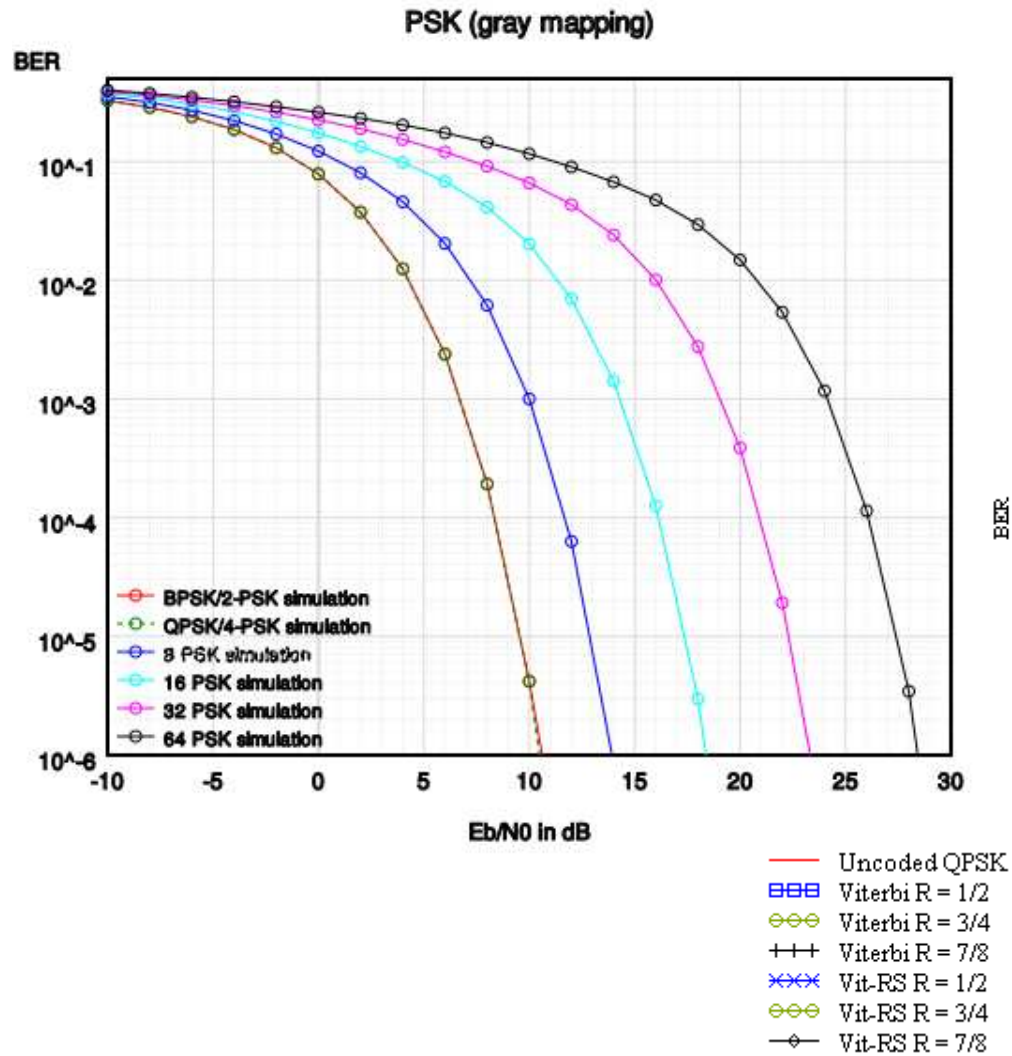
- Adaptive modulation
- Carrier in Carrier
- Use of DVB for multicast stream

# Adaptative modulation

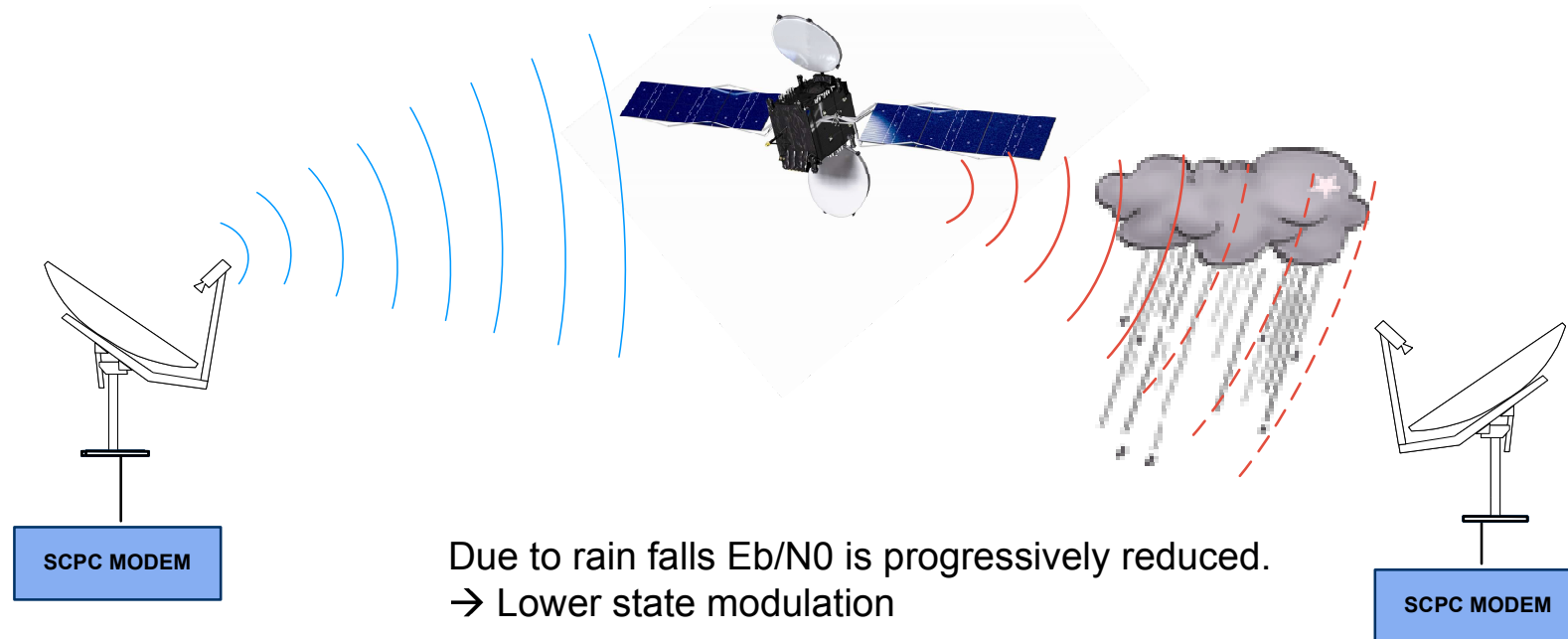


Both MODEM exchange information about the current  $E_b/N_0$ .  
A specific constructor-dependent algorithm enables a change in the modulation

# Modulation and coding influence



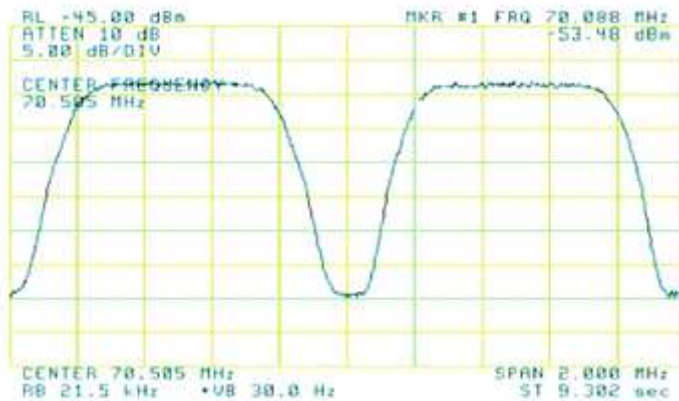
# Adaptive modulation



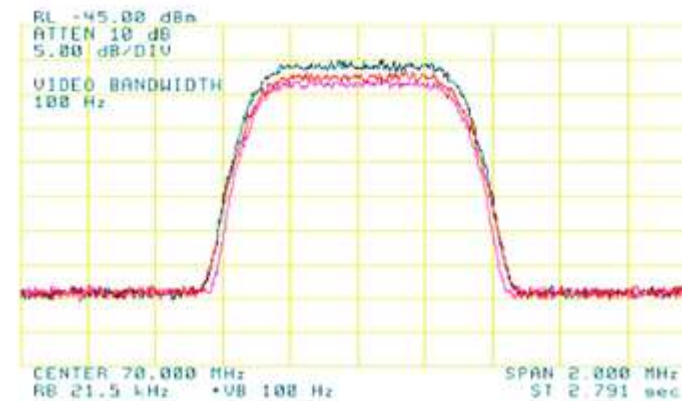
Adaptive modulation is useful for ATC technologies to get a better throughput for data transfer.

# DoubleTalk® Carrier-in-Carrier®

Based on “Adaptive Cancellation”, Carrier-in-Carrier (CnC) allows carriers in a Duplex satellite link to occupy the same transponder space



Without double talk Carrier-in Carrier



With double talk Carrier-in Carrier

Carrier-in-Carrier is a Registered Trademark of Comtech EF Data  
DoubleTalk is a Registered Trademark of Applied Signal Technology, Inc.

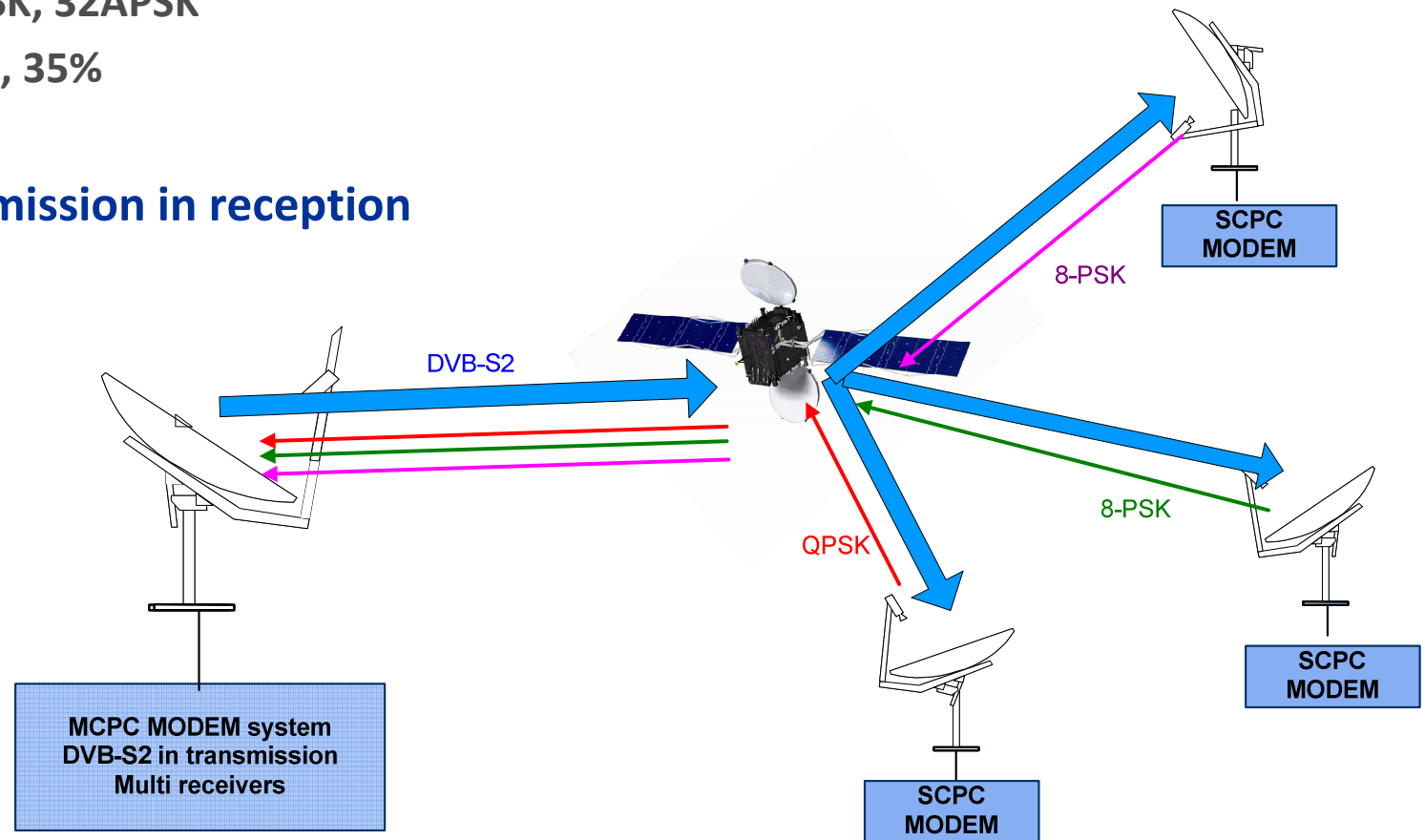
**Combined with proper Modulation and FEC, Carrier-in-Carrier allows for multi dimensional optimization**

- **Reducing bandwidth**
  - > Occupied Bandwidth & Transponder Power
- **Reducing earth RF segment**
  - > BUC/HPA Size and/or Antenna Size
- **Increasing throughput**
- **Increasing link availability**
- **Or a combination to meet different objectives**

## DVB-S2 in transmission from the hub

- QPSK, 8PSK, 16APSK, 32APSK
- Roll-off : 20%, 25%, 35%
- ACM capable

## Classic 8/Q PSK transmission in reception



## Advantages

- PAMA oriented connection
- Cheaper RF part on the remote site
  - Well suited for desert area
  - Low upload traffic
- Cheap unit price
- Star topology
  
- MCPC :
  - Well suited for asymmetric traffic
  - Cheaper hardware (less modulators)

## Drawbacks

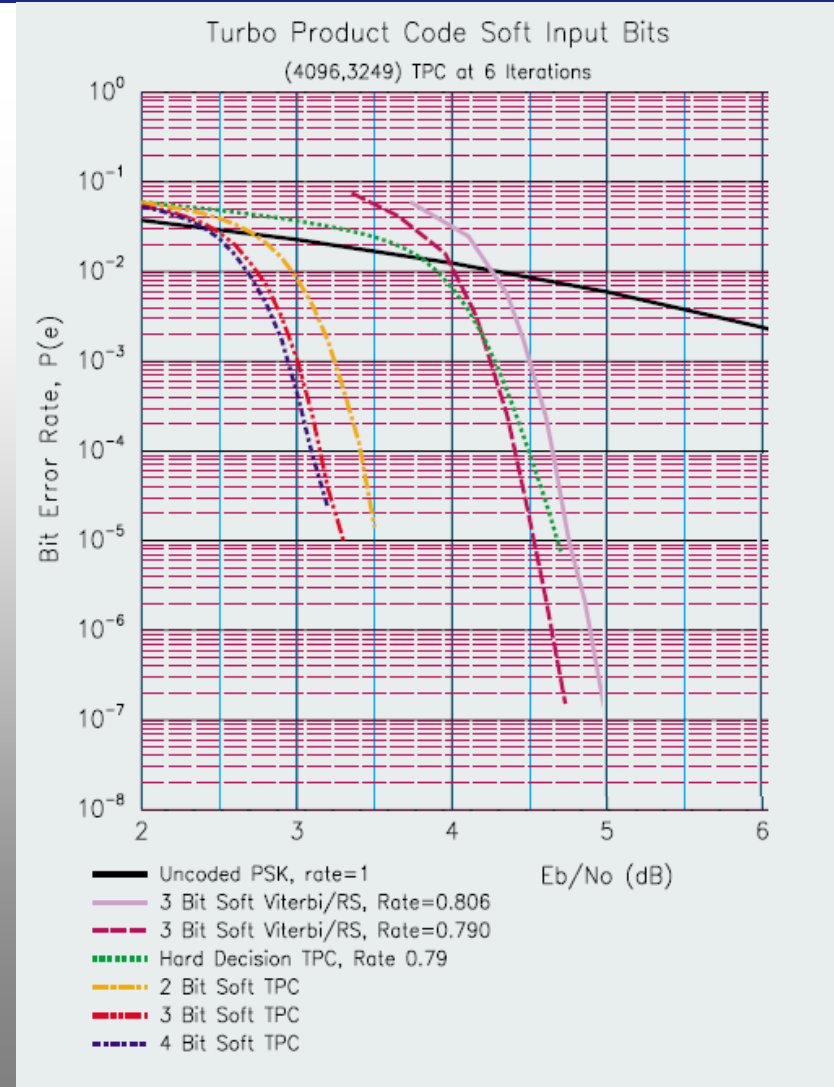
- No bandwidth on demand (FDMA systems exists)
- Higher frequency spectrum consumption
- Bad suited for Hybrid / Meshed topology
- Requires hardware and frequency spectrum for new connections

**SCPC MODEM are cheaper by 30% to 70% compared to TDMA MODEM, depending on options and features**

- **SCPC are suitable for network with few inter-site connections (1 to 3 connections).**
- **When more connections are required MF-TDMA is more effective**
  - > Reduced number of hardware
  - > Shared bandwidth

# TDMA improvements

- Use of turbo-codes: TPC and company-restricted codes (Turbo- $\phi$ ).  
→ Lower  $E_b/N_0$  than Vitterbi and Reed Solomon codes
- Use of lower Roll-off factors (0.2)  
→ Improves MF-TDMA bandwidth shaping
- No need for an expensive station for time synchronization:  
→ integrated in the MODEM (master MODEM)
- Improved safety



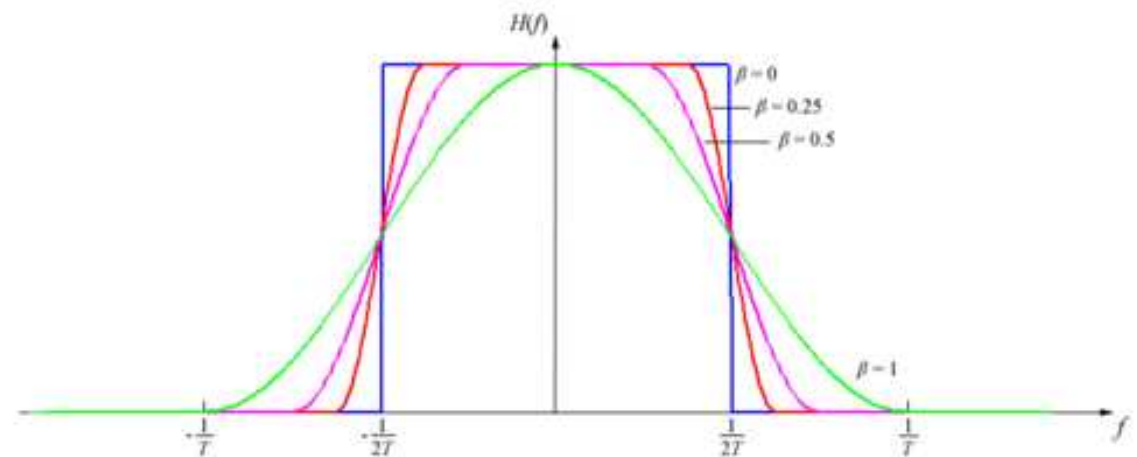
# Roll-off factor optimization

- A better (lower) Roll-off factor enhances the spectral efficiency of the system:

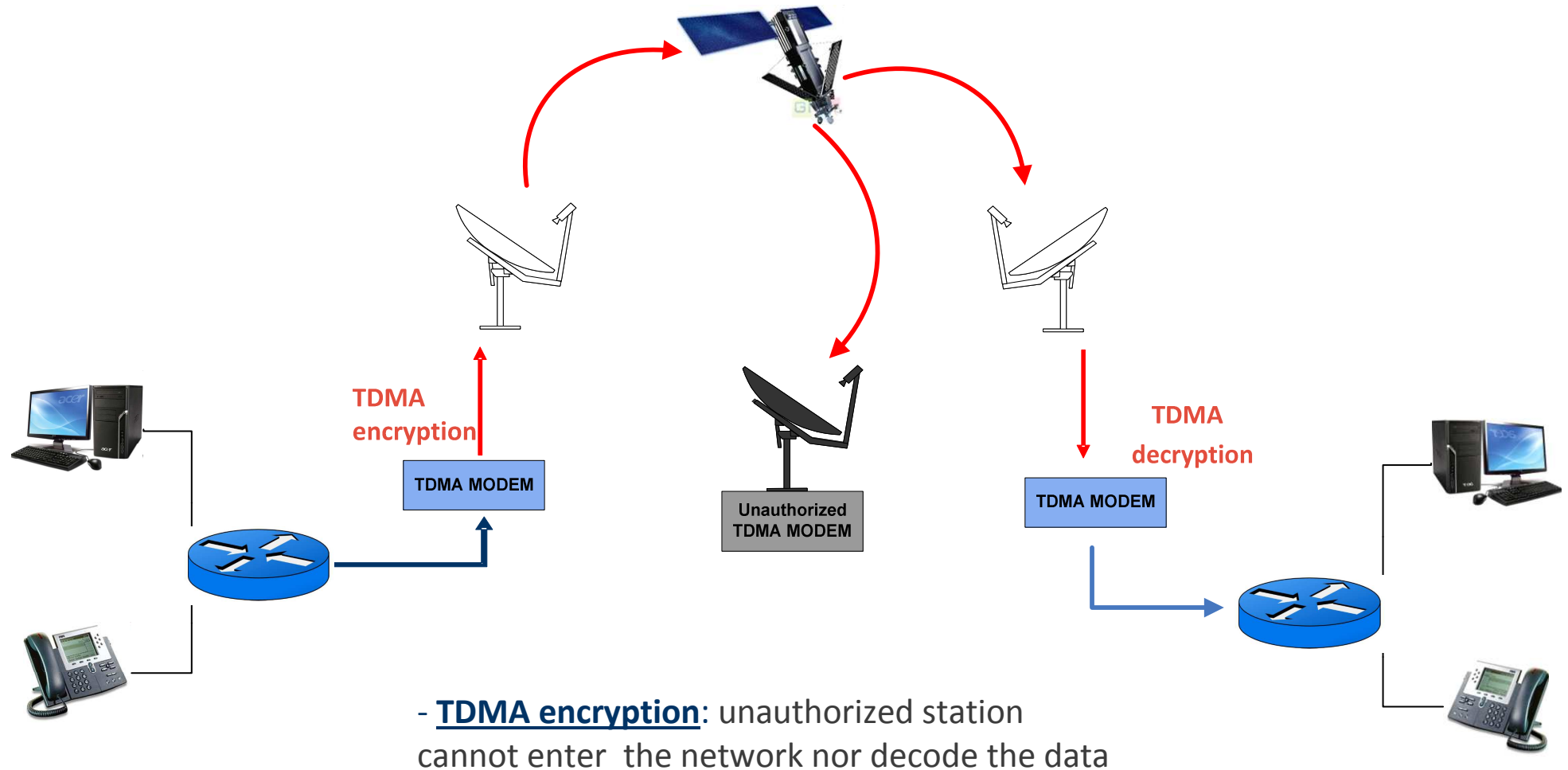
$$Bw = \text{Symbol\_rate} \times (1 + \text{Roll-off\_factor})$$

→ Reduces consumed bandwidth

→ Useful in MF-TDMA



# Improved safety by authentication

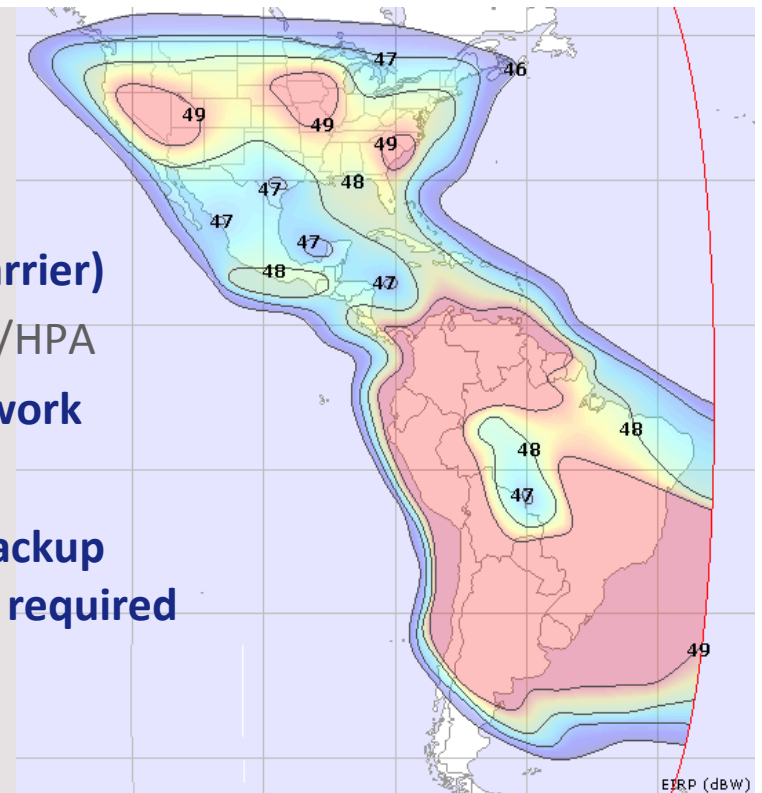


## Advantages

- Bandwidth on demand
- Tighter frequency spectrum
- Network flexibility:
  - Add station
  - Add circuits / services
- Powerful in meshed network
- Less hardware

## Drawbacks

- Modem cost
- Big RF part (large carrier)
  - Larger Antenna/HPA
- Same RF in the network
- Sync station (and backup sync station ) station required
- TDMA header (SLL)



Satmex6 - Ku

# TDMA vs MCPC/SCPC

**TDMA is more flexible than MCPC/SCPC, at the expense of RF part.**

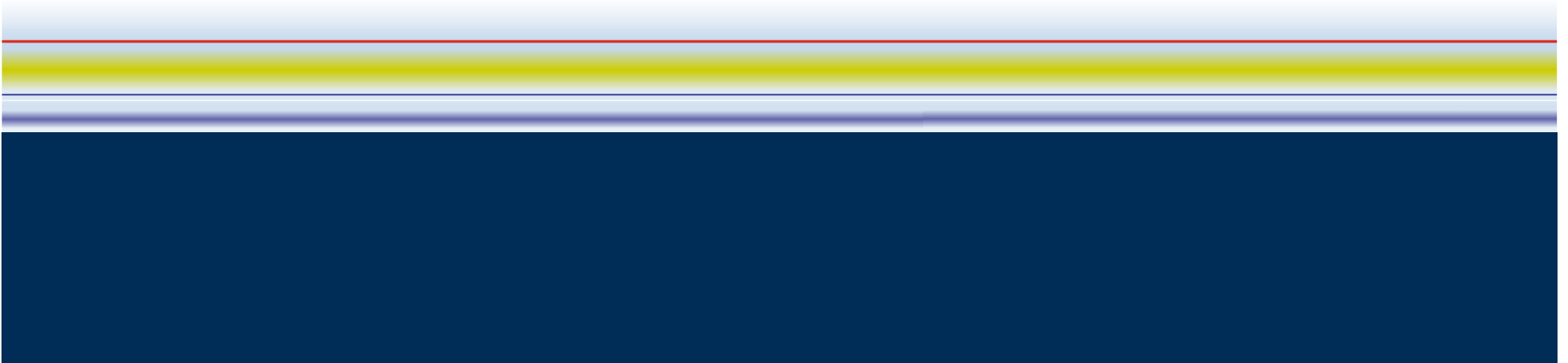
**Both technologies evolve in parallel, TDMA is not newer or better than MCPC/SCPC (both technologies now support Turbo coding), they answer to different needs and topology**

→ **Strategic and political choice**

→ **SCPC/MCPC is suited for STAR topology and Autonomous remote sites**



## The IP convergence



## Voice communications

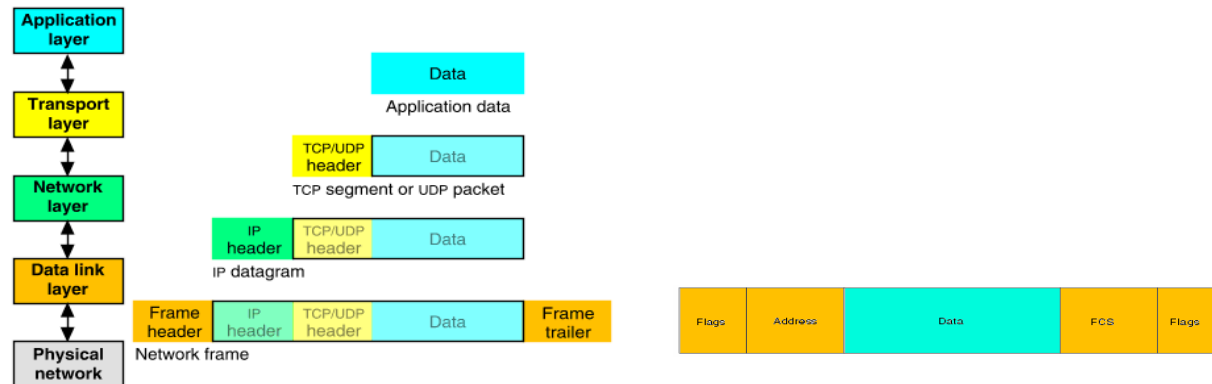
- VCSS will be compatible to be connected directly over IP (and ideally, not through a box converting Voice to IP)
- ATS communication will be fully compatible with VoIP

For the **Mobile Service**, Frame Relay remains one of the best options:

- Efficient (low overhead)
- Reliable (INEO installed more than 100 stations in Frame Relay)

# IP vs Frame Relay

Frame Relay is a layer 2 protocol, whereas IP is at layer 3



	IP	Frame Relay
ISO level	3	2
Encapsulation	packet	frame
Efficiency	Low	High – 85% for voice
G729 data rate	27 kbps	11 kbps
Advantages	<ul style="list-style-type: none"> <li>- Flexibility of configuration</li> <li>- Mesh structure with automatic routing (static or dynamic)</li> <li>- Low price (widespread)</li> </ul>	<ul style="list-style-type: none"> <li>- Optimization of space segment</li> <li>- QOS</li> <li>- Supports various protocols (async, sync, E&amp;M)</li> </ul>
Drawbacks	<ul style="list-style-type: none"> <li>- Bandwidth not optimized</li> <li>- QOS</li> </ul>	<ul style="list-style-type: none"> <li>- Hardware cost</li> <li>- Proprietary of access device type</li> </ul>

# A declining technology

## Frame Relay Access Devices are no longer improved

- Evolutions and new feature only
- No major product evolutions

## Satellite MODEM are dropping Frame Relay:

### New ND Satcom IDU 1070: Fully IP

- Problems for spare parts
- Small market with higher product cost



# Data transfer tendencies

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Most of Data services are turning to IP

- **AMHS** over IP instead of AFTN
- **RADAR** service over IP instead of serial

**RADAR** service requires fixed delay to compute country-wide data

→ Jitter is critical

→ IP is bad suited to synchronism and jitter-free application

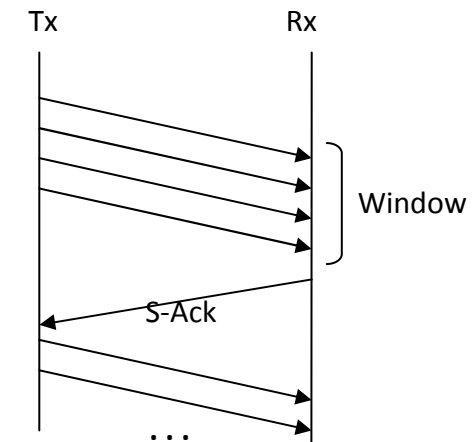
**SOLUTION:**

Huge bandwidth (Optical Fiber)

Use of smart concepts: **QOS/TOS IP**

## TCP-A:

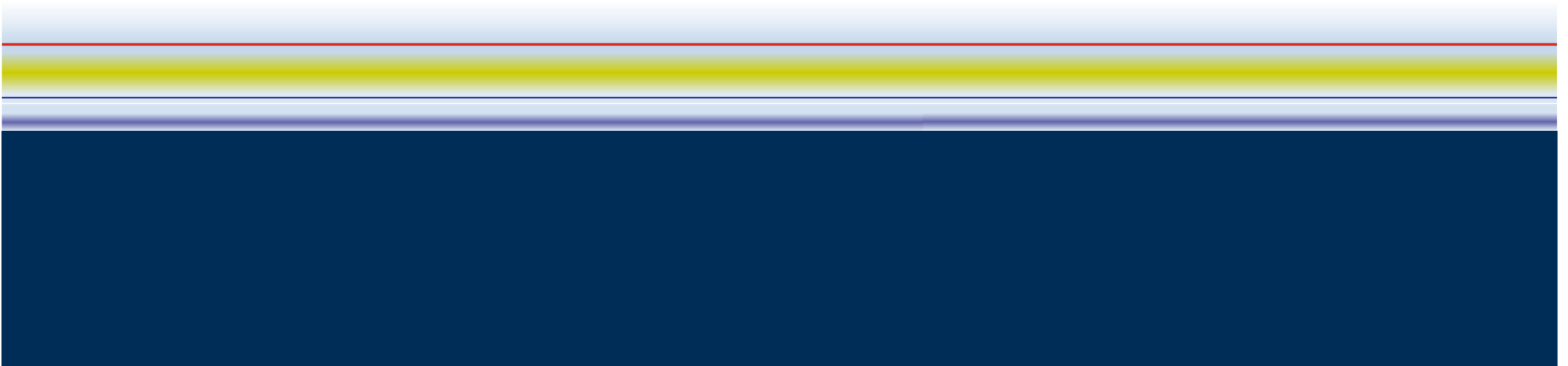
- Selective acknowledgement
  - > Receiver informs the transmitter which packets must be re-sent
- Multiple packet emission: large « Window » transmission
  - > Transmission of multiple packets without Ack
  - > Reduced number of Ack
- Improved file transfer through satellite
  - > Lower delay impact on file transfers
  - > Higher data throughput





## INEO E&S

Thank you for your attention



# Contacts



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