INEO

GDF SUEZ

REDDIG II

Presentation summary

- The need for REDDIG II
- Technologies for REDDIG II

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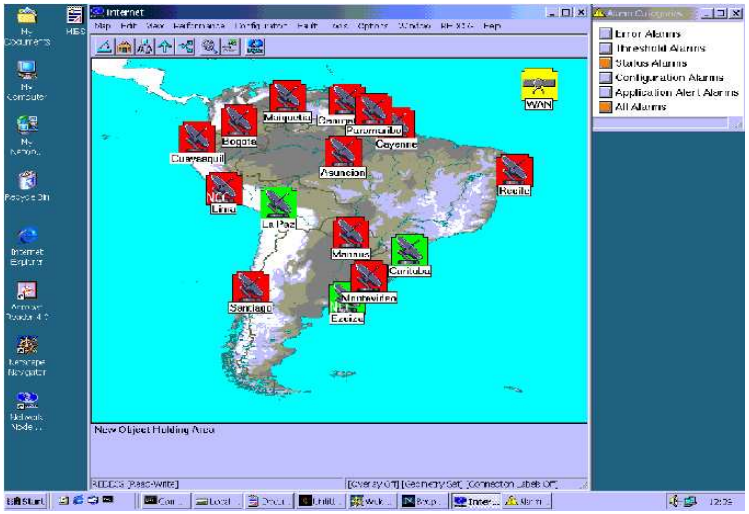
The need for REDDIG II

REDDIG

- **Reddig** (‘’Red Digital’’) is a **private network** that ensures the communications between all the Civil Aviation Authorities in South America. This project was carried out by SEEE (now **INEO E&S**).



- One of the **best example of ATC cooperation** in the world that underlined the benefits of such a project:

  Economy: scale-cost saving

  Safety

INEO E&S - Integrating the needs

ATC communications are highly sensitive services relying on highly available integrated systems

→ few technological revolutions

→ need of mature technologies

→ integration of older and newer technologies

Integrating is taking into account a 4-time process

- **What was ?**
- **What Is ?**
- **What will ?**
- **What might ?**

ATC Evolutions

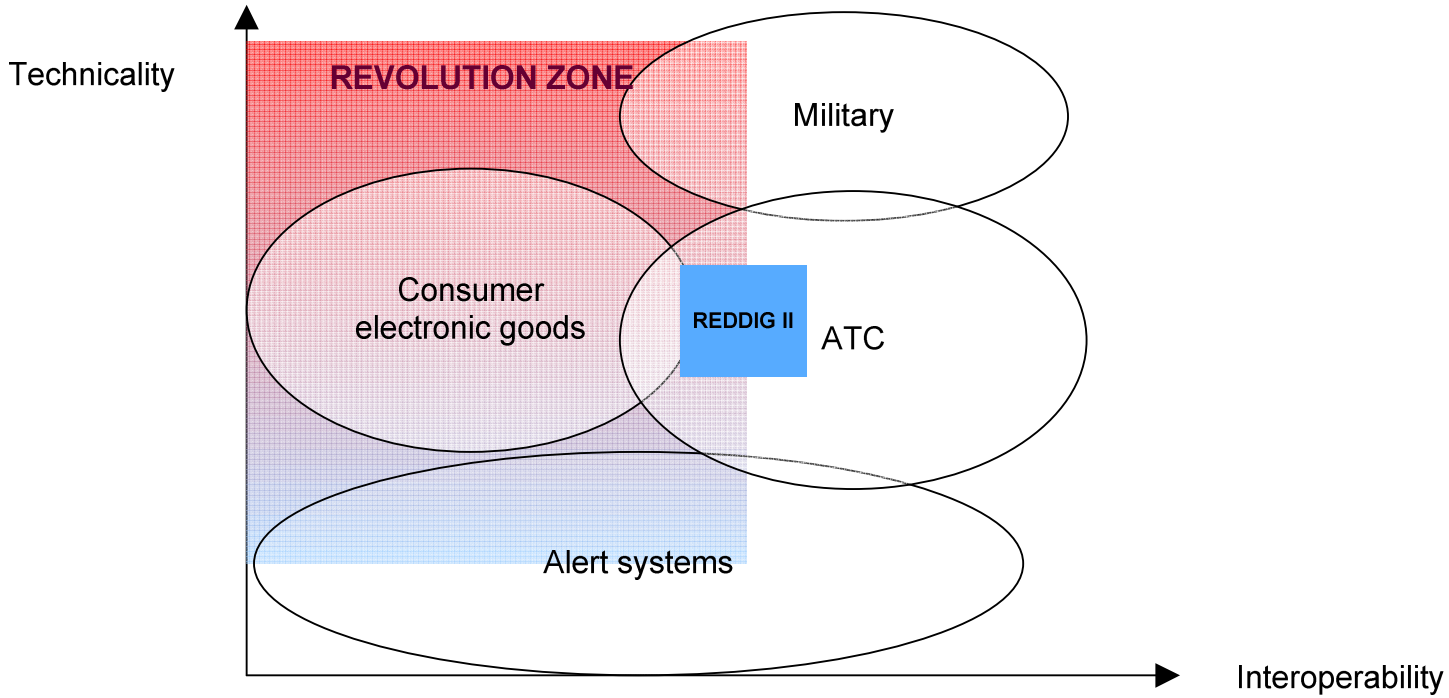
ATC evolution is motivated by two principles

- technological paradigms
  - Integration of new services
  - Integration of new transmission means
- safety improvements
  - Hardware redundancy
  - Backup links

ATC Evolutions

ATC are rarely subjects to revolutions.

→ Some networks have a tendency to the step forward: REDDIG I (first ATC TDMA Network) and REDDIG II (first fully IP based VSAT network)



ATC technological evolutions

Analog voice and legacy communications are being changed to IP

- VoIP: progressive conversion of analog phones to native IP phones
- VHFoIP: transport of voice and signalization over IP
- RADAR over IP
- AMHS

The expansion of IP was necessary by the growing need to interconnect devices and networks.

→ the amount of user data doped the expansion of IP (AMHS, surveillance services using Asterix)

Frame Relay is a declining technology

→ **Frame Relay Access Devices have slow improvements**

→ **New MODEM are only IP based**

→ **DECLINING TECHNOLOGY**

ATC technological evolutions - Turning into IP

New ATC devices are connected directly on IP:

- **ADS-B**
- **new services are available by the use of IP:**
  - conference calls, easier video broadcasting, CCTV…
  - Use of encryption

… and new integration possibilities

→ IP based VHF equipments

→ Unification of all equipments on IP

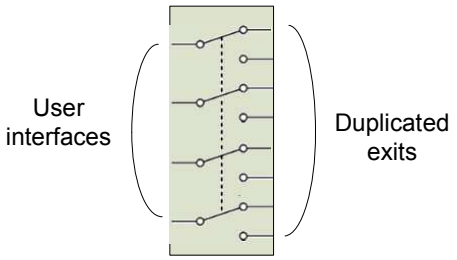
→Densification on one equipment (Mux + Router)

ATC safety improvements

ATC safety improvements is focused on 2 aspects

- hardware redundancy

- Use of electromechanical switches



- Use of redundancy protocols (proprietary or standardized)

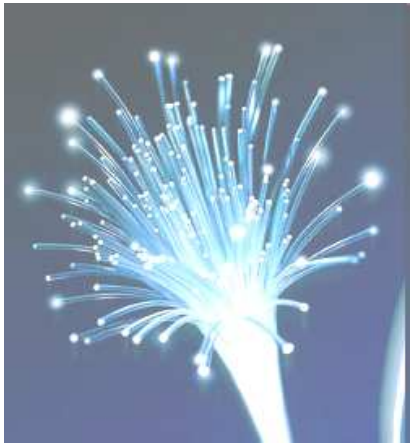
- double transmission means

- use of backup links

examples: REDAP, INAC network on VHF equipments

- use of <u>different</u> transmission links

examples: REDDIG (ISDN backup), IVSAT (ATNS)



ATC safety improvements – incidents analysis

Incident on Optical Fiber in Peru on April 2011

An intervention on an optical fiber caused a rupture of communications in the south part of Peru. Despite their local different transmission ways, both links were carried on the same optical cable.

Hearthquake of Chile on February 27th 2010

The 2010 Chile earthquake occurred off the coast on February 27, 2010, at 03:34 local time rating a magnitude of 8.8 on the moment magnitude scale. It ranks as the sixth largest earthquake ever to be recorded by a seismograph.

REDDIG remained the only ATC network running in Chile

ATC safety improvement : Optical fiber analysis

Optical fiber advantages

- Large bandwidth
- Low maintenance
- Low delay

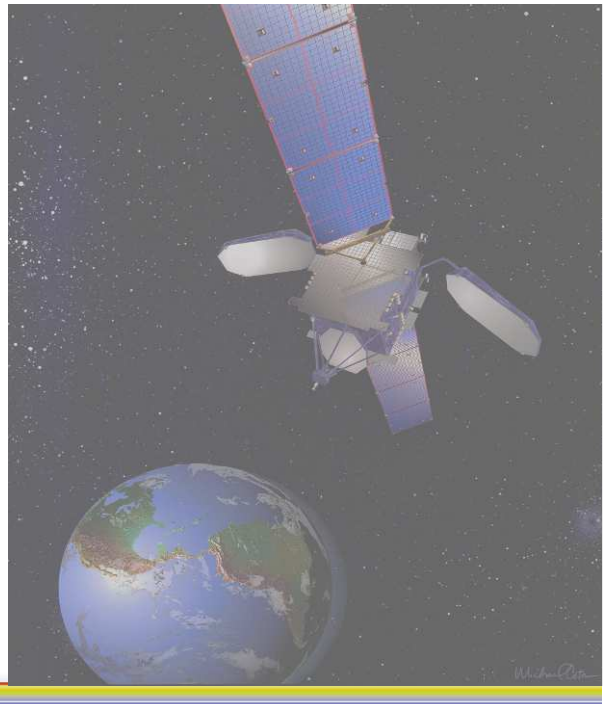
Optical fiber drawback

- High installation cost (civil work)
- Physical weakness
- Shared resource (if purchased to a provider)
- High cost

ATC safety improvements – incidents analysis

Incident of ANIK E2 on January 20th 1994

On January 20th, 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.



- **Telesat has one of the biggest availability: more than 99.97% (99.989 % in 2004)**

ATC safety improvement : VSAT networks analysis

VSAT Advantages

- Satellite bandwidth allocated by 100kHz
  - > no shared capacity
  - > Independent network
- Robust network configuration
  - > Hubless
  - > backup Synchronization station functionality
- Easily deployed
  - > Low infrastructural needs
  - > Autonomous solutions (solar panels)

VSAT Drawbacks

- Limited bandwidth
  - >Fine-tune engineering
  - >Need of efficient technics
- Dependant on one single satellite
  - >Sun outages
  - >Technical problems
- High bandwidth cost

ATC safety improvement – analysis conclusion

- Both transmission have their strengths and weaknesses

- Due to availability requirements both technologies can be used

→ SYNERGY

→ CORPAC's new network is the perfect example of those concepts

CORPAC network features

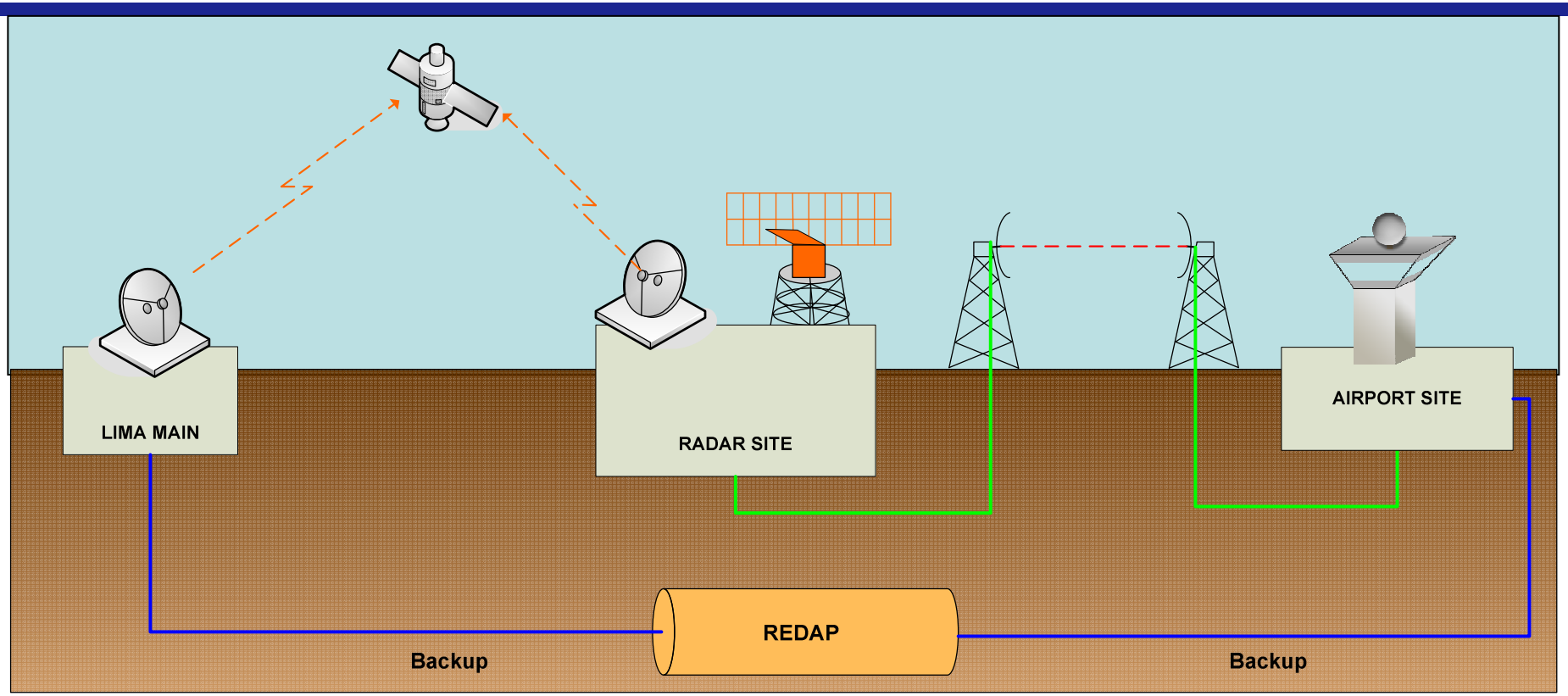
- **Hardware redundancy**

- **Communication link diversity**
  → Improved safety

- **Dual technology support: IP and Serial/Analog interfaces**
  → First step to the IP convergence

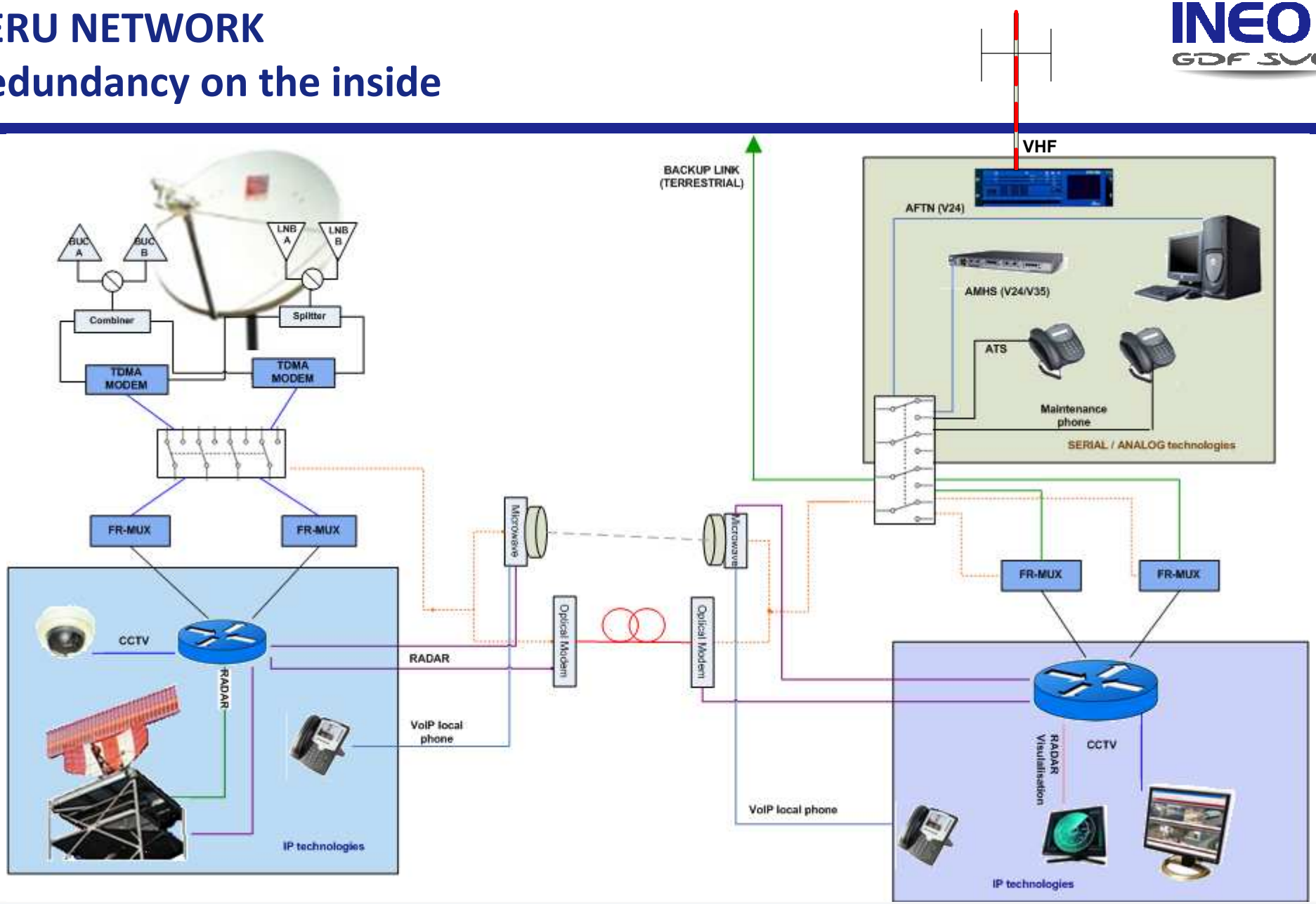
- **Use of backup sync station functionality for TDMA administration**
  →Primary sync station in LIMA
  →Secondary sync station in IQUITOS
  GEOGRAPHICAL DIVERSITY

PERU NETWORK
Dual links architecture



- Main link through Satellite link
- Backup link through REDAP network
- RADAR flows are transmitted **simultaneously** on **both links**

PERU NETWORK
Redundancy on the inside



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Technologies for REDDIG II

INEO E&S tests

As an integrator, INEO must stay 360°- opened to the trends and evolutions in telecommunications

→ INEO E&S is a member of EUROCAE working group 67 (about IP evolutions)

- **IP devices bench tests : new multiplexers / routers**
  - Routing protocols (BGP, OSPF, RIP)
  - Use of bandwidth optimization techniques (header compression)
  - Redundancy tests (VRRP)

- **Satcom devices**
  - Bandwidth optimization techniques (roll-off factor optimization, use of frequency hopping on emission and reception, QoS…)
  - Use of multi-destination techniques (multicast IP)
  - Compatibility of header compression with the payload

Satellite access method

REDDIG counts 16 nodes, each one having generally more than 3 links

→ SCPC network would be too expensive.

→ TDMA is required

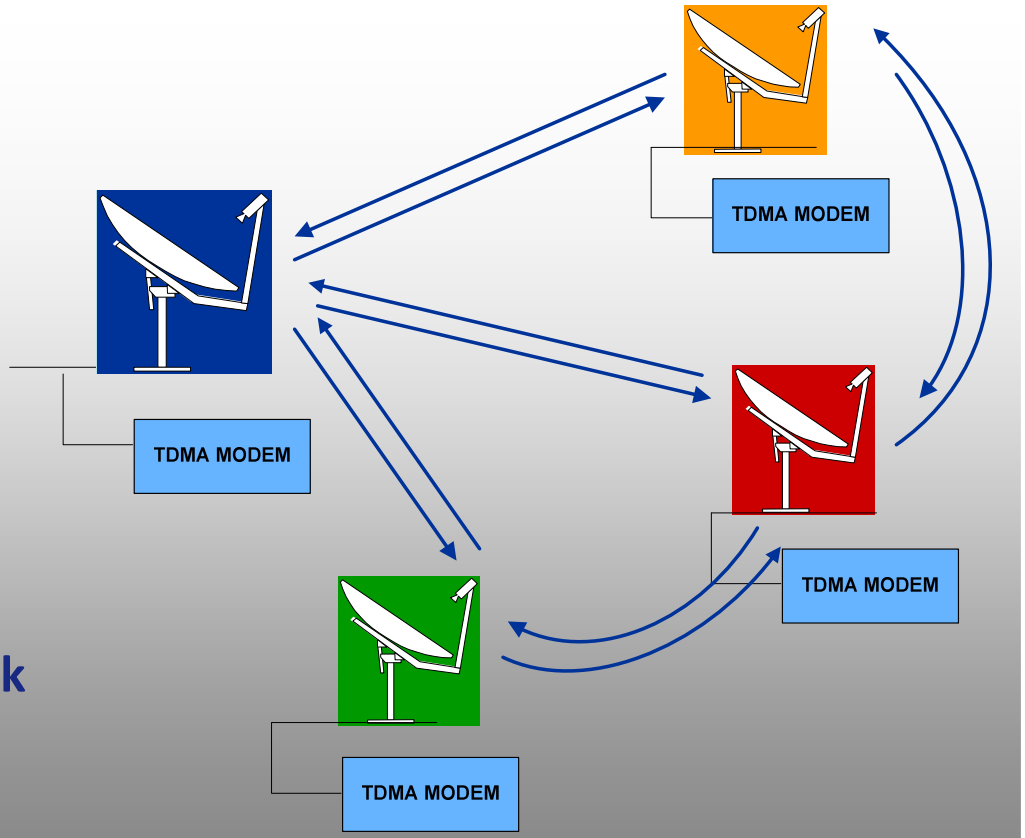
New satellite MODEM only requires a MODEM to be a synchronization reference:

→ Network Monitoring System is distinct of synchronization system

→ Possibility to separate satellite access administration from global network monitoring system

REDDIG II technology requirements

- Use of TDMA MODEM
- Use of BGP protocol for IP routing
- Use of terrestrial link for backup network (MPLS for example)



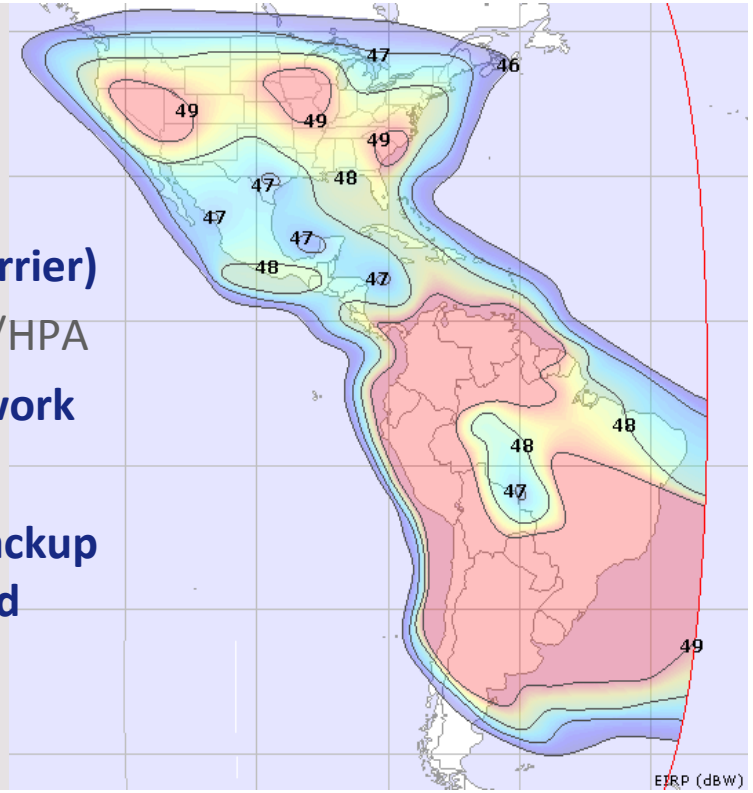
TDMA analysis

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) required**
- **TDMA header (SLL)**



Satmex6 - Ku

Bandwidth Allocation

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 (real time)
- RCMS (VOR, Radar, VHF, etc)
- M&C

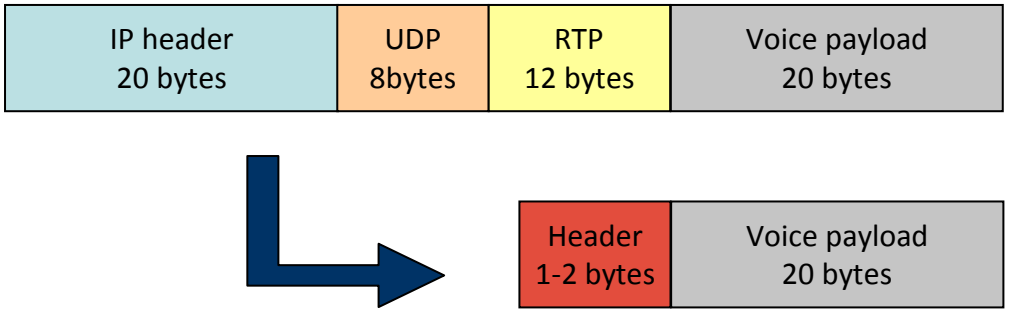
BW on demand
PAMA on demand for real time (low jitter)

Header Compression

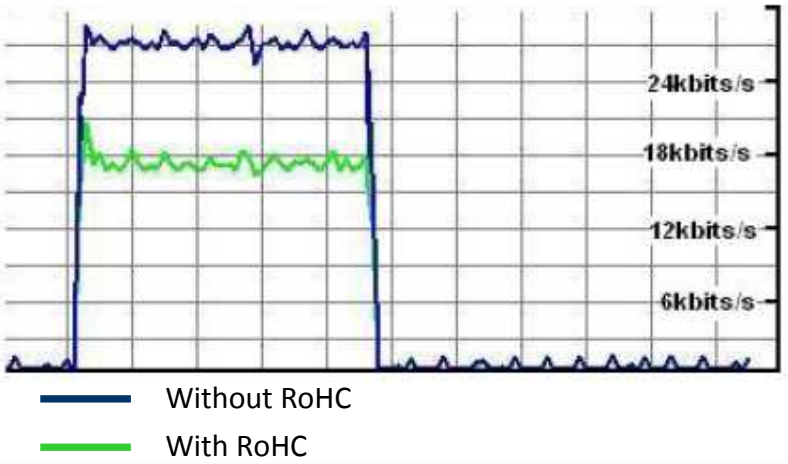
Header compression is performed by the modem.
It enhances the efficiency of voice over IP.

→ When used with proprietary protocols without IP/UDP/RTP/identified codec , header compression cannot be performed

→ efficient for telephone applications



Header compression is a decisive step to make VoIP over Satellite competitive



Header compressed up to 1 (RoHC) or 2 bytes (CRTP)

Usual compressed header size: 2 to 4 bytes

> **Data rate 11.6 kbps (theoretical, 17 in practice)**

> **Full packet needs to be sent periodically**

BGP Protocol

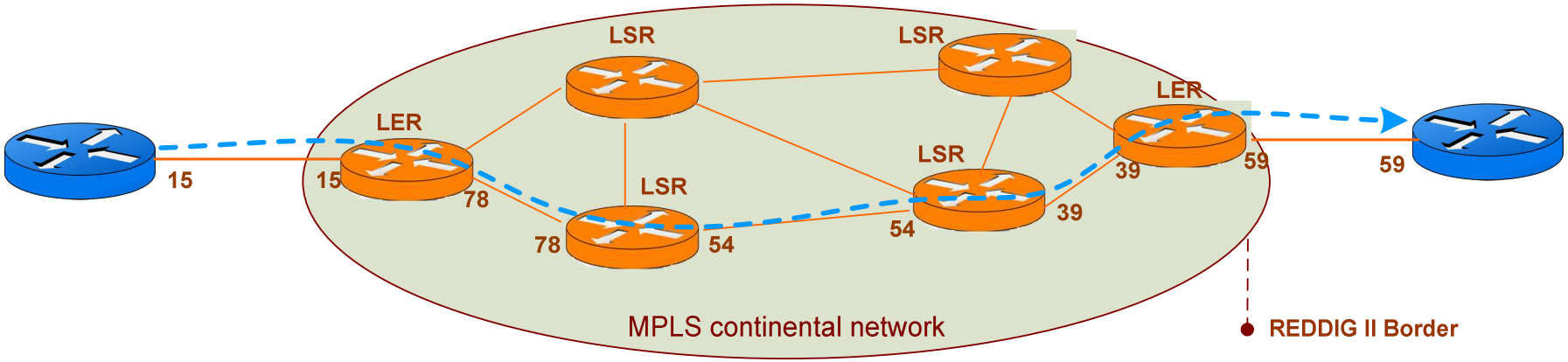
- **REDDIG II being a continent-wide network, BGP protocol is useful to interconnect heterogeneous networks**
  - > Enables the use of different dynamic routing protocols in the national networks defined as ***Autonomous Systems***.
    - → internal routing protocol: OSPF, RIP
  - > Exchange of tables is made through a TCP connection between routers
    - → can be routed transparently through static routing

- **Considered as the external routing protocol, it defines the router as the AS routing authority**

- **Powerful IP routing protocol through MPLS**

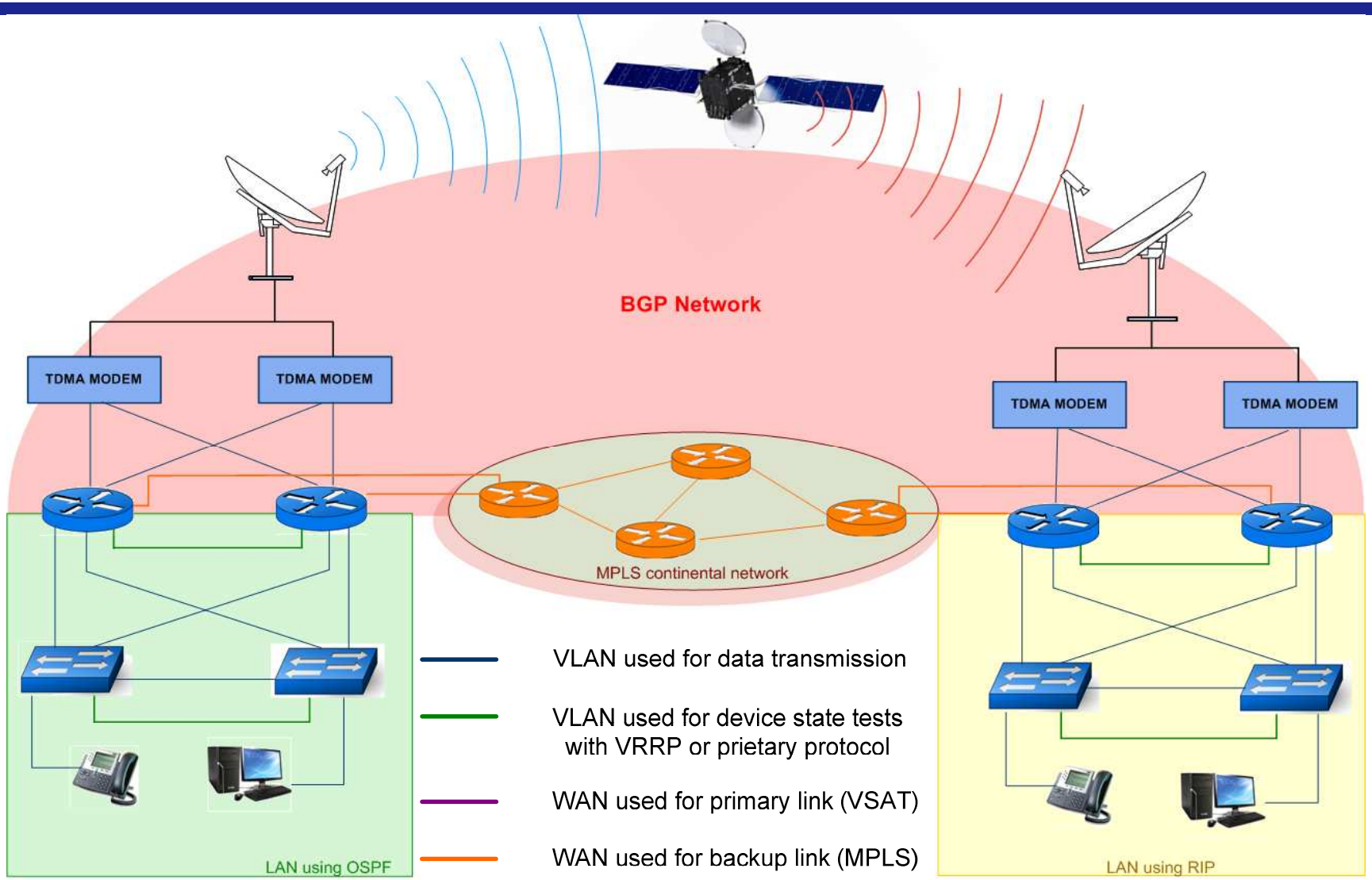
MPLS

- **Based on label switching**
  - Small 4 bytes label (Shim MPLS) between the Layer 2 header and Layer 3 header (IP)



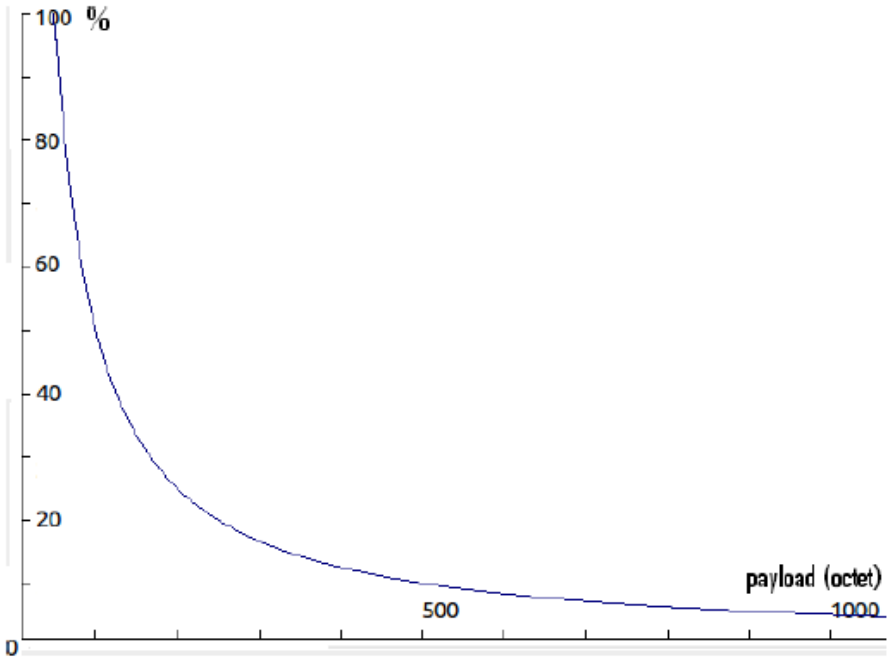
- **Wide spread technique**
  - Large use of VPNs in association with BGP
  - Use of FEC (Forwarding Equivalence Class) for traffic prioritization

REDDIG II architecture



Transport of legacy data

- Legacy serial data such as HDLC are to be encapsulated into an IP frame.
- UDP is the most spread level 4 protocol to carry HDLC synchronous data
- Due to the heavy IP header, the consumed bandwidth will be function of the payload



TOS/QOS IP

- **Use of Type Of Service (TOS) IP**
  - Identify the type of service associated to an IP flow
  - Associate special treatment according the service
    - Real time circuit (voice, streaming)
    - Non-real time circuit (data transfer)
    - Flow distribution: unicast/multicast

- **Use of Quality Of Service IP**
  - Prioritization
  - Use of header compression

Confidentiality and Security

IP convergence and world-wide interconnections made possible country-wide cyber-attacks.

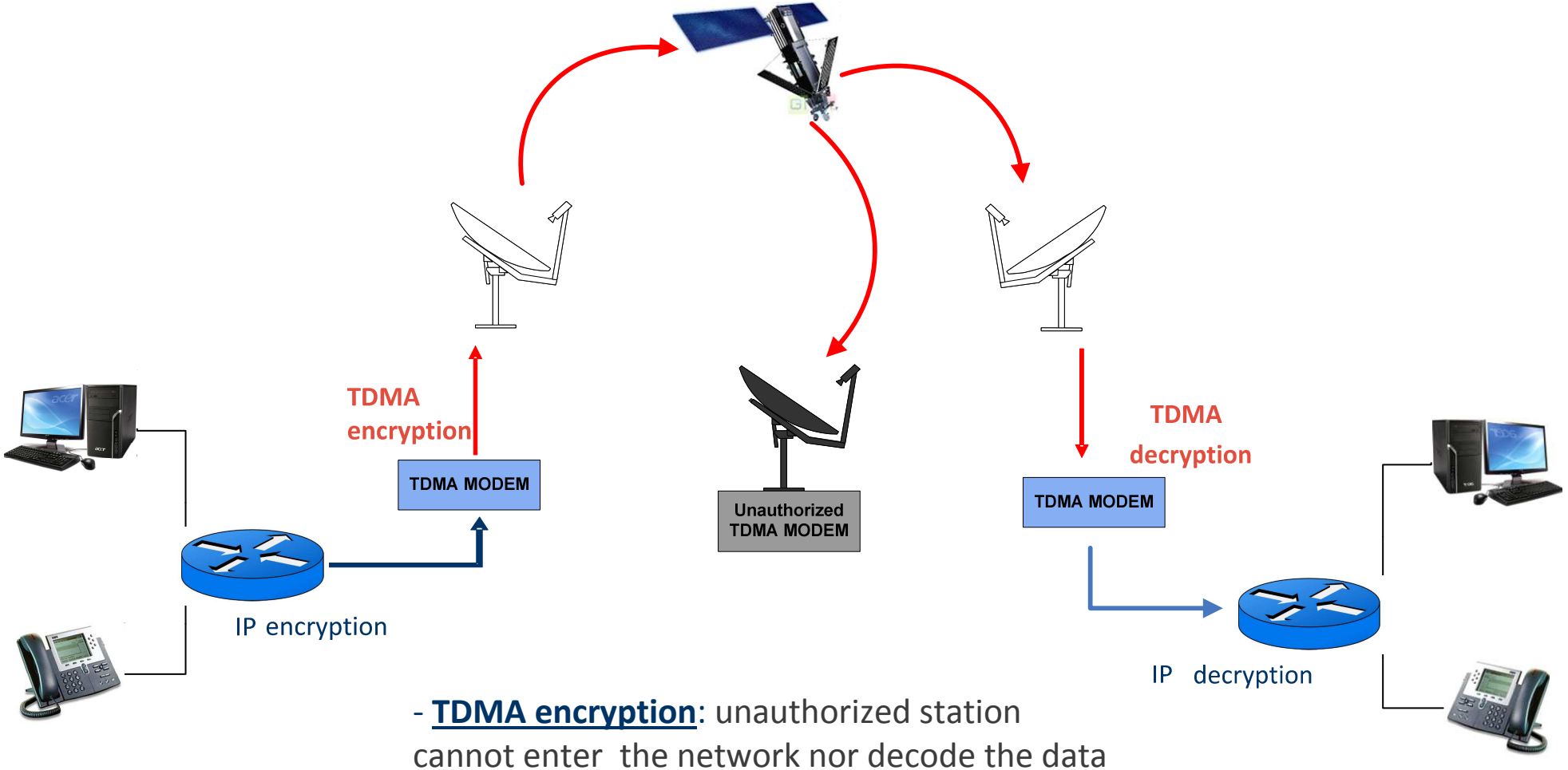
→ Flooding or intrusion

→ Security in IP networks is a key issue

Solution

- Encryption: IPsec
- Firewalls to prevent intrusions
- TDMA encryption to prevent intrusion or spying

Double encryptions



- **TDMA encryption**: unauthorized station cannot enter the network nor decode the data
- **IP encryption**: second encryption
- **Drawback**: slower data rate/bandwidth

Innovative NMS systems

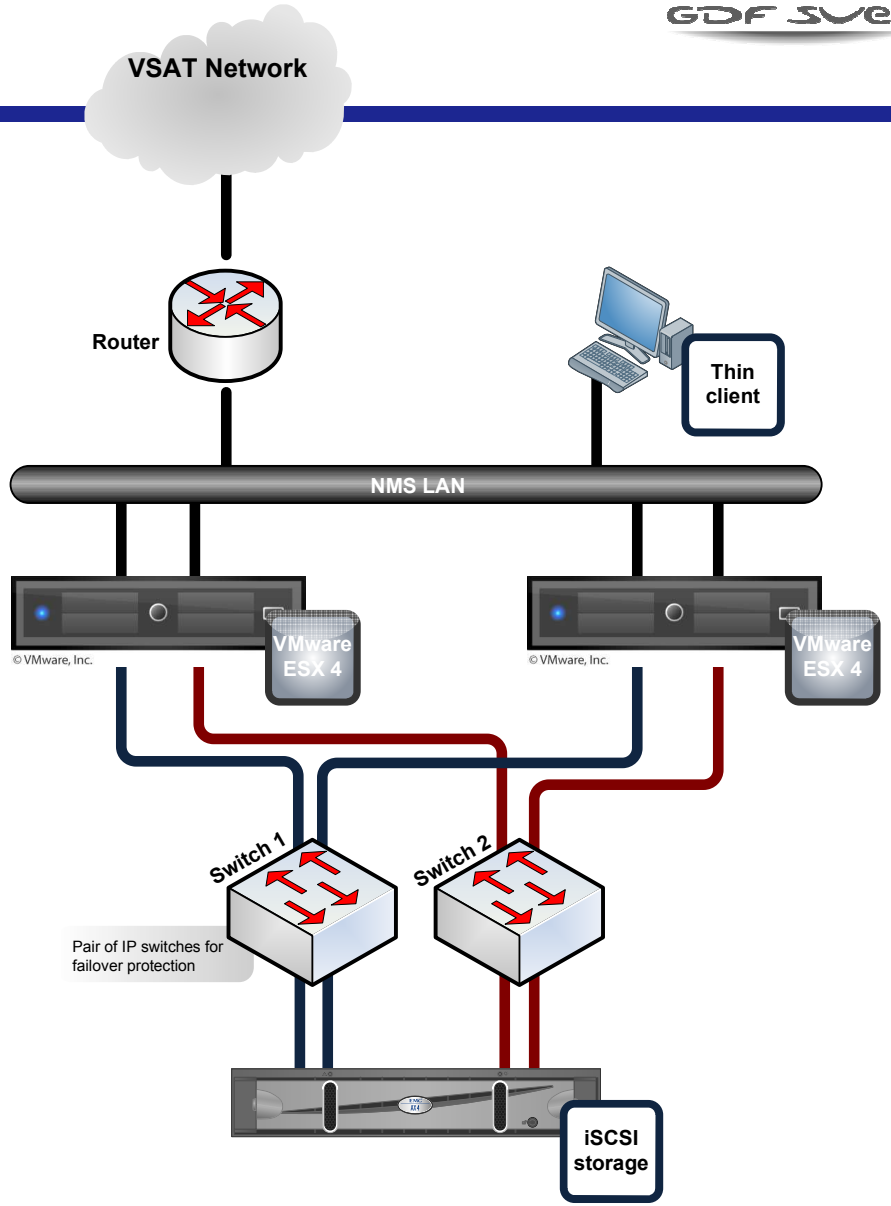
High redundant systems: Peruvian example

Redundant server with virtualization

Redundant disk array using RAID 5

INEO E&S uses all kind of supervision software:

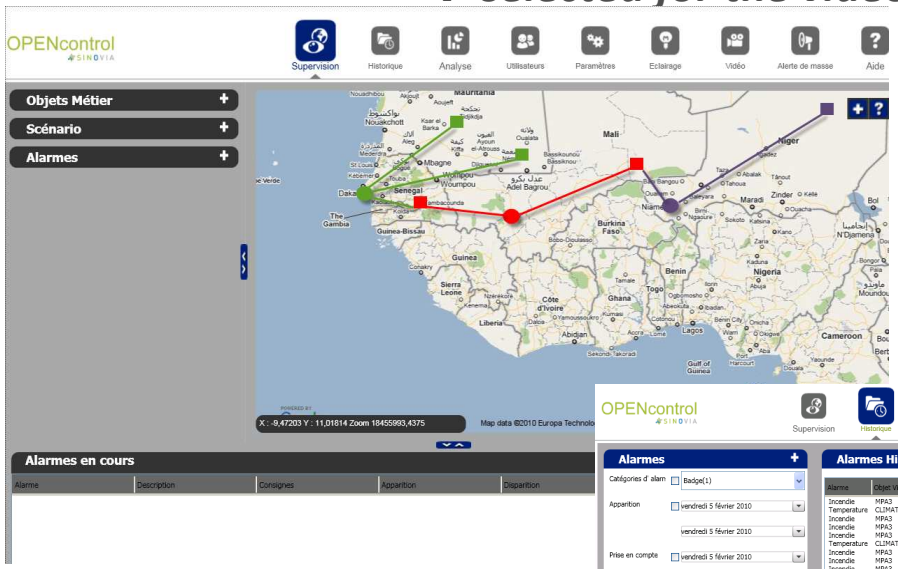
What's Up Gold, IP 21, HP Open View, and OPEN CONTROL



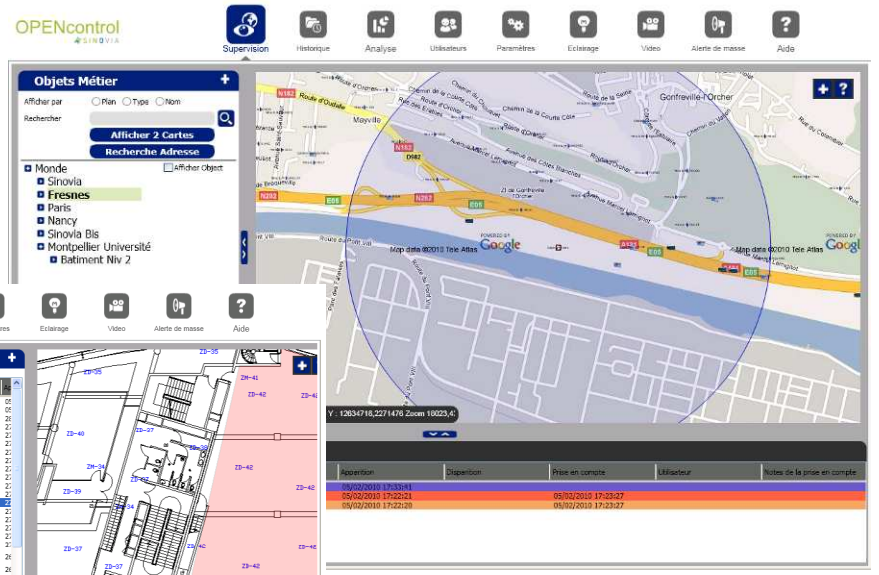
Innovative NMS systems

INEO E&S' branch SINOVIA develops NMS systems for all kind of application:

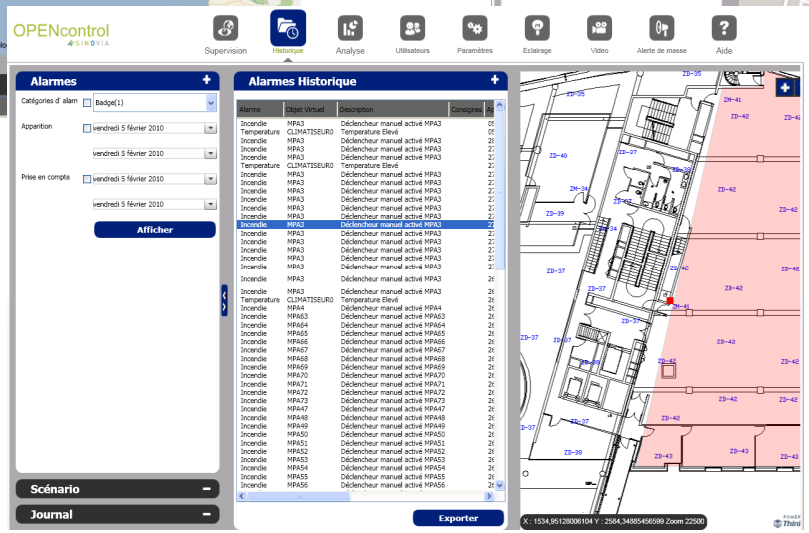
→ *selected for the video protection plan for Paris (13M€ project)*



Vectorial map approach



Automatic alarm zooming



Alarms/logs traceability

INEO E&S

Thank you for your attention

Contacts

INEO ENGINEERING & SYSTEMS - Head Office
Zone Aéronautique Louis Breguet – Route Militaire Nord – Bât. 8
78140 Vélizy Villacoublay (France)
Tel. : 33 (0)1 39 26 15 00 / Fax : 33(0)1 30 70 17 20
http://www.ineo-es.fr/

INEO do Brasil Integrãcao de Sistemas Ltda
Av. Almirante Barroso, 52-14 andar (parte)
20031-000 Rio de Janeiro (Brazil)

Contact: Jacques Olivier Klotz
Head of Aeronautical Export Department
jacques-olivier.klotz@ineo-gdfsuez.com
+33 6 80 61 38 72