

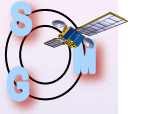
IABSE - Venice, September, 25th 2010

Telecommunication Infrastructures for Emergency Management

Prof. Michele Luglio
(luglio@uniroma2.it)

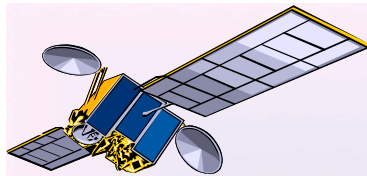
University of Rome "Tor Vergata"
Department of Electronics Engineering



[illegible]

- Terrorist attack
- Criminal action
- ➡ **Disaster** (earthquake, tsunami, storm, etc.)
- Search and rescue
- Road accident
- Medical epidemic
- Boundary violation
- War





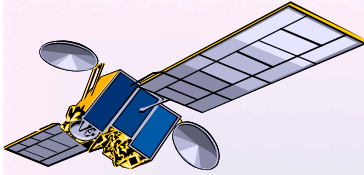
Operational activities

- Monitoring
 - Check and control
 - Prevention
- Emergency management
 - Medical assistance
 - Damage info collection
 - Team coordination
 - Access to database
 - Evacuation coordination
 - Search survive people
 - Check infrastructure status
 - Restoration

**Telecom
Infrastructure
may be
independent on
the kind of
emergency and
on service type**

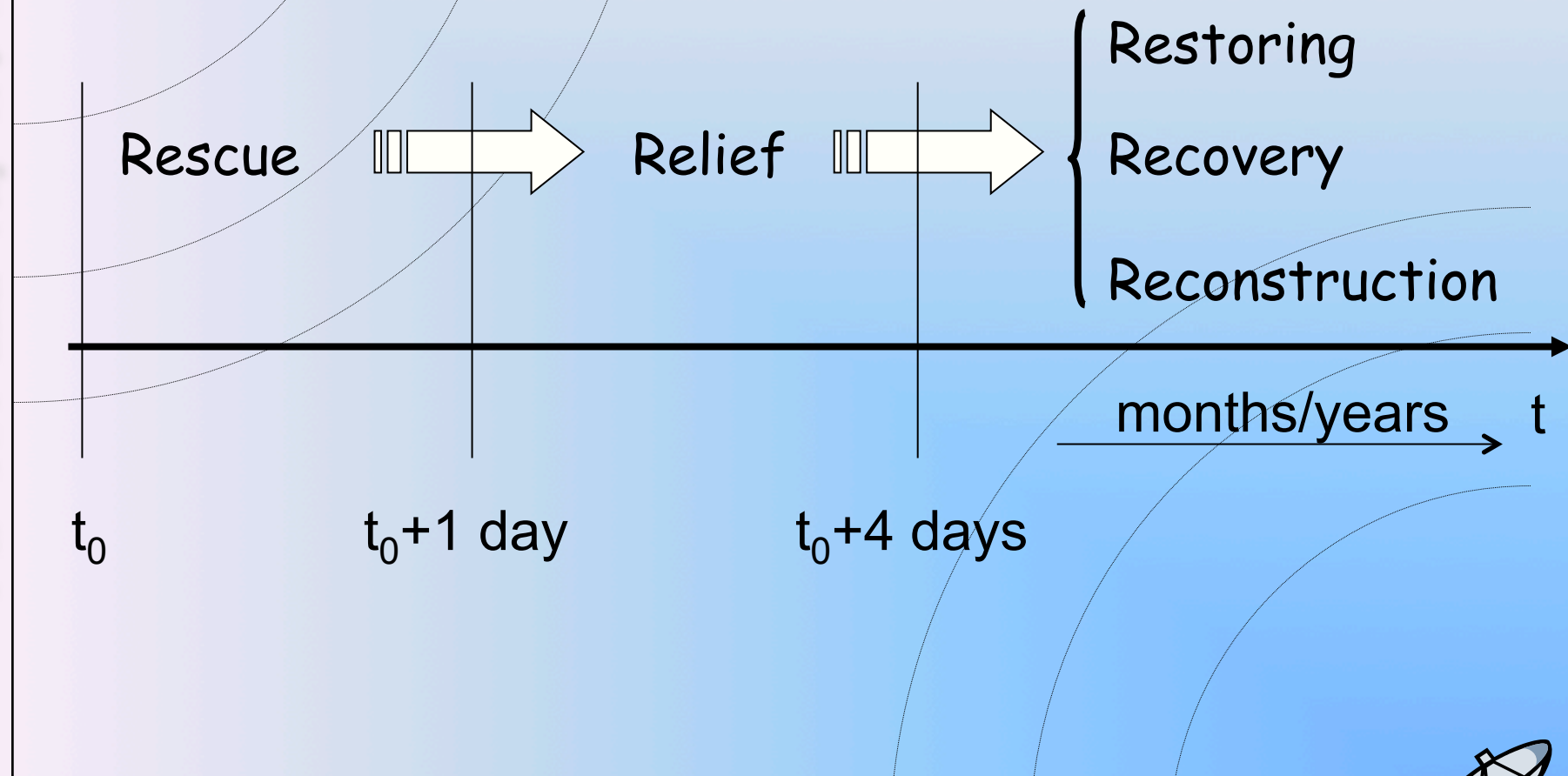
Infrastructures for
Emergency Management

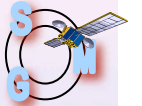




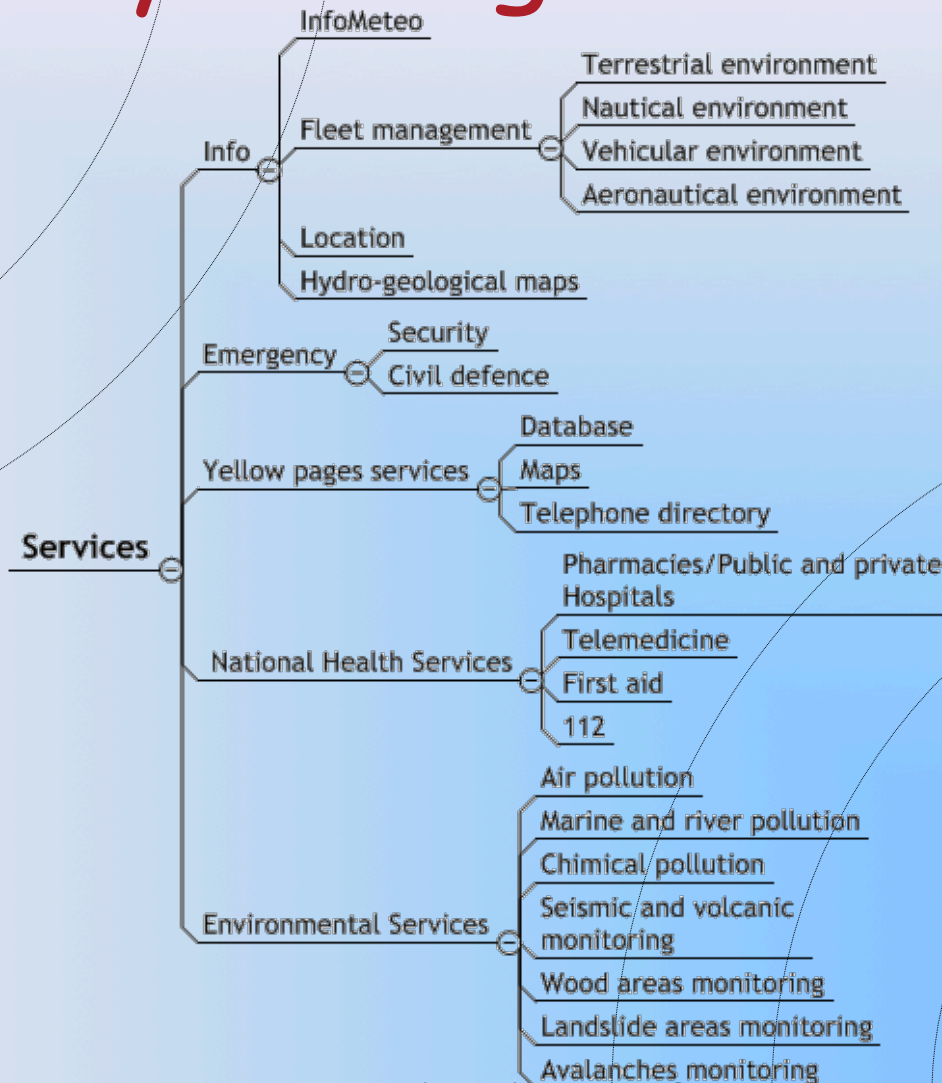
Emergency activities timeframe

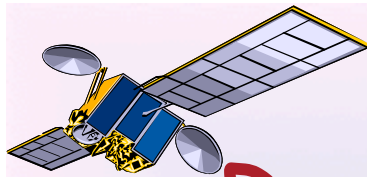
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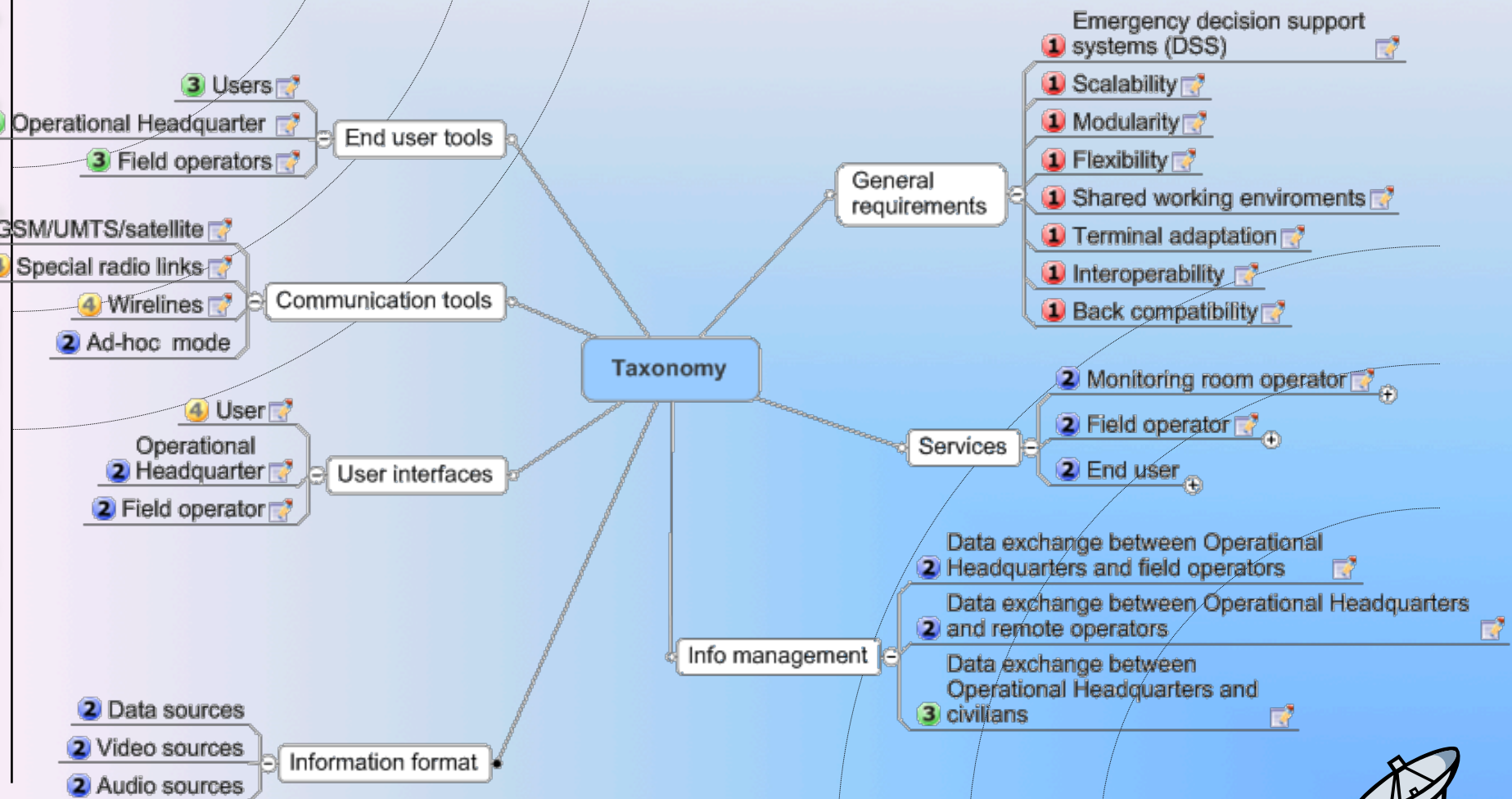
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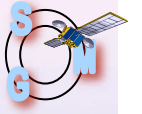




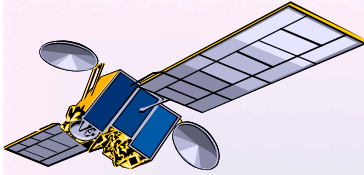
Requirements classification

U
T
o
V
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t
a



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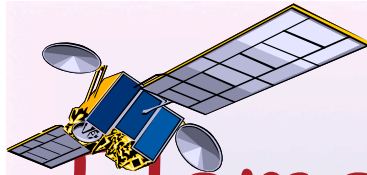
- Scenario?
- Elements exchanging information?
- Which information?
- Which direction?
- Which services?



Scenario

- Usual infrastructures may be severely damaged or out of order
- Access required in any location
- Large quantity of extra traffic overloads the networks (those or the portion still working)
- Large quantity of traffic generated to manage the emergency



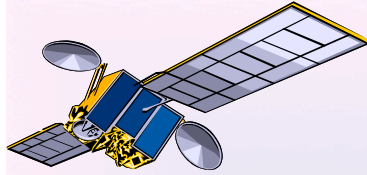


Elements exchanging information

- Citizens
- Operators on the field
- Coordination
 - Support to decision system
- First aid and medical entities
- Machines
 - Robots
 - PCs
 - Detectors
 - Sensors (chemical, physical, biological)



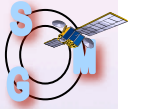




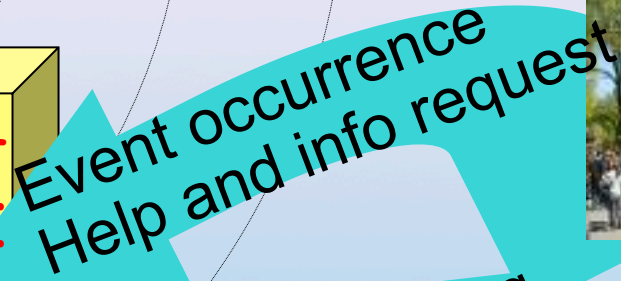
Information types

- From citizens
 - Event alert
 - Help request
 - Info request (for example on evacuation)
- Service
 - Information exchange
 - Ask for orders
 - Orders distribution
 - Data among machines-sensors-operators
- Message broadcasting to citizen
 - alarms
 - info

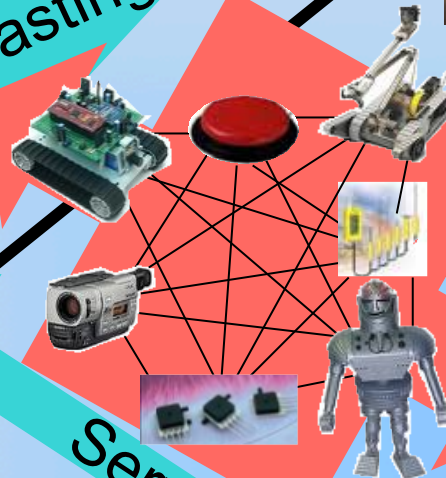




Citizens



Alarm/info broadcasting



Operators on the field



Instructions



Service

Transport



Check availability

Availability



Medical facilities

IABSE September 25

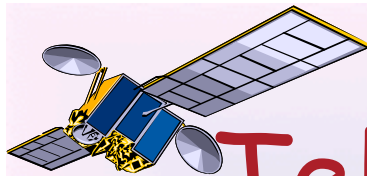
Telecommunications Infrastructures
Emergency Management



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- Messaging
- Voice
- Fixed images
 - Pictures
 - Maps
- Video
- Data (among machines)



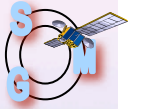


Telecommunication services

SERVICE	APPLICATION
Messaging	PC networking
	E-mail
	Paging
Information retrieval	Data base access
Telephony	Voice, data, etc.
Video- communication	Videophone
	Videoconference
Video- information (VOD)	Telemedicine
	Tele-education
Broadcasting (even area differentiated)	Analog TV
	Digital TV (DVB)
	HDTV
	Analog Radio
	Digital Radio (DAB)

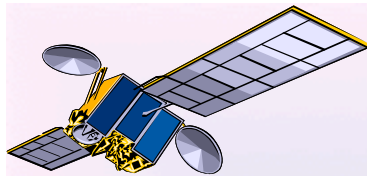
**Localization
based
services**



[illegible]

- Independence from fixed terrestrial networks
- Flexibility
- Quick set up
- Mobility (personal and vehicular)
- Compatibility among standards (even analogical-digital)
- Standard independency (software radio)
- Reliability
- Capillary unlimited coverage
- Security
- Service continuity
- Localization and navigation





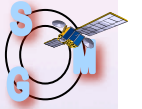
Feasibility key issues

Open
standards

Integration
(interoperability)
among systems

Convergence
(e.g. IP)





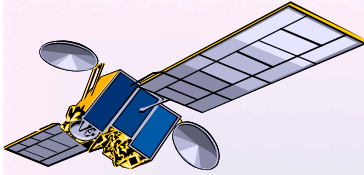
ICT

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IABSE September 25th 2010

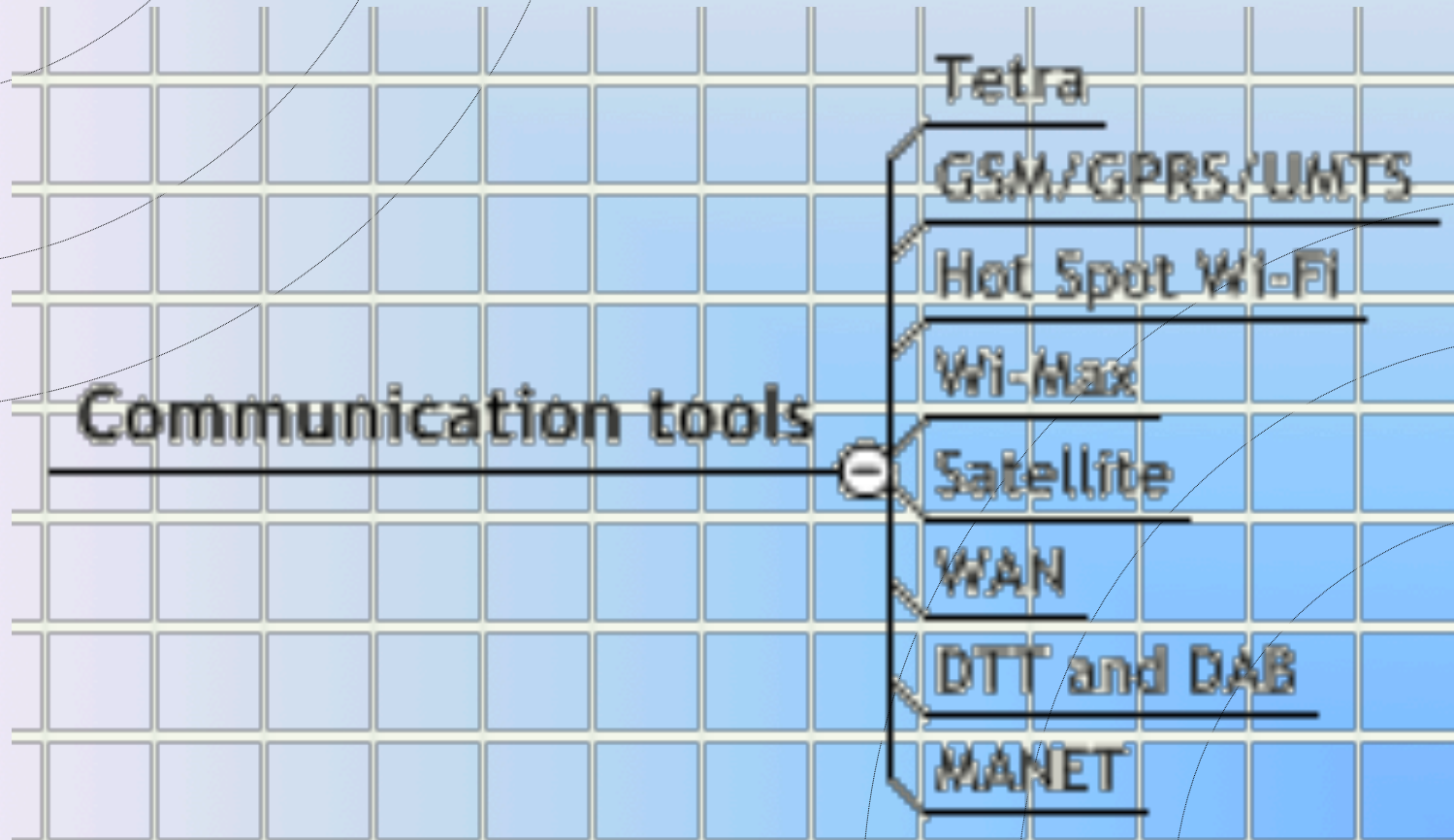
Telecommunications Infrastructures for Emergency Management

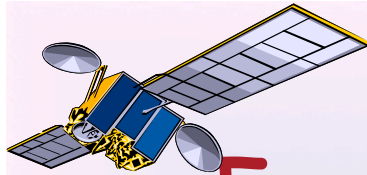




Communication tools

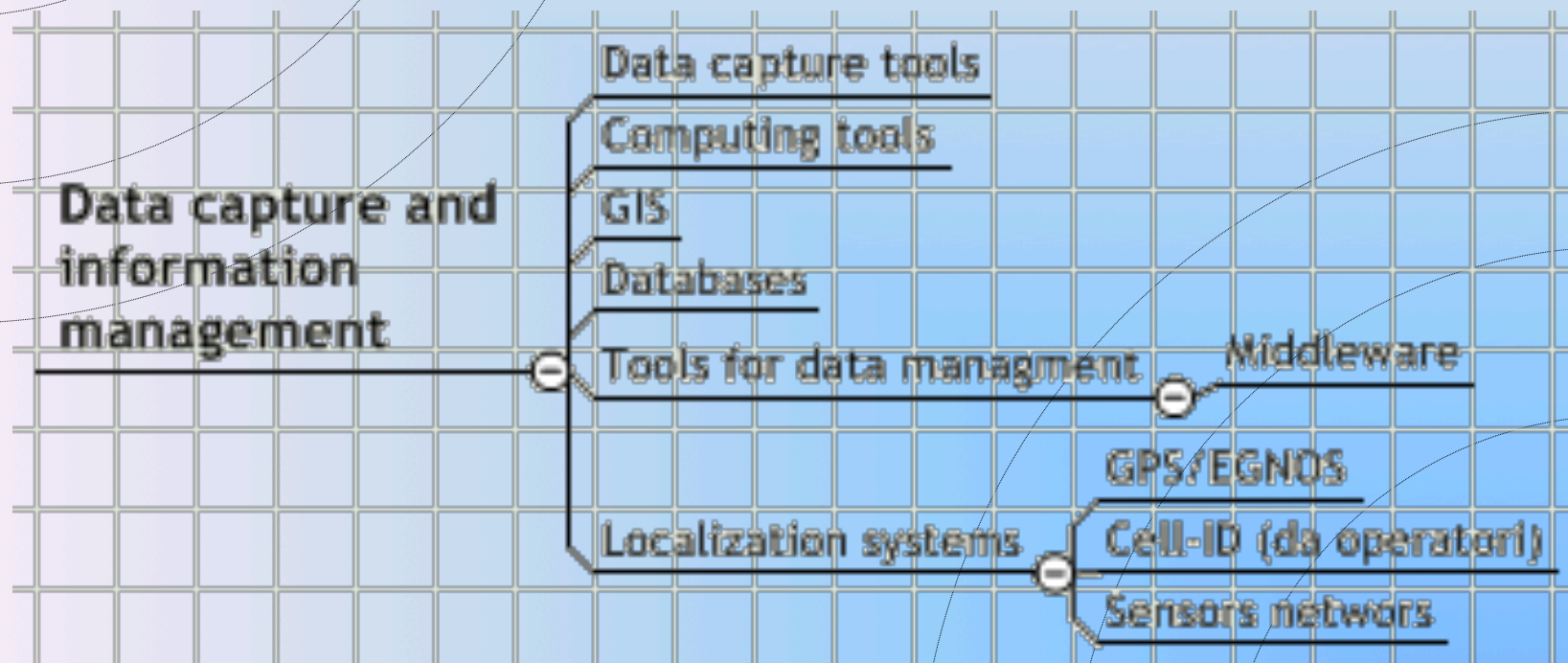
מחשבים, טלפונים, רשתות, וכו' - כלים לתקשורת

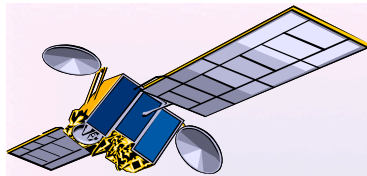




Tools for data collection and management

שירותי מידע וקשרים
מחלקת המידע והקשרים
מחלקת המידע והקשרים





Interface tools

מחשבים, טלפונים, מכשירים, ציוד, תשתיות, שירותים, מידע, אבטחה, חירום, מדיניות, חוקים, תקנות, סטנדרטים, מודלים, כלים, פתרונות, שיתוף, קואורדינציה, תכנון, מימון, בטיחות, אמינות, יעילות, גמישות, סלולריות, ניידות, מרחב, זמן, מקום, אדם, חומר, אנרגיה, מידע, אבטחה, חירום, מדיניות, חוקים, תקנות, סטנדרטים, מודלים, כלים, פתרונות, שיתוף, קואורדינציה, תכנון, מימון, בטיחות, אמינות, יעילות, גמישות, סלולריות, ניידות, מרחב, זמן, מקום, אדם, חומר, אנרגיה, מידע

Interfaces

Warning devices

Communication terminals

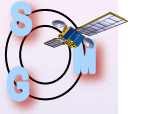
Multimedia devices

Special equipment

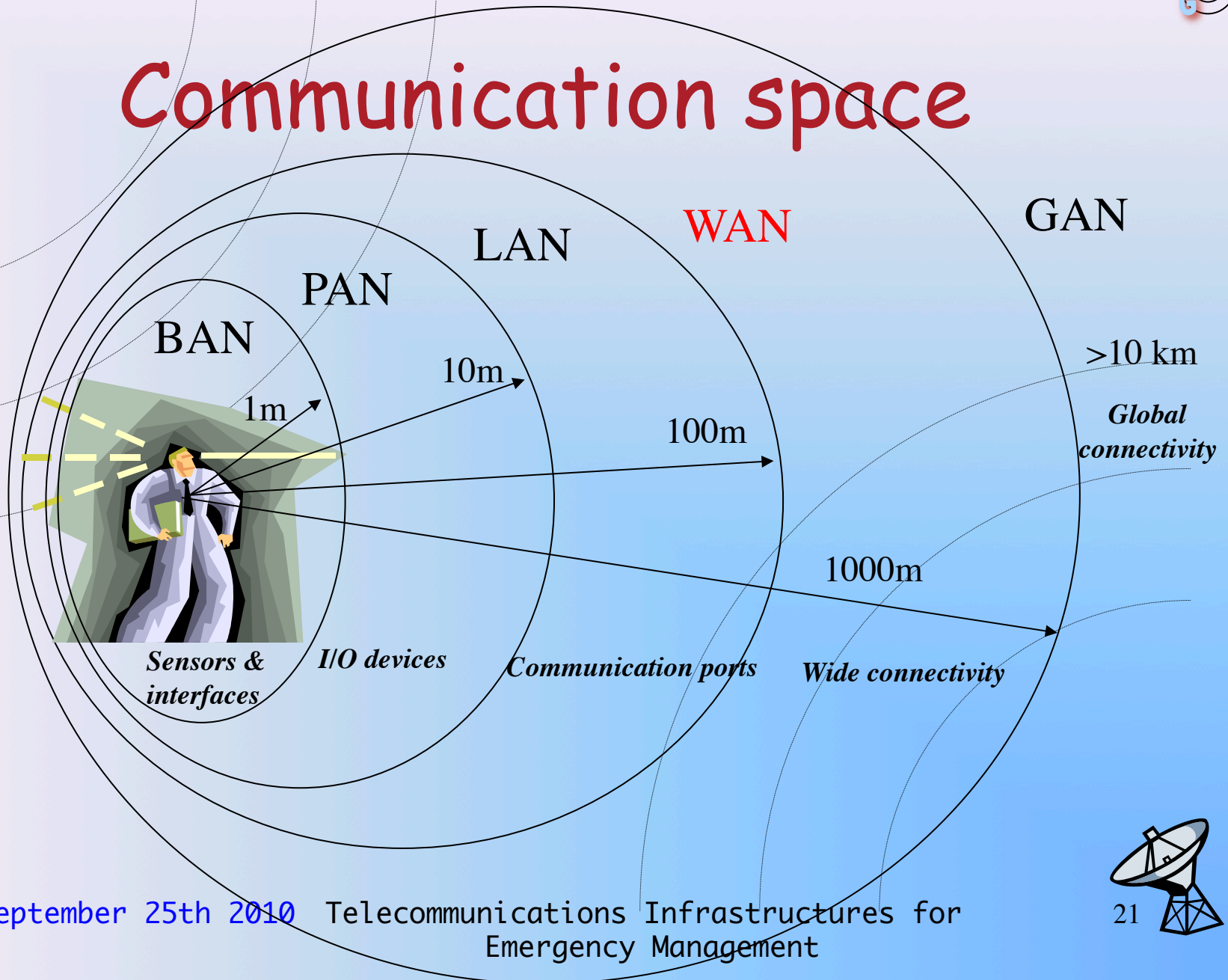
WEB

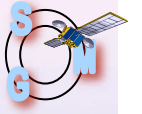
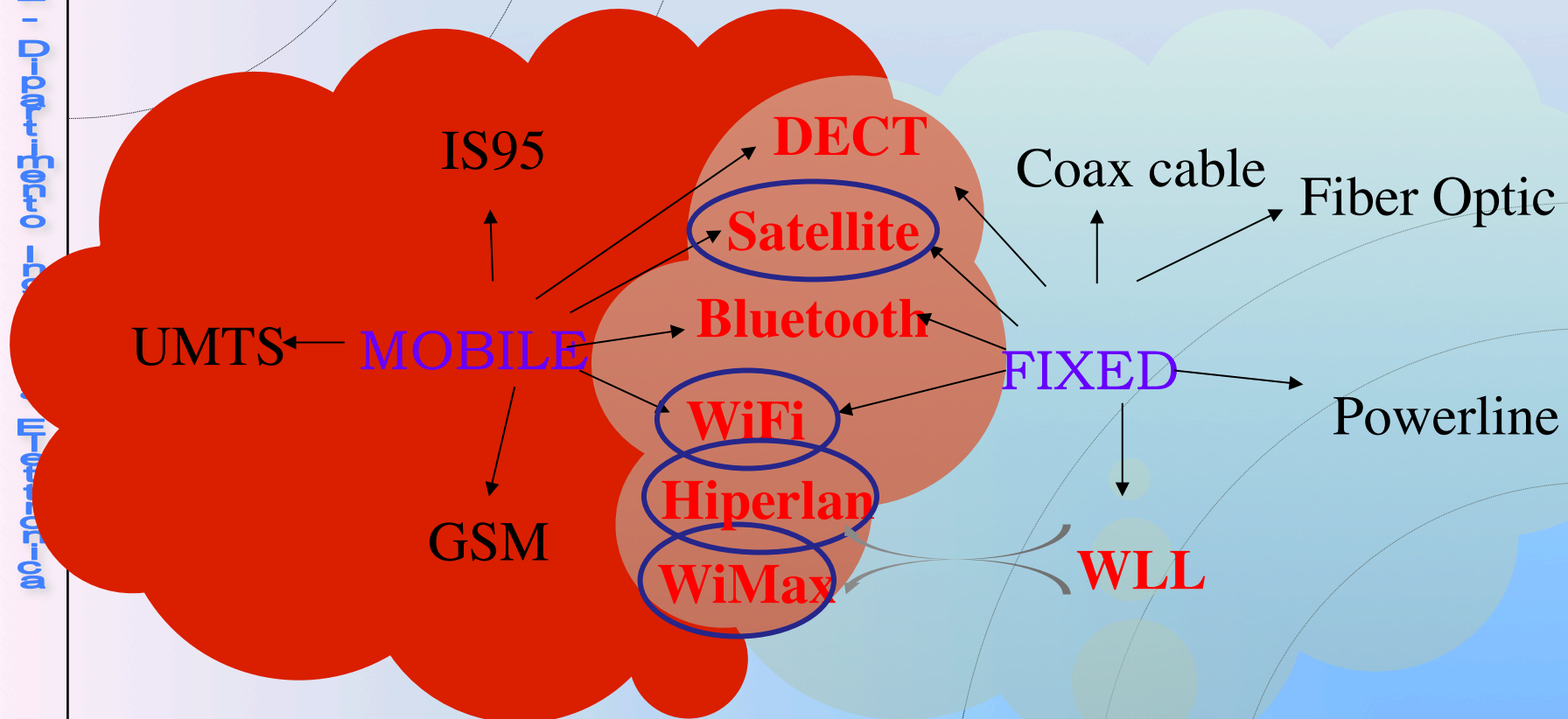
TV channels

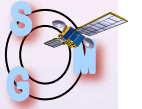
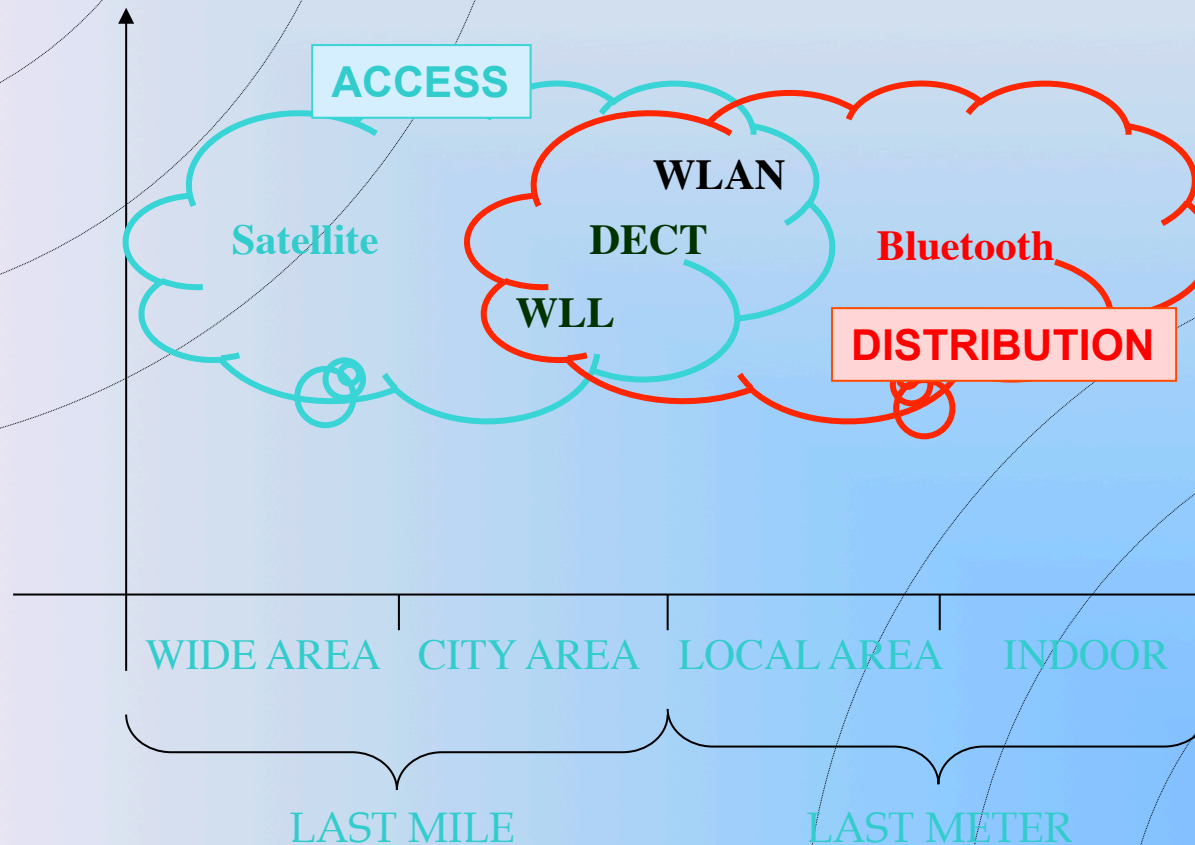


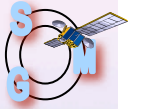


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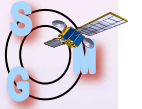
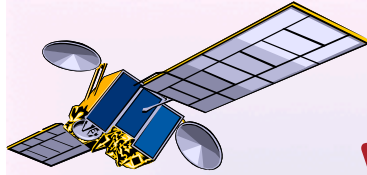
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[illegible]

[illegible]

- Terrestrial
 - Licenced
 - Tetra / analog PMR
 - GSM
 - UMTS
 - WiMax
 - DVB T / analog TV
 - DAB / analog radio
 - Unlicensed
 - WiFi
 - Hiperlan
 - Ad hoc networks (no infrastructure)
- Space based
 - Satellite
 - DVB RCS
 - Proprietary standards
 - HAPs
 - Communication standard TBD

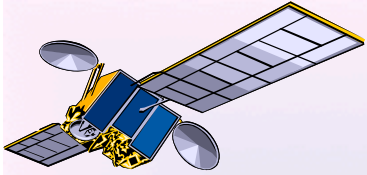




Why to use satellites?

- Costs independent on distance (within one satellite coverage)
- Collecting and broadcasting characteristics
- Particularly suitable and cost effective for multicasting
- Irreplaceable in areas with scarce or no infrastructures
- Irreplaceable in case of disaster
- Extremely suitable for localization services worldwide
- Suitable for large coverage areas and long range mobility

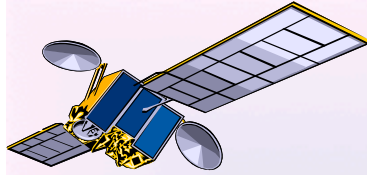




Why to use satellites? (2)

- **Relatively short deployment time**
- Flexible architecture
- Bypass very crowded terrestrial networks
- With the same infrastructure both fixed and mobile services
- Wideband
- Same or better quality of service than terrestrial networks
- Security



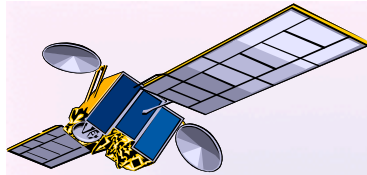


VSAT generalities

- Star architecture
- Based on the capability to provide direct user access to satellite
 - Utilization of high frequencies (Ku band, Ka Band)
 - Increased power generation capabilities on board
 - Use of multibeam antennas on board
- Utilization of small terminals
 - Antennas 1-2 m diameter
 - RF power 1-4 W
 - Modem dimensions VCR like
 - Low cost

0-1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-31-32-33-34-35-36-37-38-39-40-41-42-43-44-45-46-47-48-49-50-51-52-53-54-55-56-57-58-59-60-61-62-63-64-65-66-67-68-69-70-71-72-73-74-75-76-77-78-79-80-81-82-83-84-85-86-87-88-89-90-91-92-93-94-95-96-97-98-99

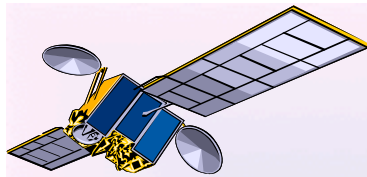




VSAT systems

- A private/shared VSAT Network is suitable both for two way and one way (unicast) IP applications both broadcast and multicast allowing interconnection with WAN and Multi-PC networks without requiring additional hardware.
- A VSAT system is well suitable both for Web-Based Intranet access and for Internet access. They are also well suitable to set up Virtual Private Networks (VPN) with Headquarter and offices remotely located.
- The Satellite Router supports different applications on the same platform utilizing the same network both for interactive IP communications and for video and audio multicast streaming.

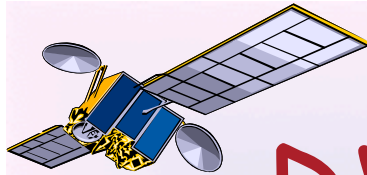




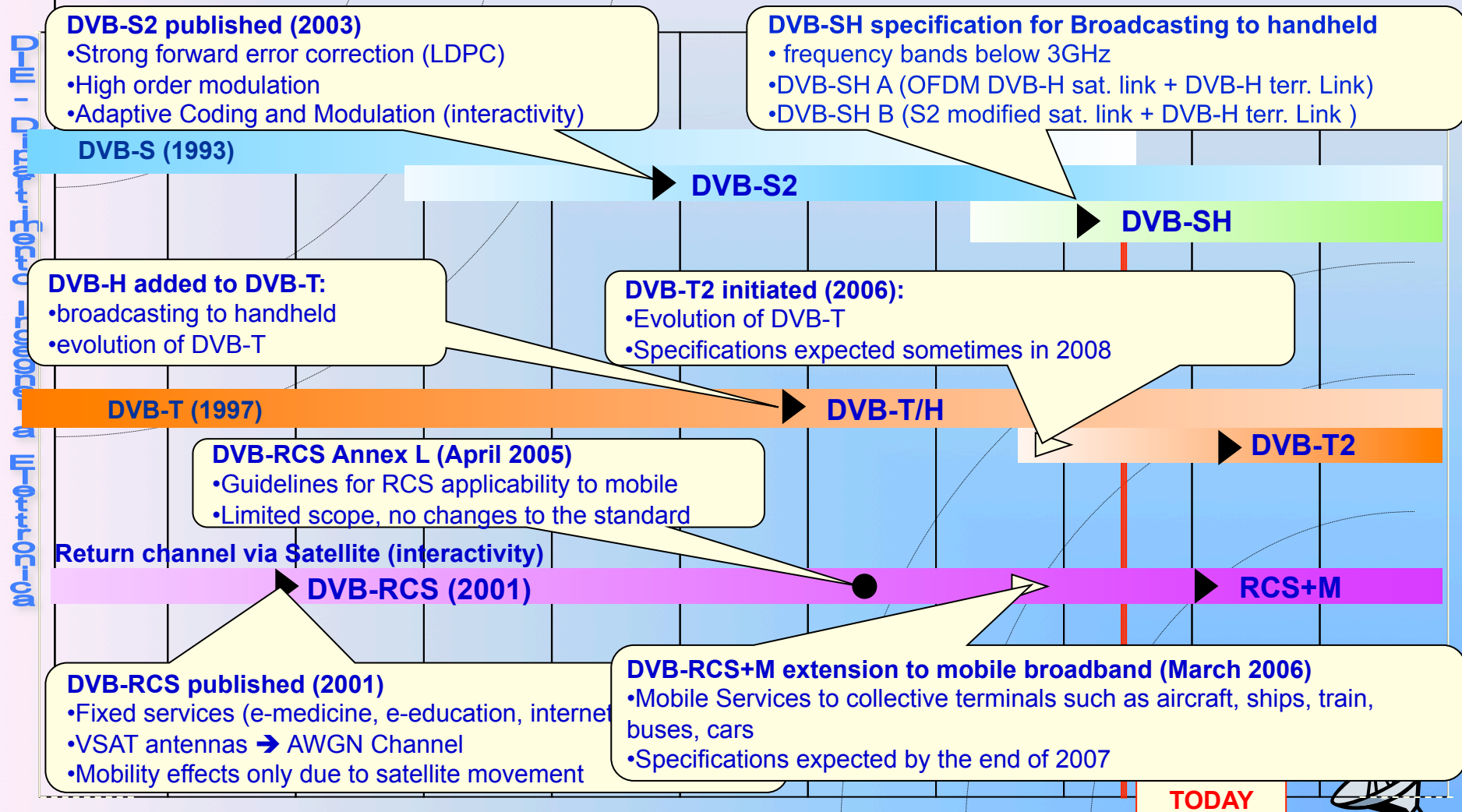
DVB Standards

- DVB-S (Satellite) EN 300 421
- DVB-C (Cable) EN 300 429
- DVB-T (Terrestrial) EN 300 744
- DVB-S2 (2nd Generation Satellite) EN 302 307
- DVB-H (Mobile) EN 302 304
- DVB-RCS (Return Channel via Satellite) EN 301 790
- DVB-SH (satellite services to handheld devices) (Std. in progress)



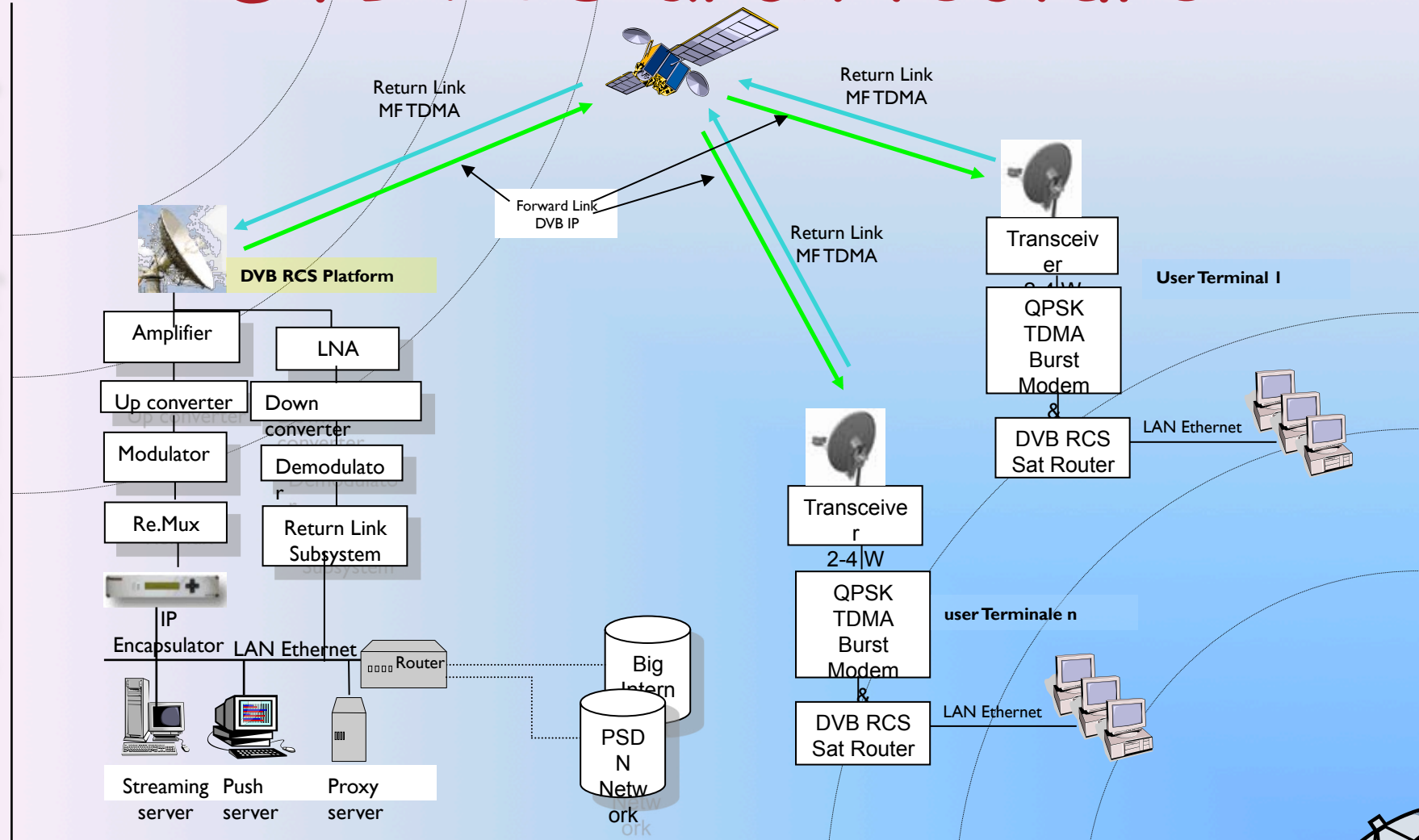


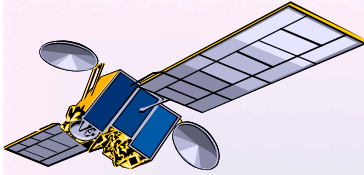
DVB Systems (standards)



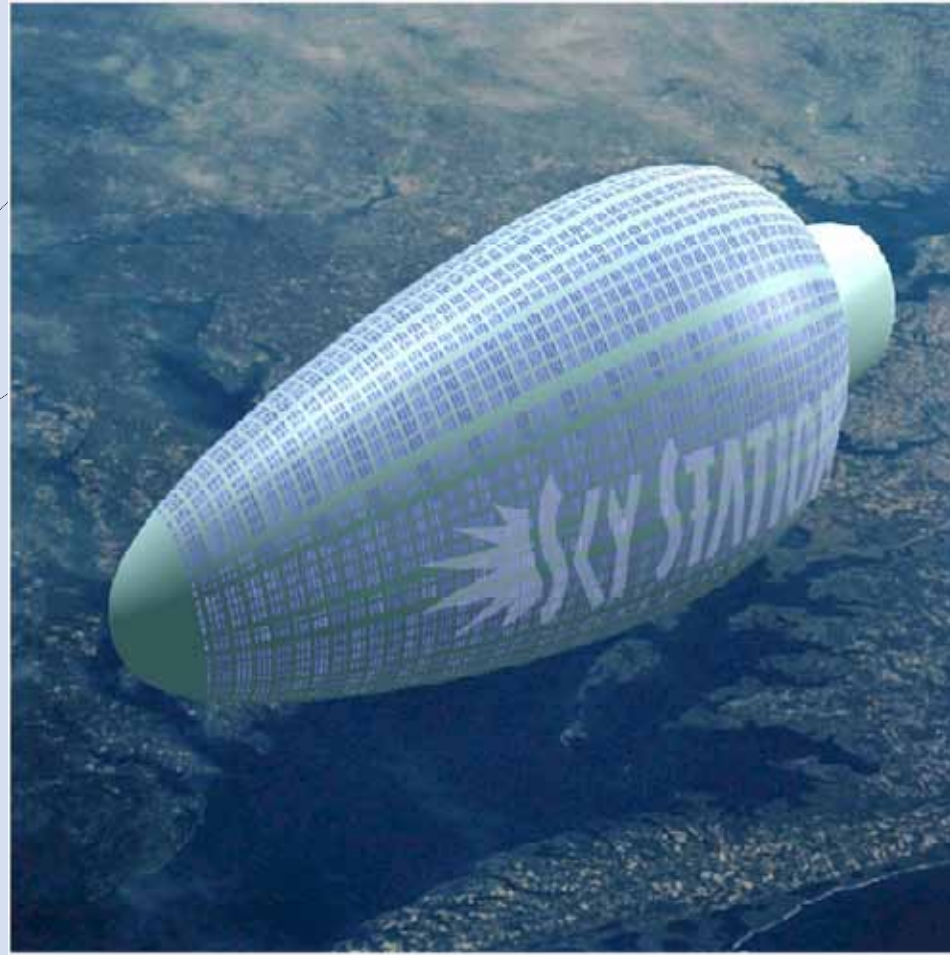


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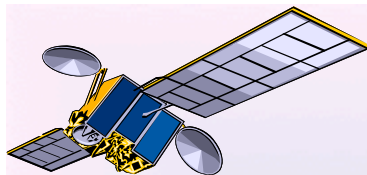


Sky Station

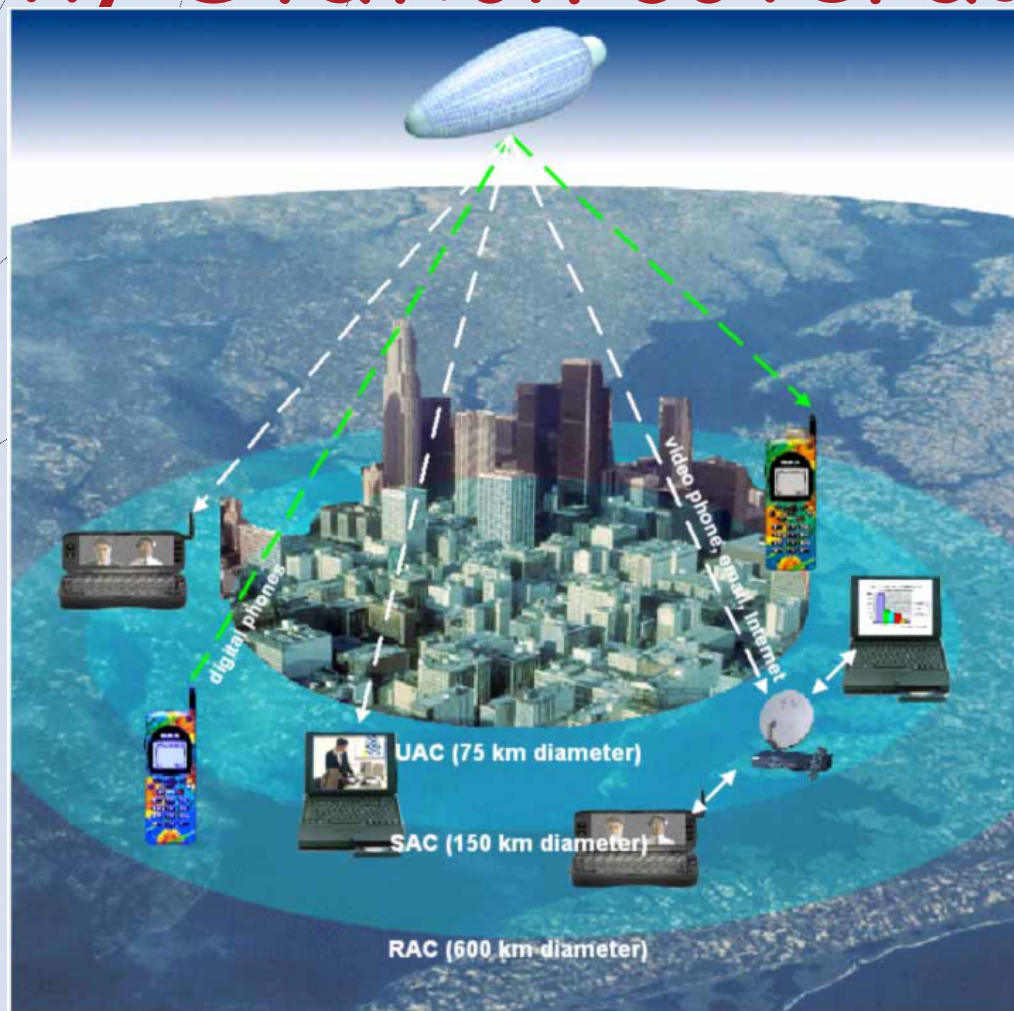


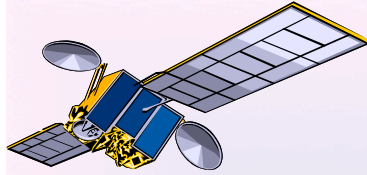
מרכז המידע והתקשורת - משרד המבחן - משרד המבחן - משרד המבחן





Sky Station coverage



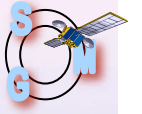


Sky Station Advantages

- Rapid deployment
- UMTS compatibility
- Sky Station platforms do not require a launch vehicle, they can move under their own power throughout the world or remain stationary, and they can be brought down to earth, refurbished and re-deployed.
- Once a platform is in position, it can immediately begin delivering service to its service area without the need to deploy a global infrastructure or constellation of platforms to operate.

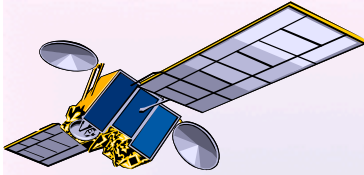
0-10-20-30-40-50-60-70-80-90-100-110-120-130-140-150-160-170-180-190-200-210-220-230-240-250-260-270-280-290-300-310-320-330-340-350-360-370-380-390-400-410-420-430-440-450-460-470-480-490-500-510-520-530-540-550-560-570-580-590-600-610-620-630-640-650-660-670-680-690-700-710-720-730-740-750-760-770-780-790-800-810-820-830-840-850-860-870-880-890-900-910-920-930-940-950-960-970-980-990-1000



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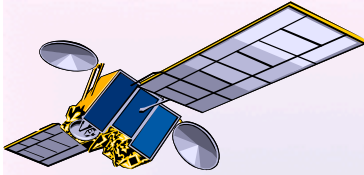
- The altitude enables the Sky Station system to provide a higher frequency reuse and thus higher capacity than other wireless systems.
- The low cost of the platform and gateway stations make it the cheapest wireless infrastructure per subscriber conceived to date.
- Each platform can be retrieved, updated, and re-launched without service interruption. Sky Station platforms are environmentally friendly. Powered by solar technology and non-polluting fuel cells.
- Short paths through the atmosphere and unobstructed line-of-sight.





Disadvantage/Open issues

- Small coverage
- Stability
- Regulation

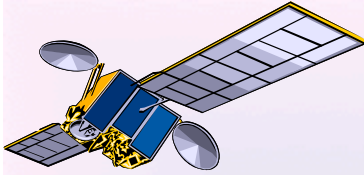


Alternative configuration



Fig. 6 Helios. AeroVironment's craft has a wing span of 75 m and aims to operate up at 100 000 ft under solar power (Photo: NASA Dryden/Tom Tschida)



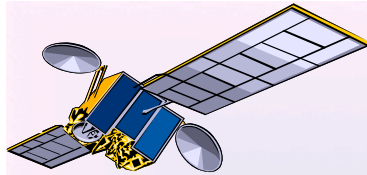


Alternative configuration (2)



Fig. 7 HALO Proteus aircraft. Note the pod for the payload underneath. (Courtesy of Angel Technologies Corp.)



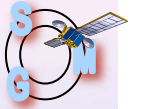
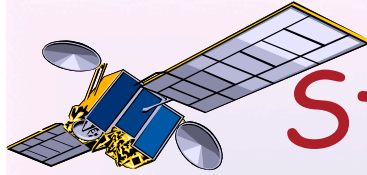


Alternative configuration (3)



Fig. 8 Predator, a military UAV (Courtesy of General Atomics Aeronautical Systems Inc.)





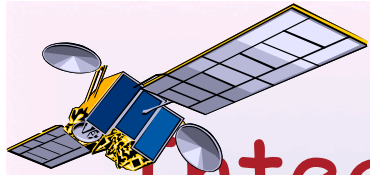
Stand alone satellite/HAPS characteristics

- Independence on terrestrial facilities
- Suitability for emergency
- Promptness to set up (for the satellite once in orbit)
- Occasional Hot spot capacity provision capability
- Suitability for multicast and broadcast
- Cost-effective provision of telecommunication capabilities
- Flexible architectures
- No real limitations to applications
-

CONCLUSION

Are they in competition?





Integrated architecture rationale

With respect to stand alone architectures

HAPS can help satellites

Satellites can help HAPS

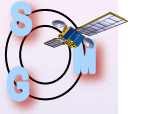
- To relax user terminal and sat payload requirements
- To use terrestrial like terminals
- To use terrestrial standards
- To enhance coverage in urban areas
- To strongly decrease perceived latency
- To alleviate traffic management handling local traffic

- To extend coverage
- To connect remote locations
- To interconnect haps and clusters
- To connect other networks
- To act as backbone

CONCLUSION

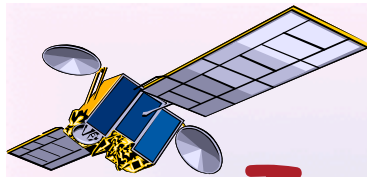
**Definitively,
they are complementary**





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- Double payload on the HAPS
- Splitting connections
- Routing
- Complexity



Integration with satellites

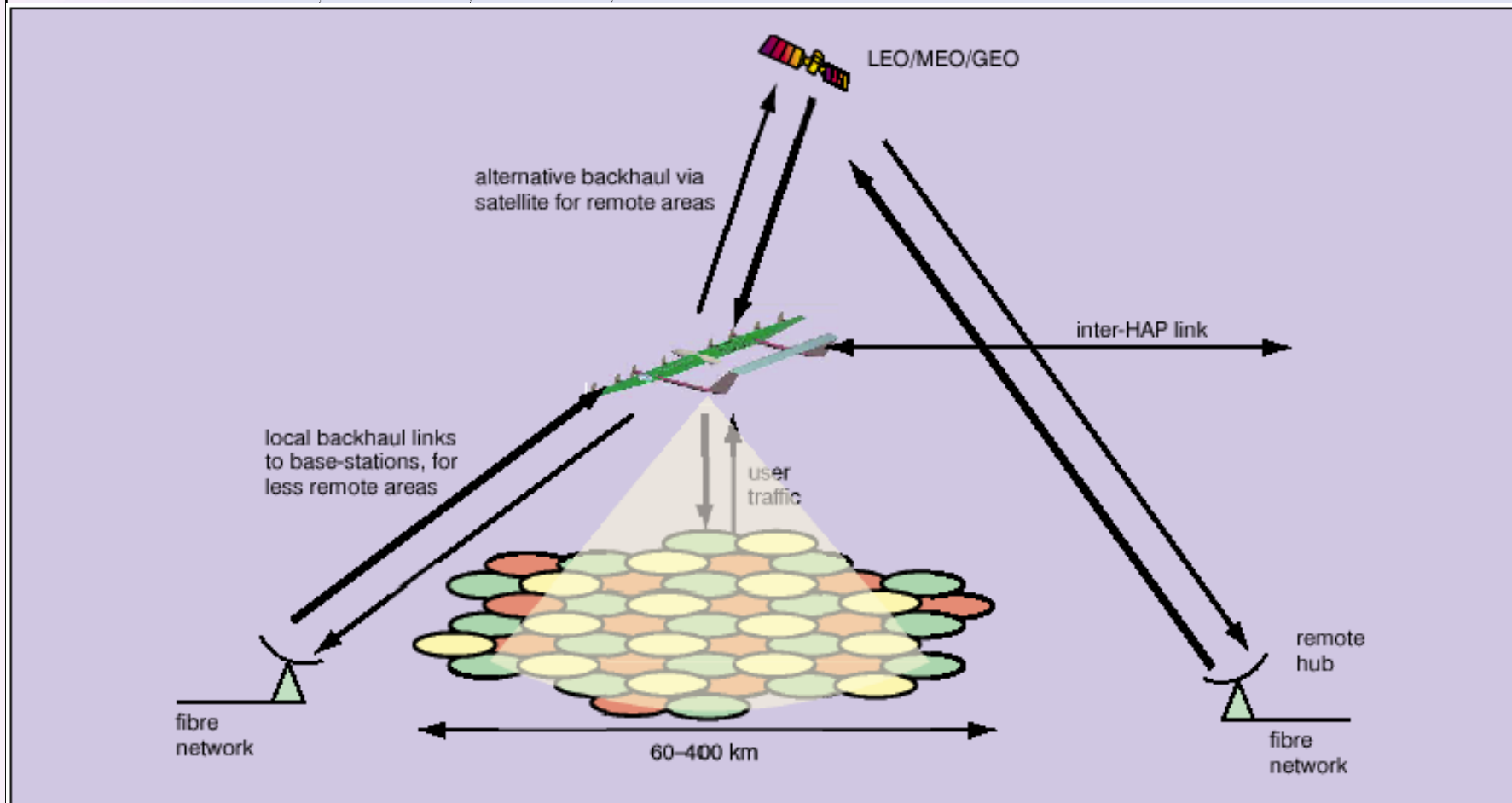
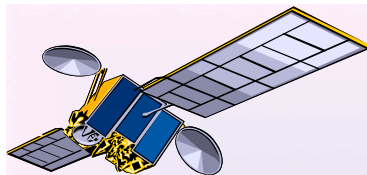
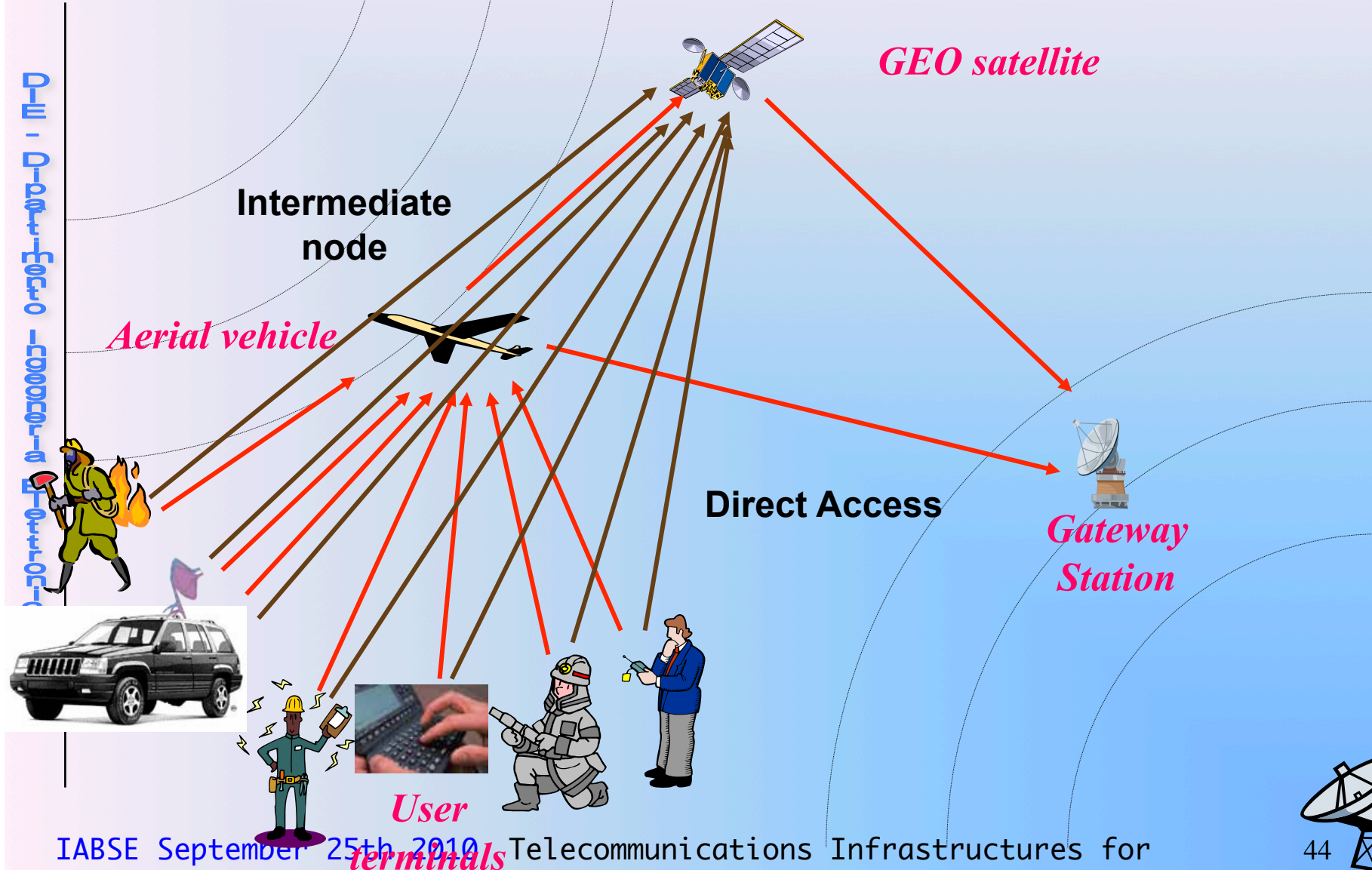


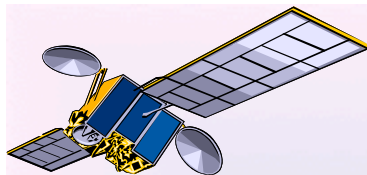
Fig. 9 HAP communications scenario



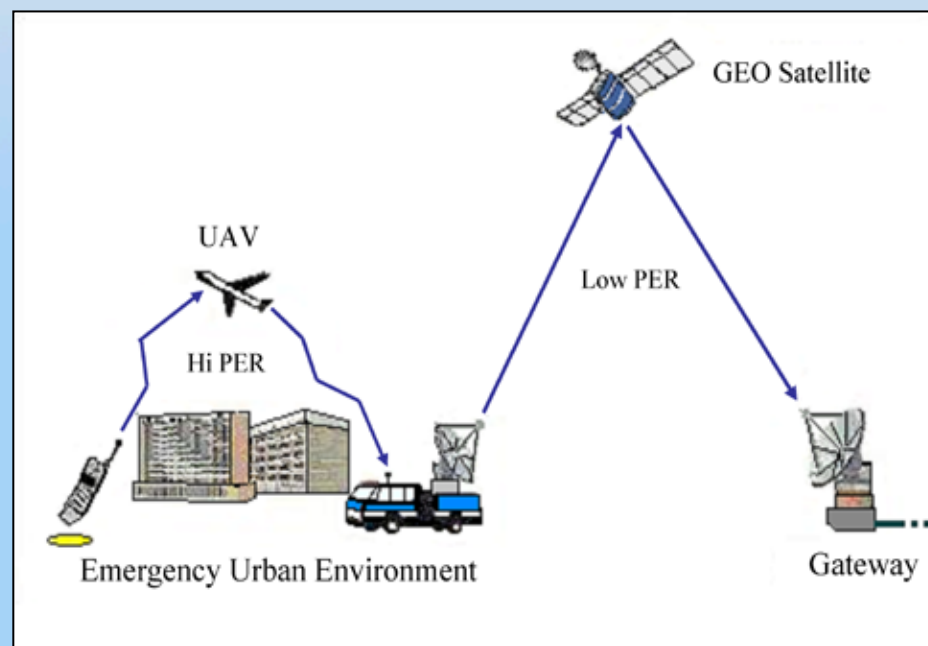
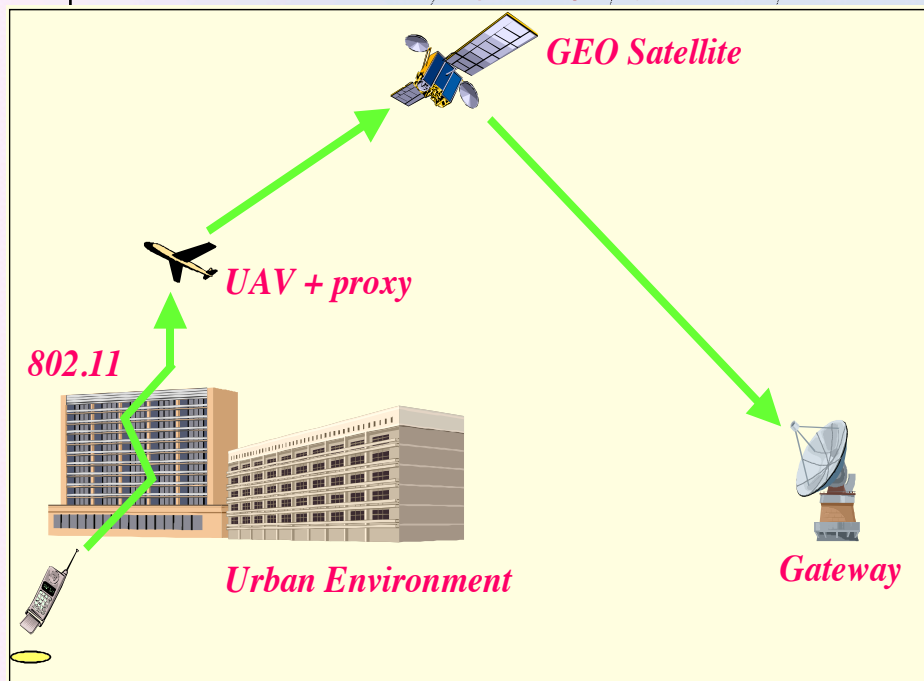


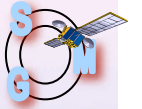
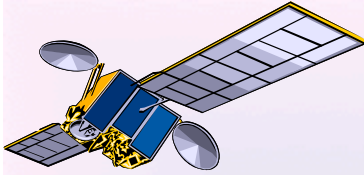
SCENARIOS





Alternative configurations

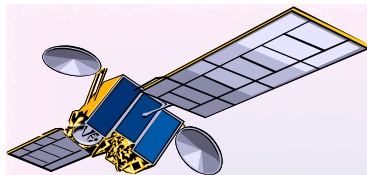




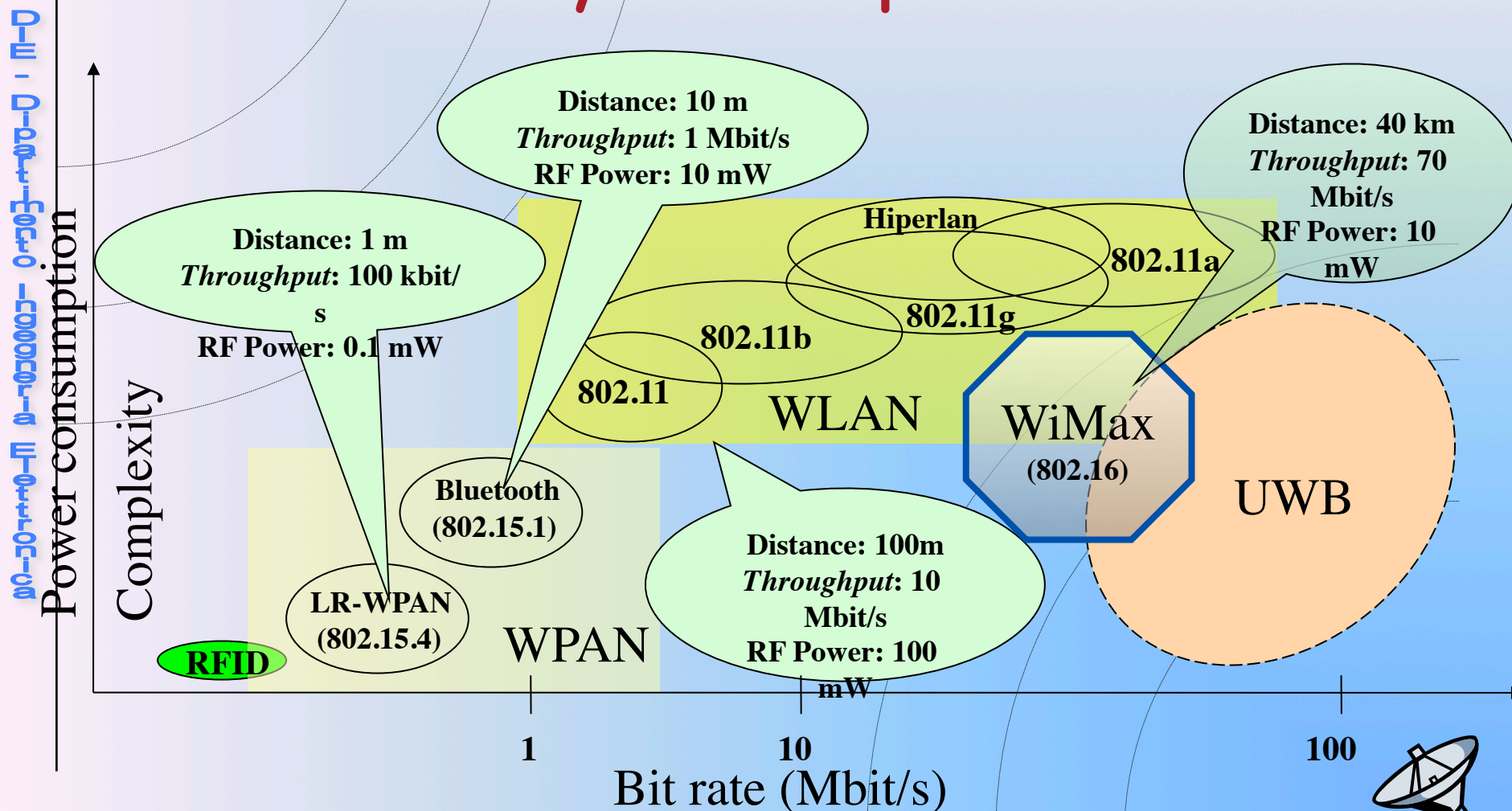
Wireless broadband terrestrial standards

- Hiperlan
 - Fixed services
- WiMax
 - Current standard: fixed services
 - Forthcoming standard: fixed and mobile services
- WiFi
 - Last mile and last meter
 - High availability of technology
 - Low cost





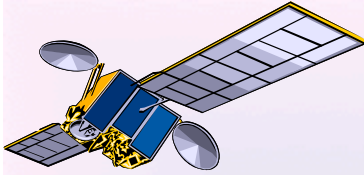
Wireless systems performance





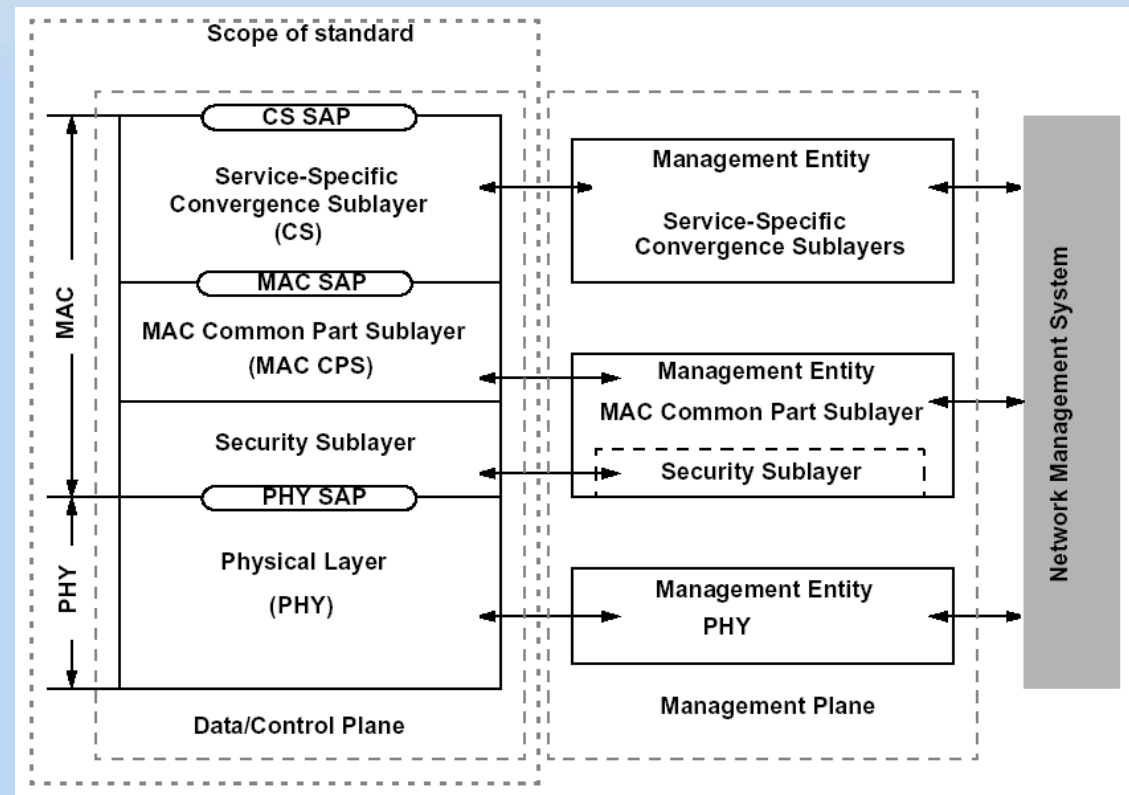
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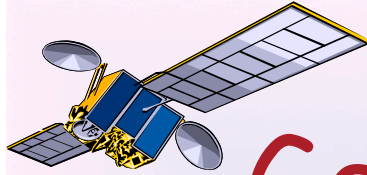
- STANDARD 802.16c (10-66 GHz, 2002) - Obsolete
- STANDARD 802.16a (2-11 GHz, 2003) - Obsolete
- STANDARD 802.16d (2-11 GHz, 2004) - In use, certified hardware available. Fixed terminals.
- STANDARD 802.16e (2-11 GHz, 2005) - Certification process ongoing by WiMAX Forum. Amendment to std "d" for mobility.



WIMAX - Protocol architecture

- IEEE 802.16 specifies:
 - PHY
 - MAC
- Four PHY layers
- One MAC layer

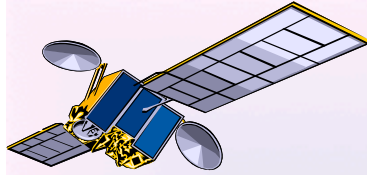




General characteristics of PHY WiMAX interfaces

- **Channel bandwidths**
 - can be an integer multiple of 1.25 MHz, 1.5 MHz, and 1.75 MHz (in Europe) with a maximum of 20 MHz.
- **Duplexing:**
 - The WIMAX system can support frequency-division duplex (FDD) and time-division duplex (TDD).
- **Adaptive modulation techniques**
 - allowed modulation schemes: BPSK, QPSK, 16-64 QAM
- **Concatenated and turbo codes**
- **Support for adaptive antennas and space time-coding (Alamouti scheme)**

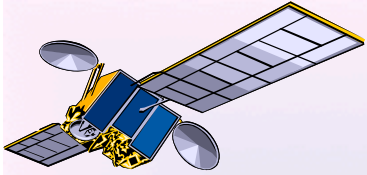




IEEE 802.16e

- Mobile/nomadic version of the standard
 - Adds functionalities for the support of:
 - Handover of terminals between WIMAX cells
 - Roaming
 - Defines the Scalable OFDMA (SOFDMA)
 - Supposed to keep communication up to 120 km/h

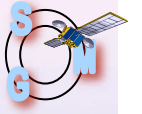


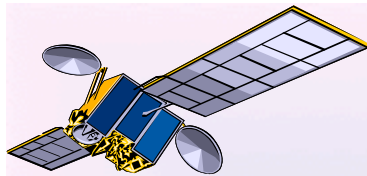


Hiperlan

- ETSI Standard
- Supposed to outperform WiFi but not WiMAX. Not really widespread.
- Coverage: some tens of km
- License free (ISM) frequency usage.
- Power: 1 W (imposed to license-free transmissions)







WLAN Architecture

Based on 802.11 standard

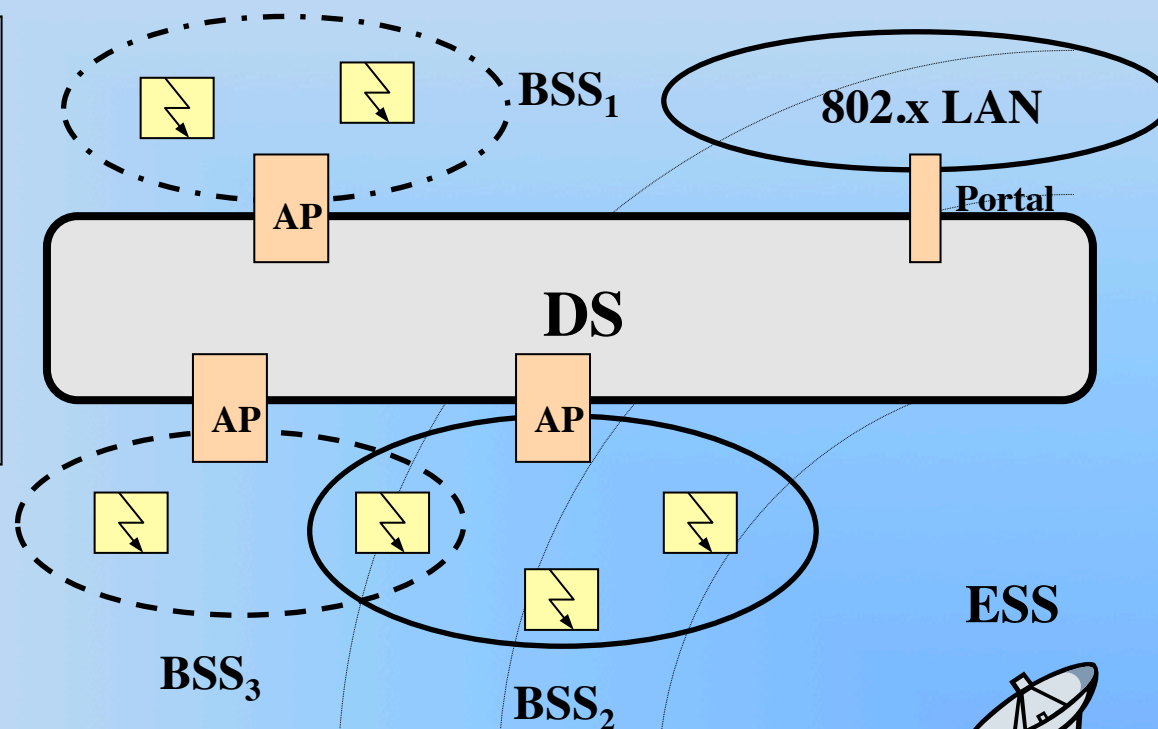
Legenda

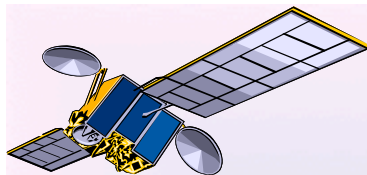
BSS: *Basic Service Set*

DS: *Distribution System*

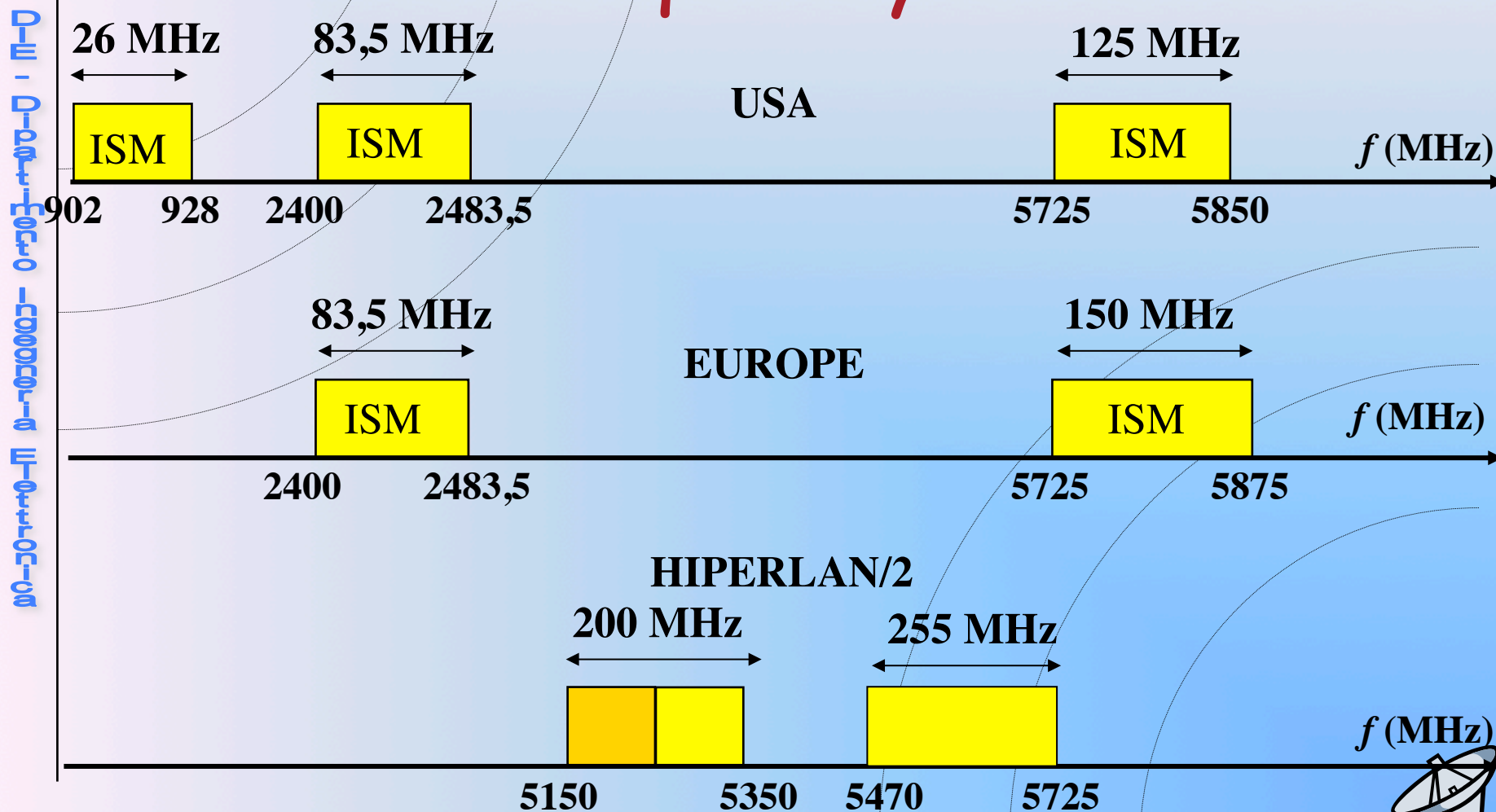
AP: *Access Point*

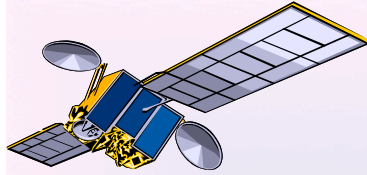
ESS: *Extended Service Set*





WLAN Frequency Allocation

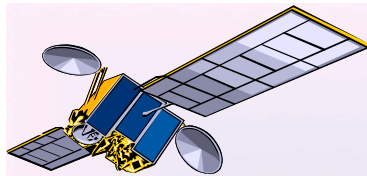




State of Art

IEEE Standard	Context	Frequency (License-free / ISM bands)	Bandwidth	Max. Speed (gross)	Note
802.11a	Connectivity (PHY and MAC)	5 GHz	300 MHz	54 Mbit/s	
802.11b	Connectivity (PHY and MAC)	2.4 GHz	83 MHz	11 Mbit/s	Used as reference connectivity standard.
802.11g	Connectivity (PHY and MAC)	2.4 GHz	83 MHz	54 Mbit/s	Backwards compatible with 802.11b at 11 Mbit/s
802.11n	Connectivity (PHY and MAC)	2.4 GHz and 5 GHz	TBD	540 Mbit/s	Use of multiple antennas (MIMO). Under development TBD within 2007. Backwards compatible with 802.11g
802.11e	QoS (MAC)	n.a.	n.a.	n.a.	Quality of Service handling at MAC layer. Applicable to connectivity standards .
802.11i	Security (MAC, IP)	n.a.	n.a.	n.a.	Security improvements for connectivity standards.
802.11r	Fast Roaming (PHY)	n.a.	n.a.	n.a.	Fast Roaming for high mobility users. Under development.





Bluetooth Network topology

Radio Designation

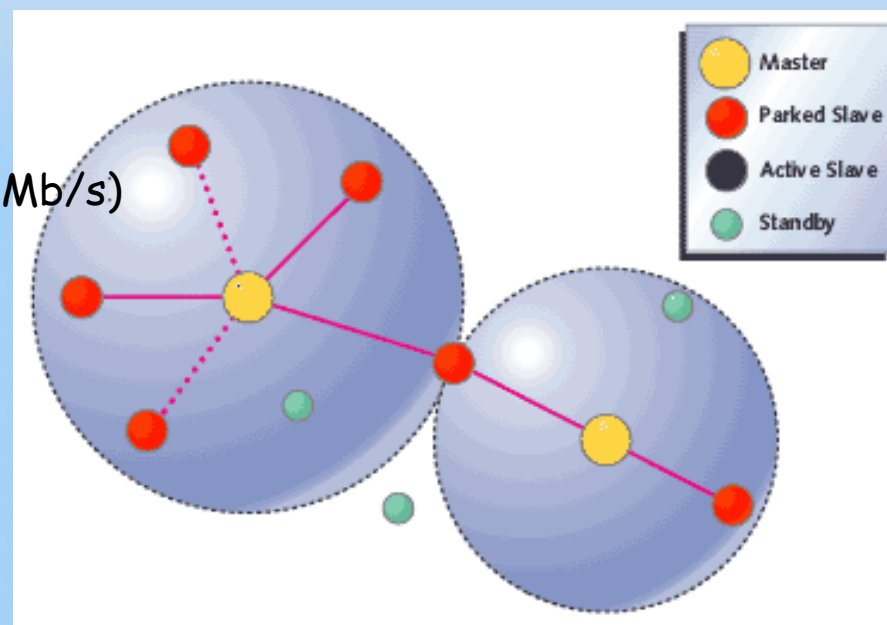
- Connected radios can be master or slave
- Radios are symmetric (same radio can be master or slave)

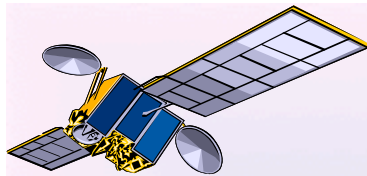
Piconet

- Master can connect up to 7 simultaneous active slaves per piconet
- Each piconet has maximum capacity (1 Mb/s)
 - Unique hopping pattern/ID

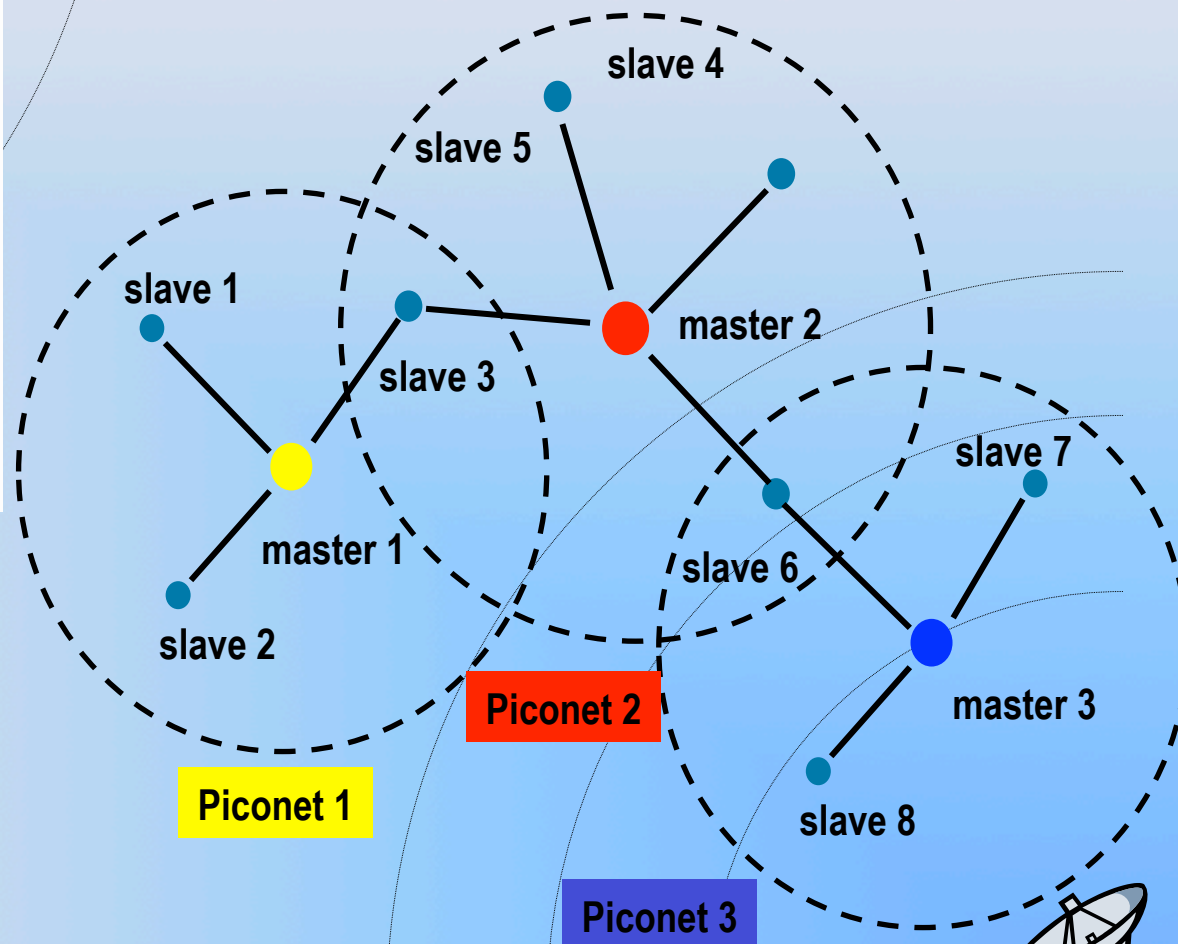
Scatternet

- High capacity system
 - Minimal impact with up to 10 piconets within range (10 m)
- Radios can share piconets!





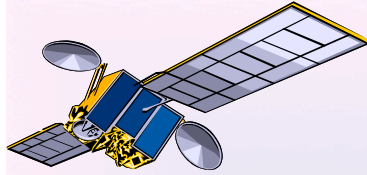
Piconet and Scatternet



[illegible]

- Independent devices
 - Cell Phones
 - PDAs
 - PCs, notebooks, ...
- Bluetooth-connected peripherals
 - HID: keyboards, mice, etc
 - Network adapters & modems
 - Cell phones acting as modems
 - Imaging: printers and cameras
- Radios with HCI (Host Controller Interface)



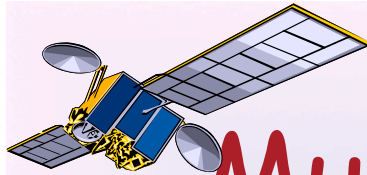


Radio parameters

- Transmit power
 - Nominal 0dBm
 - Up to 20 dBm provided power control
- Receiver sensitivity
 - -70 dBm @ 0.1% BER
- Different classes of device for different ranges

Class	Output Power	Nominal range
1	100mW (20dBm)	100 m
2	2.5mW (4dBm)	16 m
3	1mW (0dBm)	10 m





Multiple Users on the Same Bandwidth

Private Call

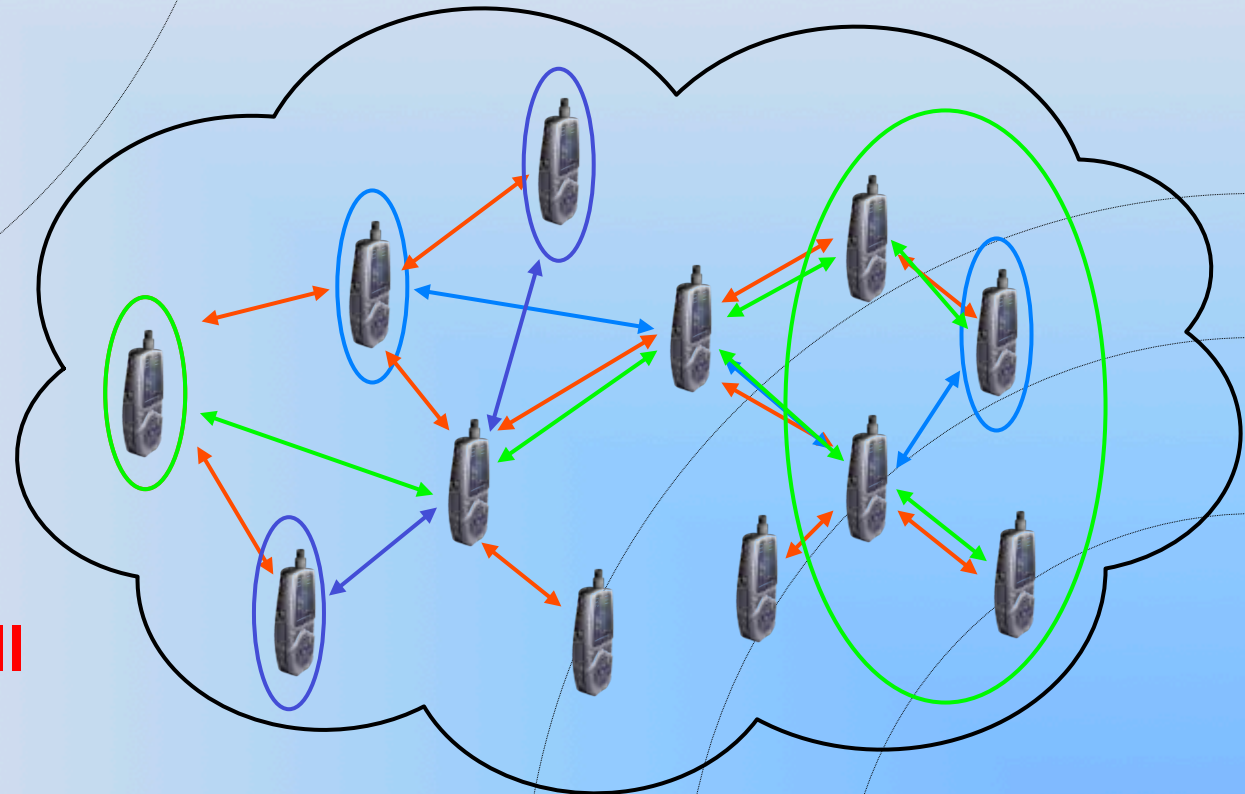
Multi Session

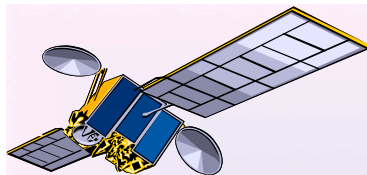
(10 sessions)

Group Call

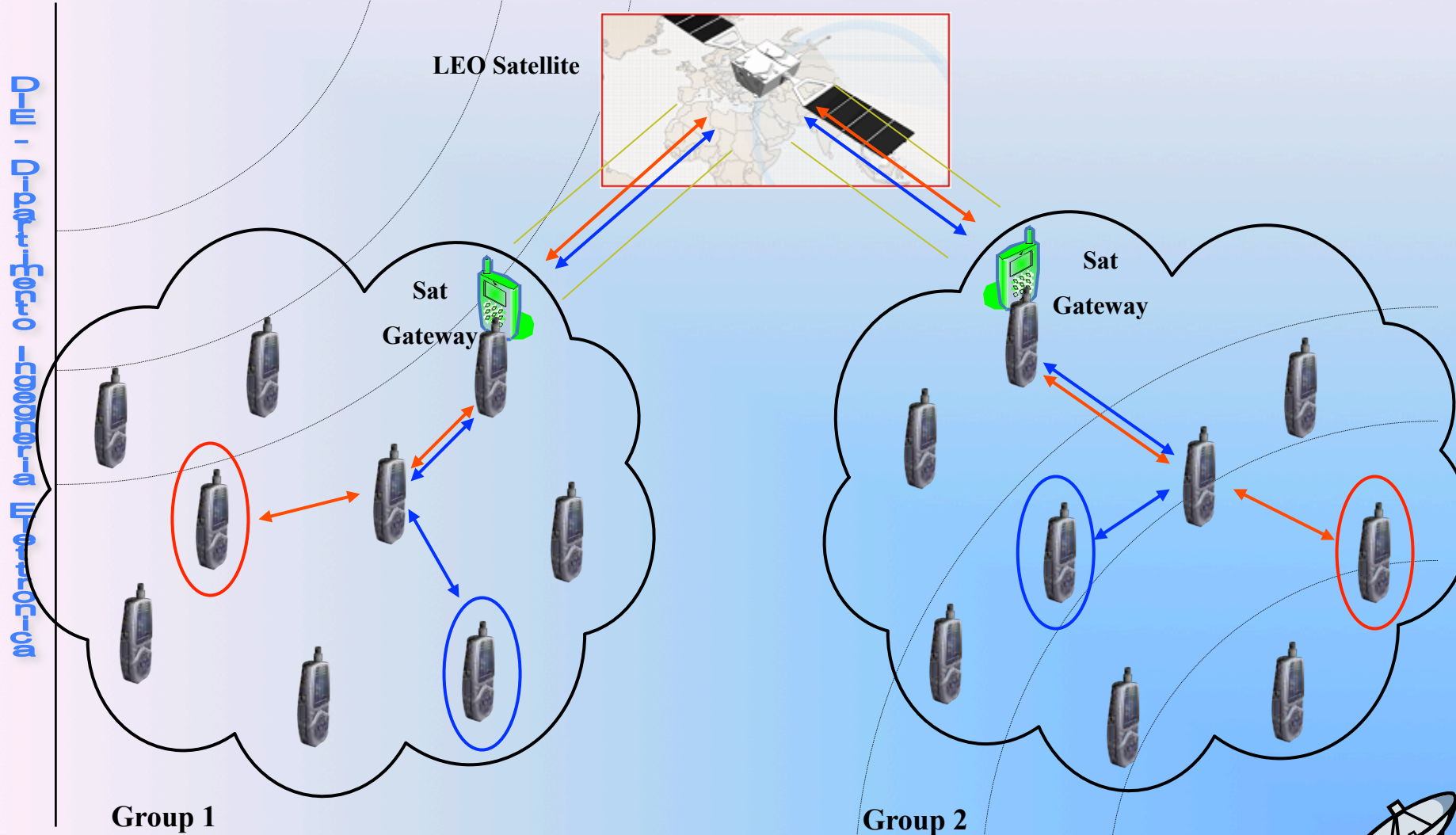
Broadcast to All

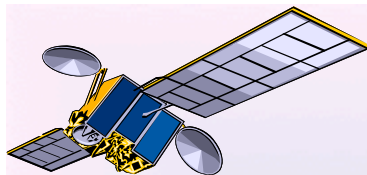
(with priority)



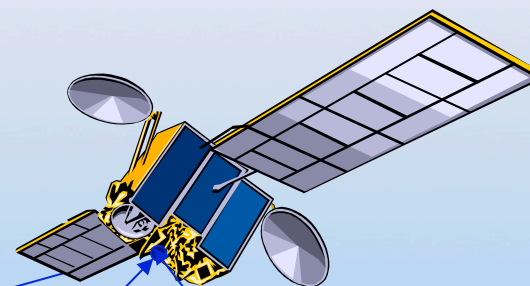
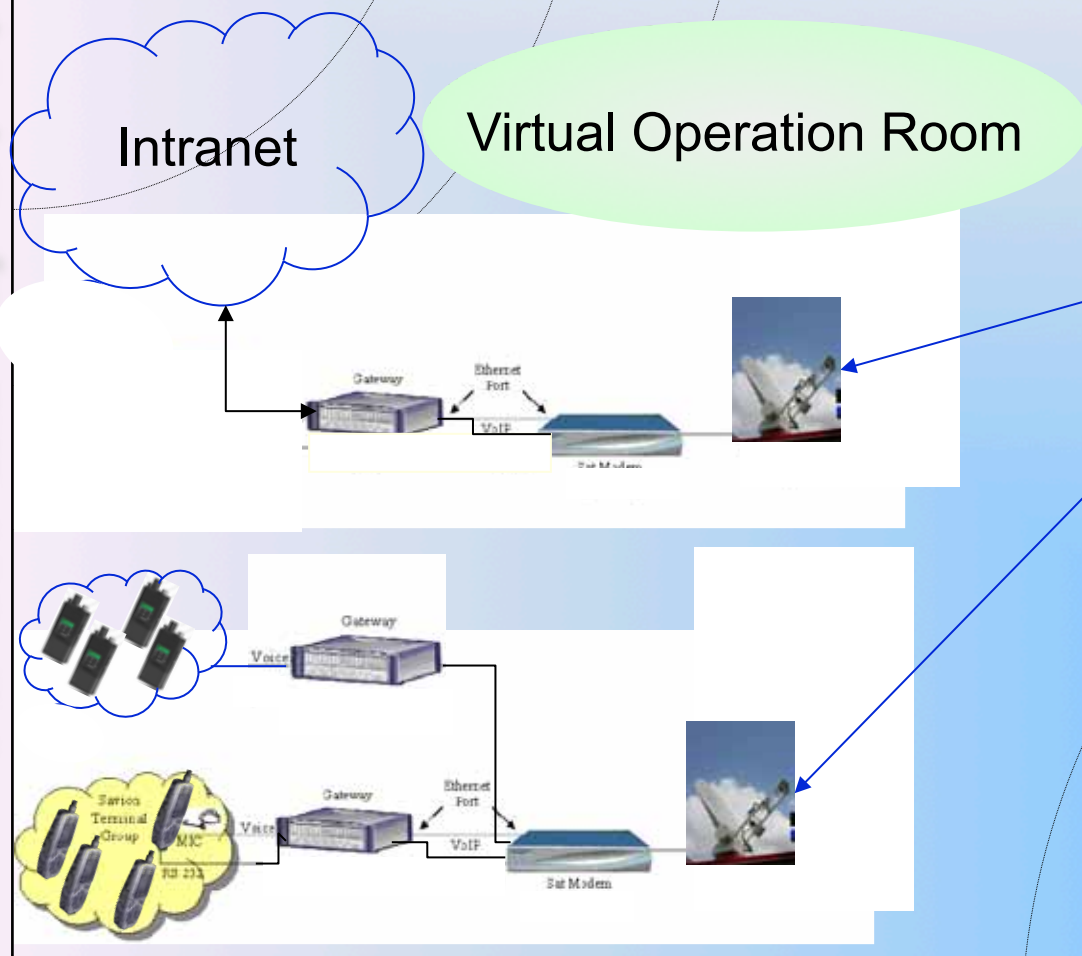


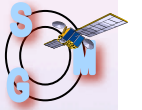
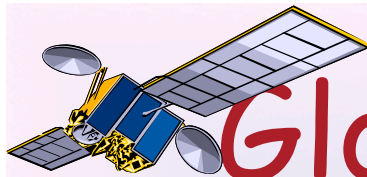
Remote interconnection





Interoperability Architecture





Global telecommunication scenario

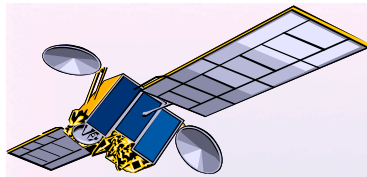
שירותי טלפון ניידים - שירותי טלפון קו - שירותי אינטרנט - שירותי טלוויזיה - שירותי רדיו



Inter-Network Roaming

Seamless end-to-end Service





Integration levels

1. Geographical

- Satellite provides service only in areas not covered by terrestrial networks; services and technologies can be different.

2. Services

- Implies geographical integration and compatibility among services provided by the two networks; performance can be different.

3. Network

- Same procedures and protocols allowing to dial the same number independently on the used terminal; different carrier frequency eventually utilized by the two segments must be taken into account.

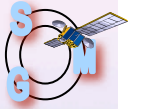
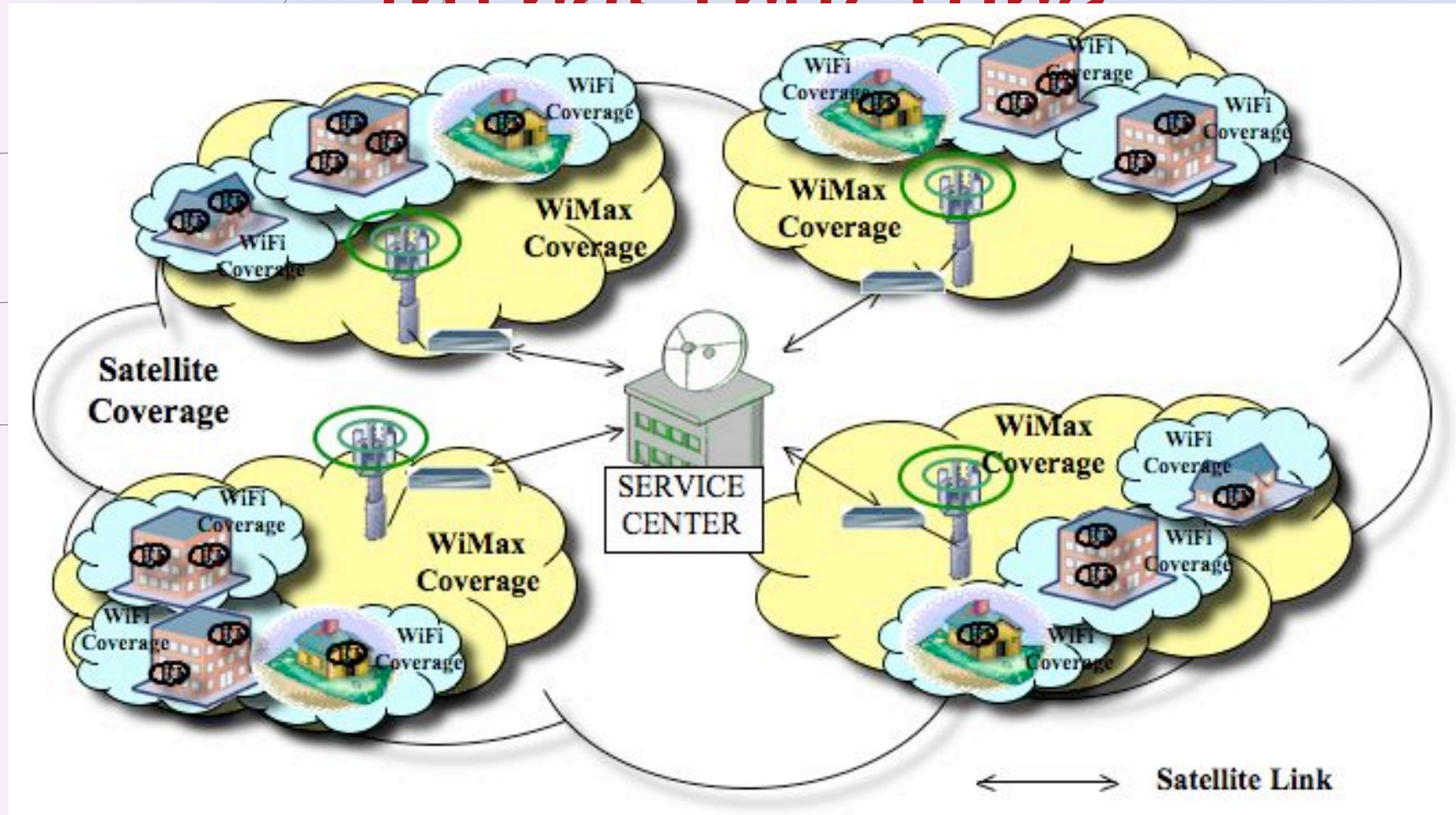
4. Equipment

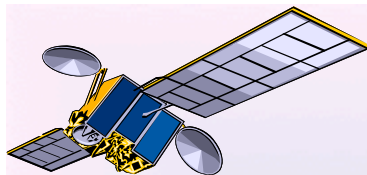
- Compatibility in terms of access, protocols, data rate so that at least a part of the circuits could be shared.

5. System

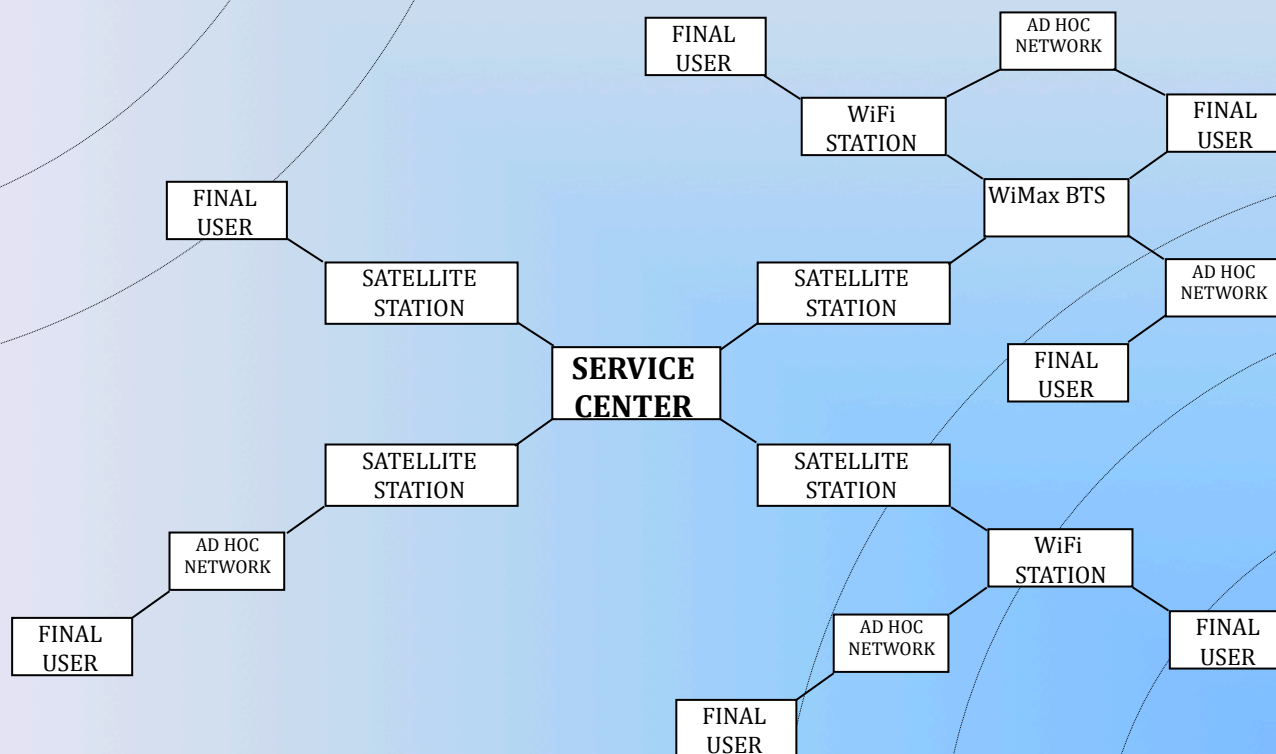
- Maximum level; users are not aware of what kind of connection has been established.

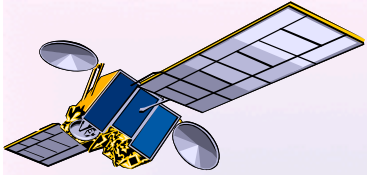


[illegible]



Network Topology





Backbone

- **Description**
 - WiMax cellular networks interconnected through a satellite network.
 - A WiMax base station handles up to 75 Mbit/s
 - Only a portion will be transferred via satellite
- **Services and applications**
 - Transport
 - Business continuity
- **Market segments**
 - Areas with no terrestrial infrastructures
 - Operators

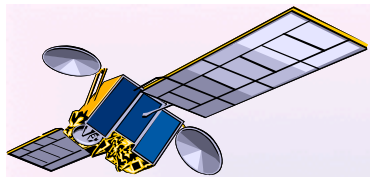
0-10-20-30-40-50-60-70-80-90-100-110-120-130-140-150-160-170-180-190-200-210-220-230-240-250-260-270-280-290-300-310-320-330-340-350-360-370-380-390-400-410-420-430-440-450-460-470-480-490-500-510-520-530-540-550-560-570-580-590-600-610-620-630-640-650-660-670-680-690-700-710-720-730-740-750-760-770-780-790-800-810-820-830-840-850-860-870-880-890-900-910-920-930-940-950-960-970-980-990-1000



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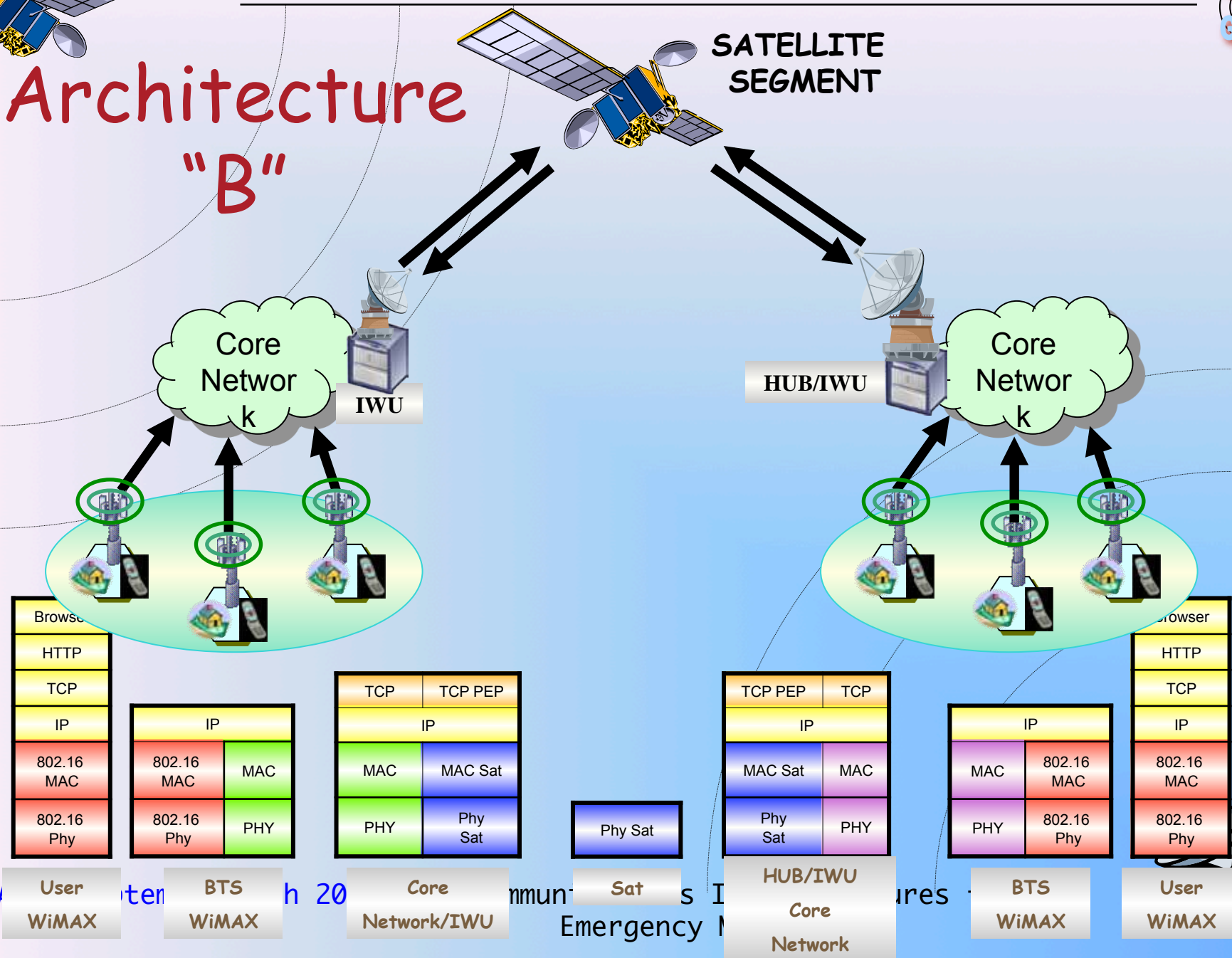
- **Description**
 - Coverage in areas not covered
 - To guarantee continuity to mobile users
- **Services and applications**
 - Mobile telephony, SMS, MMS
 - Internet access, videocommunication
- **Market segments**
 - business market

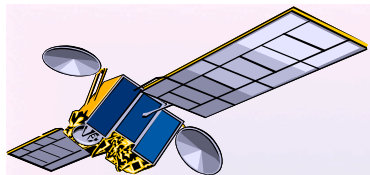




Architecture "B"

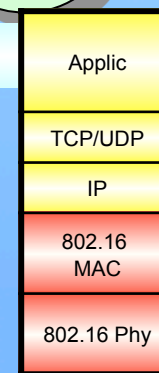
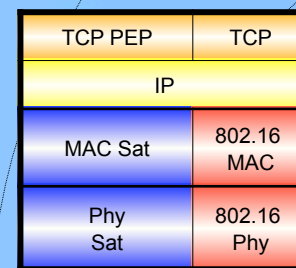
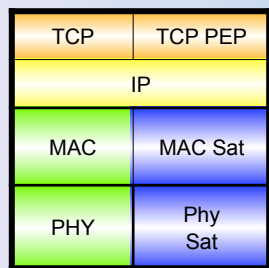
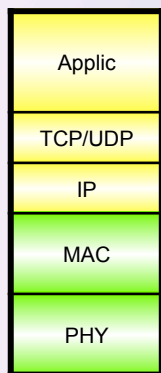
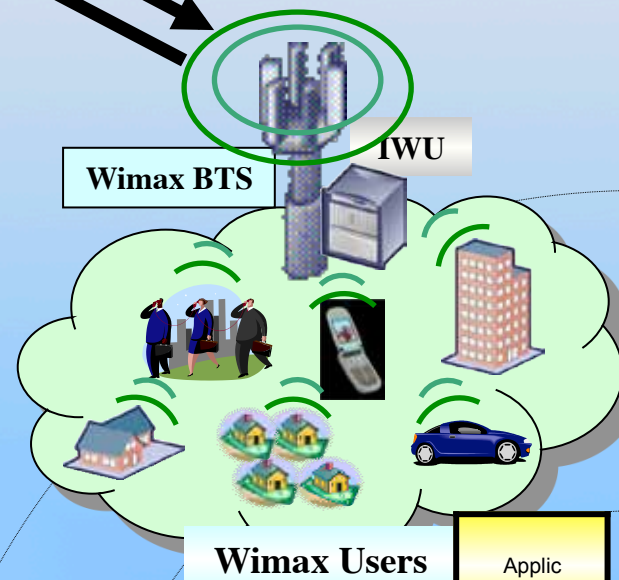
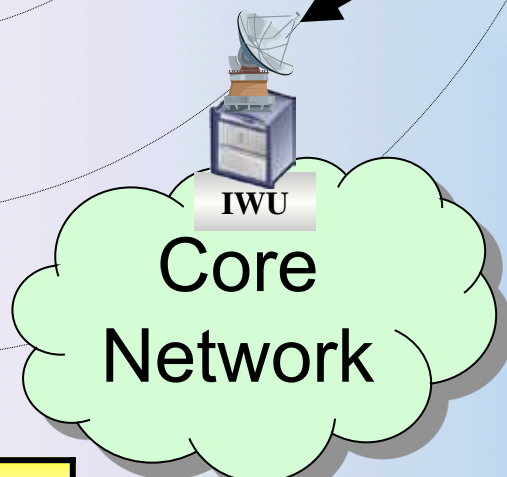
SATELLITE SEGMENT





Architecture "C"

SATELLITE SEGMENT



IAE

User WiMAX

emb

Core Network/IWU

10

Telecommur

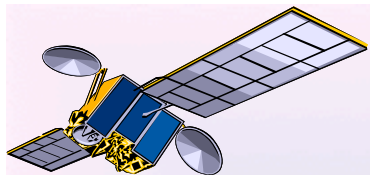
Sat

ns Infrastru

BTS WiMAX/IWU

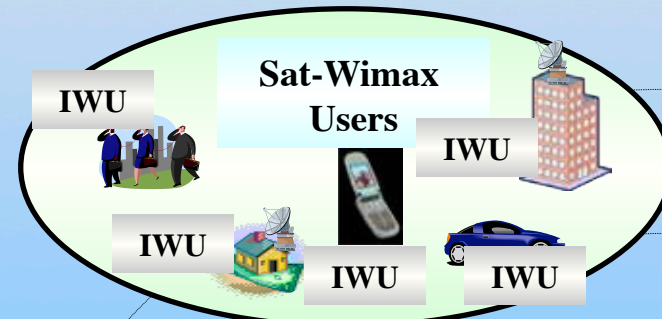
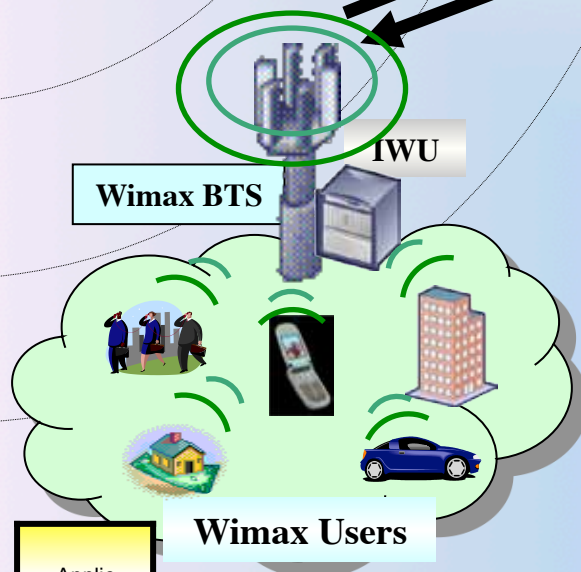
User WiMAX

Emergency Managemer



Architecture "D"

SATELLITE SEGMENT



Applic
TCP
IP
802.16 MAC
802.16 Phy

TCP	TCP PEP
IP	
802.16 MAC	MAC Sat
802.16 Phy	Phy Sat

Applic	
TCP	
IP	
MAC Sat	802.16 MAC
Phy Sat	802.16 Phy

Phy Sat

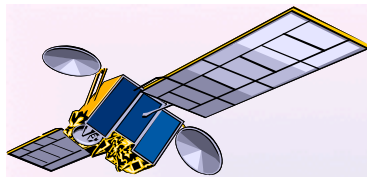


IAB: User mber

BTS
WiMAX/IWU

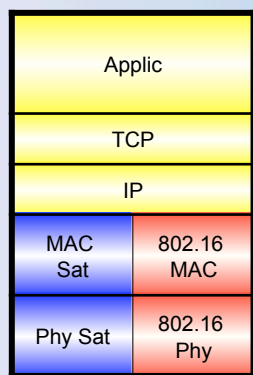
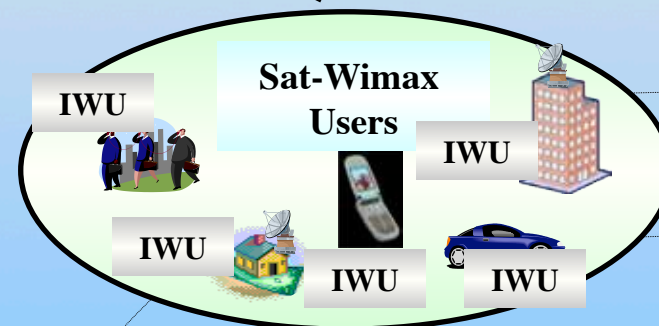
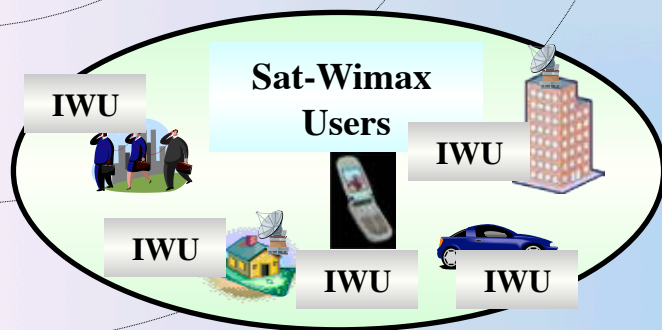
telecommunicat
Emergency Management

User
WiMAX

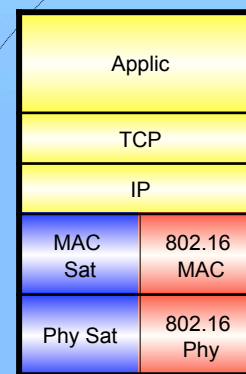


Architecture "D1"

SATELLITE
SEGMENT



User
WiMAX

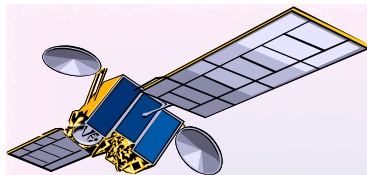


User
WiMAX



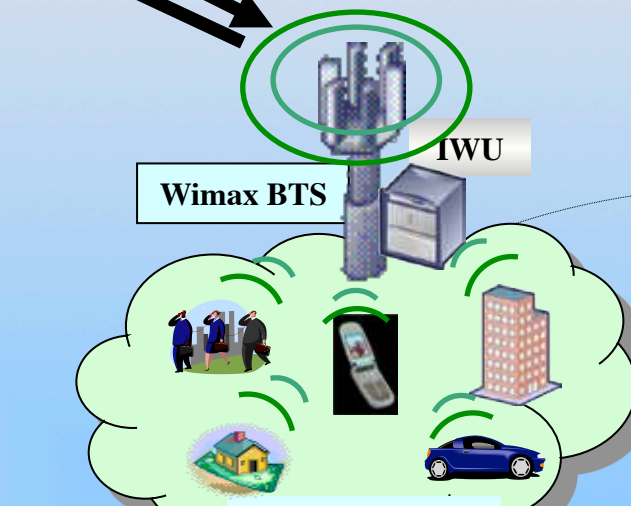
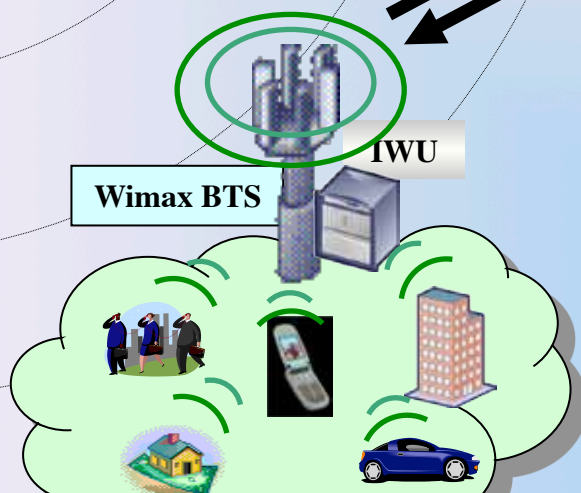
Sat





Architecture "E"

SATELLITE
SEGMENT



Applic
TCP
IP
802.16 MAC
802.16 Phy

Wimax Users

TCP	TCP PEP
IP	
802.16 MAC	MAC Sat
802.16 Phy	Phy Sat

Phy Sat

TCP PEP	TCP
IP	
MAC Sat	802.16 MAC
Phy Sat	802.16 Phy

Applic
TCP
IP
802.16 MAC
802.16 Phy





Architecture “CH”

HAPS Cluster

IWU

Core Network

Wimax BTS



Wimax Users

Applic
TCP/UDP
IP
802.16MAC
802.16 Phy

User

Core

Network/IWU

S

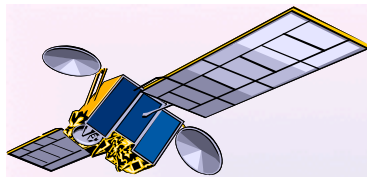
HAPS

HAPS

BTS
WiMAX/IWU

User

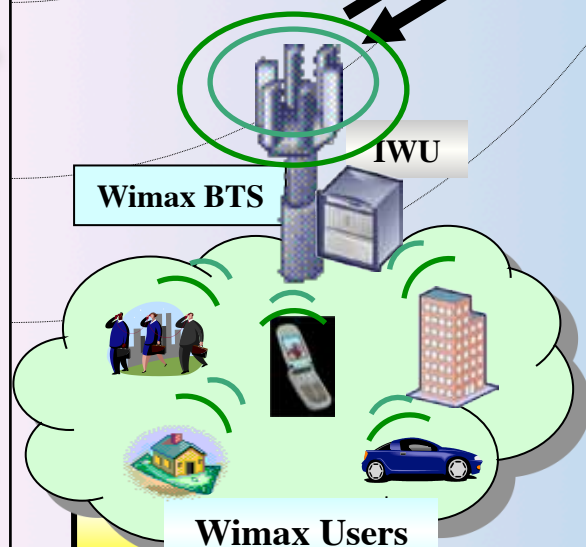
WiMAX



SATELLITE SEGMENT

Architecture "D1H"

HAPS Cluster



TCP	TCP	TCP PEP
IP	IP	
802.16 MAC	802.16 MAC	MAC Sat
802.16 Phy	802.16 Phy	Phy Sat

IAE

User

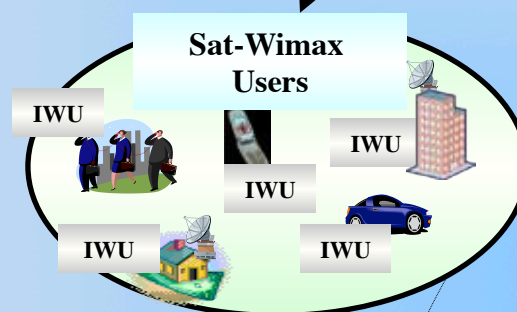
en

BTS

010

WiMAX

WiMAX/IWU



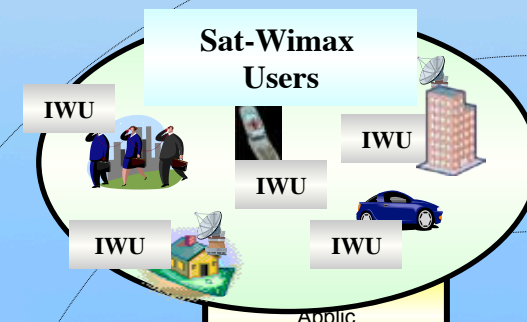
IP	Net HAPS
MAC Sat	MAC HAPS
Phy Sat	Phy HAPS

Phy Sat

Sa HAPS

Manager

HAPS



Applic	
TCP	
IP	
MAC HAPS	802.16 MAC
Phy HAPS	802.16 PHY

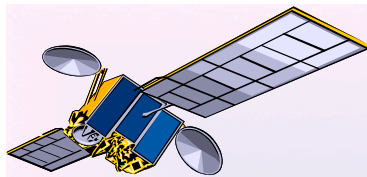
User

Sat-WiMAX



Telecommunications Infrastructures for

32

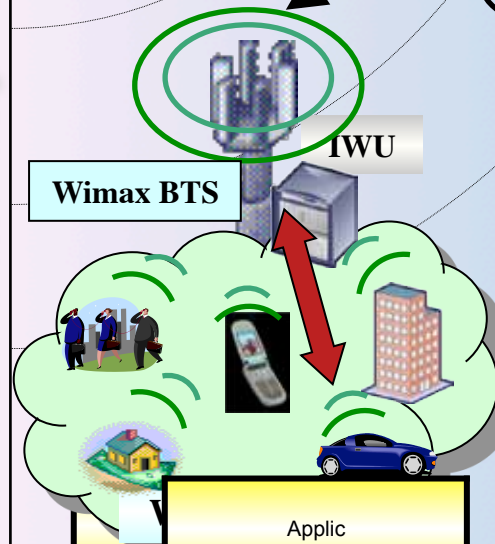


SATELLITE
SEGMENT

Architecture "FH"

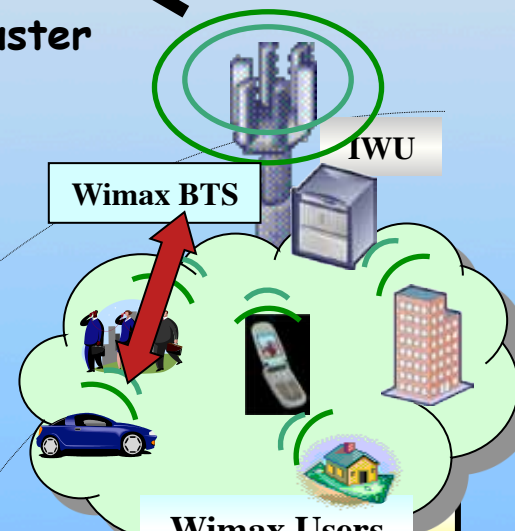


HAPS Cluster



Wimax BTS

IWU



Wimax BTS

IWU

Wimax Users

Applic			
TCP	TCP	TCP	TCP
IP	IP		IP
802.11 MAC	802.16 MAC	2.16 MAC	MAC HAPS
802.11 Phy	802.16 PHY	2.16 Phy	Phy HAPS

Net HAPS	IP
MAC HAPS	MAC Sat
Phy HAPS	Phy Sat

Net HAPS	IP
MAC HAPS	MAC Sat
Phy Sat	

TCP PEP	TCP
IP	
MAC Sat	802.16 MAC
Phy Sat	802.16 PHY

TCP
IP
802.16 MAC
802.16 Phy

IAE

User

Mobile User

2010

HAPS

HAPS

BTS

User

WiMAX

WiMAX

IWU

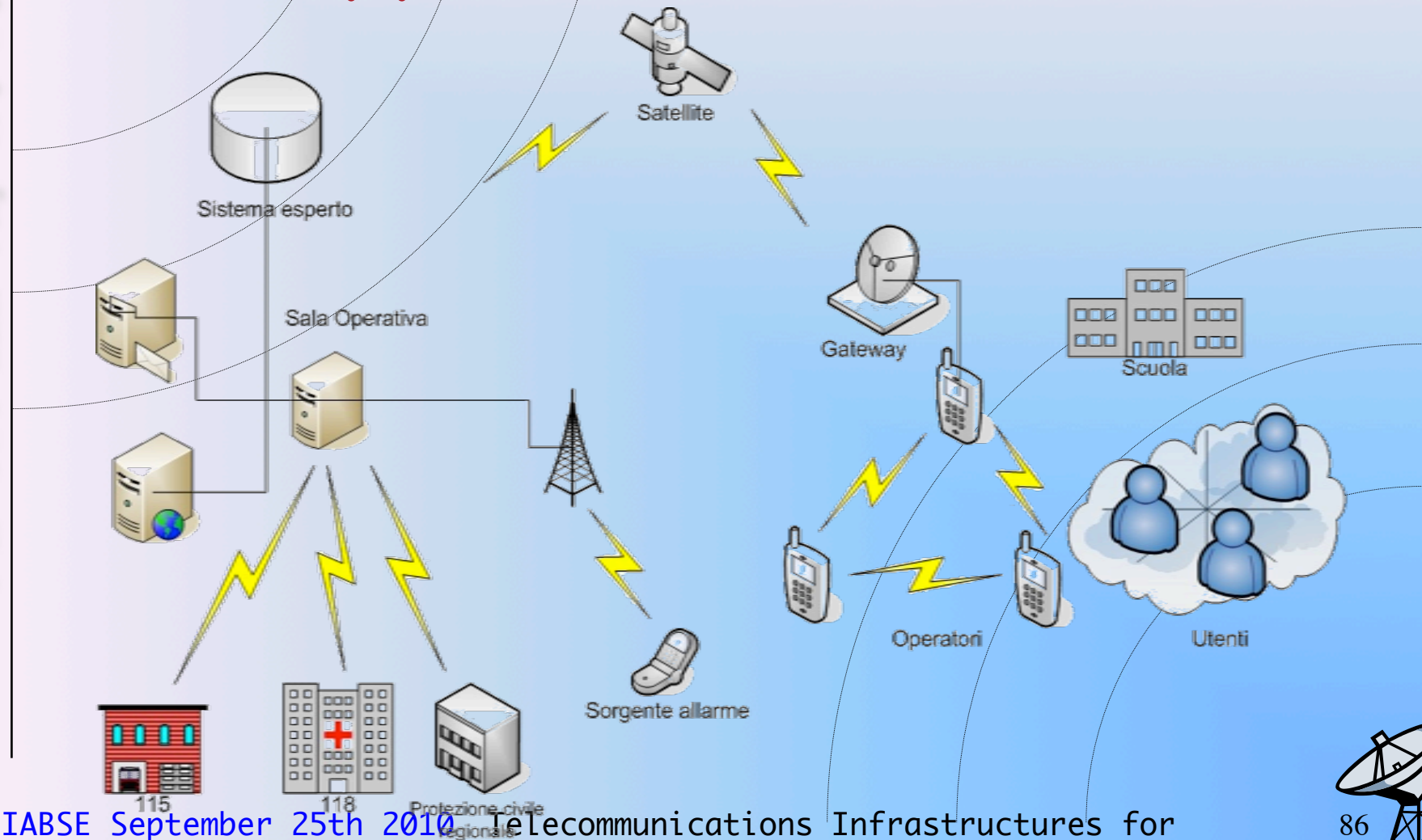
WiMAX/IWU

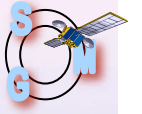
WiMAX

Communication Infrastructures
Emergency Management

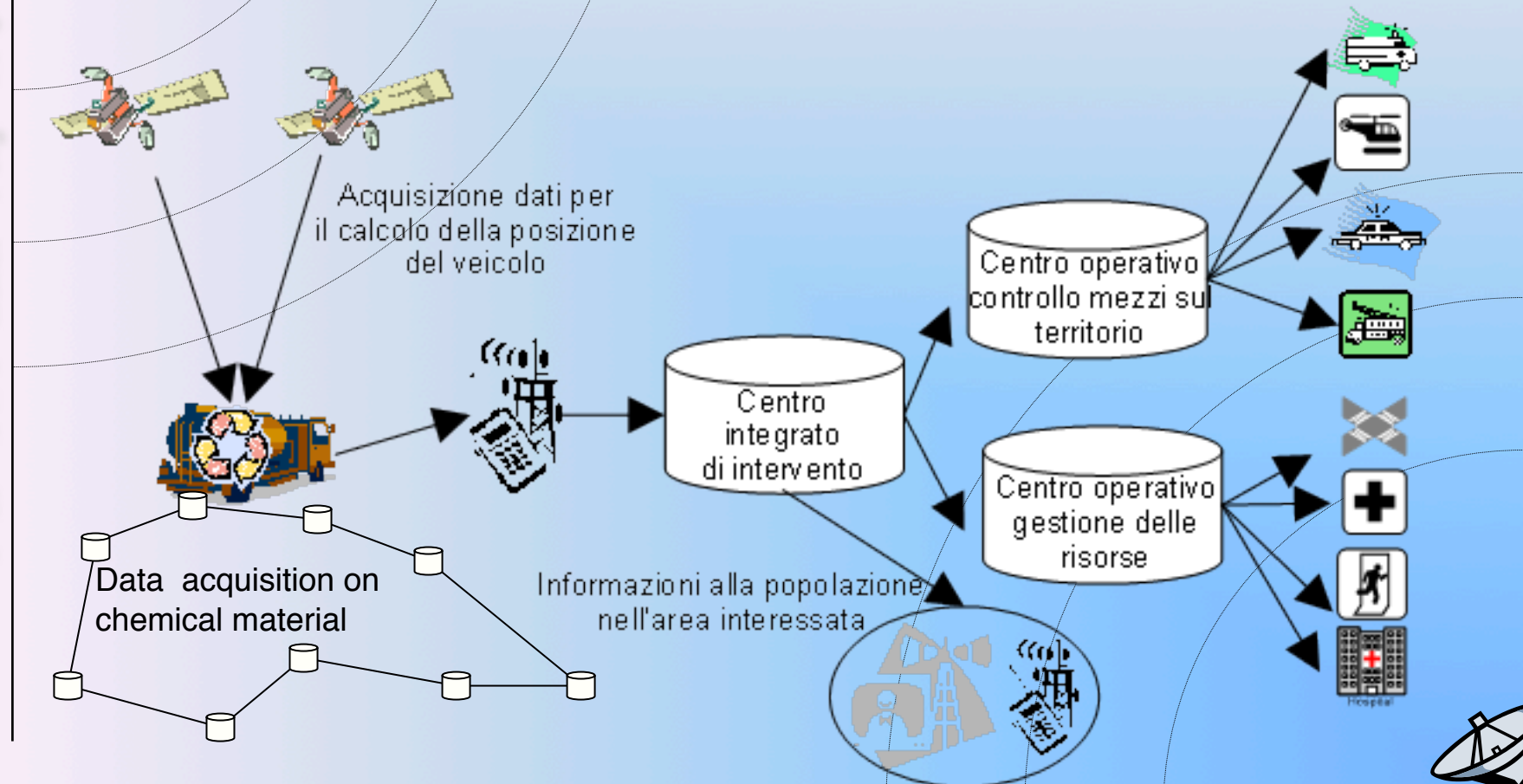


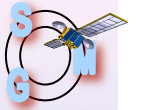
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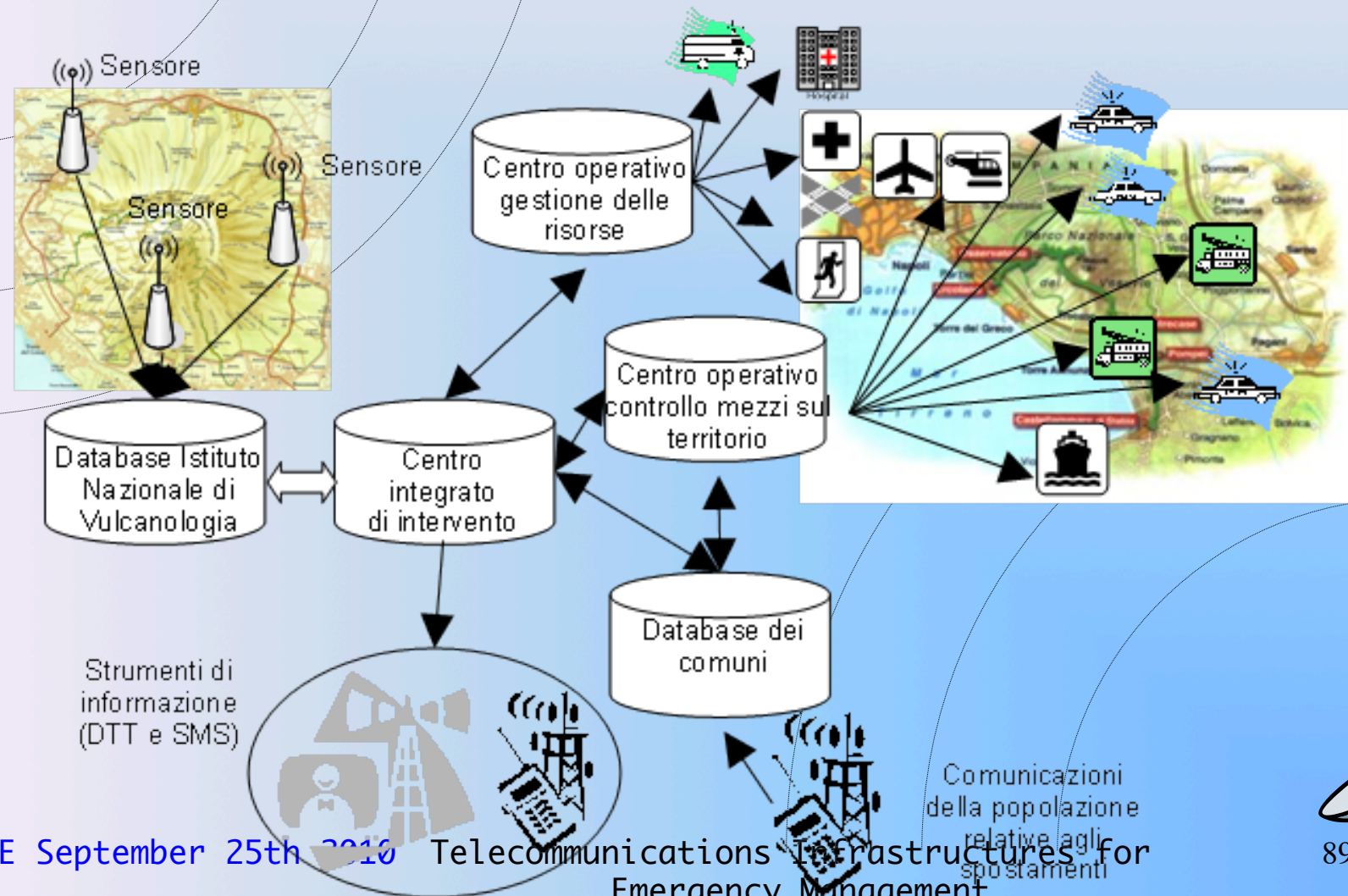


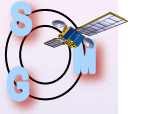
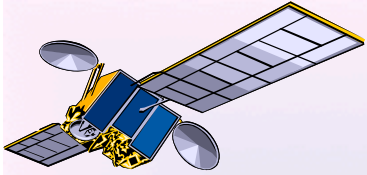
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Innovation

- Integration of different technologies
- Interoperability of heterogeneous technologies
 - Analogical (Isofrequency) and digital systems (IP)
- Support to decisions, even through simulation systems
- Integrated terminals (software radio)



Routing



Call Reception

- Reception
- Number and localization identification
- First aid standard procedure

- Immediate connection with emergency brigades
- Immediate connection with selected data base

GPS



Mobile Units (Voice & Data)

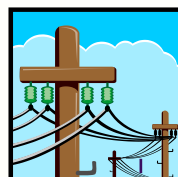


Radio

AVL

TV User

Public network



Emergency Center



DVB T Production Center

Infomobility Center



Call

- Emergency call 911 or 112

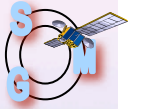


Service center

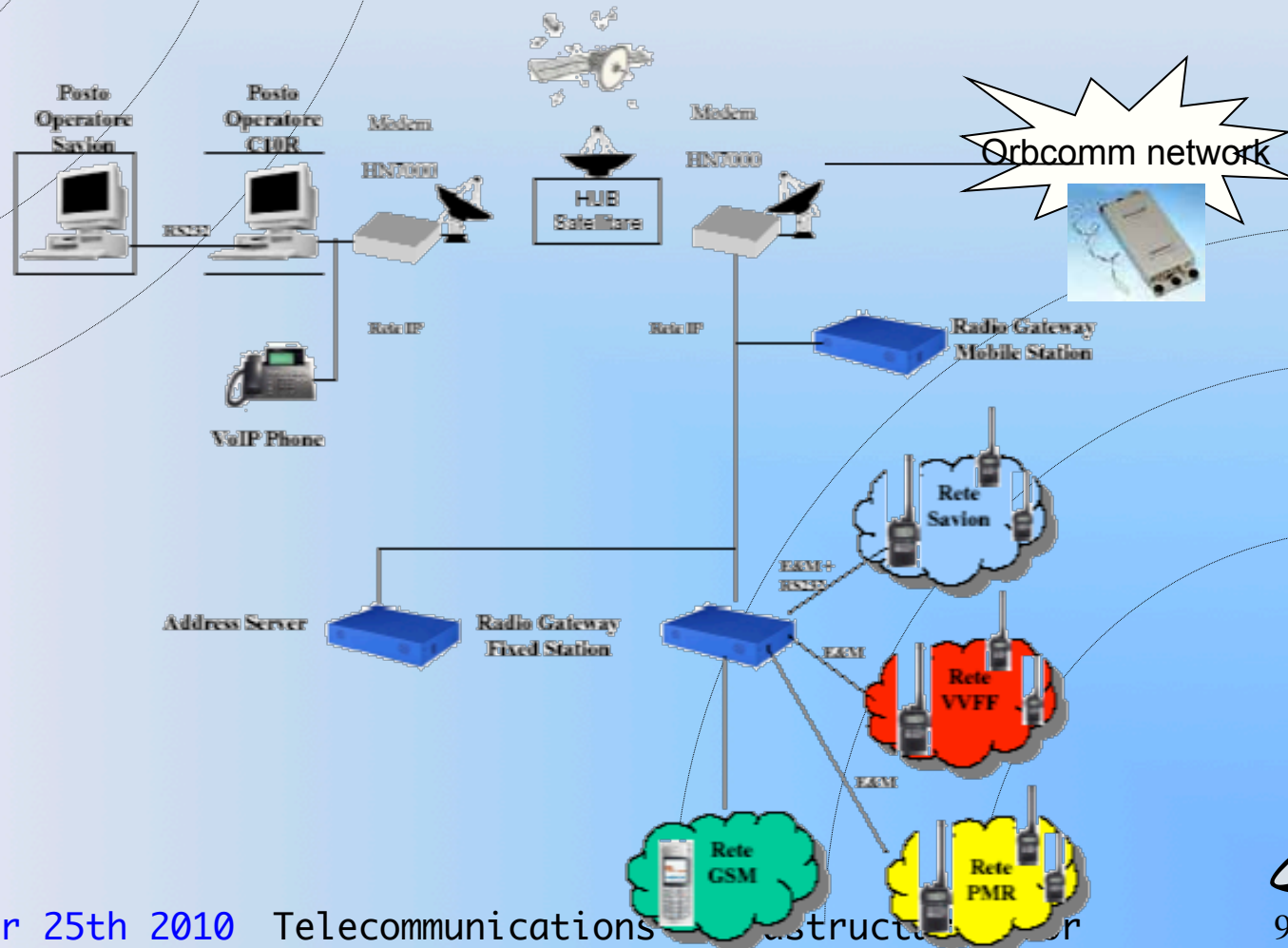
Emergency M...

ber 25th 2010



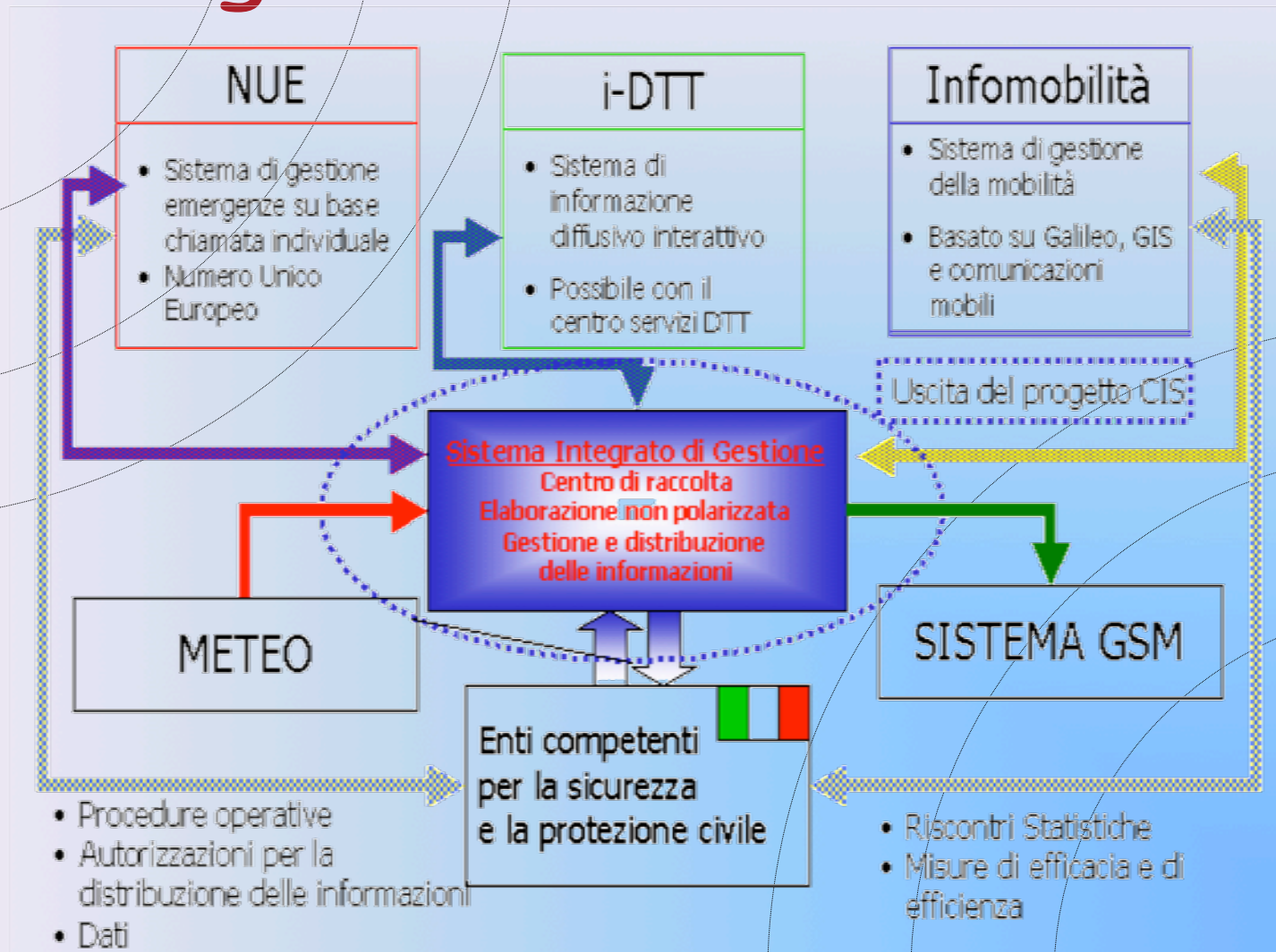


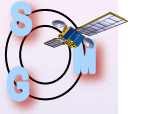
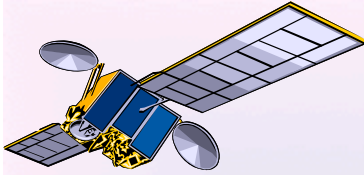
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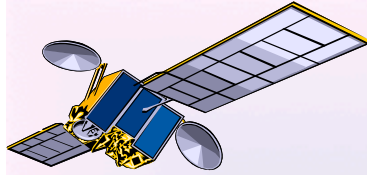
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The EMERSAT Project

- Funded by Italian Space Agency (ASI)
- 14 partners
- Time frame: 2009-2011



The whole presentation can
be downloaded from:

www.tlcsat.uniroma2.it

