Multimedia Satellite Telecommunications Group

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per i Trasporti
e la Logistica

- VSAT Networks
- Heterogeneous networks
- DTN
- Emergency communications
- Telemedicine
- Sat WSN
- Broadcasting contribution networks

- ACM
- Channel modeling
- Link budget

- Analysis
- Performance evaluation
- Design of efficient solutions (TCPN and TCPN+)
- PEP
- TCP-Wave

- DAMA in DVB RCS
- Resource assignement for multibeam systems
- Random Access in DVB-RCS2

- End to end IP
- Multimedia traffic
- Traffic shaping
- Deep Packet Inspection
- MPLS

- Handover
- Channel impairments countermeasures
- Mobile IP
- Protocol adaptation

- Architecture and messaging
- Joint protocol optimizations

- IPsec
- Transport layer adaptation
- Vulnerabilities and countermeasures
- Key management
- DVB RCS encapsulation

- Internet via satellite
- Telecommunication networks
- Telecomunication Fundamentals
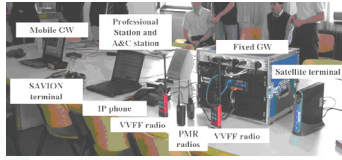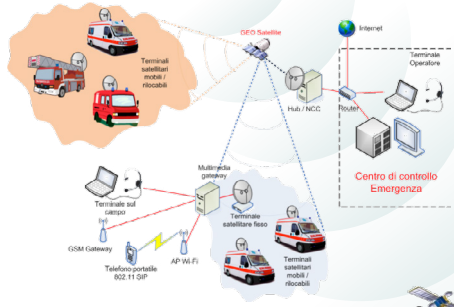- Laboratory of Signal trasmissions
- Broadcast communications

- Traffic analaysis
- New web application assessment
- Cloud Computing
- Transmission optimization
- IoT
- SDN
- 5G integration

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Emuser
(Enhanced MUltiSEnsor data handler for Railways)
- Safety enhancement for level crossing

Cadmo
- Sensor networks for safety/security on public transportation bus

Impulso
- Sensor Networks for logistics

Telesal
- Design of telemedicine and emergency satellite based architectures
- Optimization of network capabilities for heterogeneous application including electroencephalogram transfers
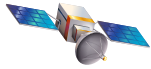
Emersat
Design and set up of a satellite based pilot network for emergency management

Savion
- Interconnecting ad hoc networks with satellite in emergency scenario
- Interface between analogical PMR and digital telephony
- Interface between ad hoc network and two satellite systems (Globalstar, Hughes) for voice and data services

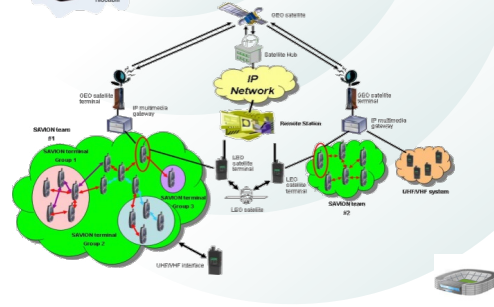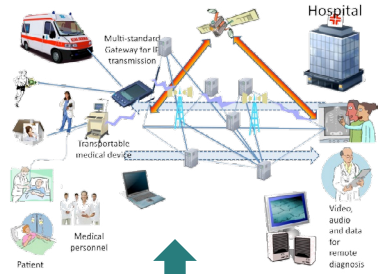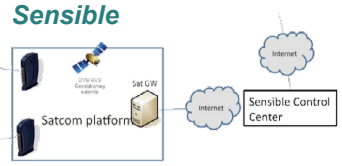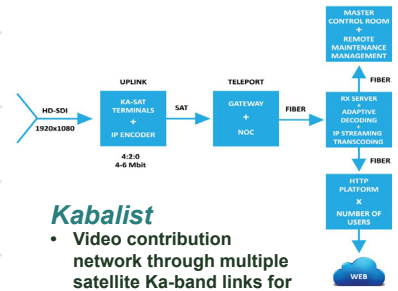### Sensible
- Protocol architecture definition: Broadband on Vessels

Satnex III
- Delay Tolerant Networks
- Wireless Sensor Networks
- Integration of wireless terrestrial and satellite systems

Kabalist
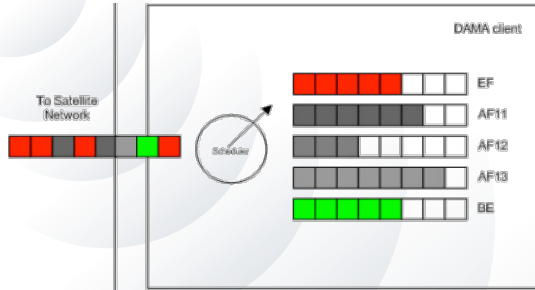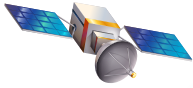- Video contribution network through multiple satellite Ka-band links for IP based web TV platform

System architecture

Telesal

- **Implementation of static and dynamic QoS for satellite segment based on DiffServ**
- **Tests on NS2 and the emulation platform**
- **OBP and transparent payloads**
- **Real Multimedia application (VoIP, skype, etc.) testing on the emulator**

Lift Off

- **Dynamic traffic shaping through Deep Packet Inspection (DPI)**

PST (Athena Fidus)

- **VoIP over satellite**
- **Codec optimization**
- **QoS**
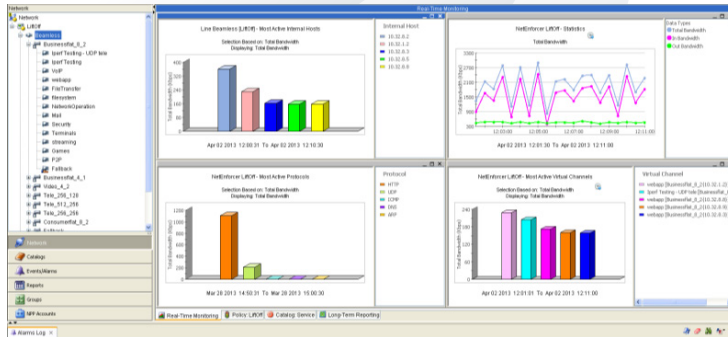
Quality of Service

Locksat (*ESA Innovation Triangle*)

- LOCal Key Synchronization and generation for data security in sATellite communications
- Security key renewal algorithm with frequent key renewal without exchanging data messages over the un-secure channel

Key management

- Design of efficient key management system for data security in satellite communications
- Adaptation to DVB CA and IP
- Simulations in NS2

Satnex
CL-IPsec

- IP Sec adaptation to UDP Lite to provide secure multicast services over satellite systems
- Linux implementation

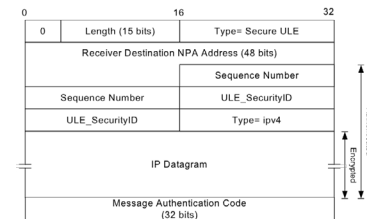| Applications | Services: | • File deliver, video streaming |
UDP-Lite	Services:	• Integrity of sensitive bytes
IP/CL-IPSec	Security services:	• Integrity • Authentication
CL-Link protocol	Services:	• Integrity at link layer

Intersection

- Identify vulnerabilities of interconnected infrastructures
- Identify and deploy countermeasures
- Design and implement an integrated security system
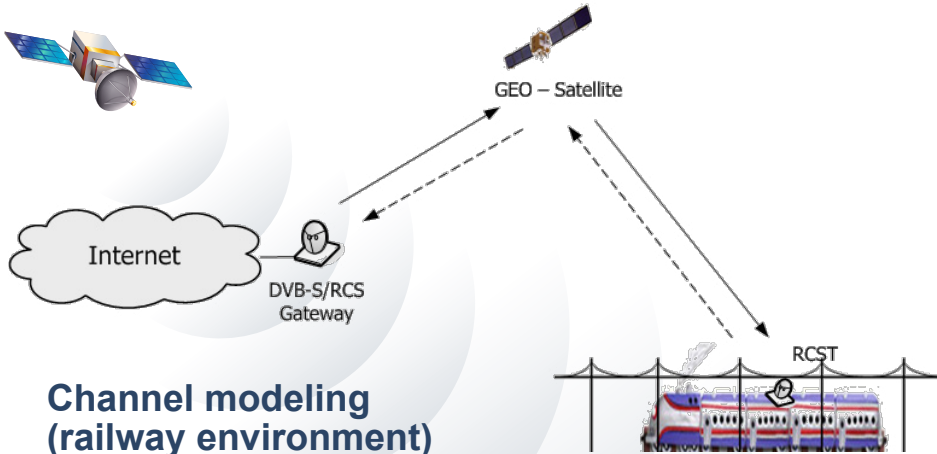- Intrusion prevention

Satellite Vulnerabilities

- Identification classification and countermeasures study (prevention, detection, reaction);
- Test bed implementation
- Linux implementation

DVB-RCS ULE Security

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GEO – Satellite

Internet

DVB-S/RCS
Gateway

RCST

Emersat

Link Budget (Matlab)

- **Interface with STK**
- **Updated propagation models**
- **Complete set of modulation and coding schemes**
- **ACM**
- **OBP and transparent payloads**

Channel modeling (railway environment)

Simulations in NS2 and Matlab

Emersat

(Enhanced MUltiSEnsor data handler for Railways)
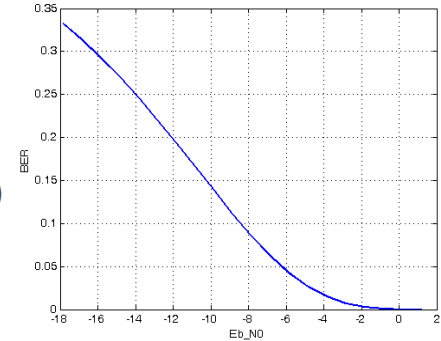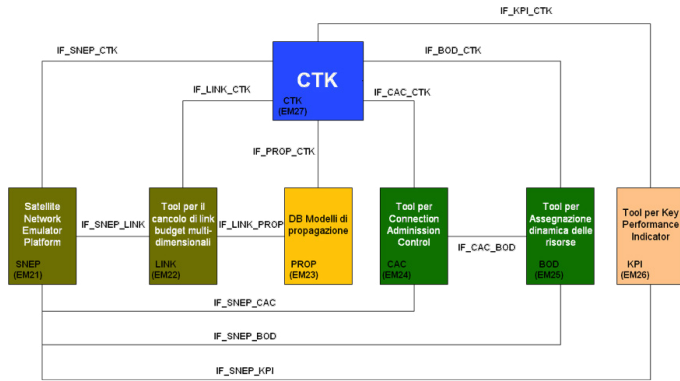
- **Link dimensioning**
- **Network dimensioning**

MUFA

(Metasurface Ultra-Flat Antennas)

- **Link budget**
- **Requirements definition**

Physical Layer

Sensible

- **IP layer bandwidth management**

Emersat

- **Pilot network set up for Civil Protection needs**
- **Network emulation,**
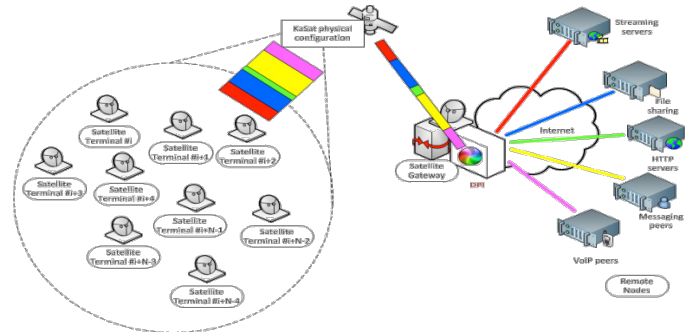- **capacity dimensioning,**
- **STK interfacing**

C2P

**Dynamic resource management
with connection control protocol**

RANDOM ACCESS for DVB-RCS NG
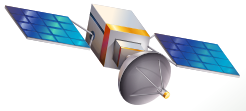
- **Simulations in NS2 and NS3**

Lift Off

- **Dynamic efficient assignment and network dimensioning in multibeam systems**

DAMA for DVB-RCS

- **Standards compliant**
- **New algorithms**
- **NS2 simulations**
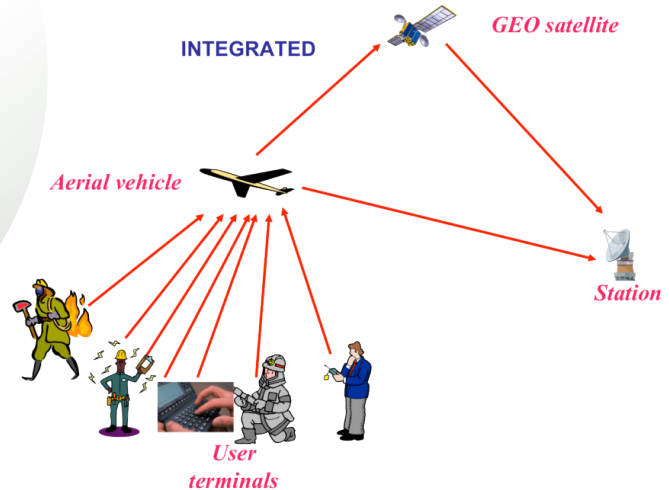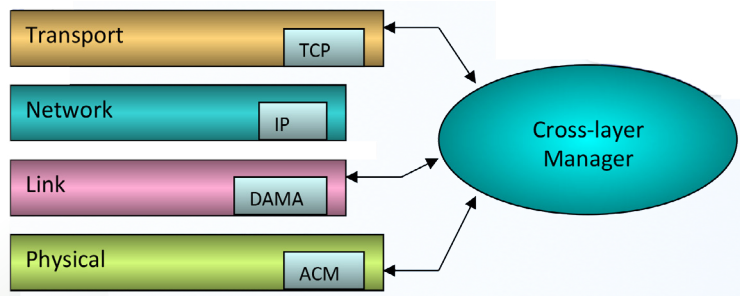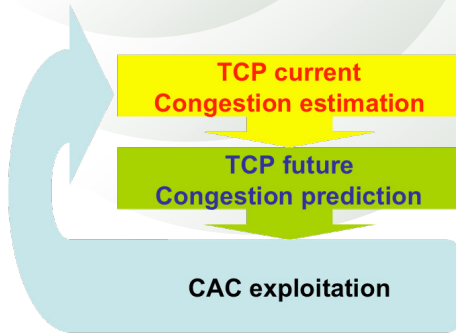- **Linux implementation**

Resource Management

Satnex (I and II)

Multiple cross-layer

- MAC-PHY-Transport Layer mutual information exchange for optimal TCP data transfers
- Simulations in NS2

CAC-TCP in HAPS/Satellite scenario

- Simulation

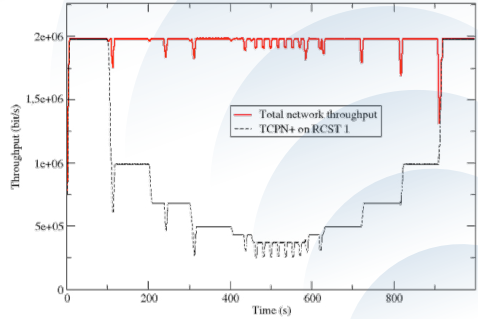**TCP current Congestion estimation**

TCP future Congestion prediction

CAC exploitation

Transport — TCP

Network — IP

Link — DAMA

Physical — ACM

Cross-layer Manager

INTEGRATED

GEO satellite

Aerial vehicle

Station

User terminals

Cross Layer
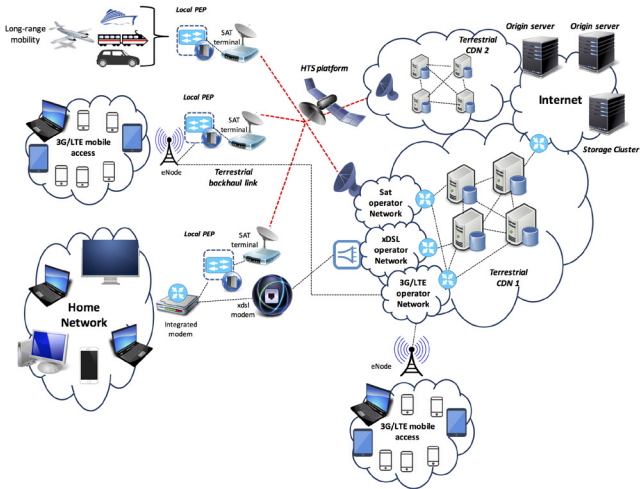
Satnex III

- **Traffic modeling**
- **Testbed set up to assess SPDY protocol performance**
- **New Web traffic analysis**

Cloud Computing and SDN transmission optimization

- **TCPN+ Priority management at transport layer**
- **TCP WAVE (no PEP, terrestrial iot/networks, generalizations of TCPN concept on future heterogeneous networks)**
- **IoT and sensor networks**

Future Internet

RBDC

CRA

TOP

- **Develop and prototype a PEP-transport protocol fully interoperable with Satlabs' I-PEP specification**
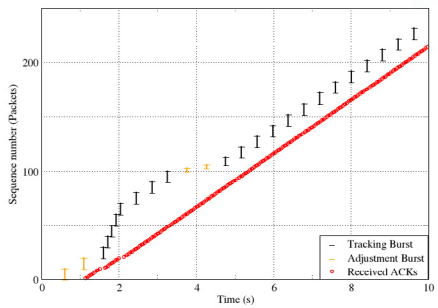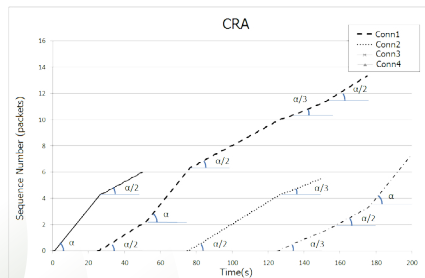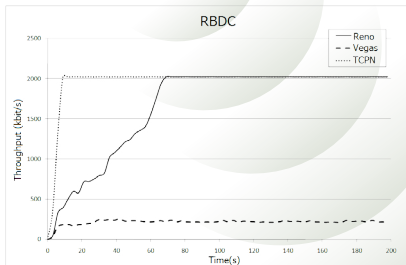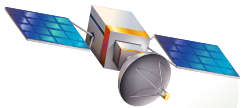- **Interoperable with SCPS-TP**
- **Fair sharing among competitive TCP flows Co-existing with UDP flows Compliant with DVB-RCS DAMA**
- **Optimized for web browsing applications**
- **Fast deliver of short data bursts**
- **Keeps good performance for longer transfers (images, files)**

Satnex I and II

- **Comparative Performance Analysis (Reno, Vegas, Westwood, Hybla, Noordwijk)**

Satnex III

- **Adaptation to Delay Tolerant Networks (DTN)**

VBDC - Friendliness

TCP-Noordwijk

- **New burst-based approach**
- **Outperforms current SCPS-TP**
- **Maximization of the capacity utilization, especially for Web-based traffic**
- **Preservation of fairness among flows**
- **Friendliness with TCP Reno**

TCP/IP
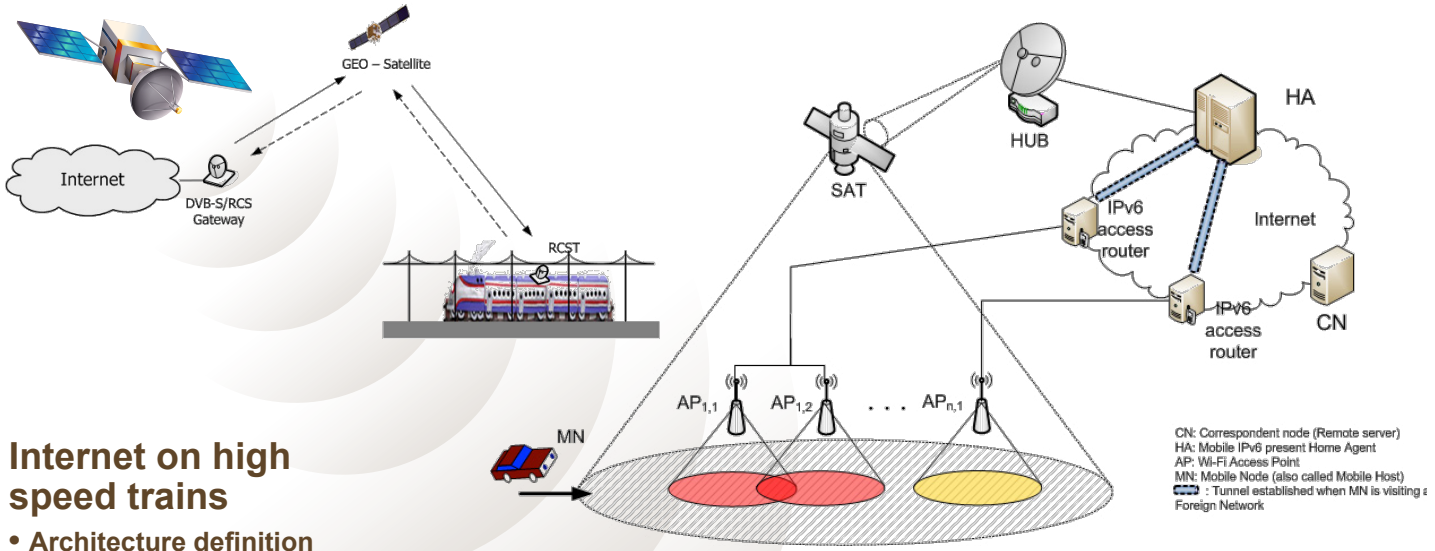
Internet on high speed trains

- **Architecture definition**
- **Trellis impairments characterization**
- **Transport layer countermeasures**
- **Performance evaluation**

Handover

- **MIP**
- **Transport layer adaptation**
- **Multi segment networks (satellite/terrestrial wireless)**
- **TCPN optimizations mobility**
- **Vertical handover/SDN**

Mobility

Internet via satellite class

Up to 50-60 hours teaching (organized in independent modules)
Adaptable to specific requirements

Architecture

| Application | Transport | Internet | Data | link | Physical |

Main topics

CHARACTERISTICS AND PERFORMANCE OF SATELLITE SYSTEMS
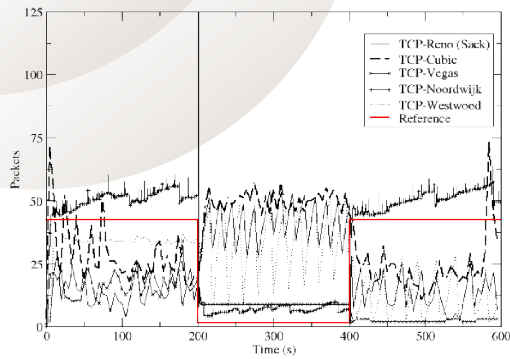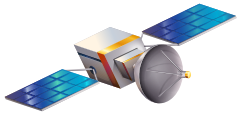
- Orbits
- Physical layer
- Multiple Access
- Network issues

- Spectrum
- Design
- Cost
- Equipment

- Systems
- Services & applications
- DVB RCS systems
- Space and ground segment

INTEGRATION AND INTERWORKING IN THE GLOBAL INFORMATION INFRASTRUCTURE (GII)

SECURITY

NETWORK INTEGRATION

SERVICE SET UP WITH OPERATIONAL SATELLITE SYSTEMS

TESTBED UTILISATION

EXPERIMENTAL RESULTS FOR REAL SYSTEM ENHANCEMENTS

Teaching and training

Telecommunication networks

- Introduction to communication networks
- Basics on communication mechanisms and protocols
- Network architectures
- Internet and the WWW
- TCP/IP stacks
- Web 2.0 and HTML5

Laboratory of Signal transmissions

- Signal generalities
- Basics on Matlab programming
- Signal sampling
- Sampling applications
- Discrete signal convolution
- FFT
- Development of small tools

Broadcast communications
(Transmission of Multimedia Data)

- A brief history of the TV
- Digital TV Systems
- The MPEG Data Stream
- IP Multimedia Subsystem (IMS)

- IPTV Functional Architecture
- Cloud applications
- IP Multicast
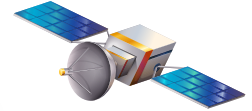
Fundamentals of Telecommunications

Deterministic continuous-time signals

- Telecommunication systems and services
- Definition of signals and ideal transmission
- Representation of signals in time and frequency domain
- Affinity: cross correlation and autocorrelation
- between energy and power signals
- Linear and time invariant transformation between signals and linear time invariant systems
- Multiplexing, analogue digital conversion, basics on channel coding, basics on modulation

Time continuous random variables and stochastic processes

- Random variables theory
- Stochastic processes, generalities, properties and moments
- Gaussian stationary noise not in base band, white Gaussian noise in the signal space
- Markov processes: properties, continuous and discrete time
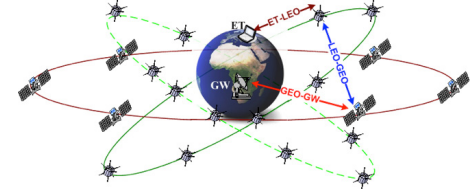
Disturbs and additive noise

Analogue modulation

Teaching and training

Simulation activity

- DVB-RCS2 access scheme has been implemented as core functionality of NS2
  - Combinations of CRA, RBDC and VBDC or Random Access request schemes are available
- S-NS3 Simulation real TCP
- Random access
- Sensor networks

Satellite constellation tool

Developed to perform analysis of satellite constellations.

Able to evaluate coverage areas, delay, link budget, interference with extremely flexible capabilities to vary input parameters such as: orbit configuration (altitude, elevation, number of satellites), antenna patterns, user distribution on ground.

Implements and performs evaluations on double orbit constellations (composed of both LEO and GEO segments). Hybrid constellations architecture foresees a bi directional communication with high capacity link between Earth Terminal (ET) and LEO satellites, which exchanges data with the GEO component, which exchanges data with the end user through the gateway and the terrestrial network.

Evaluates the visibility time for the hybrid architecture (in terms of cumulative distribution and average value) and the amount of data transferred between the network elements. The hybrid configuration can include more LEO satellites and more GEO satellites (interconnected through IOL) according to the service and traffic requirements.

Link budget tool

Realized in Matlab is able to perform a multi-dimensional satellite link budget for transponders (transparent and regenerative) operating in K (Ku/Ka) and EHF band for different communication satellite scenarios (TV broadcasting, telemedicine, emergency positioning "Galileo", and others scenarios).

The LBT can be integrated into a confederation of simulators, such as STK (Satellite Tool Kit) tool, Satellite Network Emulator Platform, and external propagation models.

To perform its functionality and to obtain link budget results the LBT can accept as input the output of an external software exploiting the propagation model which can provide the antenna temperature and/or the attenuation evaluated on the basis of the ITU recommendations.

A graphical user interface has been developed to manage the LBT.
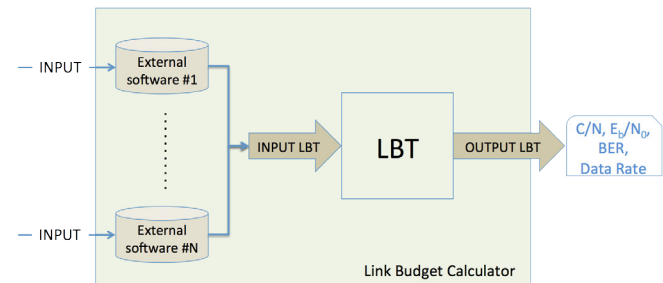
SatCom Emulator: description

- PC/Linux based emulation platform
- Flexible design and realization
- Real time operation
- Star/mesh topology
- Centralized control/management
- Interfaced with real networks
  (Internet, WiFi, GSM, WiMax, etc.)
- Interconnection with other test beds

SatCom Emulator: configuration
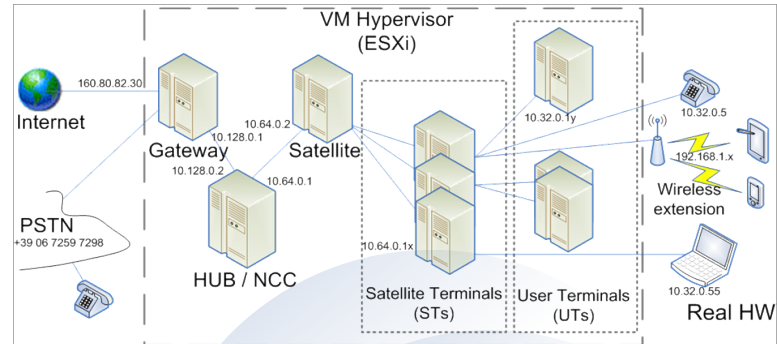
Key features and standards supported

Communication
- Broadband mesh or star architecture
- Narrow band and LEO links
- Real IPv4/6 for uni-multicast/broadcast
- Multiple Virtual Satellite Terminals
- NAT or direct addressing of
   Virtual Sat Terminals
- Acceleration with PEP selecting TCP versions
- Fine tuning of SAT terminals profiles
- Several Bandwidth Allocation Algorithms
- Layer 3 (and above) security frameworks
   (e.g.OpenVPN)
- Connection Control Protocol (C2P)
   for resources on demand

Error models
- Quasi-Error Free (QEF) channel

- Error distribution at the IP level (Ka/Ku bands)
- Plug-in for custom error models
   and external tools

Forward Link Characteristics
- Adjustable maximum rate for broadcast channel
- DiffServ profile for fwd link priority multiplexing
- Multispot support with networking
   management

Return Link Access Characteristics
- Terminal login and synchronization
- Fixed or variable bandwidth allocation:
  - Constant (session-based pre-assignment or SCPC)
  - Dynamic (superframe-based BoD/DAMA)
- DiffServ with MAC mapping
   for fine-tuned QoS

External Interfaces
- Web configuration and test execution GUIs
- Real time probes for system monitoring
- IP tunnel endpoints for remote connectivity
   to other testbeds
- VLAN switch for local interconnections with real
   HW and 3rd parties testbeds
- XML over TCP interface for configuration
   and scenario updates
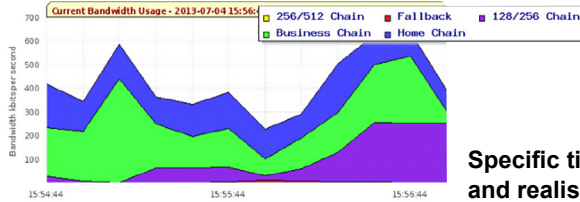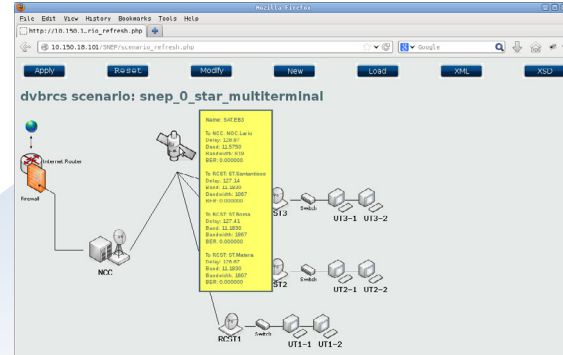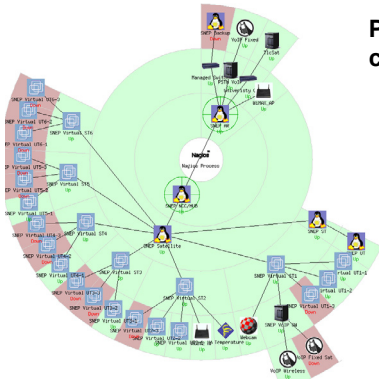
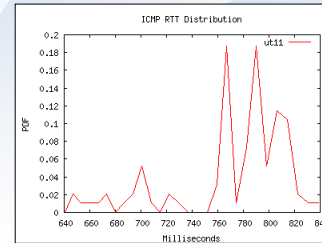**Federation with other tools**
- Matlab
- STK
- NS3
- Open Sand

Emulator Applications and Use Cases

Platform real time configuration status

Specific time-dependent and realistic traffic loads

Real HW, application and realtime monitoring

And much more (real protocols tuning, applications monitoring and setup: Voip, Telemedicine, CCTV, etc.)!

WEB interface

dvbrcs scenario: snep_0_star_multiterminal

Ping Distributions of emulated satellite systems

Emulator Hardware

We can bid with companies and academic institutions in public (ESA, EC, etc.) funded projects and support industries to design, develop and optimize their products.

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Francesco Zampognaro (zampognaro@ing.uniroma2.it)