DEMONSTRATIONS OF NEW TELECOMMUNICATION SERVICES USING STENTOR SATELLITE

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ASTRACT:

This paper presents the project "Demonstrations of new telecommunication services using STENTOR satellite".

The paper indicates the architecture of STENTOR space segment. The features of the payload are given, evidencing the main parameters and the configurations achievable.

The aim and organisation of the future demonstration activities is presented as well as the software tools associated.

Then, the hardware specifically developed for the experiments and demonstrations is presented; it is a set of a few telecommunication ground stations of various sizes, allowing to access the satellite at different data rates.

Finally, the policy applicable to the bodies wishing to participate to telecommunications experiments or service demonstrations is presented; the rules and schedules to be satisfied are explained.

1 THE STENTOR PROGRAM

In October 1994, the French government decided the STENTOR technological satellite program (ref 1) financed by the French Space Agency, CNES, with contributions from the Ministry of Defence and from two industrial companies, ALCATEL SPACE INDUSTRIES (ASPI) and MATRA MARCONI SPACE (presently ASTRIUM), co-prime of the development ; its goal is to develop the national competitivity in the space telecommunications field.

In this respect, the first objective of the STENTOR program is to develop, qualify on ground and validate in orbit new technologies both for the satellite platform and for the payload, which would be integrated in the next generation of telecommunication spacecraft. Thus, STENTOR is the frame in which a large part of the developments of the MMS Eurostar 3000 and ASPI Spacebus 4000 families has been performed.
These developments will be tested in orbit through an intensive set of technological experiments and the hardware behaviour will be analysed throughout the life of STENTOR.

The second objective of the program is to help and promote new transmission techniques and new telecommunication services, thanks to experiments and demonstrations carried out throughout the life of the satellite. Access to the satellite will be possible to telecommunication operators, to industry, to universities…. aiming at developing new technologies, ground hardware and software or telecommunications services.

The STENTOR satellite will be launched in september 2001 by an Ariane V launcher in double launch configuration and will be located at 11°W on the geostationary orbit. The planned lifetime is 9 years.

2 THE STENTOR SATELLITE:

2.1 The platform:

STENTOR spacecraft incorporates a number of innovating technologies:

- the plasmic propulsion subsystem for on-orbit control ; the quantity of Xenon required for plasma propulsion is sufficient for nine years in orbit leading to a 2080 kg launch mass for STENTOR (for a conventional 4 tons launch mass satellite, the plasmic propulsion would save more than 400 kg at launch),
- the plasmic thruster orientation mechanism, improving the thrust efficiency,
- the high pressure tank, allowing a more efficient gas storage,
- the high efficiency gallium arsenide solar cells, integrated in a 2.5 kW solar array,
- the capillary pumped loops, which will be integrated in the thermal control and be electronically activated; in particular, a deployable radiator will provide additional surface to discharge the calories,

- the lithium-ion battery, providing a factor 2 saving on the energy stored by mass unit,
- a GPS receiver which will allow investigations into autonomous station keeping,
- the data handling subsystem, based on 1553 B bus, CCSDS protocol for on board/ground links, redundant central computer, flight software coded in ADA.

2.2 The payload:

The payload is divided into the Ku payload and the EHF payload.

2.2.1 Ku band payload:

The Ku band payload operates within the following frequencies:
uplink: 14.0 GHz-14.25 GHz, downlink: 12.5 GHz-12.75 GHz.

Three antenna are available:
- an ultralight deployable reflector antenna (2.4 m diameter, 9 kg for reflector and source), both receive and transmit, linear X polarisation, fixed coverage centered over France,
- a steerable spot beam antenna, both receive and transmit, linear Y polarisation, allowing to access any point in the visible earth,
- an active antenna, transmit only, linear X polarisation, allowing to generate up to 3 different simultaneous transmissions with different coverages over Europe. The active antenna is made of 48 transmit modules based on MMIC technology allowing individual amplitude and phase control.

The Ku payload configuration is very flexible; the block diagram is given in figure 1; the various switches available can be controlled individually which allows more than twelve Ku payload configurations. The available bandwidth can be split into channels of 36 MHz, 72 MHz or 220 MHz.
The signals can be transmitted either through the active antenna or through the high efficiency linearised TWTA amplifiers, connected to either the large reflector fixed antenna or the spotbeam antenna.
The G/T at the edge of the coverage is 4 dB/K for the spotbeam antenna and 8 dB/K for the large reflector. The maximum possible operating EIRP is 56 dBW edge of coverage.

A digital processing equipment (DVBPROC, ref 2) performs demodulation and decoding of up to 12 uplink carriers in FDMA mode (Frequency Division Multiple Access) compliant with MPEG2/DVB-S format, and gathers them, including coding and modulation, on a single TDM (Time Division Multiplex) downlink.
The maximum useful total data rate is 38 Mb/s, each uplink channel rate being in the range 1.095-7.664 Mb/s.

Apart the path through the DVBPROC, all the other Ku band payload configurations provide transparent transmission.

2.2.2: EHF band payload:

The EHF band payload operates within the following frequencies:
uplink: two channels of 40 MHz, 44.0 GHz- 44.04 GHz and 44.96 GHz-45.0 GHz,
downlink: two channels of 40 MHz, 20.2 GHz-20.24 GHz and 21.16-21.20 GHz.

In addition, two CW beacons are implemented, one at 41.4 GHz, the other one at 20.7 GHz.

Two antenna are available, in right hand circular polarisation:
- a fixed reflector transmit antenna around 44.5 GHz, coverage centered over France and French Guyana,
- a fixed reflector receive antenna around 20.7 GHz, coverage centered over France and French Guyana.

The guaranteed EIRP at saturation and G/T obtained are thus, at the edge of coverage (-3 dB) and for a single carrier 42 dBW and - 3 dB/K for transmission; for the beacons the EIRP is 15 dBW at 20.7 GHz and 22 dBW at 41.4 GHz.

3 THE DEMONSTRATION OF NEW TELECOMMUNICATION SERVICES USING STENTOR:

3.1 Aim of the activity:

The aim of the activity is to help telecommunication operators, industries, universities… to validate in orbit new techniques of transmission or new telecommunication services and applications, thanks to experiments and demonstrations carried out throughout the life of the satellite.

This will contribute to promote to the largest extent the field of space telecommunication, from the ground hardware and software to the satellite payloads.

3.2 Examples of demonstrations:

At the moment, some demonstrations or transmission experiments are already planned :

- ASPI is defining demonstrations involving the DVBPROC equipment, both for video and multimedia applications,
- ASTRIUM has proposed to test air interface dedicated to multimedia satellite communications and to validate applications using these interface. Transmissions tests (propagation..) are also proposed.
- The High Schools in Telecommunications have expressed their interest to test ATM and IP protocols on satellite, and to use STENTOR as a bench for specific applications,
- CNES has planned a series of activities on protocols, modulations and new services,
- Some industrials companies have expressed interest in the field of file transfer or new services (cooperative work…).

3.3 Organisation of the activity:

A specific project team has been settled at CNES to develop the means necessary to provide access to STENTOR to external bodies for demonstration or experimentation purposes.
These means will be gathered into an entity named SSDS (Segment Sol Démonstrations de Services).

The experimenters will have to send an official request to the SSDS, precising the technical details of the demonstration or transmission experiment planned and the associated satellite and ground resources necessary and those wished from CNES.

DGA/CELAR from the French Ministry of Defence will be associated to the SSDS as concerns the EHF payload use.

3.4 Definition of the SSDS:

The SSDS will be split into two main parts:

- the UCE (Unité de coordination et d'exploitation), where the centralised tasks of management will be performed
- ground stations, transportable or fixed, available to the experimenters in the frame of their activity with STENTOR.

3.4.1 The UCE:

The UCE tasks will be as follows:

- to inform about STENTOR and the demonstrations of service
- to analyse and process the experimenters requests, to analyse them technically, to provide telecommunication system support, to identify the means and the tasks necessary,
- to plan the various demonstrations, to interface with the STENTOR ground control segment,
- to manage the means deployment and operation,
- to control the signals transmitted by the users, at least at the beginning of their experiments,
- to analyse frequency technical issues,
- to process data, eventually data from the experiments themselves, on a case by case basis,
- to archive the data.

The experimenters requests will have to arrive to the SSDS several weeks before any demonstration; the SSDS will manage a global planning of the activity.

3.4.2 The ground stations:

The experimenters wishing to use STENTOR may use for the access to the satellite their own hardware, i.e. their own ground stations, if compatible with the satellite payload. For the other users who would not have this hardware, the SSDS will be in a position to provide them with ground stations for the period of their experiments, according to the hardware availability.

In this purpose, CNES is procuring a number of various ground stations, whose preliminary list is given below:

- 3 User Terminal stations: antenna diameter 2.4 m, maximum operation EIRP : 65 dBW, G/T : 25 dB/K,

- 1 Multimedia stations: antenna diameter 2.4 m, saturation EIRP : 75 dBW, G/T : 25 dB/K,

- 1 Mobile stations, on board a van : antenna diameter 1.5 m, saturation EIRP 65 dBW, G/T 22 dB/K,

Complementary stations should be ordered in the future and in addition, two other types are under analysis :

- High Rate: antenna diameter 3.7 m, saturation EIRP : 80 dBW, G/T : 30 dB/K,

- 20 GHz receive, 44 GHz transmit: antenna diameter 1.2 m, G/T : 21 dB/K, 71 dBW.

The access to the stations will be possible for the users either:

- at intermediate frequency at L band typically, the experimenter being responsible for the modulation and coding of the signal in this case,

- on a data link such as an Ethernet bus, or a SDH interface, the ground station in this case dealing with the coding and modulation.

The stations to be developed by CNES will potentially be organised in a network, to allow experimenters to settle simultaneous communications between various experimental sites, typically 4 to 6 sites simultaneously. Thus, remote LAN interconnection will be possible to test new applications or services.
2 to 3 groups of such user networks may access the satellite simultaneously to perform different experiments and demonstrations.

Three examples of such possible networks using CNES stations are listed below (not exhaustive list):

- at intermediate rates between 1.095 and 7.664 Mb/s, it will be possible to establish a full mesh communication network (figure 2) between up to 12 sites, using the DVBPROC equipment, allowing to broadcast MPEG2 TV signals or to communicate between the stations with an IP protocol,
- at rates between 10 and 100 Mb/s, it will be possible for the stations to communicate in FDMA mode using IP protocol in a full mesh configuration; the individual data rates will be defined not to exceed a global rate about 100 Mb/s
- it will be possible to establish point to point communication using ATM protocol at 155 Mb/s.

4) Rules for access to STENTOR:

The major rules concerning the access to STENTOR will be:

- An agreement document has to be signed between CNES and the experimenter on a case by case basis, recalling the general rules and the particular conditions of the experiment or demonstration,
- The access to the demonstration activities is free of charge, but the experimenter should participate to the additional costs induced to CNES by its experiment (operators for the satellite, transport of the hardware, installation support…)
- The use of STENTOR will be possible on an experimental basis nominally, excluding commercial use,
- No commitment of CNES about a satellite or ground segment availability figure, STENTOR being an experimental satellite, but guarantee of best efforts from CNES so that the demonstrations are successful,
- Commitment from the experimenter that he will publish about his demonstration, expectations and major learnings, but his intellectual and industrial property rights will be guaranteed,
- CNES will inform widely about STENTOR, the associated means, the demonstrations program, the list of the experiments effectively conducted and the major outcomes,
- The experimenter is responsible for his demonstration and commits to conduct it; the experimenter also commits on processing the data,
- The intellectual property rights of CNES, DGA, France Telecom, ASTRIUM and ASPI are preserved in the frame of the demonstrations,
- Non-French experimenters will be welcome, provided they can establish a cooperation with a French partner at a major level for their demonstration.

5) Conclusion:

The STENTOR satellite will be sent in orbit in September this year ; it will be a major step in the space telecommunications field, allowing in orbit validation of numerous new technologies.

The STENTOR satellite will also be a very powerful tool to experiment new transmission techniques or demonstrate new telecommunication services and applications.

CNES is now developing the means to provide access to the satellite to the largest possible community of users (universities, laboratories, administrations, industry, operators…) intending to promote as far as possible the space telecommunications.
More information on the project can be found in the NSS WEB server at the following address : **nss.cnes.fr**

6) References:

1- STENTOR programme, B.Ehster, proceedings of the Euro-Asia space week on cooperation in space, 23-27 November, 1998, Singapore (ESA-SP 430, February 1999)
2- The DVB processor on STENTOR, A.Duverdier et al, ECSS conference, Toulouse, september 1999.

Figure 1: Ku band payload block diagram:

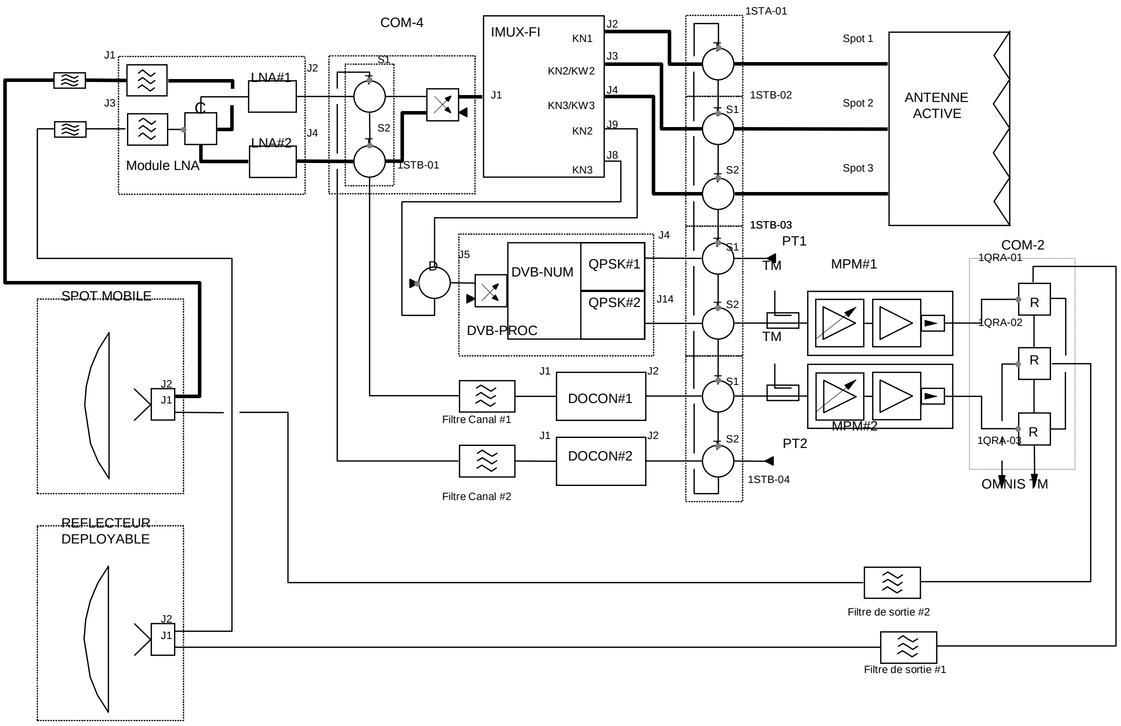

Figure 2: Network configuration using on board regenerative DVBPROC equipment: