ITU Symposium and Workshop on small satellite regulation and communication systems

Small satellites missions from the French space agency (CNES) and application of the ITU Radio Regulations

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1. **EYESAT very small satellite from CNES: purpose and description**

2. **Vision of CNES concerning small satellites and future developments vis à vis the Radio Regulations**

EYESAT: CNES satellite: observation of the zodiacal light

CNES EYESAT is a small telescope in a triple Cubesat. It should provide a survey of the intensity and polarization of the light scattered by interplanetary dust cloud, leading to a better understanding of the properties and origin of its particles.

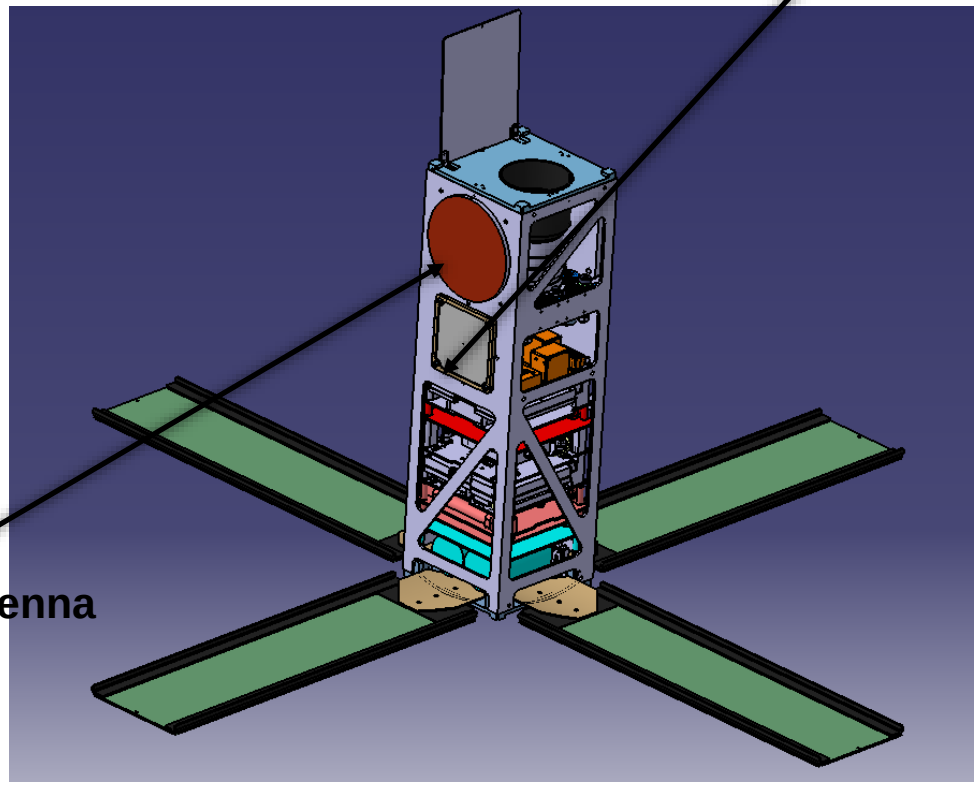
The interplanetary dust cloud extends from the Sun to at least the asteroid belt, with a symmetry plane slightly inclined on the ecliptic plane. Studying, from Earth's orbit, the intensity and linear polarization of the solar light scattered by interplanetary dust, the so called zodiacal light, is of high interest.

Deep overall image of the Milky Way 360 in the visible and near infrared.

EYESAT satellite

Sun synchronous orbit 6h/18h, altitude 700 km, almost circular

25 minutes of visibility in Toulouse at 10° of elevation angle



S band transmitter/receiver: RF characteristics

For the satellite transmitter

Frequency band: within the band 2200-2290 MHz
RF Power from 27 to 33 dBm
Data Rate: One fixed rate from 10 kbps to 3 Mbps
Modulation: QPSK/OQPSK
Convolutionnal Coding (7;1/2)
Consumption: around 9.0W for 2W RF output

For the satellite receiver

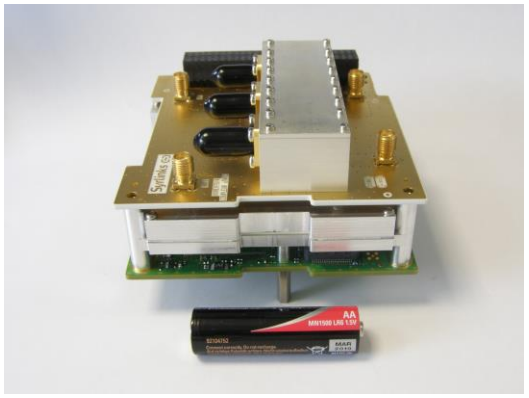
Frequency band: within the band 2025-2110 MHz
Modulation: PCM/SP-L/PM
Data Rate: One fixed rate selectable between at least 8, 16, 32, 64, 128, 256 kbps
Maximum Doppler shift: +/-66kHz

S band transmitter/receiver: mass and volume characteristics

Mass: less than 400 g

Dimensions without diplexer: 96 x 90 x 22,8 mm3

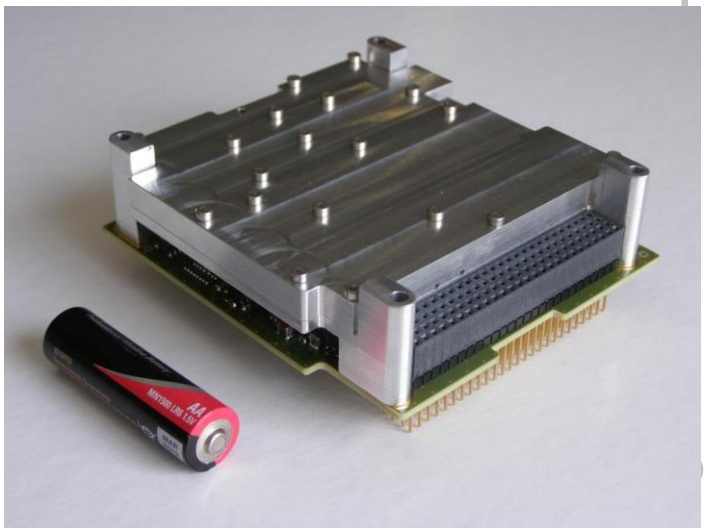
Consumption : 10 W for 33 dBm RF output



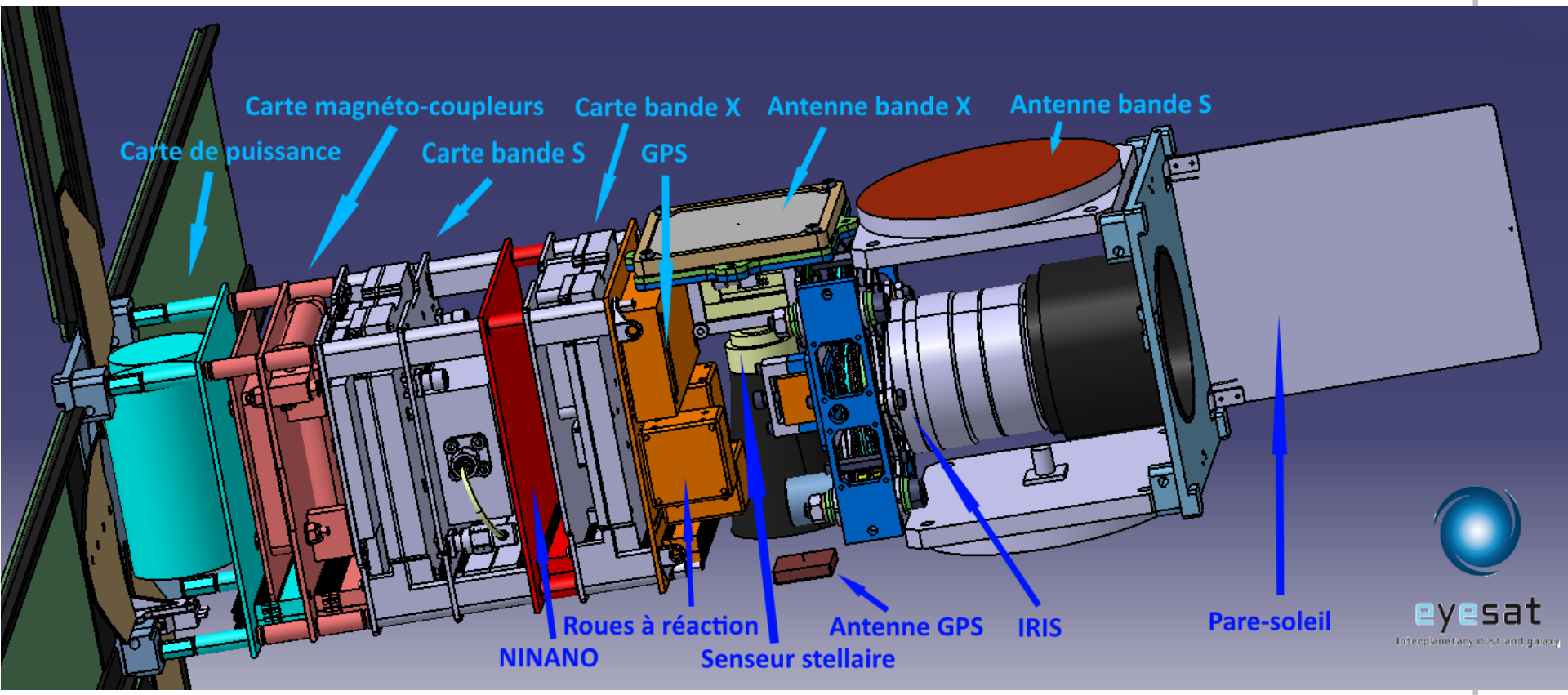
Views of the S band TT&C transponder with 2 diplexer configurations

X band transmitter and EYE-SAT X-band antenna

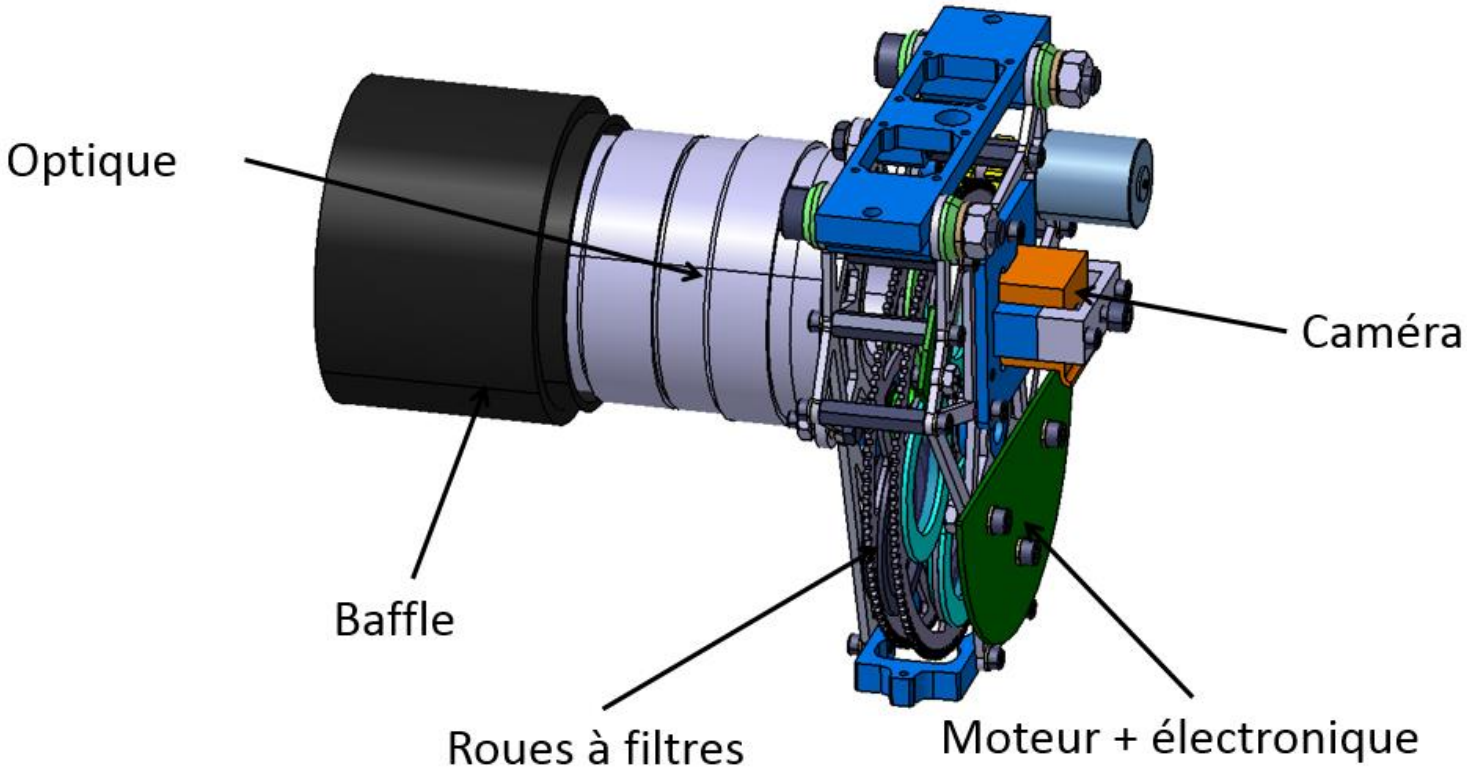
Mass: less than 400 g
Dimensions : 96 x 90 x 22,8 mm3
Consumption : 10 W for 33 dBm RF output
Useful data rate from 2.8 up to 50 Mbps (up to 100 Mbps in specific case)
Offset-QPSK modulation + CC(7,1/2) coding
Transmit power = 3 dBW at 8.4 GHz
Antenna gain (boresight) = 11 dBi
On board losses = 3 dB
Eirp = 11 dBW



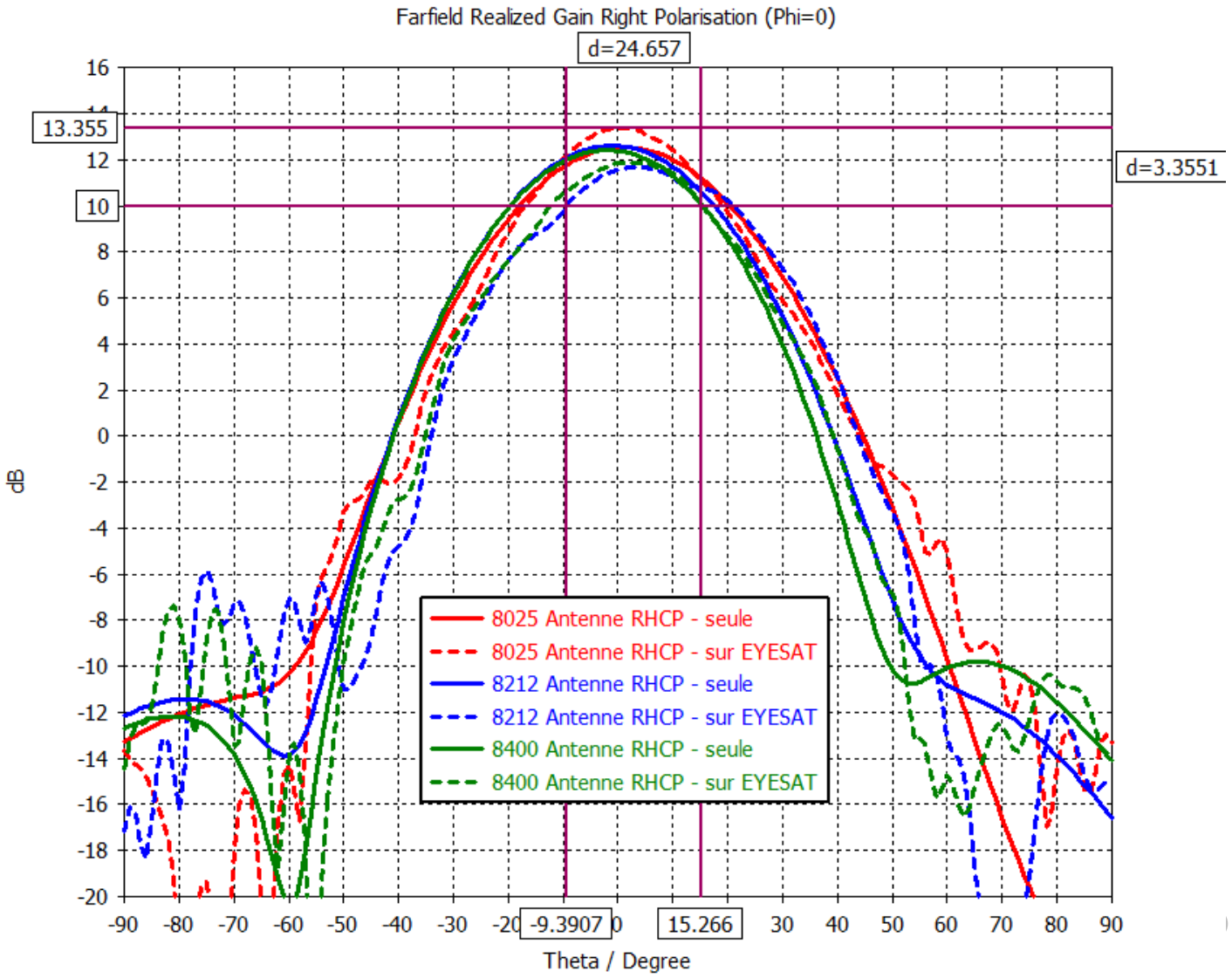
EYESAT satellite



IRIS instrument:
Imager Realized for Interplanetary dust Study



EYESAT on BOARD Antenna



EYESAT PERFORMANCE

EYESAT mission: to make a 3U CubeSat as efficient as possible.

Communication system: about 15 Gbits per day.

EyeSat integrates the Micro X-Band HDR-TM transmitter connected to a directive antenna with an axis gain of 10 dBi. Eye-Sat should reach data rates of 47 Mbits/s during pass, thanks to a ground station pointing mode of the satellite.

4 solar panels, 6 cells of 1 W per panel: 24 W in total

Total mass of EYESAT = 5 kg

1 year expected life time

SUGGESTION OF RULES FROM CNES TO LIMIT INTERFERENCES IN THE BANDS USED BY ITS VERY SMALL SATELLITES

The following rules for S and X bands will be observed for CNES/JANUS/nano satellite program led by CNES (EYE-SAT is the first JANUS nanosatellite, among about 10 nanosatellites to follow).

Rule 1 : The total band used for a transmission: maximum of a third of the total band allocated (X-band, Ka band for the future) or the maximum band recommanded (S-band) :

- **For X band Telemetry Payload, the total band allowed is (375 MHz)/3 = 125 MHz**

- **For S band TT&C, the total band allowed is (6 MHz)/3 = 2 MHz**

Rule 2 : The total RF transmitted power is fixed by the link budget with a data rate limited by the bands mentioned above, with a 3 dB margin as a maximum for Telemetry Payload, and 10 dB for TT&C to cover safe mode and tumbling.

CNES VIEWS on SMALL SATELLITES

This example shows that EYESAT can use traditionnal satelliteTelemetry-Telecomand frequency bands without causing interference to existing systems and while not using the entire available bandwidths.

EYESAT will be filed soon to BR as a "normal" satellite.

Importance of taking care of the existing usage of satellites.

Recently, some satellite providers operating small or very small satellites such as micro microsatellites (10–100 kg), nano-satellites (1–10 kg), and pico-satellites (0.1–1 kg) have declared satellite networks using for telecommand purposes, frequency bands within the current MSS, METSAT and EESS allocations, especially below 1 GHz.

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In these networks, output powers at the antenna port of these telecommand links (Earth-to-Space) from the Earth stations to the satellites: up to 50 W or more, within the METSAT, EESS and MSS frequency allocations bands below 1 GHz.
These telecommand links: ground antennas having maximum gains up to 10 dBi or more.

Corresponding e.i.r.p (Earth to Space) up to 27 dBW.

The range of these ouput powers/eirp envisaged for these small satellites are much higher than the moderate/low powers traditionally used for service links in those bands, especially in the frequency bands dedicated to Data Collection using satellite, such as 401-403 MHz or 399.9-400.05 MHz.
These telecommand links could cause a total blindness - during significant amounts of time - of the existing receivers when interfered by telecommand links in the same frequency band.

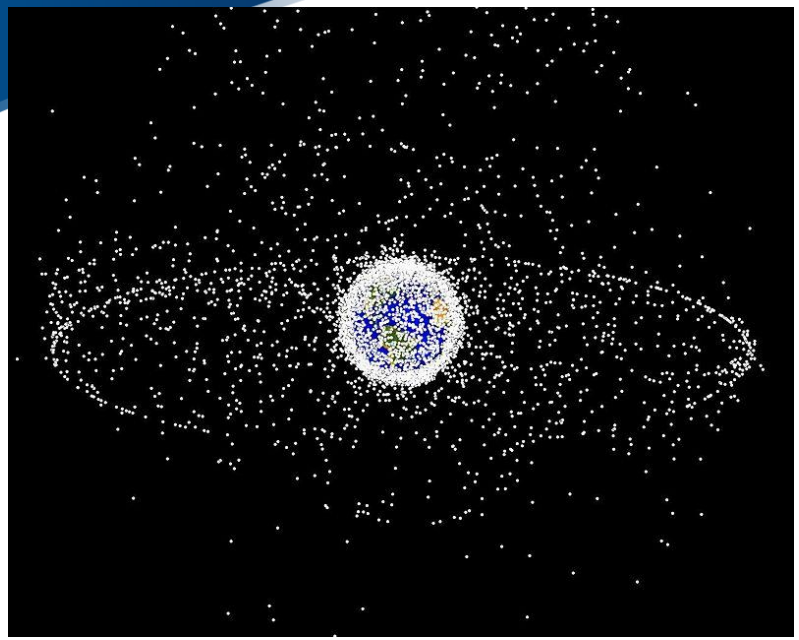
CNES VIEWS on SMALL SATELLITES

Should the developpment of small and very small satellites grows, importance of finding Space operation service frequency bands that would fit to small satellite networks, having specific characteristics (RF power, antenna gains, …).

The existing Earth Exploration Satellite band, METSAT and MSS bands SHALL NOT be interfered and remain unaffected.

Need of a search of frequencies below 1 GHz and above 1 GHz for small satellites.

SPACE DEBRIS ISSUE



Agreement on the 25 years: nations should not launch objects whose lifetime in space will exceed 25 years after the completion of their missions.

French law on Space Operations also called LOS (Loi Opération Spatiales, December 2010): many issues on space debris including the rule of the 25 years

SPACE DEBRIS ISSUE

Type of space object	Altitude in km	Time to enter the atmosphere
Small satellite of 5 kg	600	25 years
Small satellite of 10 kg	600	25/30 years
Space station	400	1 year
Big earth observation satellite	830	200 years
GEO transfert orbit	600 x 36000	10 000 years
GEO orbit	36000	Millions of Years

EYESAT: natural de orbit in less than 22-24 years: accordance with the LOS (no device is expected to accelerate the satellite return).

CONCLUSION

3 preliminary conclusions

1. Very small satellites can be a nice solution for some scientific missions which do not need big satellites.

2. Importance of filing the satellite network taking care of the radio frequency existing usage.

3. Rule of the 25 years to avoid space debris: suggestion of application of rules similar to the french law called LOS.

Thank you for your attention!