Arsat-2 Debris Mitigation Plan

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1. Introduction

This document describes the space debris mitigation plan that Arsat shall apply to the **Arsat-2** space station.

Arsat-2 is based on the indigenous Arsat-3K bus and it was manufactured according to European and American standards. The satellite is 3-axis stabilized and it uses bi-propellant chemical propulsion for attitude and orbit control. Main components (including tubing) are made of titanium.

Arsat-2 was launched September 30th 2015 and the end of its operational life is not expected to be before early 2030.

The Arsat-3K platform was developed in the frame of the SSGAT program in Argentina. As the aim of the program was the development of a telecom satellite platform in a relatively short time, it was decided to rely on well proven design concepts and suppliers. Its main structure and propulsion subsystem inherit heavily from the well-known Spacebus 3000B from TAS (same central cylinder and propulsion subsystem design and components, except for thruster's location). Power generation uses Airbus solar arrays, with an ETCA PCU identical to the units used in the Galileo program. Main computer is also from Airbus (although the attitude control electronics was designed and build in Argentina), and attitude sensors and actuators are from Selex-ES and Honeywell. Battery is Lithium Ion from SAFT. All in all, the platform design goal was to lower the risk, so the structure has high safety margins, mainly made of carbon-carbon composites.

The propellant tanks are OST series, 760L manufactured by Airbus Bremenn with Ti6A14V alloy. Burst pressure is 29.95 bar, with an operating pressure less than 19.5 bar (design margin is 1.5 against burst, 1.25 against rated pressure). Current tank filling is 312 Kg (237 liters) of MMH and 209 Kg (216 liters) of MON. Launch filling is 1033 Kg and 640 Kg respectively. Tank pressure is monitored during normal mode operations. The system operates in pure blow-down (no possibility to repressurize).

The helium pressurant tank is 89.5 liters, COPV, manufactured by Airbus SAS. Rated pressure is 375 bar, and burst pressure 600 bar. Current helium pressure is 47 bar.

2. Arsat-2 Operations

- Arsat operates its satellites in order to control and limit the amount of debris released in a planned manner during normal operations, and assesses and limits the probability of the space station becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal.
- The spacecraft structure is made of carbon and aluminum composites, which constitute a good shield against small meteoroids. Moreover, the platform design is robust to any single failure, in such a way that any foreseeable collision wouldn't preclude the resume of normal operations or, in the worst case, deorbiting.
- Arsat has assessed the amount of debris released in a planned manner and no intentional debris will be released during normal operations of the **Arsat-2** spacecraft. A safe operational configuration of the satellite system is ensured thanks to the hardware design and operational procedures.

- Arsat minimizes the probability of the satellite becoming a source of debris by collisions with large debris or other operational satellites. **Arsat-2** is operated in 81.1ºW +/- 0.05º by standard orbit control maneuvers. There is no overlapping with other satellite's window. In case that any satellite anomaly leads to a window violation, the Guidance, Navigation and Control team will plan the required reinsertion maneuvers as soon as it is operationally feasible.
- Arsat has assessed the probability of accidental explosions during and after completion of mission operations. Thanks to design safety margins and enough safety barriers, the probability of occurrence of accidental explosion of the Arsat-2 satellite is negligible.
- The satellite propulsion system is disabled during normal operations, and it is enabled just during the station keeping maneuvers, which last about 2 hours, twice every week, thus unforeseen thruster activity which may cause unexpected changes in the satellite orbit are impossible, except in case of a catastrophic failure of the propulsion subsystem.

3. Arsat-2 End of Life disposal

The orbit of the satellite will be raised by 350 km in order to ensure that the spacecraft will not re-enter into the GEO protected region (GEO height +/- 200km) in the long term. A mass of 6.34 kg of propellant have been allocated and reserved with a confidence level of 99% to carry-out the post-mission disposal maneuvers. The FCC will be informed of any significant change to the above quantity of propellant. Nevertheless, the platform design allows for deorbiting even using propellant residuals and remaining pressurant in the propellant tanks.

The minimum perigee height to avoid re-entering into the GEO protected region can be computed using the IADC formula applied to this satellite:

ΔH (km) = 235 + 1000.(C_r.A/m) = 267 km
With C_r=1.5, A=28m^2 and m=1307 Kg

Therefore, the planned 350 km above GEO height is sufficient to satisfy the 267 km requirement. During the satellite lifetime, Arsat determine the remaining propellant tanks using both bookkeeping and PVT methods.

As part of the end of life activities Arsat-2 energy sources will be rendered inactive, such that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the satellite. For Arsat-2, this involves the following:

- depleting the chemical propulsion system, and where possible leaving open fuel lines and valves[1]. A de minimis amount of helium pressurant—47 bar— will remain at satellite end of life. This is well below the 375 bar pressure rating for the vessel, and provides a safety margin of 12 times the burst pressure of 600 bar..
- leaving all batteries in a state of permanent discharge by disabling the battery charge circuits and depleting the batteries before satellite deactivation.

[1] There is nothing in the design which may preclude emptying the propellant tanks to exhaustion. However, the operation to do it shall be planned carefully to have a safe attitude control in order not to jeopardize the disposal orbit parameters.

- The satellite tracking, TM and TC usage during reorbiting are planned so as to avoid interference to other satellites and coordinated with any potential affected satellite networks.
- During the orbit raising maneuvers the tracking, TM and TC frequencies were limited to those where the satellite is authorized to operate.

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