



# POLITECNICO MILANO 1863

## Reverse Engineering of Juno Mission Homework 5

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### Group 5

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# Notation

TCS Thermal Control System

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## 1 Introduction of TCS

## 2 Analysis of thermal conditions along the mission

## 3 Architecture and rationale of TCS

The TCS of Juno must tackle a wide range of thermal environments, as discussed in [REFERENCE](#). The cold case however is the most critical condition for the S/C, so TCS is mainly designed on this situation: the vault, the main body and the external hardware are all thermally insulated and decoupled. Heaters are also present on each individual section/sensor. This guarantees flexibility in order to ensure the operating temperature for each component. Despite the insulation, more than half of the power generated at Jupiter is demanded by the TCS just to heat up the S/C.

Four main zones were identified for the following analysis:

- **Vault:** all the main electronic hardware is contained here. The size of this box is  $0.8\text{ m} \times 0.8\text{ m} \times 0.7\text{ m}$ . The lower surface is attached to the main body while the top surface is linked to the HGA, lateral surfaces points outwards and mainly to deep space. The walls are made of 1 cm thick titanium walls. This metal has a low conductivity value ( $\approx 6.7\div 7.4\text{ W/mK}$ ) which is a positive feature for the cold case at Jupiter. Also, major heat generation happens during science orbits since all the instrument electronics is powered on. In addition, the low external thermal flux during science imposes additional requirements in relation to the optical properties of the lateral vault surfaces. Tantalum MLI blankets were used in order to ensure both low emissivity and absorptivity ( $\epsilon \approx 0.01 \div 0.035$  [REFERENCE](#)). However, during the phases in which the thermal flux is at its highest (TP3), the vault shall be able to dissipate enough power. This is in contrast with the above mentioned design choices. To ensure compatible thermal environment in the vault, three louvers were applied on its external lateral surfaces in order to point deep space and have an efficient IR emission. The dimension of a single louver is  $0.53\text{ m} \times 0.40\text{ m}$ , two of them are placed vertically while one of them is placed horizontally. The motivation for this choice is relative to the internal configuration of the electronics. The opening of the louver' shutters raises the emissivity value from 0.14 to 0.74 ([REFERENCE](#) produttore), enabling higher out-going radiative heat flux. The justification for this passive and low complexity solution was mainly due to the fact that the hot case scenario was encountered only during a restricted time of the overall mission. Moreover, the louver technology effectiveness was tested and ensured by previous interplanetary mission such as Rosetta and New Horizons. However, most of the radiation coming from the sun was shielded by the HGA which protected the vault. The Germanium coated Kapton used to cover the antenna dish has an operating range temperature of  $-200^{\circ}\text{C} \div +200^{\circ}\text{C}$ , while its absorptivity and emissivity values are  $\alpha = 0.568$  and  $\epsilon = 0.72$  respectively [REFERENCE](#). The HGA will heat up and exchange radiative heat with the lower vault, hence the necessity to dissipate heat also from the electronic vault with louvers. The electronics contained in the vault are tightly packed to reduce the effects of internal reflection of high energy particles that can still penetrate the walls. From a thermal viewpoint this means that the generated heat is better retained and the internal temperature of the hardware is fairly uniform.
- **Main body:** it is the hexagonal prism that contains most of the propulsion subsystem hardware (propellant and pressurizer tanks, feeding lines and ME). Two payload sensors are also present inside, namely UVS and JunoCam. All of this elements
- **External hardware:**
- **Solar panels:**

## 4 Reverse sizing of TCS

## Bibliography

- [1] Richard Grammier. *Overview of the Juno Mission to Jupiter*. Site: <https://www.jpl.nasa.gov/missions/juno>. 2006.