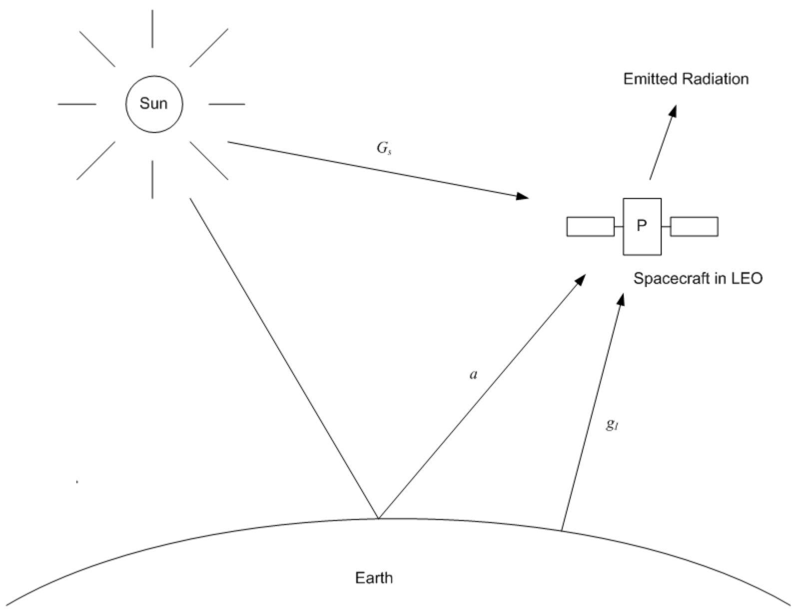
6 Thermal

6.1 Thermal Equilibrium Temperatures

In order to make a design for a thermal control system to meet the temperature requirements one need to identify the heat sources affecting the system. The heat sources for a spacecraft orbiting planet Earth is the Sun, the Earth and also the heat produced by the system itself denoted P below:



The estimated equilibrium temperature for a body in space is obtained by the energy balance equation which is a derivative from the conservation of energy:

$$Absorbedenergy + Dissipatedenergy - Emittedenergy = 0$$

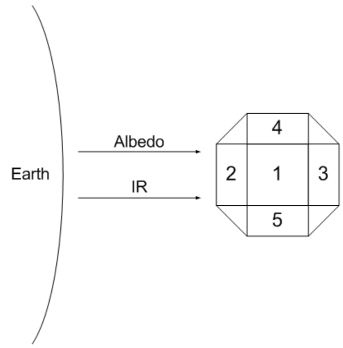
$$q_{absorbed} + q_{dissipated} - q_{emmited} = 0$$

Case:
Let us consider an add-on spacecraft module with the structure shown below consisting of 5 surfaces

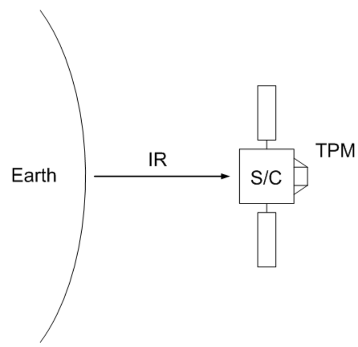
And let us also define a **hot** scenario for the module situated on a S/C orbiting Earth at an altitude of 500 km to be:

Technische Universitï¿½t Mï¿½nchen
Institute of Astronautics
Boltzmannstr. 15
D-85748 Garching
www.lrt.mw.tum.de

Tutor:
Dipl.-Ing. Martin Langer
Room: MW 2602
Phone.: 089/289-15995
Email: martin.langer@tum.de



with the normal vector of surface 1 parallel to the incoming solar radiation and also a contribution of albedo and IR radiation from planet Earth. Further, a **cold** scenario can be defined as illustrated below



without any influence of direct sunlight or albedo.

- Solar constant at 1 A.U is 1418 W/m2
- Earth IR emission at 500 km altitude is 222 W/m2
- Earth albedo 0.35
- Internally generated heat dissipation is 40 W (hot case only)
- Consider white painted surfaces
- Side x=0.2 m

Answer the following questions:

1. What will be the uniformly distributed equilibrium temperatures for the system containing surface 1 to 5 in the hot- and cold scenarios respectively, only considering radiation as heat transfer?

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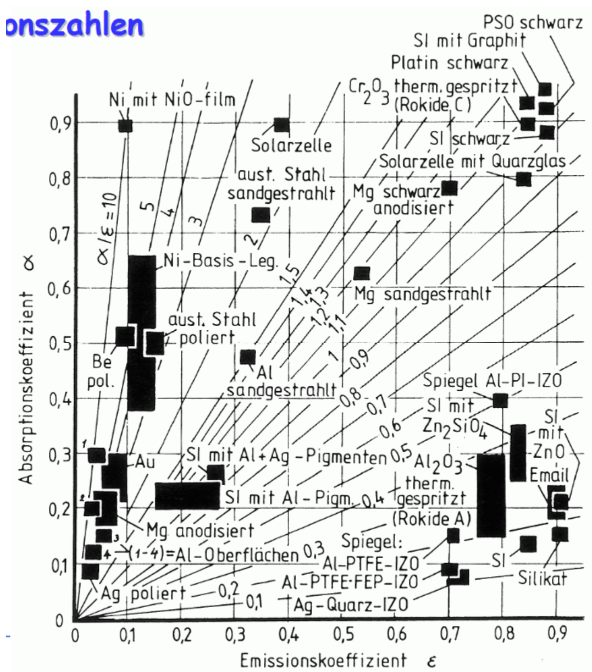
2. Consider gold coating on all the surfaces and calculate the new hot case equilibrium temperature for the system

3. Assume a heat flow from the S/C body to the module (in the cold case) that corresponds to an internally generated heat dissipation of 10 W and calculate the new cold case equilibrium temperature.

4. Assume that the internally generated heat can be transferred to a space radiator onboard the hosting S/C. What is the required area of the space radiator when its working temperature is 30°C and it is white painted?

5. Calculate the new hot case equilibrium temperature for the module when the space radiator is assumed to take care of the internally generated heat.



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