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ICOTOM: INTEGRATED NARROW BAND INFRARED RADIOMETER

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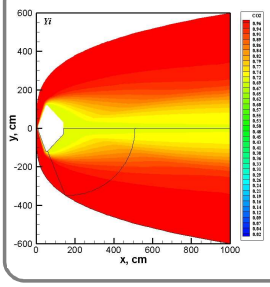
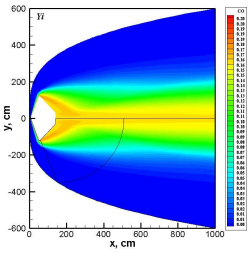
CONTEXT & OBJECTIVE



•During the entry of the EDL demonstrator in the Martian atmosphere, the module is surrounded by a heat plasma. The characterization of this gas and its radiative property are key parameters for TPS design.

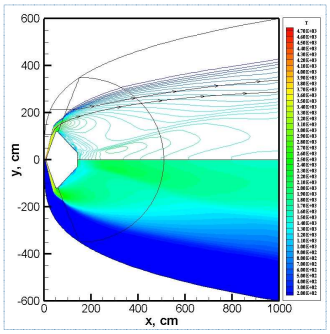
•The prediction of the radiative heat flux on the Mars space vehicle's surface relies both on the numerical simulations and on several models (mainly optical models and chemical-kinetic models). On the space vehicle back-shield, the radiative heat flux can represent up to 100 % of the total heat flux. This flux is mainly due to the infrared radiation of CO_2 and CO for low/medium Mach numbers. In order to verify the theoretical computations, the space vehicle should specifically instrumented.

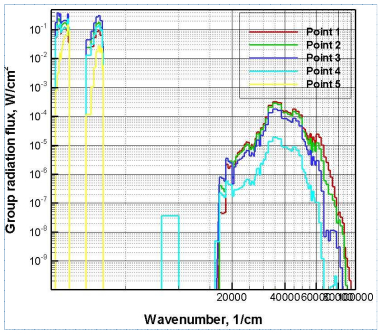
•The ICOTOM sensor unit will consist of three infrared fiber optic sensors, each sensor being designed to receive signals in two frequency bands on three different positions on the backshield .

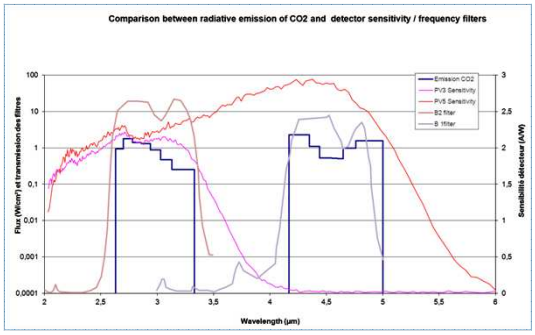


MODEL PREDICTION

Simulations have been carried out with the 2D numerical code NERAT (Non Equilibrium Radiation Aero Thermodynamics) developed by Professor S.Surzhikov in INSTITUTE FOR PROBLEMS IN MECHANICS RUSSIAN ACADEMY OF SCIENCES (IPMech RAS) [1-3].



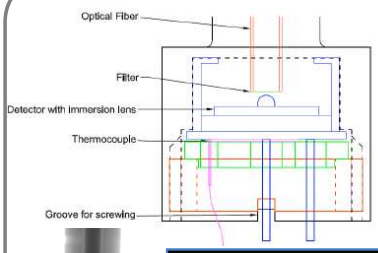


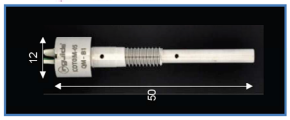


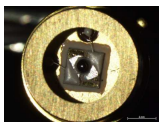
Fluid and radiative computations have been done on different point of the trajectory. The Ray-tracing method has been used to compute spectral radiation heat transfer near to surface of space vehicles. Spectra have been obtained for five points on the surface of the space vehicle following a typical trajectory [4], for 170 bands with wave numbers ranging from 1, 000 to 100, 000 cm^{-1} . Detectors and filters have been chosen to focus on two bands centered on 2.7 and 4.5µm wavelengths in which CO_2 and CO radiate.

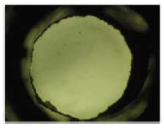
[1] Surzhikov S.T., "2D CFD/RGD Model of Space Vehicles," *Proceedings of the 1st International Workshop on Radiation of High Temperature Gases in Atmospheric Entry; 8–10 October 2003, Lisbon, Portugal. ESA- 533,* December 2003, pp.95-102.
[2] Surzhikov S.T., "TC3: Convective and Radiative Heating Of MSRO For Simplest Kinetic Models," *Proceedings of the International Workshop on Radiation of High Temperature Gases in Atmospheric Entry. Part II.30 Sept.-1 Oct., 2005. Porquerolles. France.(ESA SP-583,* May 2005, pp.55-62)
[3] Surzhikov S.T., "TC3: Convective and Radiative Heating Of MSRO, Predicted by Different Kinetic Models" Proceedings of the Second International Workshop on Radiation of High Temperature Gases in Atmospheric Entry. 6-8 Sept., 2006. Rome. Italy.(ESA SP-629, November 2006, on CD)
[4] Amandine Le Brun and Pierre Omaly INVESTIGATION OF RADIATIVE HEAT FLUXES FOR EXOMARS ENTRY IN THE MARTIAN ATMOSPHERE 4rd International Workshop on Radiation of High Temperature Gases in Atmospheric Entry EPFL, Lausanne, 12/10/10

MECHANICAL DESIGN









Product assurance expertise and Space qualified

Simple mechanical design:

- Field Angle of view is 35°
- Focus on the wave bands by filter glued directly to the fiber
- Weight: ~ 7g (50g for 6 units including wires)
- Size 12x50mm

Optical properties:

two high temperature fluoride glass infrared fibers (IRguide®- 4) which convey the IR radiation from the outside of the capsule down to the IR detectors beneath the surface, through thin film IR filters applied on the output faces of the fibers.

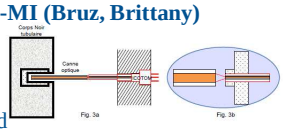
- ICOTOM B1 [4.1-5]µm
- ICOTOM B2 [2.6-3.3]µm

Power consumption: 0W

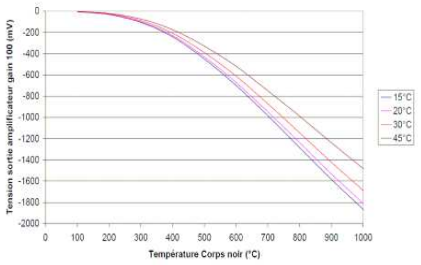
TEST PROCEDURE

Calibration by LeVerreFluoré at DGA-MI (Bruz, Brittany)

To be exploited, the response (mV) of each sensor must be converted in °C using its own calibration function.



In practice, its output voltage is amplified and treated to derive the radiative heat flux of the surrounding plasma. The calibration of each ICOTOM was performed by measuring its response to the radiation of a blackbody for temperatures ranging from -60 to + 1,000°C.



As the aperture of the IR beam from a high temperature blackbody (~7deg) does not match that of the ICOTOM (17deg), a large aperture optical duck was designed and constructed to collect and convey radiation from the core of the blackbody furnace to the input end of the sensor.

CONCLUSION & OUTLOOK

- **Compatible with all types of planetary mission (not only CO_2 atmosphere)**
- **Could be adapted to other chemical species**
- **Component scale ➔ easy integration into reentry probes**
- **Inexpensive**