European Shock-Tube for High Enthalpy Research (ESTHER)

A New Facility for Space Research in Portugal

Instituto de Plasmas e Fusão Nuclear
Instituto Superior Técnico

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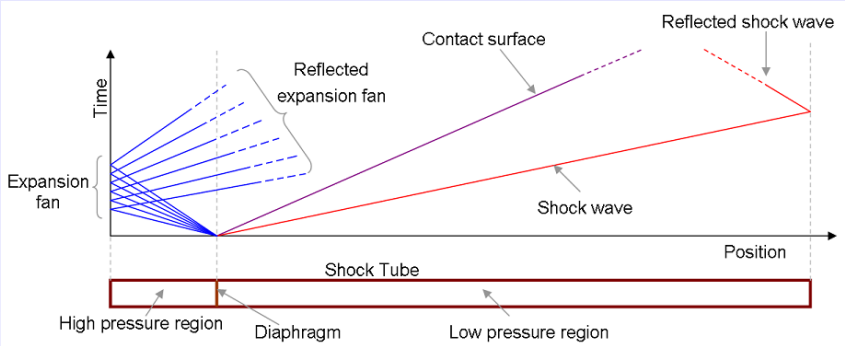
Atmospheric Entry Science: A Critical Technology for Access to Space

- Atmospheric entry: when a spacecraft enters the upper layers of a planetary atmosphere.
- Velocities from about 5-10 $\mathrm{km/s}$. Hypersonic flight regime with formation of a bow shock leading to the formation of a plasma.
- Plasma at high temperature (1,000-10,00K), leads to high convective and radiative fluxes mandating ablative thermal protections in the spacecraft walls.
- Numerical codes simulation need experimental validation.

Shock-Tubes for the Simulation of Atmospheric Entries Plasmas

- Shock-tube: A high-pressure (driver) section and a low-pressure (driven) section.
- Rupture of a diaphragm leads to the formation of a shock-wave whose speed depends on pressure ratios.
- High-speed acquisition diagnostics allow characterisation of the plasma created downstream of the shock-wave.
- Facility critical for space access. Shock-tubes available in the USA, Russia, but only European Shock-Tube facility in Marseilles was de-commissioned in 2005.



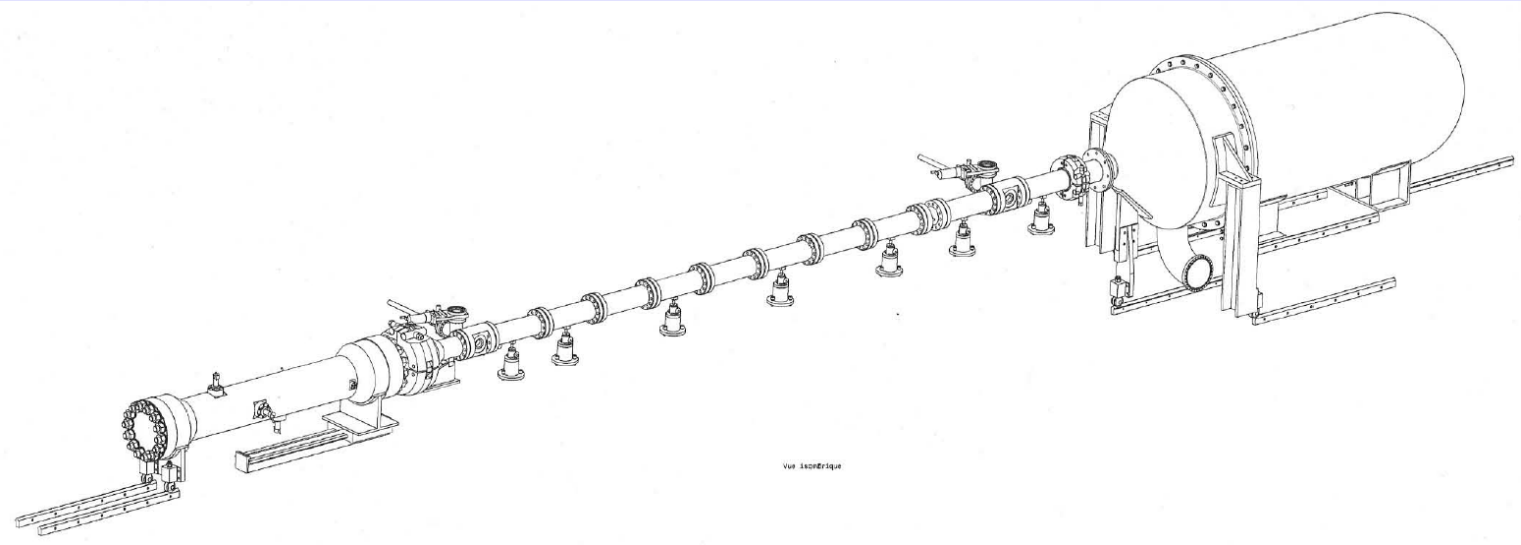
THE ESTHER Shock-Tube

- ESA awarded a 1,000,000€ contract to an international consortium led by Instituto Superior Técnico, for the development and comissioning of a novel shock-tube facility for planetary exploration research
- Consortium partners include:

  Fluid Gravity Eng. (Ermsworth, UK),
  Université de Provence (Marseille, France),
  Ingénieurie Systèmes Avancés (Bordeaux, France),
  Moscow Institute for Physics and Technology (Moscow, Russia),
  Instituto de Soldadura e Qualidade (Lisboa, Portugal),
  Shock-Waves Laboratory (Aachen, Germany),
  University of Manchester (Manchester, UK),
  Université Blaise Pascal (Clermont–Ferrand, France),
  Université Paris VI (Paris, France).

- Contract over a two-years period, initiated in October 2010. Contract is split in three fases (Phase 1: Design; Phase 2: Construction; Phase 3: Comissionning and demonstration campaign)

Support to ESA Planetary Exploration Missions



- The facility will provide support to the design of ESA planetary entry vehicles. Unique facility in Europe
- The ESTHER shock-tube will be the largest space research facility located in Portugal

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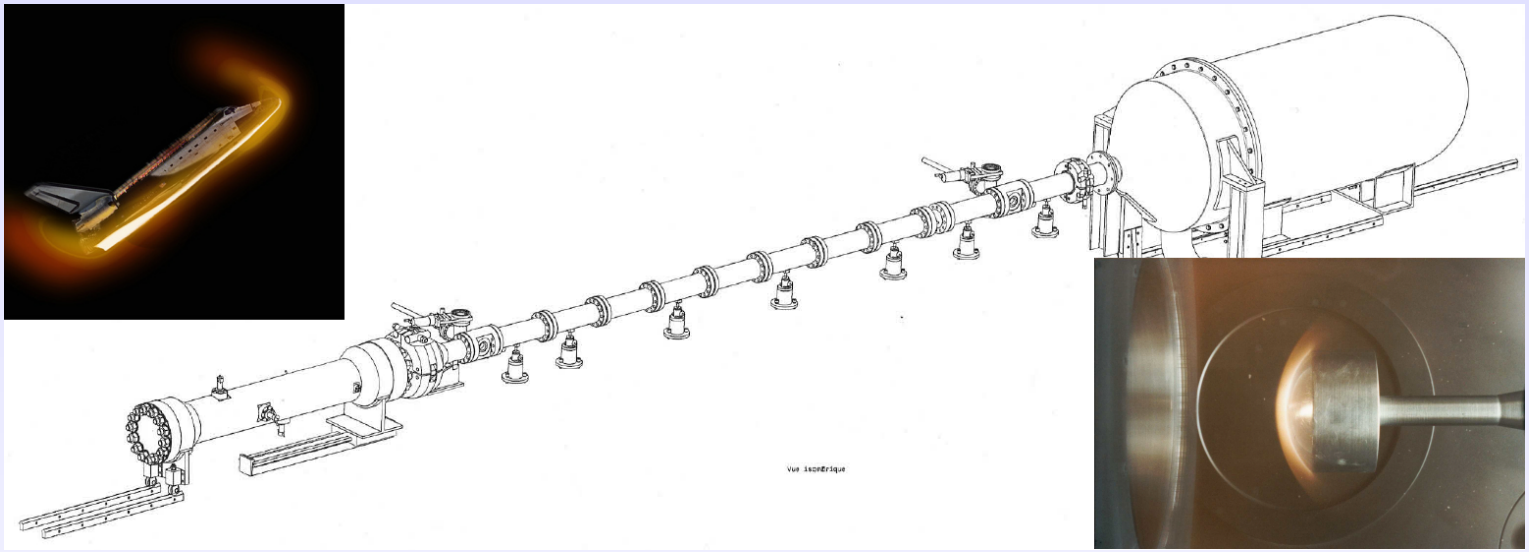

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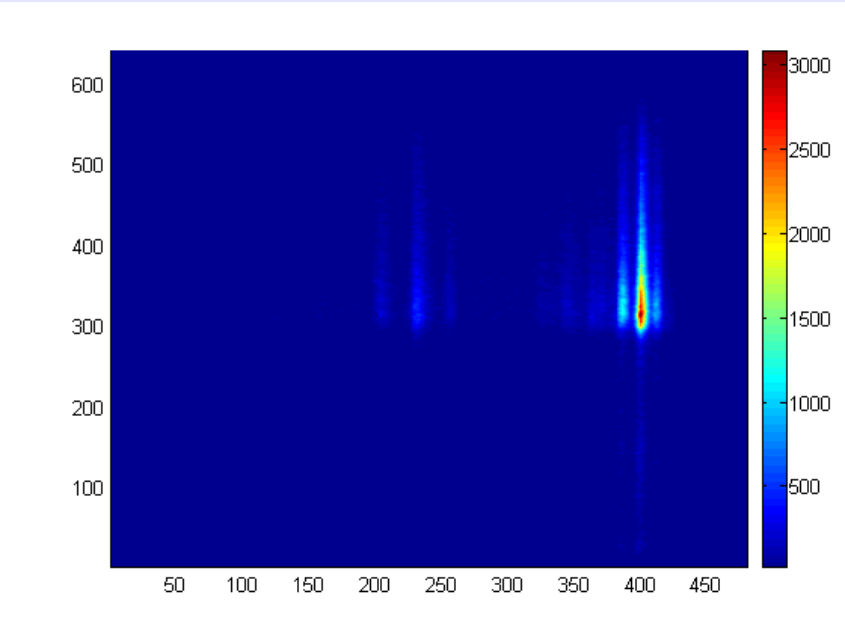
Special Conditions of the ESA Contract

- Contractor is required to provide a suitable building for hosting the facility, at no extra cost.
  "The construction of the building hosting the facility; and the acquisition of land and connection to utilities is not included in the work requested; but should be provided by the Contractor."
- Facility must be compliant with safety and quality norms ECSS-Q-20-07A; -ECSS-Q-40B; and ECSS-E-ST-10-03-C. Instituto de Soldadura e Qualidade in charge of asessing such requirements.

from **Kinetic Shock Tube For Radiation Data Base For Planetary Exploration, STATEMENT OF WORK, 2008/629 /LM, 21.4.2009, Appendix 1 to AO/1-6066/09/NL/AF**

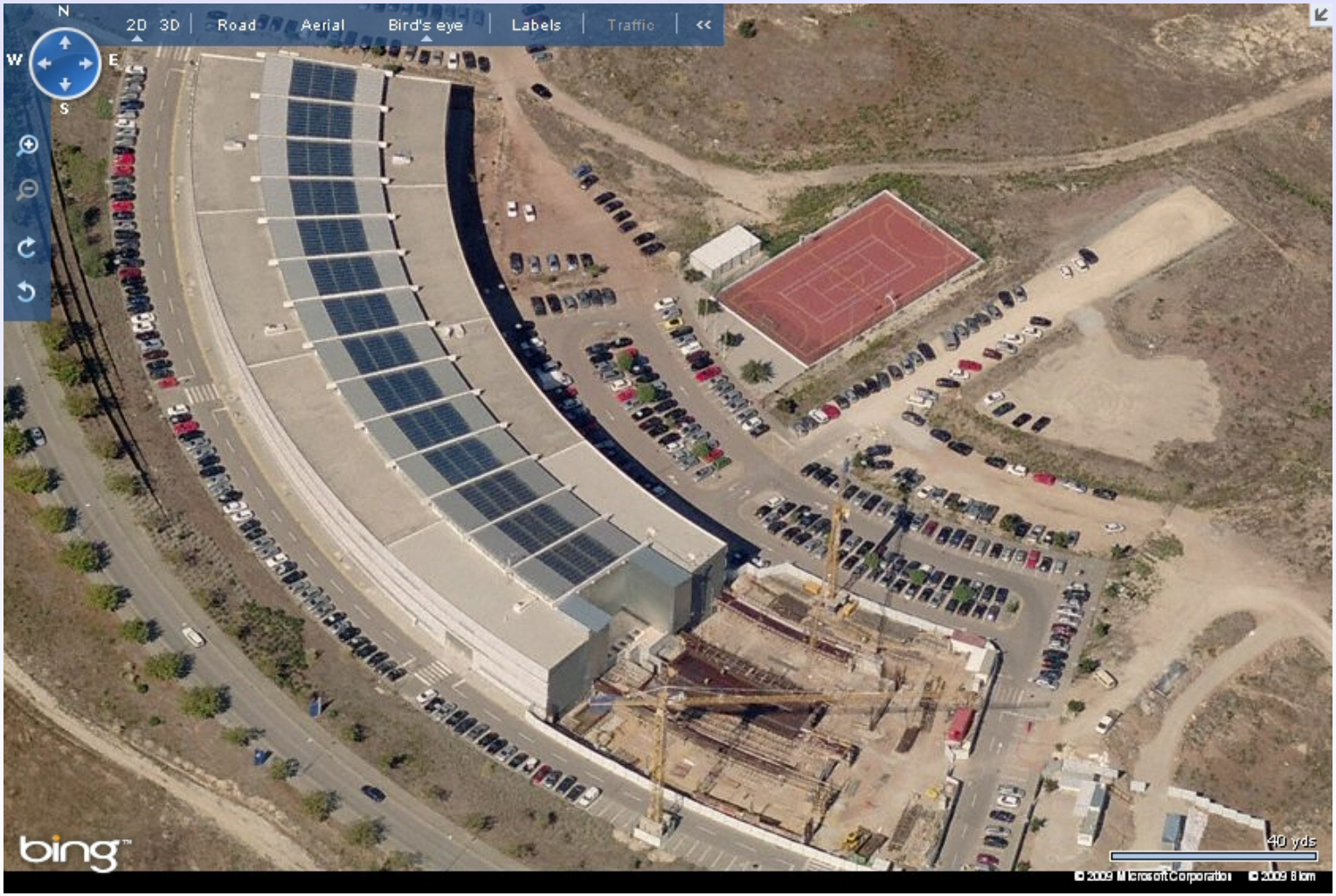
THE ESTHER Shock-Tube

- Facility capable of reproducing shock-waves for speeds of about 4–11$\mathrm{km/s}$, for gas mixtures simulating the atmosphere of Earth, Mars and Venus (CO_2–N_2), Titan (N_2–CH_4) and gas giants in the future (H_2–He).
- High pressure reached in the driver section through the deflagration of a high-pressure (50–100bar)H_2–O_2 mixture. This allows a quick-rise in pressure, enabling 3–4 shots per day.
- High-speed automated diagnostics (MHz) for collecting light emitted by the plasma.



Hosting Facility

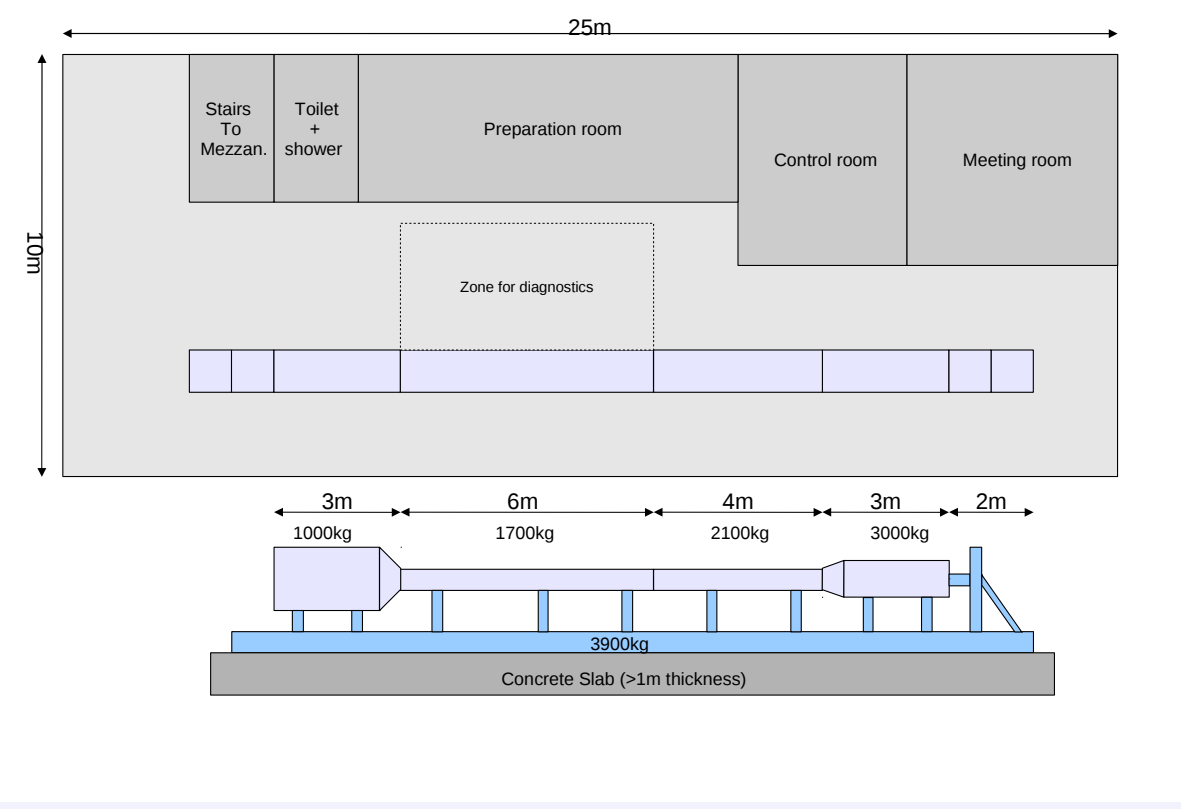
- Shock-tube placed in new $25\mathrm{m}\times10\mathrm{m}$ building in new IPFN laboratory inside the IST Taguspark Campus, built under IST internal funding



Detailed Description of the Hosting Building

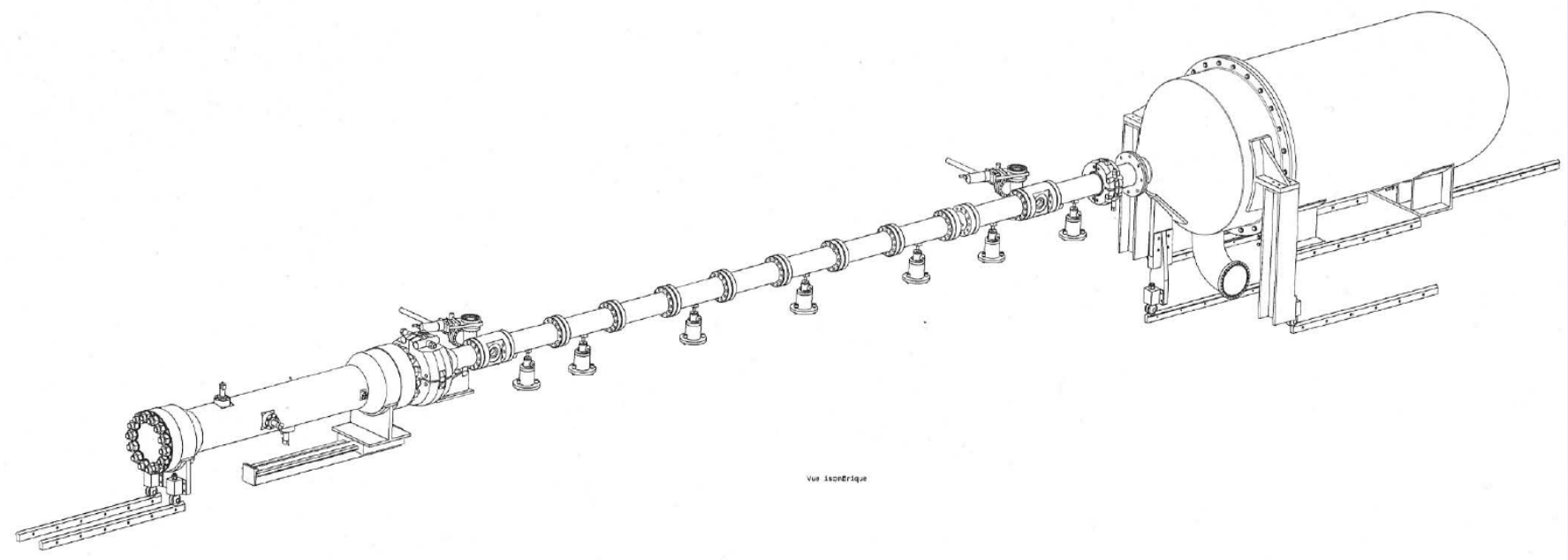
- Building must follow stringent safety measures due to the presence of explosive mixtures (H_2–O_2)
- 4 rooms: Experimental hall, preparation room (for optical setups), control room, and meeting rooms
- No personnel allowed in the experimental hall during experiment. Facility remotely operated from the control rooms
- Pumping system, gas bottles and dump tanks must be located in open-air due to safety and ventilation requirements

Requirements for the ESTHER Shock-Tube Host Facility



- Host shock-tube and future extensions (20-21m length)
- Perpendicular length for spectroscopy diagnostics in the working section
- Segregated control and preparation rooms (for safety reasons)

ESTHER Facility CAD Design



Gas Lines and Pumping Systems