von Karman Institute for Fluid Dynamics

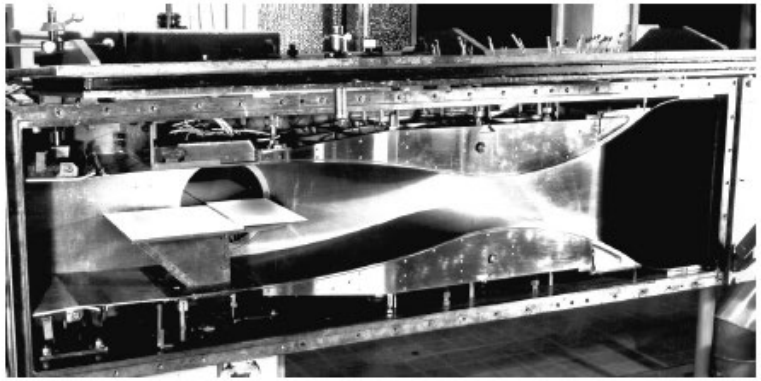
DIANA Center for Hypersonics

von KARMAN INSTITUTE
FOR FLUID DYNAMICS

Founded in 1956

THE HORIZONTAL CLOSED TEST SECTION OF THE SUBSONIC WIND TUNNEL

"Training in Research through Research"



THE NEW SUPERSONIC NOZZLE

- Founded as *Belgian-American Training Center for Experimental Aerodynamics* (TCEA), devoted to **training and research in (high speed) aerodynamics,** open to young engineers and scientists of the **NATO member nations**
- Renamed to *von Karman Institute for Fluid Dynamics* (1963)

Theodore von Kármán receiving the National Medal of Science from President Kennedy in 1963

VKI activities: overview

Education

- Short Training Program
- MaNaMa:
  Research Master
- Doctoral Programme

Contract research

- Aerospace
- Turbomachinery
- Industrial Processes
- Environmental Flows
- Fluid Engineering & Measurements

Lecture Series

- Short seminar about specific topics
- Targeting industry, academia…
- With international invited speakers

16 NATO countries support VKI for the educational programs

Onderwijs

 Belgium

 Germany

 Italy

 Portugal

 Bulgaria

 Greece

 Luxembourg

 Romania

 Czech Republic

 Hungary

 Netherlands

 Turkey

 France

 Iceland

 Norway

 United States

NATO funding model:

- Voluntary financial support from a number of NATO countries
- Funding model open for contributions from additional NATO countries
- Financial support for Research Master Programme & Short Programme, and a few PhDs

Experimental Facilities for Hypersonic Aerodynamics

Subsonic

L1 – *Large Scale Low Speed Wind Tunnel*

Transonic

S1 –*Transonic/Supersonic Wind Tunnel*

Supersonic

H3 – *Mach 6 Hypersonic Wind Tunnel*

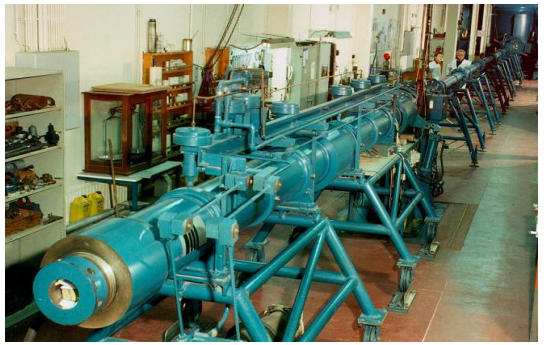
Hypersonic

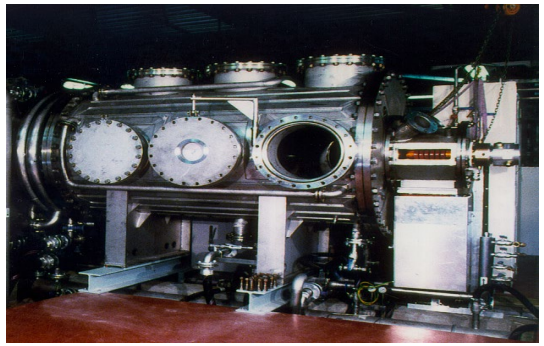
LongShot – *Mach 14 Hypersonic Wind Tunnel*

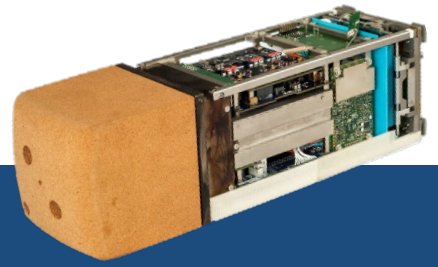
Plasma

Plasmatron – *Induced Coupled Plasma Facility*

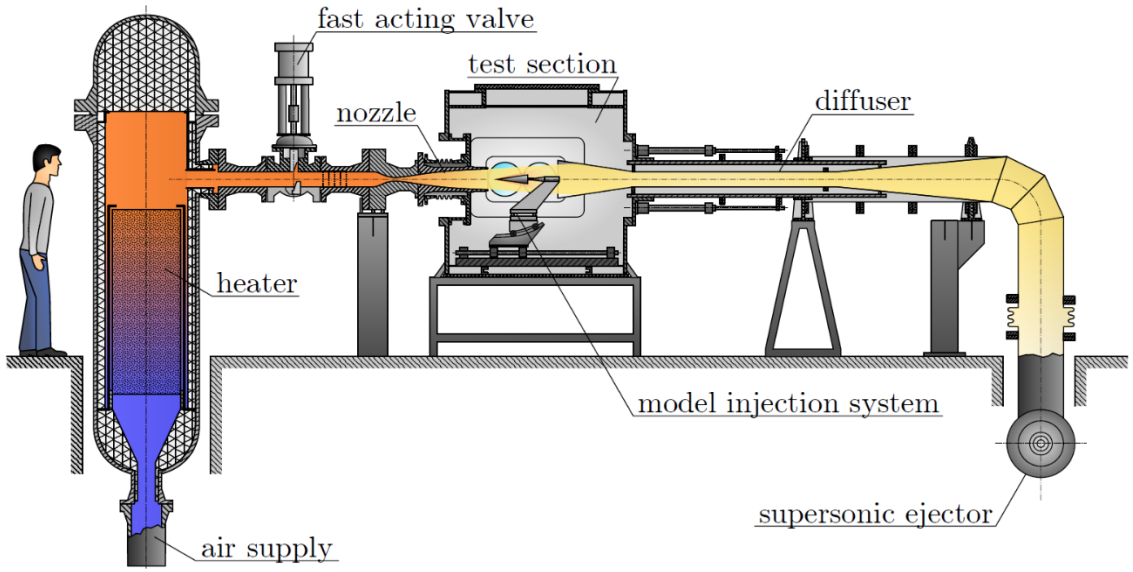
QARMAN – *flight facility for rarefied flows*



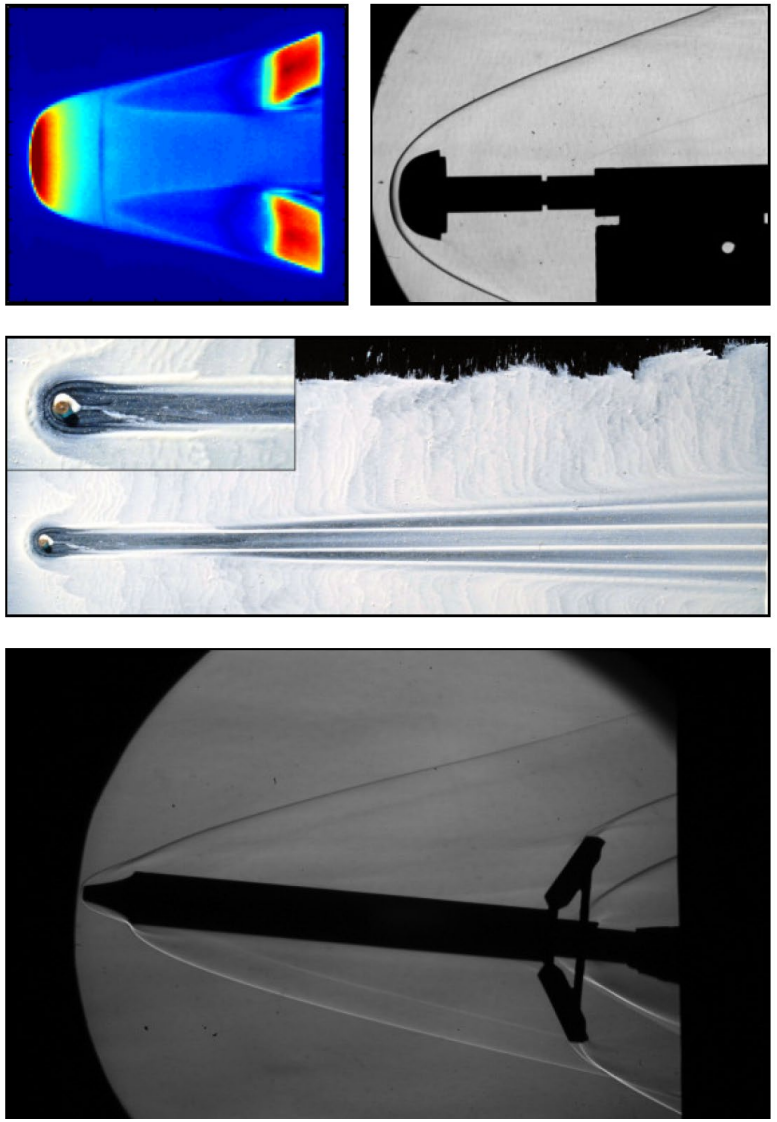




Mach 6 Facility: VKI H3 blowdown Tunnel



VKI H3: Mach 5-6, Re = up to 35×10^6 /m



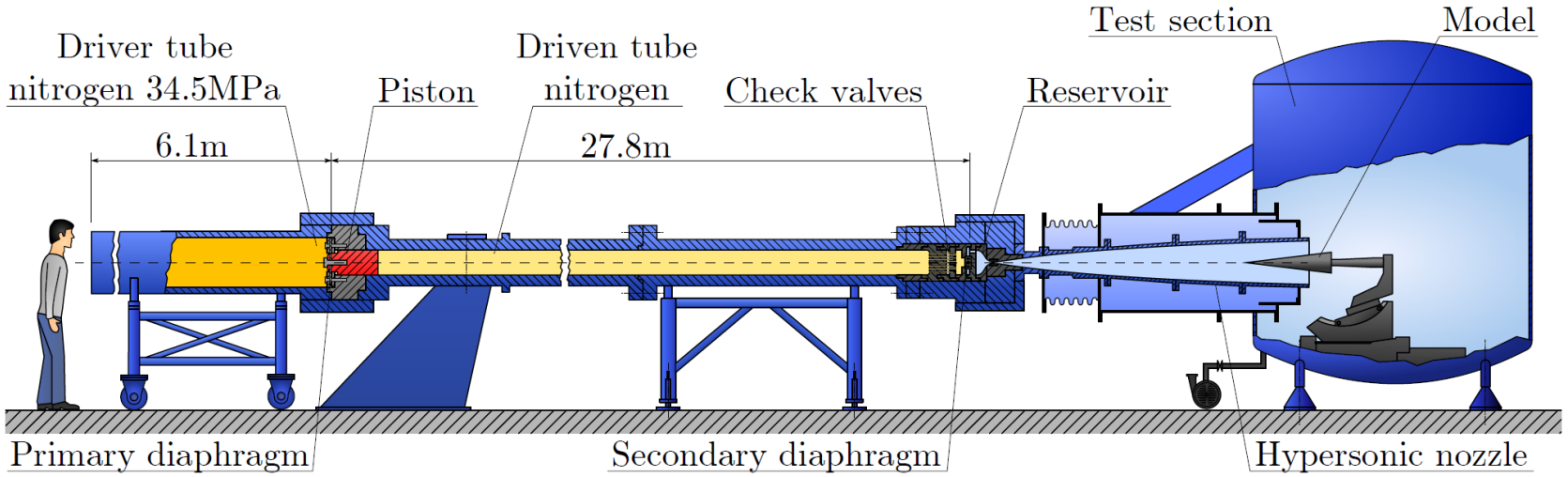
Main Purposes:

- Hypersonic aerothermodynamics
- Launchers / cruise / (re-)entry configurations

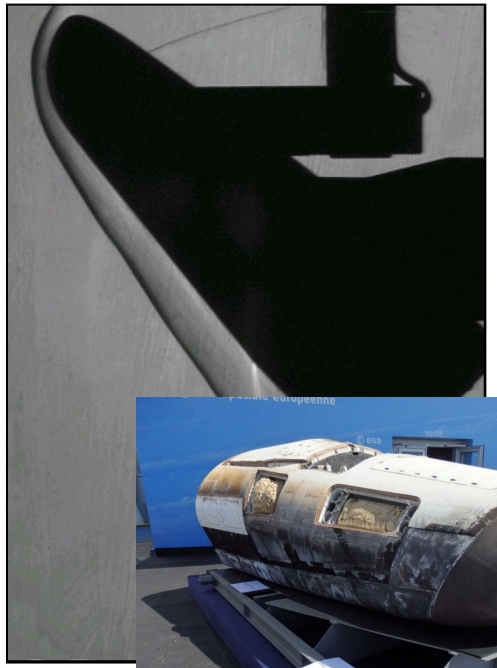
Instrumentation:

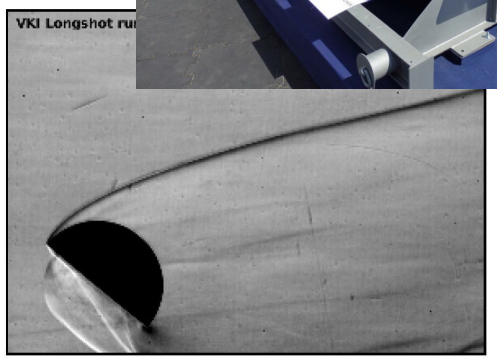
- Infrared, balances, thermocouples, pressure sensors, oil flow, Schlieren, hot wires…

Mach 10-20 Facility: VKI Longshot Gun Tunnel



VKI Longshot: Mach 10-20, Re = up to 15×10^6 /m





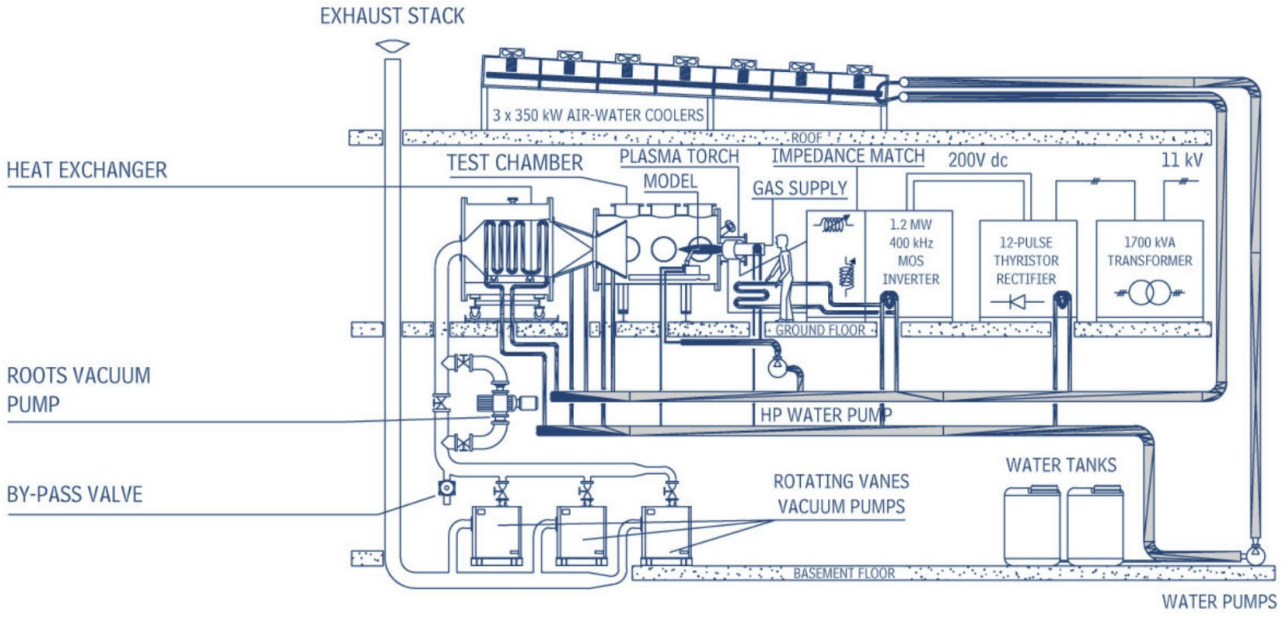
Main Purposes:

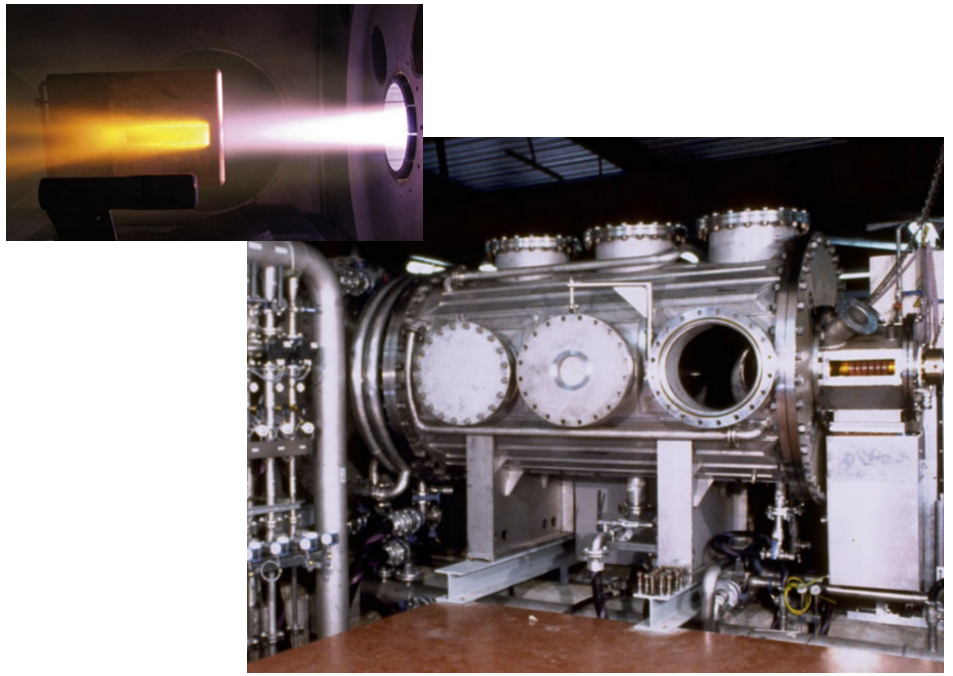
- Hypersonic aerothermodynamics
- (re-)entry configurations / Space debris
- Earth & Martian entries

Instrumentation:

- Freeflight, balances, thermocouples, pressure, Schlieren, high speed cameras

10.000K Facility: VKI 1200 kW Induction Plasmatron





Main Purposes:

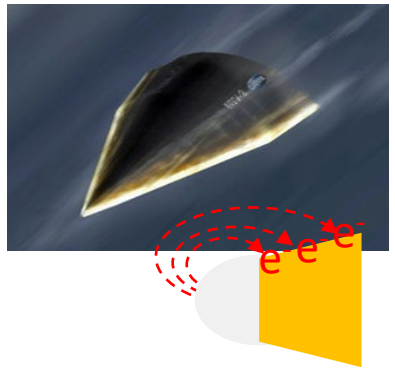
- Testing of re-entry materials for thermal protection systems at heat fluxes up to 15 MW/m²
- General studies of plasma flows

Instrumentation:

- 2 supersonic nozzles (mach 2,6 and 3,2)
- Pressure and heat flux probes, spectrometer, pyrometer

Re-usable

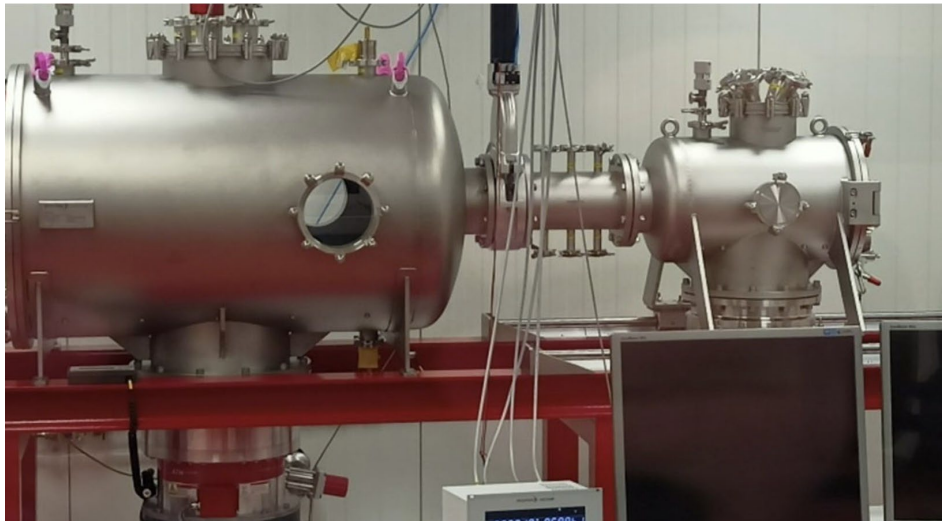
ETC

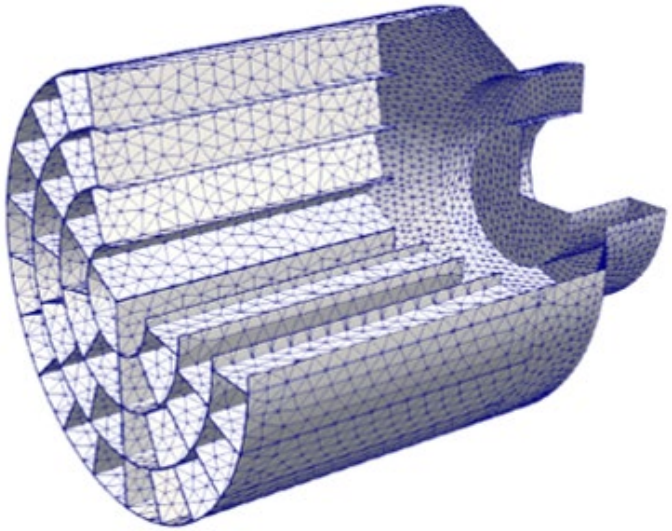


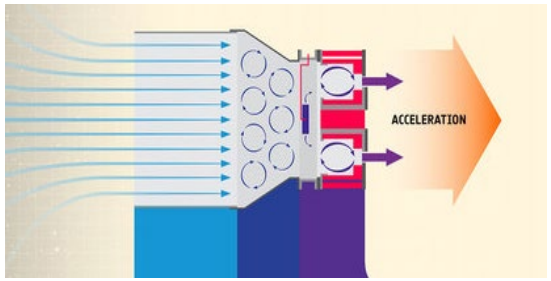
Ablative

Demise

DRAG-ON: High-Speed Low-Density Facility







- For testing Air Breathing Electrical Propulsion for Very Low Earth Orbit (VLEO) operations, where there is a residual atmosphere
- Patented geometric design for the intake of atmosphere-breathing electrical propulsion:
  - to optimize efficient intake of atomic oxygen particles
  - To optimize densification of inlet stream
- Conceptual ground based test-bench for experimental validation
- To be continued with an in-flight validation and a full drag compensation mission

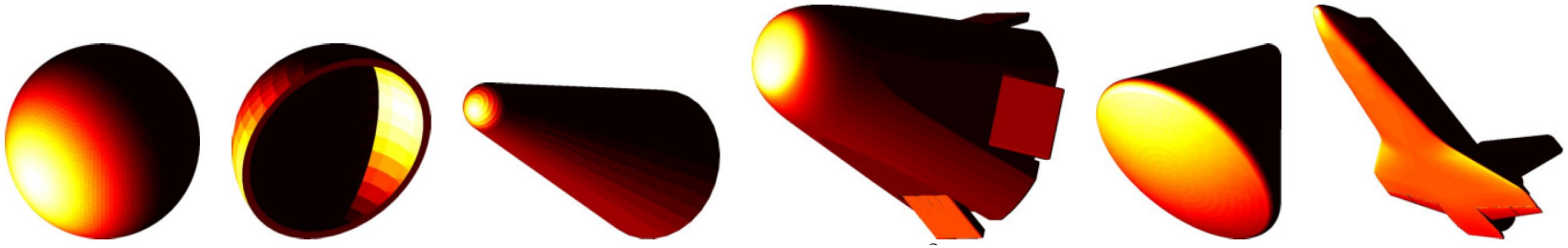
Research purposes of (Hypersonic) AeroThermoDynamics

1. Improved understanding of hypersonic flow physics and aerodynamics
   - ❑Boundary Layer laminar-to-turbulent Transition (BLT)
   - ❑Shock Wave – Boundary Layer Interactions (SWBLI)
   - ❑Viscous interactions
2. Aerodynamic heating
   - ❑Thermal Protection System (TPS) ablation / melting
3. Development of aerothermodynamic databases
   - ❑For launchers, cruise vehicles, ballistic vehicles, lifting bodies, space debris…
   - ❑For earth and martian atmosphers
4. Studies on parametric configurations

With assiocated Numerical and Theoretical Tools

- DEKAF (boundary layer code)
- VESTA (boundary layer stability
- ANTARES (hypersonic aerodynamics)

Application of **N**ewtonian **T**heory for **AR**bitrary **E**ntry **S**hapes



- ROVT (6 DoF trajectory code)
- HYPNOZE (nozzle design)
- L1d2 (internal ballistics)

Thank you for your attention

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