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Exploring the depths of Saturn

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IPPW9 – Session 2

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Formation & Origin

- In-situ measurement of chemical and isotopic compositions of the Saturn atmosphere

➔ Discriminate between formation scenarios

- **Major objective for probing Giant Planet atmosphere**

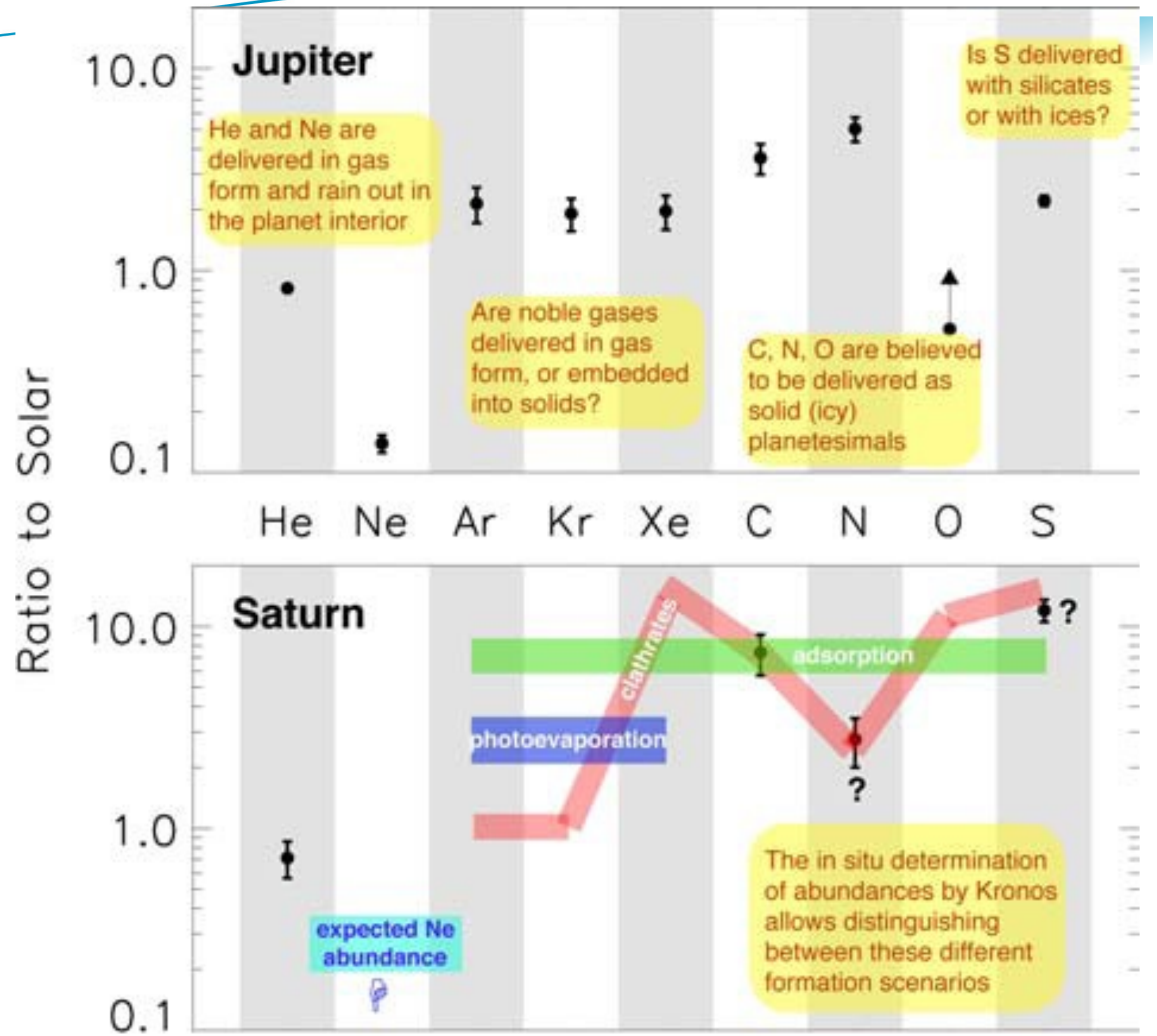


Figure issued from KRONOS proposal

- H2O is presumably the original carrier of heavy elements to Giant Planet
- Reaching the base of water cloud is an asset for giant Planet probe mission

➔ **Reaching 10 bar is a compromise between scientific need and probe complexity**

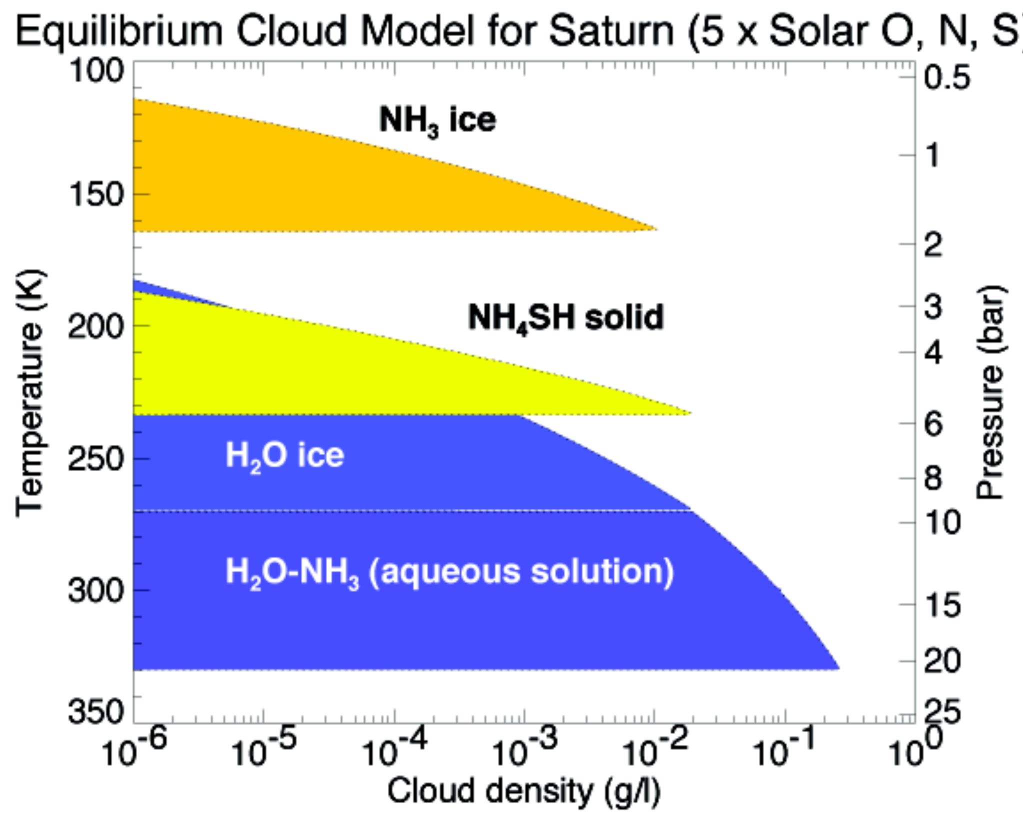


Figure issued from "Multi-probe for multi-worlds", S. ATREYA & T. OWEN, IPPW3

Long lived probe in Saturn atmosphere

- Data relay strategy for giant planet probe is:
  - Either a cost driver, related to Orbiter concept
  - Either a limitation of data return with DTE, related to the weak link budget and limited duration
- Usual mission concept for Giant planet probe mission considers:
  - Parachute deployment in relevant aerodynamic conditions (Mach)
  - Descent under parachute down to 1 bar threshold
  - Free fall down to 10 bar for quick descent, due to visibility constraints, either with Earth for DTE or with Orbiter (flyby or SOI)

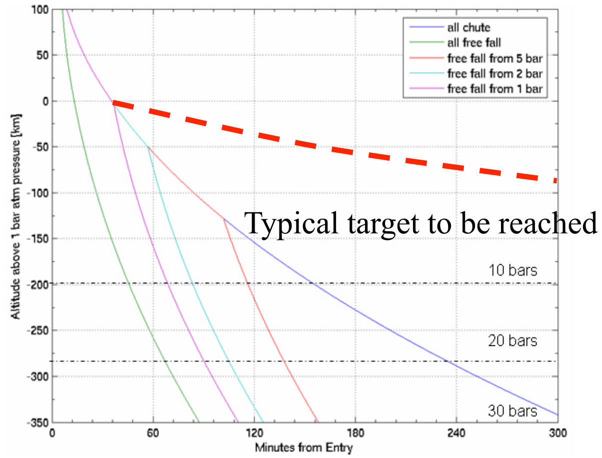


Figure derived from KRONOS proposal

Long lived probe in Saturn atmosphere

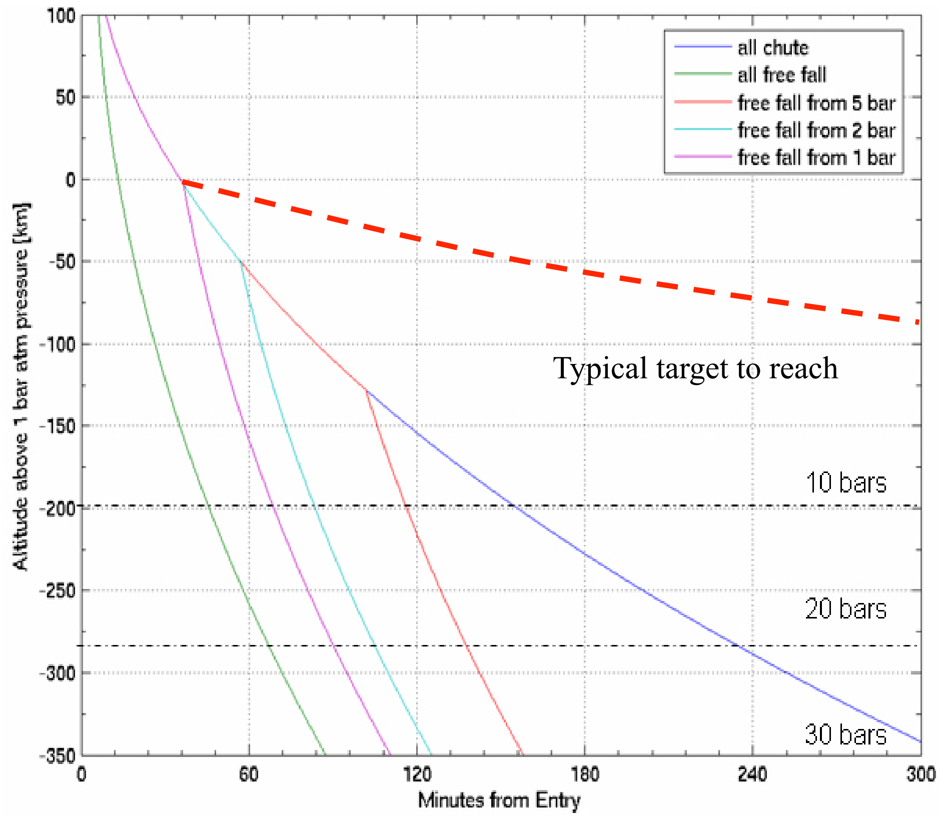
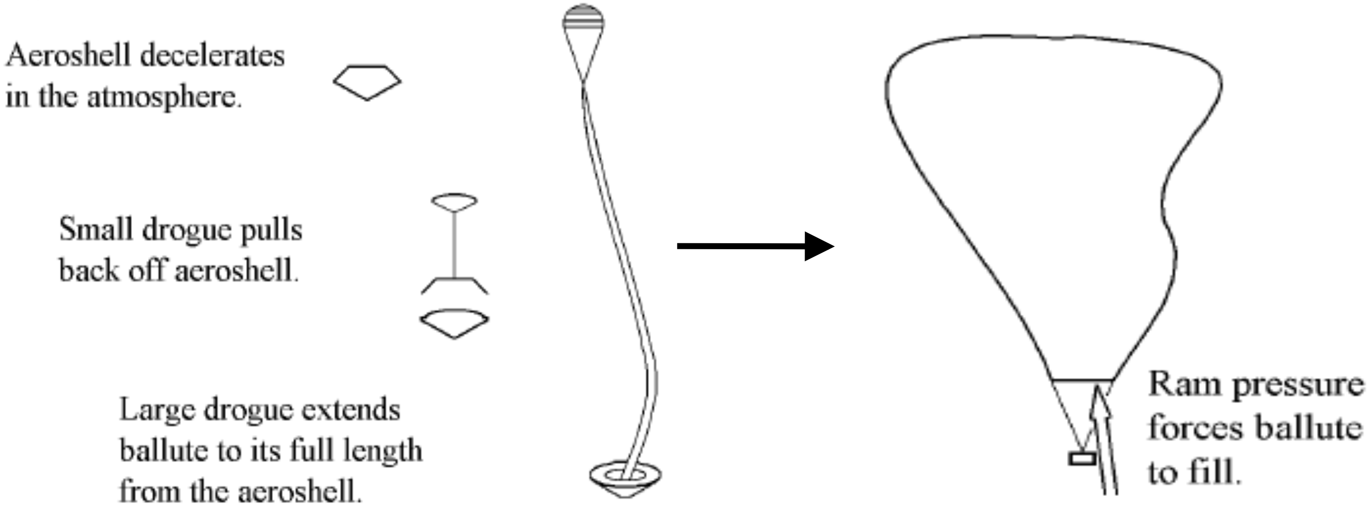


Figure derived from KRONOS proposal

- **Long lived probe using DTE will improve data return via increase of transmission duration, without the need of a costly Orbiter**
  - Extension of descent duration from 2.5h under parachute to 12h -15h, i.e. more than 1 Saturn rotation

Long lived probe in Saturn atmosphere

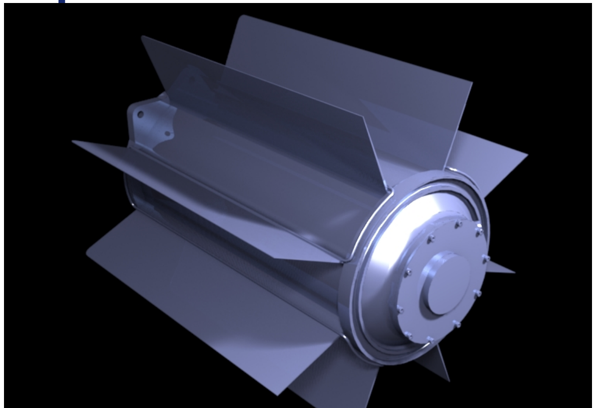
- Descent duration extension from 2.5h to [12h -15h] could be done in two ways
  - Super pressurized balloon: Extensive concept studies in the frame of "post-Huygens" mission evaluation ➔ mass of the system is prohibitive
  - Ballute (BALLoon-parachUTE)
    - Supersonic Ballute were developed in USA in the 60's for GEMINI ejection seat, and for military application
    - Ballute deployment was proposed for a Titan mission by J. NOTTS in IPPW4 and the concept could be applied for a Saturn mission



Long lived probe in Saturn atmosphere

Using primary batteries for a 12h – 15h long continuous mission will not be affordable from mass point of view

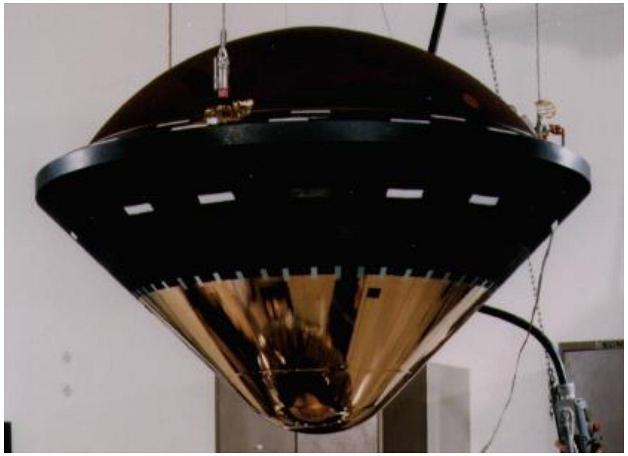
- RTG, MMRTG and ASRTG are developed by NASA since decades for planetary exploration are devoted spacecraft, with significant level of power generation


MMRTG design concept – Courtesy NASA JPL

- A small RTG is currently under development by ROSCOSMOS
  - Electrical power range is 5w to 10W, which allow extended mission when coupled with secondary battery
  - When completed, this development will provide an important step for planetary exploration, opening new opportunity for mission concept which does not fit in primary battery or large RTG/ASRTG
- The major drawbacks of RTG remains thermal control since its implementation inside the probe ➔ Special care is necessary

Probe TPS material

- The second key driver of Giant Planet probe is availability of TPS for Entry
- Baseline TPS for almost all studies of Giant Planet in-situ mission: Carbon Phenolic , as used for GALILEO and PIONEER VENUS
  - Material is considered available, for a limited number of mission, stored since this golden age
  - Show stopper is still the non availability of facility to verify material behavior after decades of storage



- Available European TPS technology had no material compatible with Saturn entry mission
  - No gap filler between light weight material as used for HUYGENS (AQ60) and now for EXOMAS (NORCOAT LIEGE), and very high density material of military application
- Proposal for Saturn entry mission are still facing this show stopper wrt management, which prevents such proposal to go through first gate of selection

Probe TPS material

- Several mission studies evaluated by ESA consider sample return to Earth, from Mars (MSR) or asteroid (MarcoPolo)
  - This induces of being able to perform high energy Earth entry
    - Peak heat flux in the order of 10-20 MW/m2
    - Dynamic pressure loads in the range 0.08 – 0.1 atm
- In this perspective, ESA initiated an activity aiming at the Development of a European lightweight Ablative Material (DEAM) for extreme heat flux applications
  - Development status was presented by H. RITTER (ESA) during IPPW8
- Two material are under evaluation within this study led by HPS
  - ASTERM from EADS-ASTRIUM
  - MonA from Lockheed-Martin UK

Picture issued from " Ongoing European Developments on Entry Heatshields and TPS Materials", H. Ritter et all, IPPW8

Probe TPS material

- Compared to Earth entry, Saturn entry leads to predominant radiative heat flux
  - This is a major difference, for both material behavior and facility design for qualification
- However, Europe has started the first step which could lead to a European solution for Giant Planet in-situ exploration
  - One of the follow-on activity identified by H. RITTER in its IPPW8 presentation was determination of material limits wrt density
  - This step, when completed, will allow to identify remaining steps allowing applicability for Saturn mission
- => A first step for European TPS applicable to Giant Planet Entry

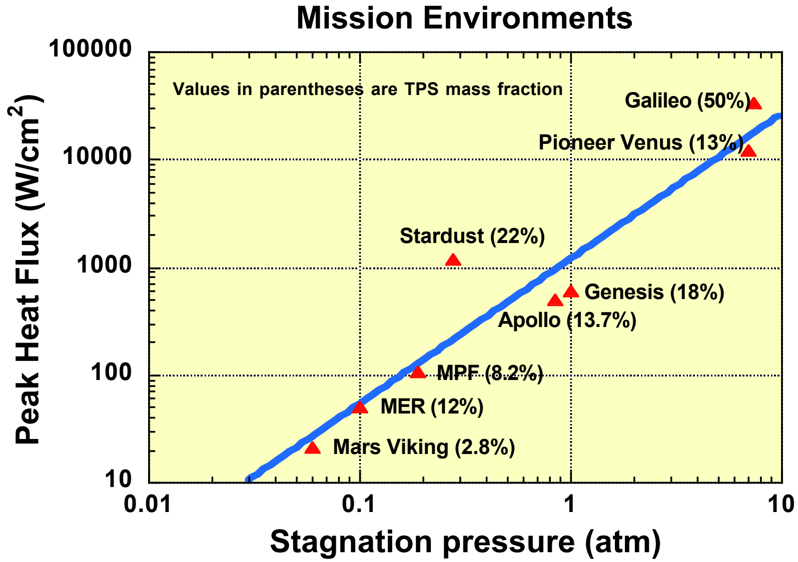


Figure issued from "Challenges and strategies for sustaining TPS/Entry technology …", E. Venkatapathy, B. Laub & R. Manning, IPPW4

Long lived in-situ probe mission concept

- A mission concept for long lived Saturn in-situ exploration could be as follows
  - A single carrier will deliver a single or twin probes for direct entry in Saturn atmosphere. Carrier is not used anymore
  - Thermal protection will be derived from European development in progress for sample return mission
  - Supersonic parachute will be deployed to cross transonic,
  - Followed by the deployment of a Ballute providing sufficient buoyancy for a 12-15h mission down to 10 bar
  - DTE data relay will be performed by the probe, based on a predefined timeline wrt Earth visibility from Saturn
  - Electrical power being provided by a small RTG, with appropriate thermal control

- Such mission concept was not evaluated in details but is believed to be feasible

Conclusion

- The necessity for in-depth exploration of giant planets has been stressed since the very first IPPW

  ➔ **Discriminate models of Planet formation and origin**

  Each call for ideas in Europe or USA repeatedly proposed missions to probe the Giant Planets

- European TPS material development will reach an important step for high energy entry

- Long life in-situ mission (1 Saturn revolution) combined with DTE could be proposed to reduce significantly mission cost while optimizing science return

- Similar concepts can be envisaged for the other giants

References

- For this presentation, authors have used material from the following references
  - KRONOS - A proposal in response to the European Space Agency Cosmic Vision Call 2015-2025 for EXPLORING THE DEPTHS OF SATURN WITH PROBES AND REMOTE SENSING THROUGH AN INTERNATIONAL MISSION
    - B. MARTY, T. GUILLOT, A. COUSTENIS & KRONOS Consortium
  - Multi-probe for multi-worlds
    - S. ATREYA & T. OWEN, **IPPW3**
  - Ongoing European Developments on Entry Heatshields and TPS Materials
    - H. Ritter, O. Bayle, Y. Mignot, E. Boulier, P. Portela, J-M. Bouilly, R. Sharda **IPPW8**
  - Challenges and strategies for sustaining TPS/Entry technology …”
    - E. VENKATAPATHY, B. LAUB & R. MANNING, **IPPW4**
  - Ballutes Launching Aerobots without compromises
    - J. NOTTS, **IPPW4**