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BB 3: STORABLE PROPULSION MODULE AND EQUIPMENT

D. Perigo

TEC-MPC

ESA/ESTEC Noordwijk

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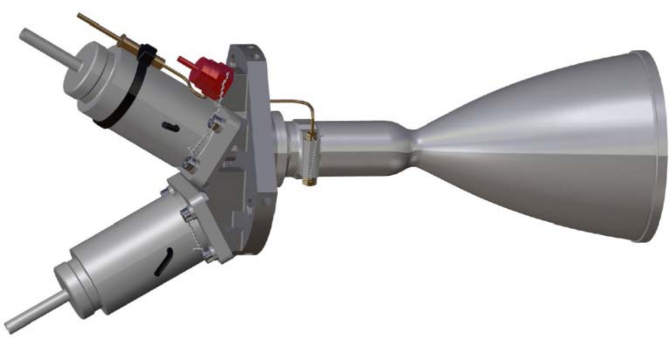
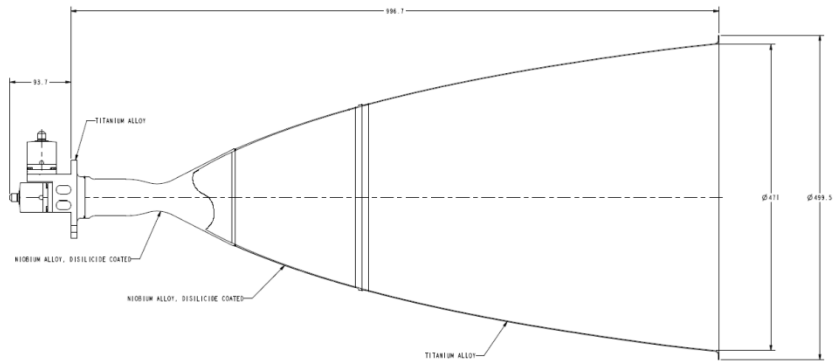
BB3: OVERVIEW

- Order of presentation:
    - Orbital and cis-lunar propulsion systems
    - Landing propulsion issues
    - Engines
    - Tanks
    - BB elements for other technical domains
    - Thought for the future

BB3: ORBITAL/CIS LUNAR PROPULSION SYSTEMS

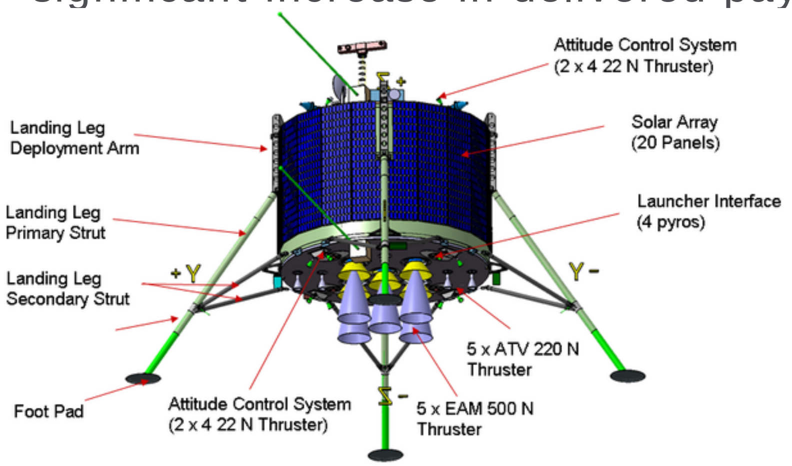
- Larger elements for transfer require higher thrust. Exploration roadmap elements currently in place are:
    - 220N continuation (MPCV)
    - 1100N completion (MREP)
- Continuation of these elements also supports small scale landing applications as per previous ESA studies (next slide)





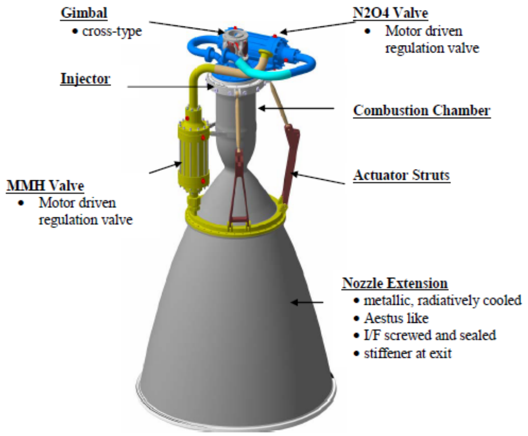
BB3: LANDING PROPULSION ISSUES

- Past studies have been based on a dedicated mission from Earth using Ariane/Soyuz and pressure fed propulsion systems.
    - Relied on OTS thruster hardware with low T/W
    - Large tanks drove the associated structural design in order to support them
    - Delivered payload was, as a result, low w.r.t initial mass on lunar orbit
- Lunar elements of the exploration technology roadmap are based on enabling independent European exploration of the moon.
- Pump fed storable systems with higher (engine level) thrust to weight are to be considered. In conjunction with structural tanking, this will enable a significant increase in delivered payload.



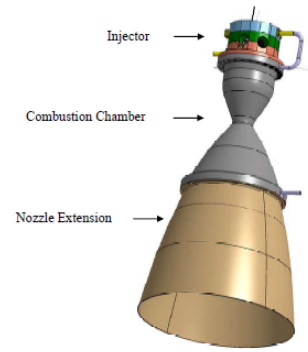
BB3: LANDER PROPULSION EVOLUTION

- Landing engine design drivers:
  - High delta V manoeuvre from LLO to surface
  - Thrust variation (100-20%)
  - High system level thrust requirements (T/M init~2-3)
  - Envelope constraint w.r.t landing clearance
- Previous studies:
  - Medium thrust (6kN) engine pressure fed throttling storable MON/MMH (TRP)
  - Needs gimbal actuator mechanism (GAM) (not covered)
  - Needs throttle valves (covered in outline)
- Resulted in a generic solution: a modular approach with 6kN engines to address a number of lander scales with a single engine design.
- Note: This partitioning and the pump fed approach can, in principle, be applied to other propellant combinations (e.g. Hybrid).

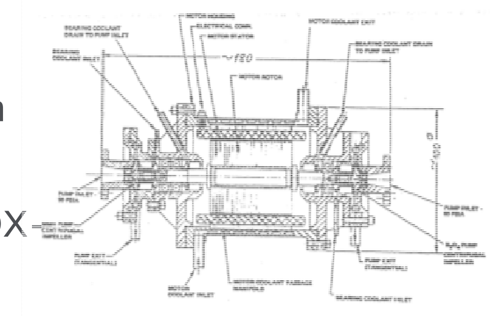


BB3: LANDER ENGINE

- Evolution of the 6kN modular concept
- Reaching higher pressures can:
  - reduce the engine envelope benefiting clearance at landing
  - increasing engine thrust to weight ratio and thus increasing the proportion of the landed mass which is payload
  - Relax tank pressures allowing lighter tank designs simplifying structural tanking

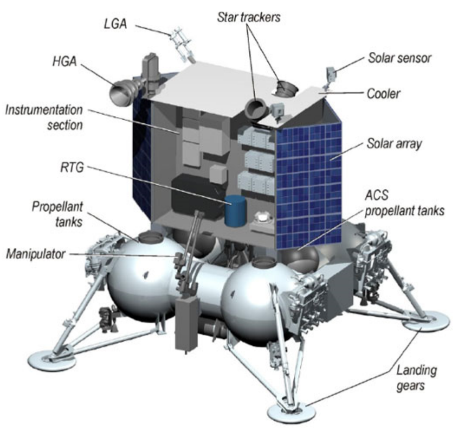


- Intended studies (TRP):
  - Medium thrust (6kN) engine: pump fed, throttling, storable (MON/MMH)
- Additional technologies:
  - Needs gimbal actuator mechanism (GAM) (not covered in studies)
  - Alternate propellants: Hybrid with peroxide (LOX-CH4 LOX-LH2 LOX-Si4 for the longer term)
  - Optional turbo alternators for electric pumps.



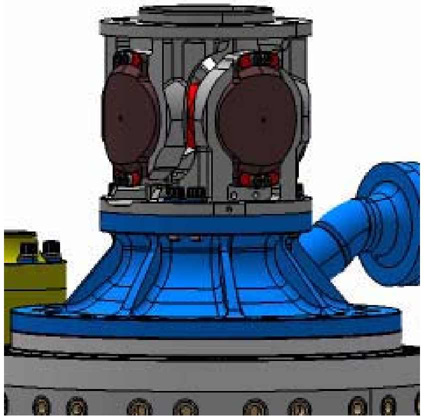
BB3: LANDER TANKS

- Tank design drivers:
  - Large capacity due to landing delta V
  - Propellant management under high dynamic accelerations
  - Minimum weight as lander configurations are highly sensitive to dry mass
- Current tank designs for storable propellants can (and have) been adapted for lander missions. However; the result is not mass optimal.
- Near to mid term:
  - Structural high pressure tanks (TRP intended)
  - Structural low pressure tanks (TRP intended)
- Mid to long term:
  - Structural cryogenic tanks (if cryogens are selected)
  - Thermal control of the above for long durations (if cryogens are selected)



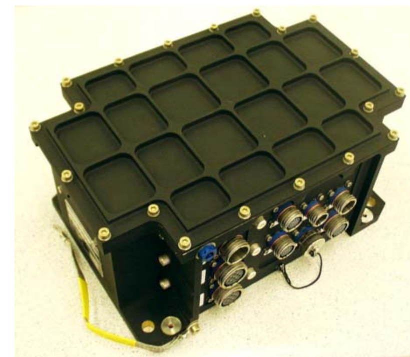
BB3: MECHANISMS

- Baseline solutions require a gimbal actuator.
  - This topic has not been thoroughly investigated and requires requirements input from GNC and mechanisms.
  - In principle the VEGA AVUM actuators are a candidate.
- Two options are possible:
  - Direct control in two/three axes using GAM.
  - Control of thrust w.r.t CoG with GAM and attitude control in 3 axes with auxiliary thrusters (e.g. 220N).
- In the case of reversion to a pressure fed engine concept additional (motor driven) regulation valves will be a compulsory development.



BB3: POWER

- Integrated power drive unit
  - Power distribution for TVC/GAM (and potentially electric pumps) will need development. Evolutions from VEGA upper stage, for the former, should be possible.



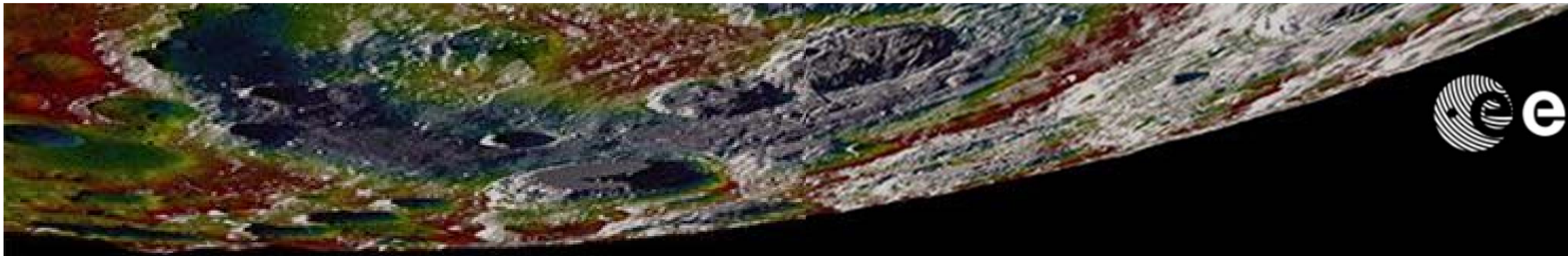
- Turbo alternator
  - Optional where as a hot gas generator cycle with small pumps can be considered, electric pumps may be an easier route to qualification - In this case power limitations of the bus may result in the need for a turbo-alternator or similar to be used during the burn.
  - This hardware could also potentially support the needs of the GAM.
  - This could also be applicable to alternate propellant combinations (e.g. hybrid).

BB3: THERMAL

- Mid to long term (short term if cryogens are baseline)
    - Thermal control of cryogenic propellant tanks (optional depending on propellant choice).

TOWARDS A PERMANENT PRESENCE - A ISPP/ALTERNATE PROPELLANTS

- Mid to long term potential need:
    - ISPP means use of LOX based combinations
    - Examine the generation, storage and use of oxygen derived from regolith
    - Fuel pairings are with H_2 CH_4 (and potentially SiH_4) ~3/4 of propellant made on surface
    - Switching early to alternate/ISPP propellants may benefit permanent presence if this is a long term goal.



THANK YOU

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