An Update on SKYLON

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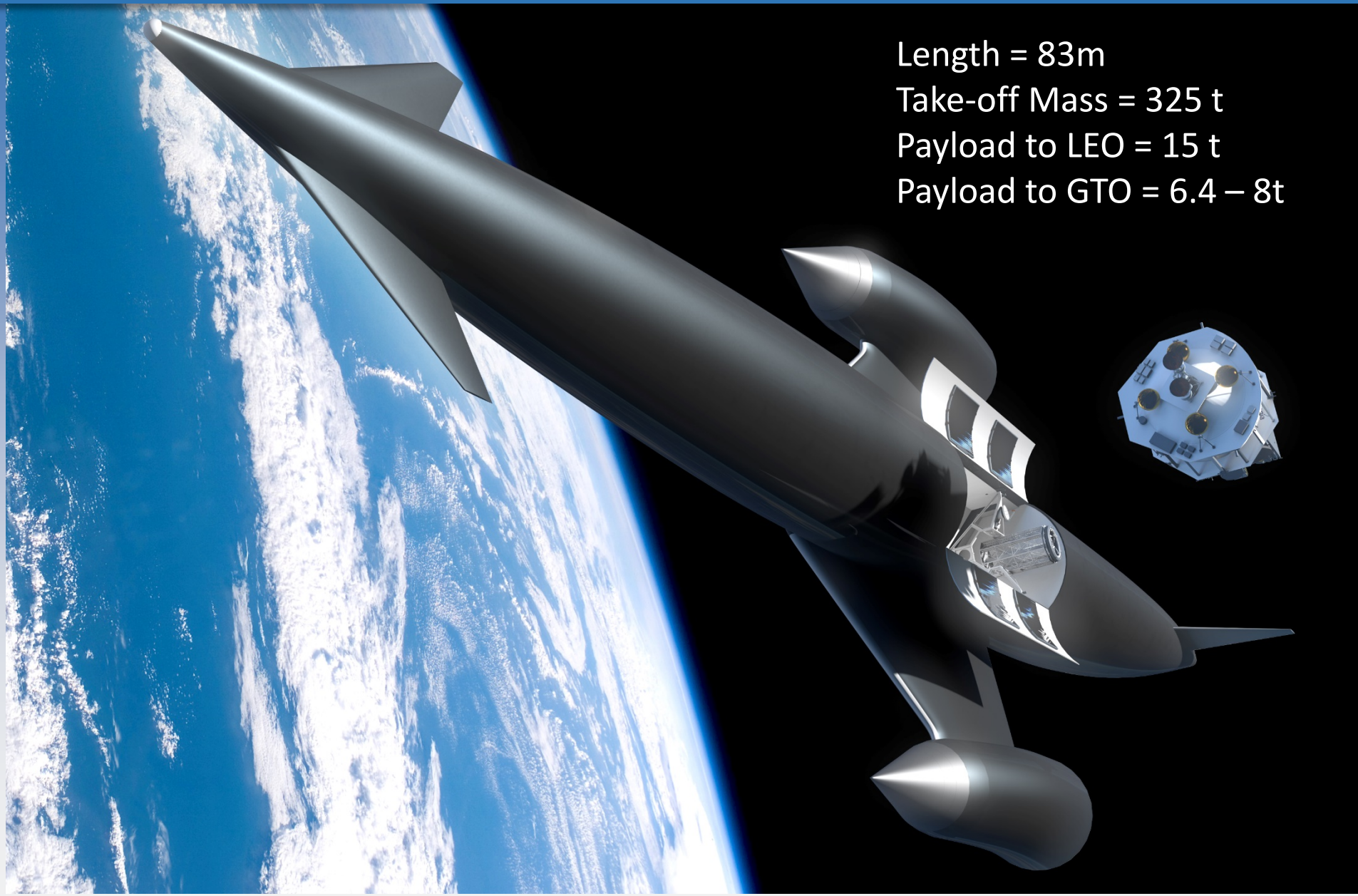
Reaction Engines Ltd.

SKYLON Operations

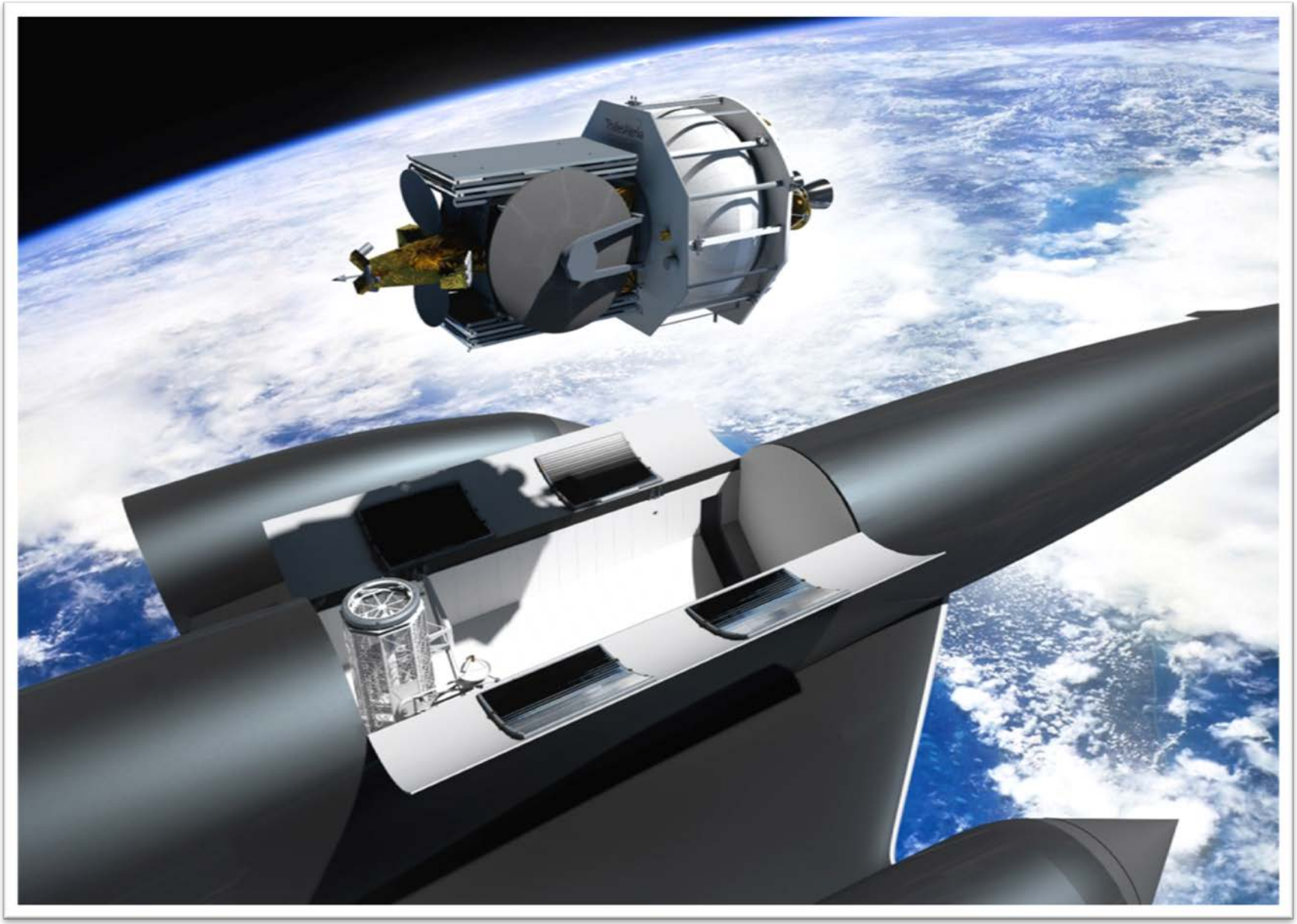
1951
Skylon Sculpture
Festival of Britain

1990
The SKYLON spaceplane…
the phoenix of HOTOL

SKYLON D1


Length = 83m
Take-off Mass = 325 t
Payload to LEO = 15 t
Payload to GTO = 6.4 – 8t

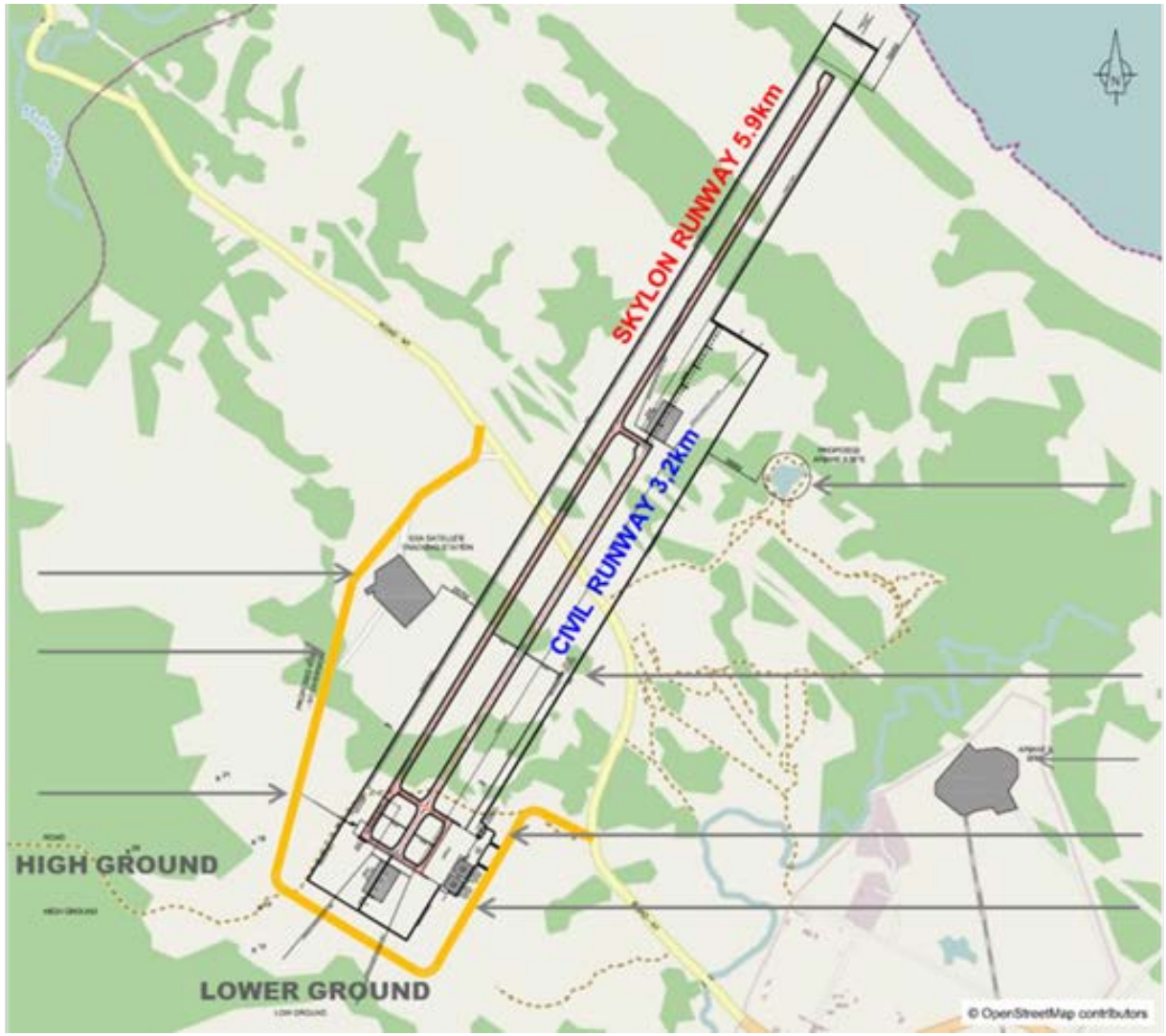
Thales Alenia Space SUS Concept Design



SKYLON & SUS Maximum Geostationary Performance

SKYLON / SUS Mission	Maximum Mass of Satellite into GTO (Tonnes)	Maximum Mass of Satellite into GEO (With 320s SI apogee engine) (Tonnes)
300 km LEO deployment Reusable SUS, 7:1 resonance return transfer orbit (GTO)	**5.58**	(3.50)
185 km LEO deployment Reusable SUS, 9:1 resonance return transfer orbit	**6.39**	(4.0)
185 km deployment Expendable SUS, destructive re-entry	**8.08**	(5.07)
300 km LEO deployment Reusable SUS 5,900 km circular MEO EP satellite, 20 kW HE thruster, 157 day transit to GEO	N/A (8.96 GTO equivalent)	**5.61**

Preferred SKYLON and Civil Runway Position & Orientation



ESA Satellite Tracking Station

Road Diversion

Fuel Access

Approx 14°

14° offset from prevailing winds

Proposed Ariane 6 Site

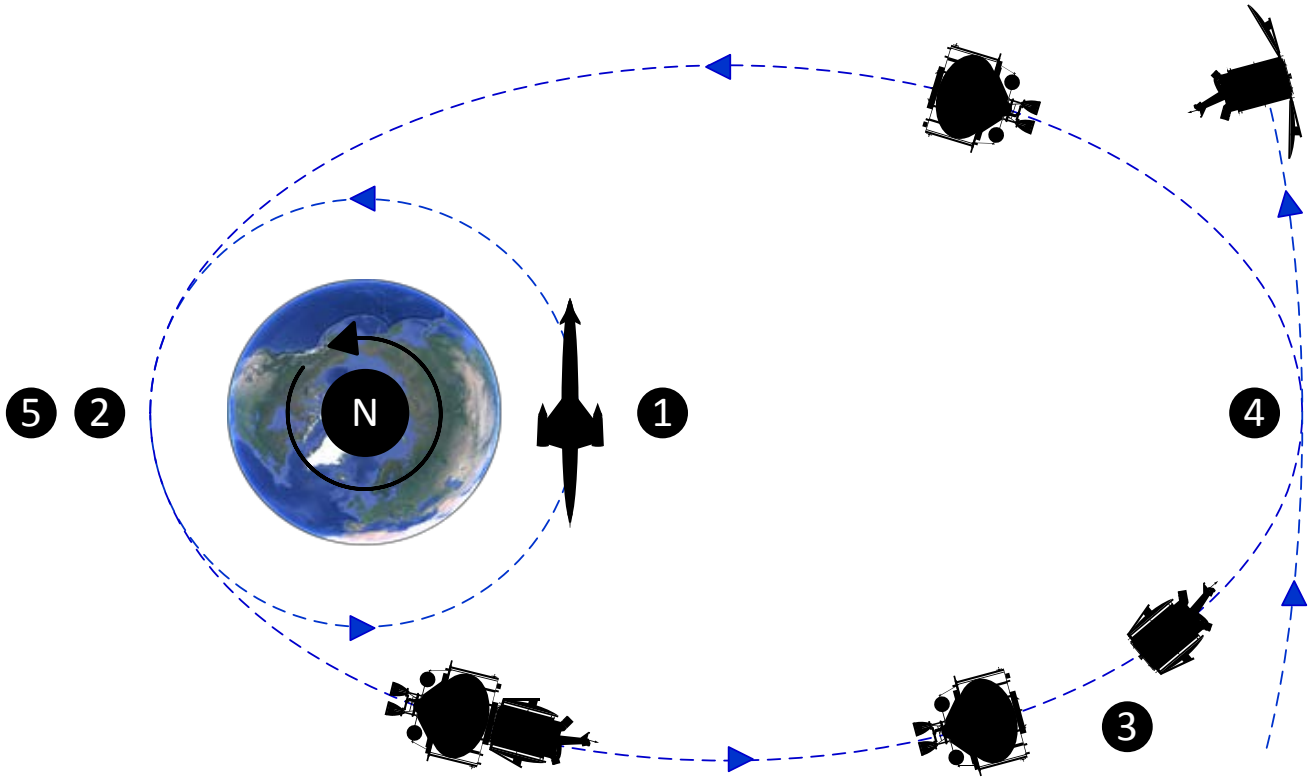
Air Traffic Control Tower & Fire & Rescue

Ariane 5 Site

Terminal and Viewing Deck

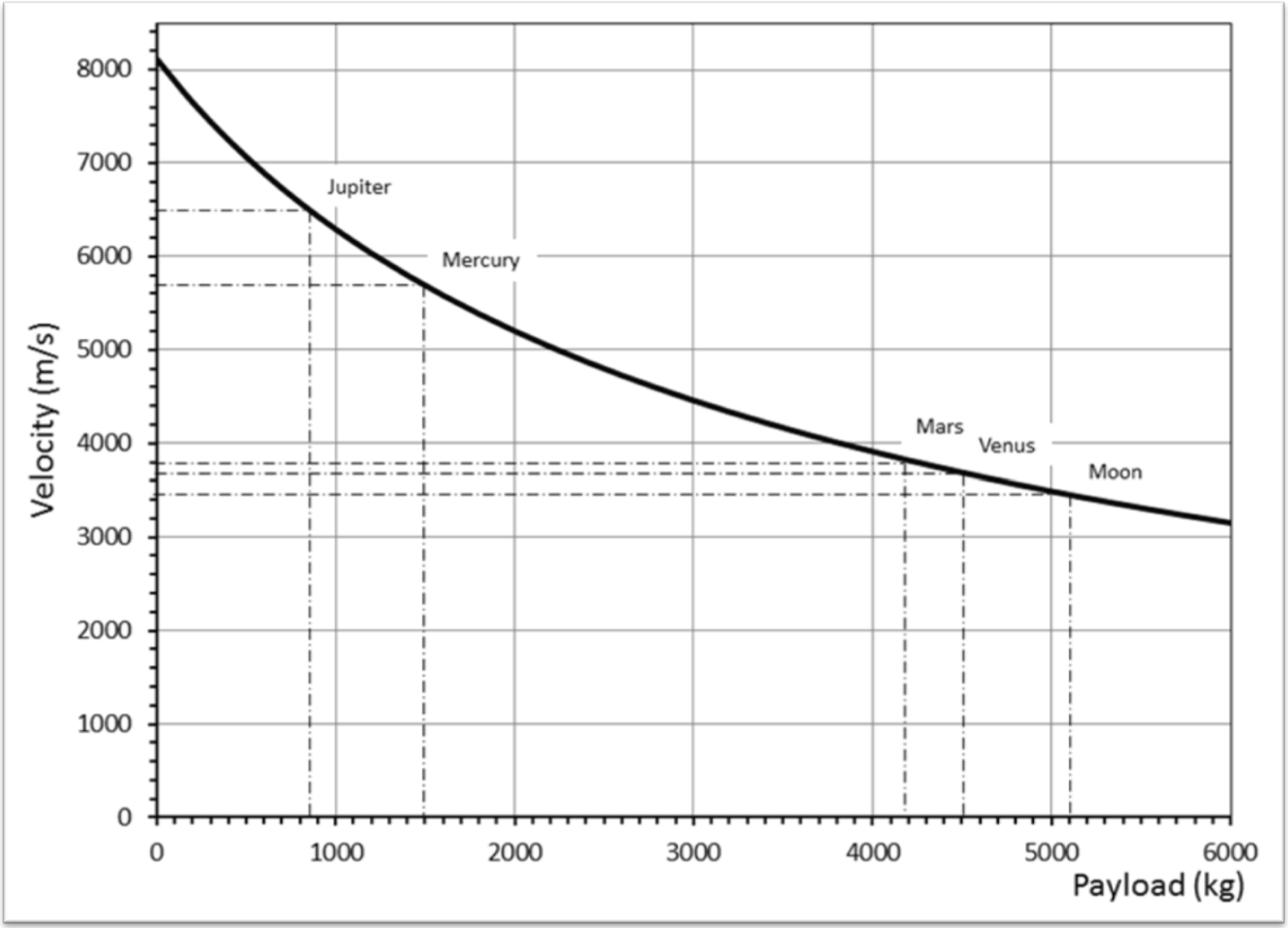
Payload Facility & Maintenance

Standard GTO Mission (7:1 resonance)



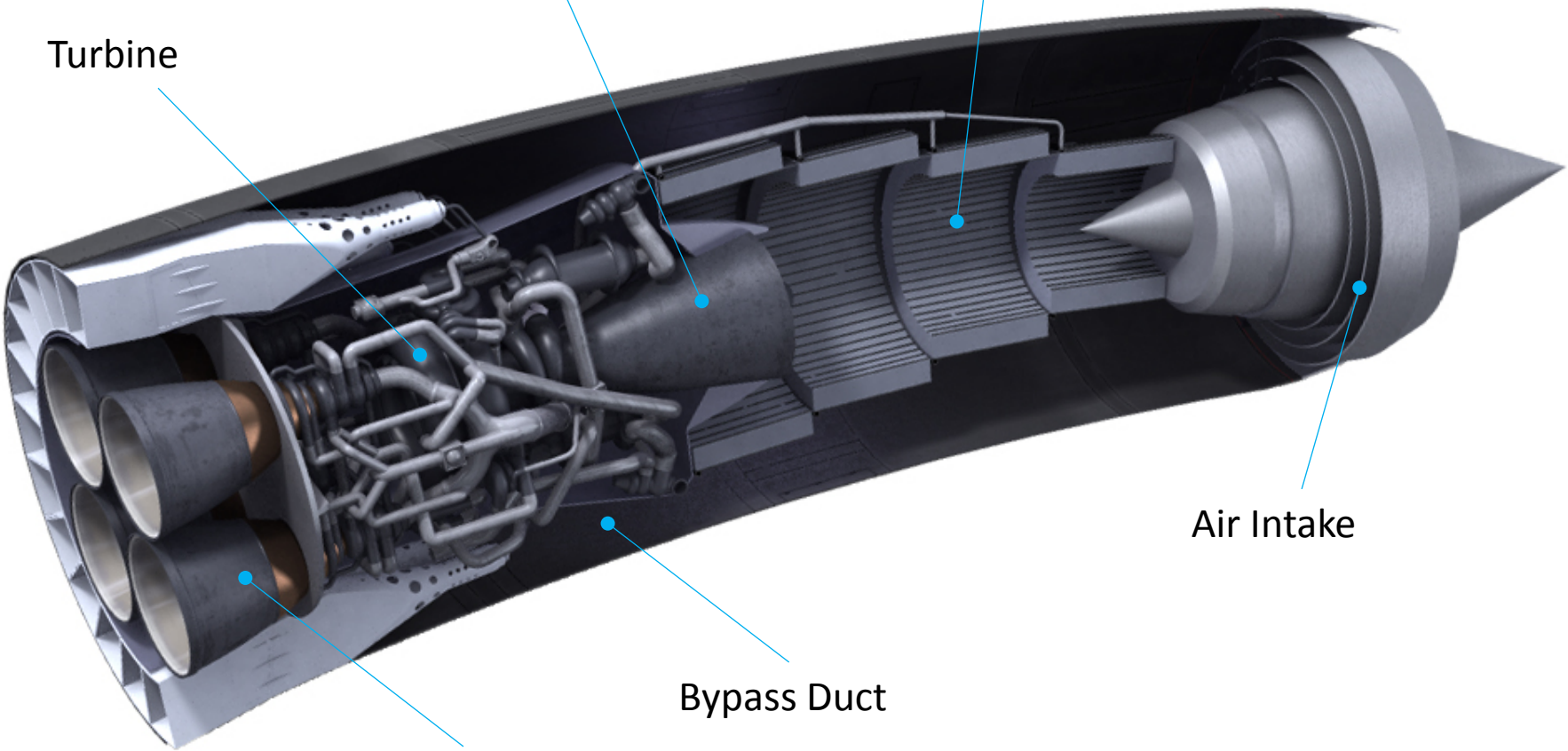
1. Skylon in 300km LEO, payload deployed
2. Perigee burn into GTO
3. Satellite serparates in GTO
4. Satellite apogee burn into GEO
5. Upper-stage LEO insertion and recovery

SKYLON/SUS Performance into Planetary Trajectories



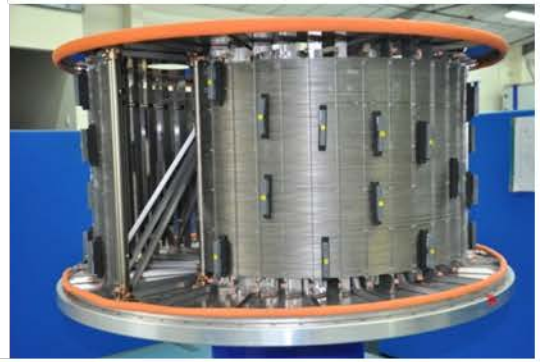
SABRE Engine

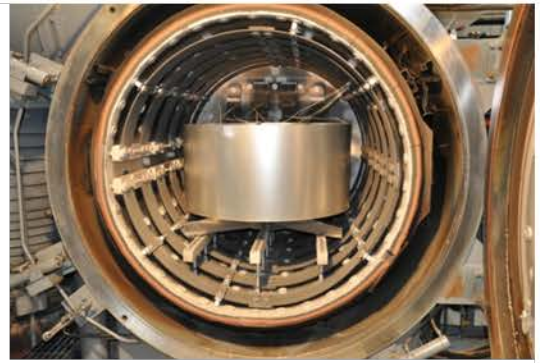
The SABRE Engine



SABRE/SKYLON Development Programme

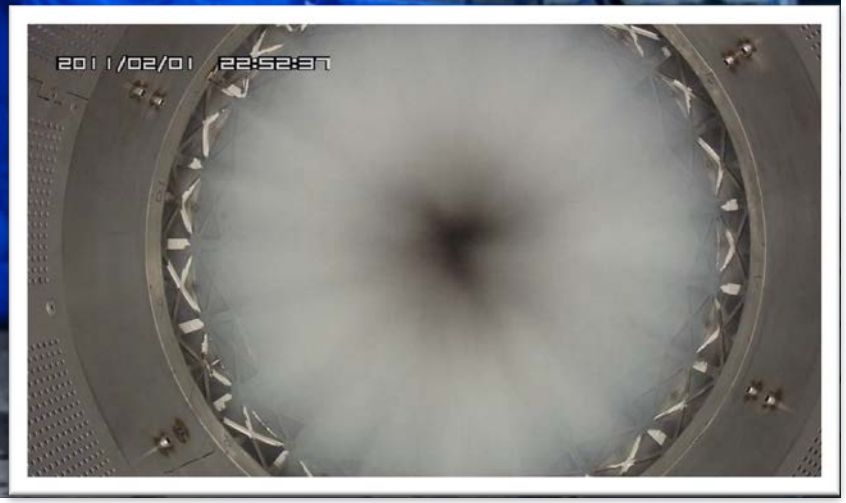
Pre-cooler Production





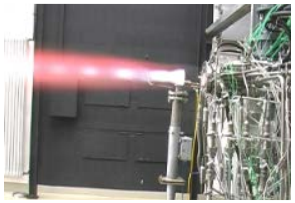
Pre-cooler Testing, B9 Culham Science Centre

- Over 700 rig tests … over 300 engine pre-cooler tests
- -150°C cryogenic temperature
- Operation of pre-cooler & frost control system
- Steady state cryogenic cooling over a sustained period
- Thermo-mechanical & aerodynamic integrity
- Technical objectives of the ESA programme



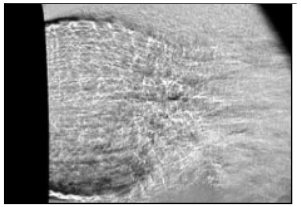
REL Engine Technologies

Contra-rotating turbine
2008



Air/hydrogen cooling
2010

LOX cooling
2010



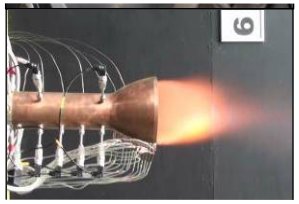
Bell nozzle separation
2010

STILETTO staged combustion
2011

Air intake
2012

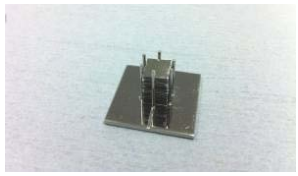
Silicon carbide high temperature Hx
2002

Advanced nozzles laboratory tests
2006



STERN E/D nozzle
2008

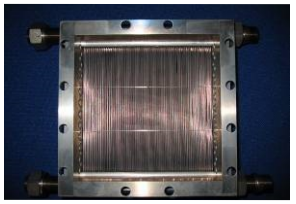
STRICT E/D nozzle
2010



Micro-channel high pressure Hx
2010

STRIDENT nozzle
2012

Laboratory scale 1GW/m³ HX
1996

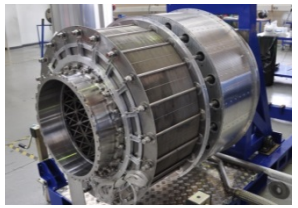


Wind tunnel Hx module
2002

Pre-cooler frost control
2004

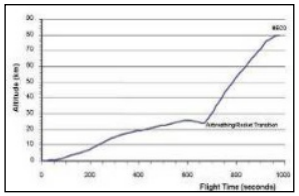
First full scale pre-cooler module
2005

Pre-cooler heat transfer augmentation
2009

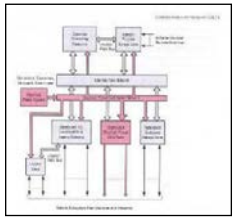


Complete pre-cooler
2012

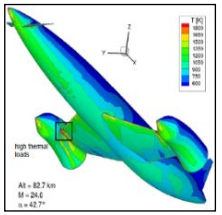
REL Vehicle Technologies



Ascent trajectory modelling

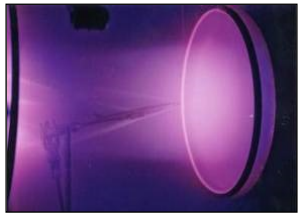


Avionics

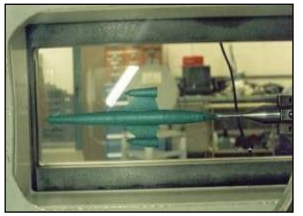


Re-entry aerodynamics

Subsonic wind tunnel



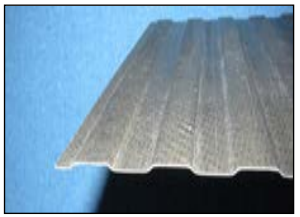
Mach 9 hypersonic wind tunnel



Mach 12 hypersonic shock tunnel

CFRP truss structure

TiSic truss structure



Aeroshell

SKYLON/SABRE Programme

SKYLON System Review

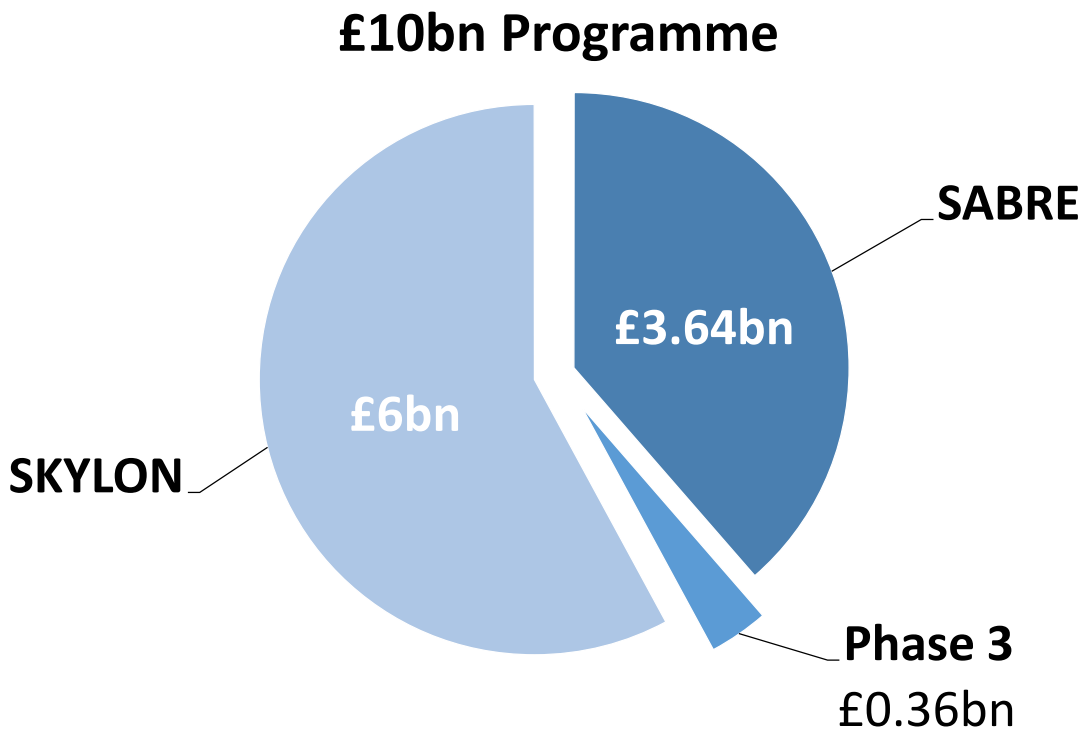
UK Space Agency independent review Sep 2010

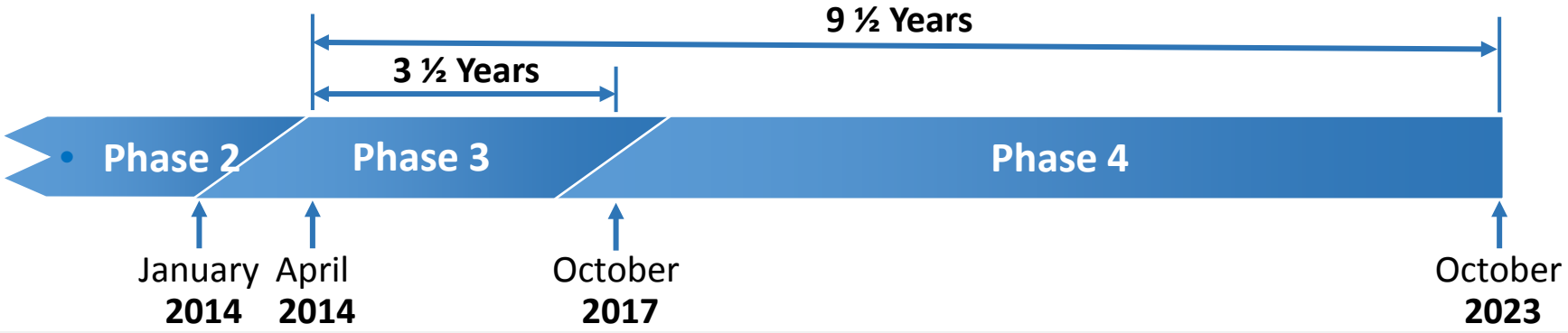
- ESA providing technical support
- Almost 100 invitees attended two day workshop
- Part of wider review including on site audit by ESA

Review Conclusions

'no impediments or critical items have been identified for either the SKYLON vehicle or the SABRE engine that are a block to further developments'.

Phase 3 SABRE Development





UK Government Grant

In July 2013 the UK government awarded REL £60M to develop the SABRE Engine

Thank you