



Solving Communications and Navigation Requirements for Small Lunar Missions

7th Nano-Satellite Symposium and the 4th UNISEC-Global Meeting

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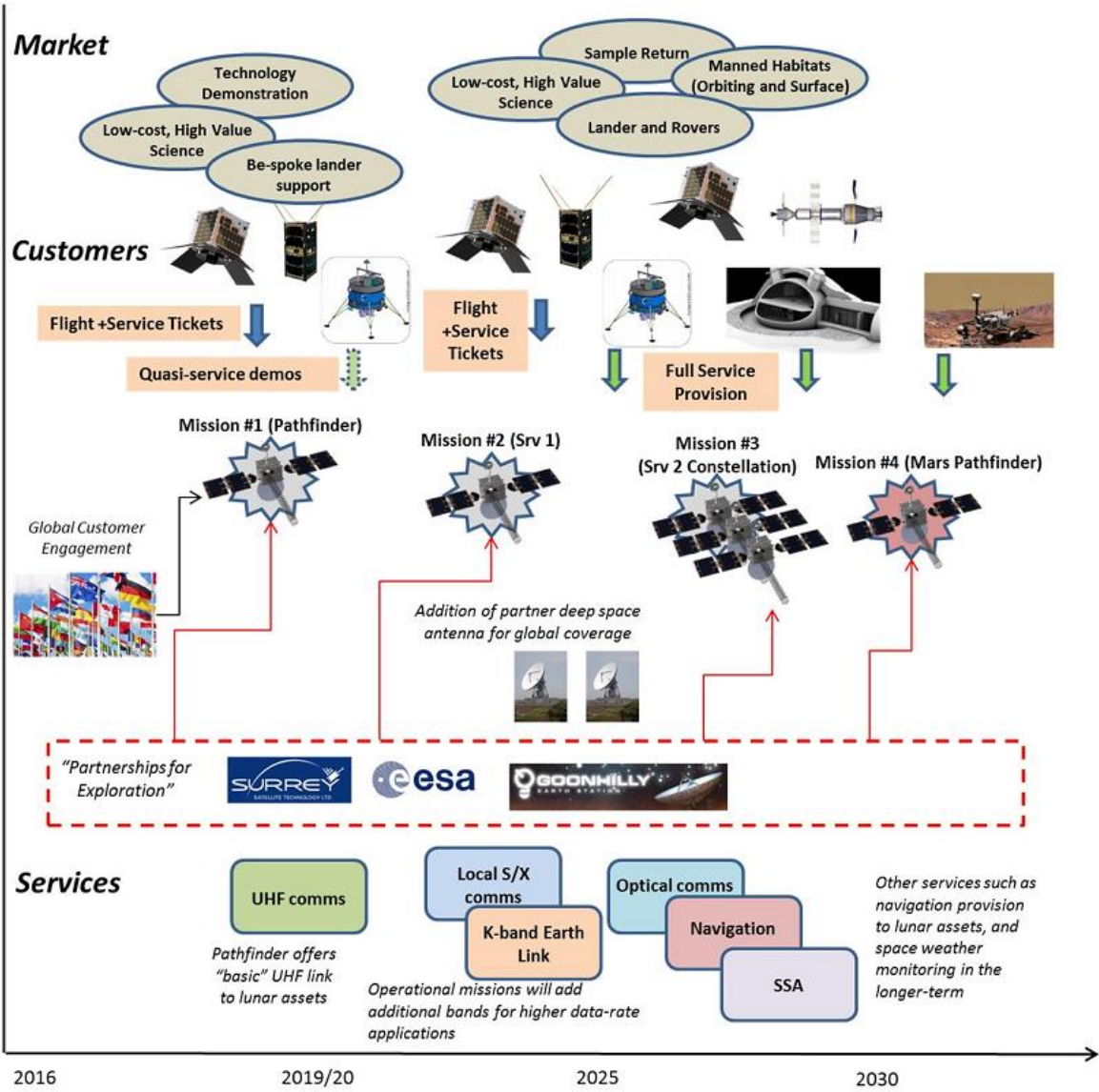
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The Future of Exploration

- Advances in nano and small satellite technology have enabled an increase in low-cost utilisation of space in Low Earth Orbit, but the same approach becomes increasingly difficult when applied to deep space missions
 - Dedicated communications and navigation infrastructure combined with frequent flight opportunities has the potential to accelerate technology development for nanosatellites, and larger missions, to the Moon, Martian and beyond.
- SSTL and GES are working in partnership with ESA in a pilot phase activity to develop commercial communications and navigation infrastructure in the solar system
 - We aim to provide a service framework to enable and enhance low-cost, high-value exploration missions throughout the inner solar system
- The first step of which will be a data relay spacecraft, to be sent to the Moon in the 2020, which will:
 - Provide an opportunity for customers to purchase a transfer to the Moon for Nano-satellites or CubeSat sized payloads
 - Supply the payloads with a CCSDS communication interface
 - Provide a data relay service for TT&C and payload data to support the nanosatellites for a 6 month baseline mission (“pay as you” beyond this point)

Long Term Vision



Partnerships for Exploration

- ESA is currently investigating ways that partnerships with industry can benefit space exploration activities
- The team is engaging with international customers to provide the user base for the first mission
- Our collaboration is open to any interested party



Space Segment

- Development of the communications spacecraft
- Launch services
- Coordination of the payload design and manufacture
- Integration of customer payloads



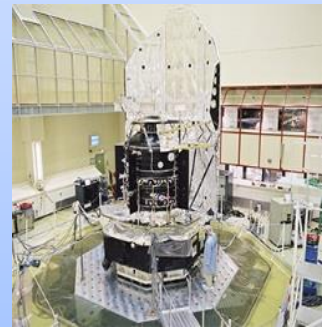
Ground Segment

- Goonhilly-6 32m antenna
- Supporting ground infrastructure, including global high speed connectivity
- Mission operations



Exploration Partnership Program

- Facilities
- Expertise
- Technology transfer
- International connections
- Regulatory support



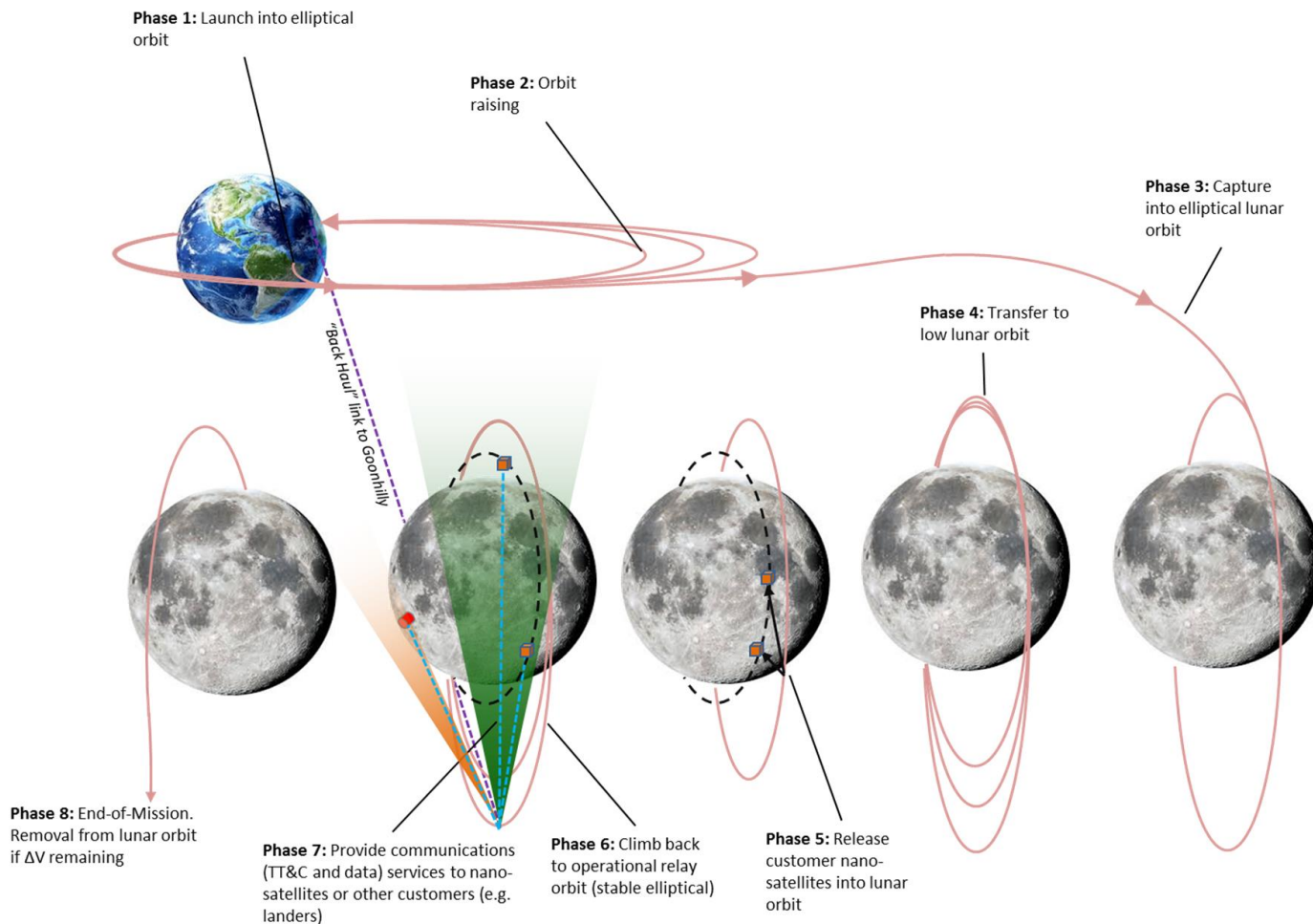
Pathfinder Mission

- ***We plan to offer nano-satellite and CubeSat users an opportunity to purchase a ticket for a ‘delivery service’ to the Moon as well as command, control and payload data relay functionality once in orbit around the Moon***
- Nominal indicative ticket pricing of £1M per kilogram
- Current working baseline is:
 - Delivery to high inclination lunar orbit with periselene over one of the two poles
 - Baseline is moderately elliptical orbit (few hundred km by few thousand km TBC as function of customer demand)
 - Minimum of 6 months communication support for all payloads + pay-as-you-go
 - UHF (CCSDS Proximity-1) for lunar links and X-band for Earth link
 - Provision of CCSDS Prox-1 Software Defined Radio card (1-off CubeSat sized PCB) to customers
- A total of ~60 kg of payload space will be available to purchase
- With this model, a small Cubesat type mission to the moon can be envisaged for a total “launch & talk” price of <£10M

Solves two problems : Delivery and communications

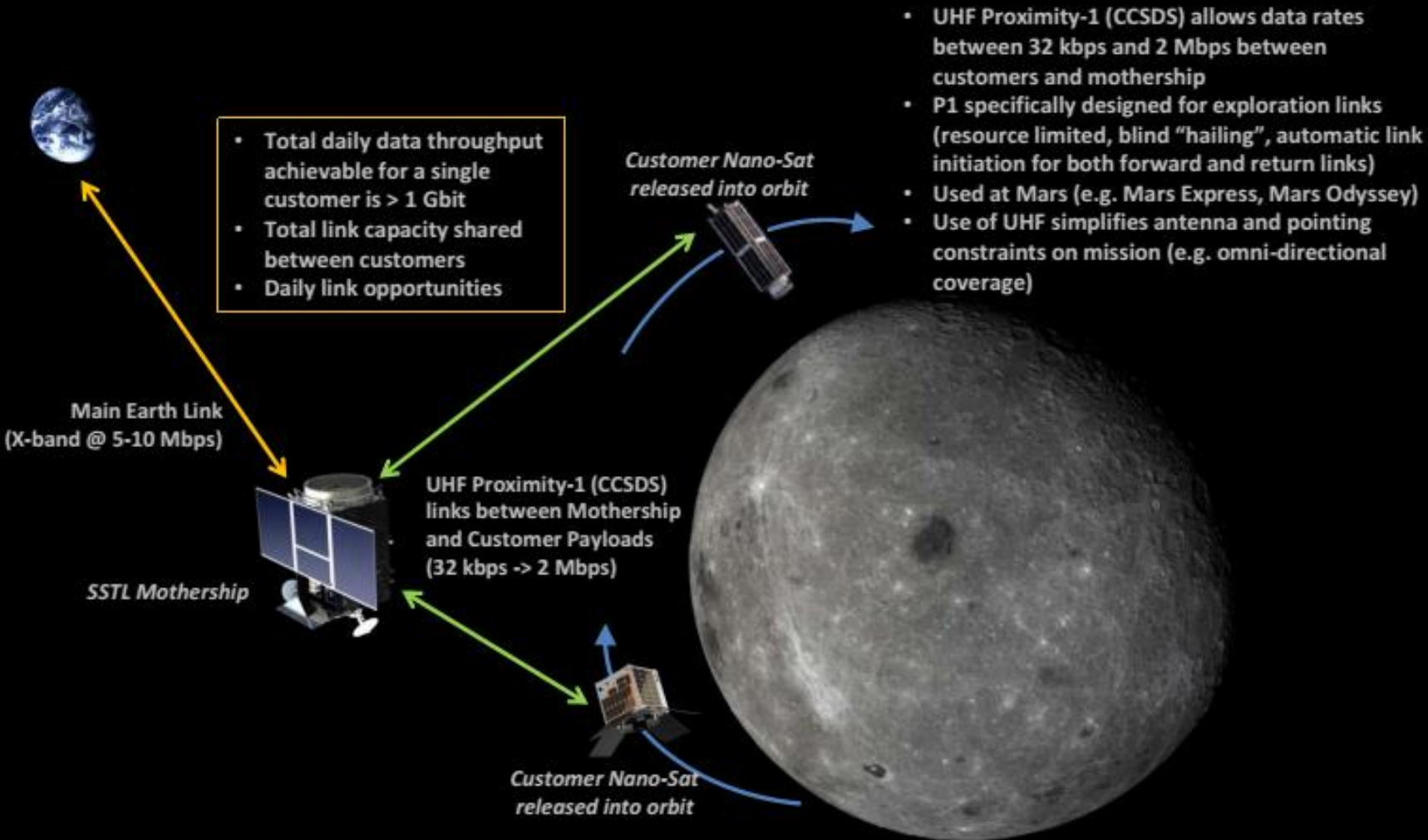
Creating new opportunities for space exploration through the provision of supporting logistics and infrastructure

Pathfinder Concept



Opportunities for releasing passenger satellites on-route to the Moon or in Lunar orbit, plus provision of communications support to surface assets. Hosted payload space on the spacecraft for 'fixed' payloads is also available.

Operational Architecture



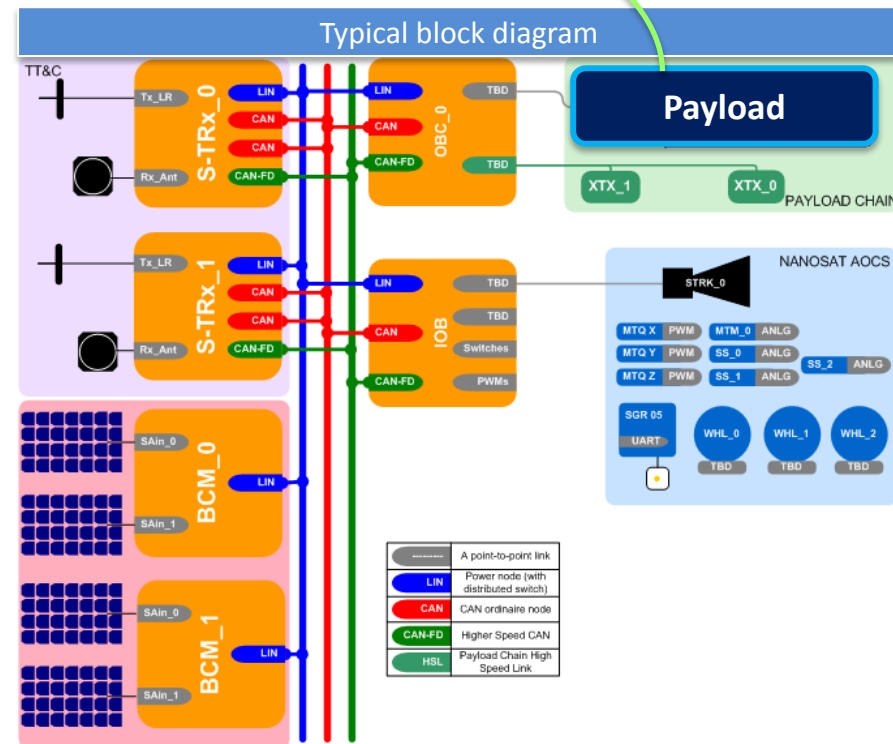
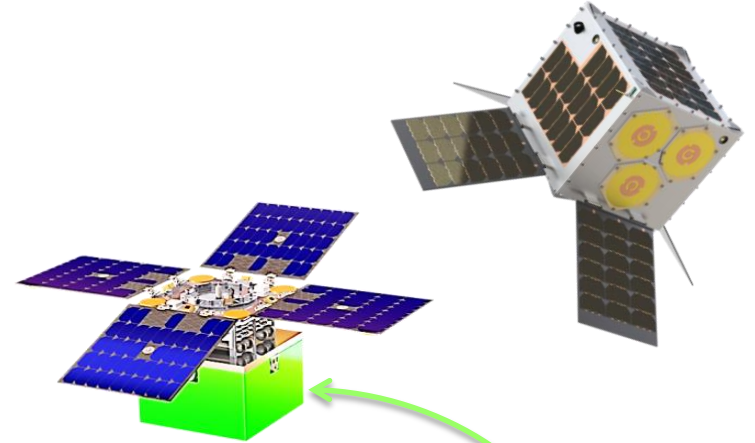
More details on the mission architecture and the communications service are available on our partners website: www.goonhilly.org/lunar

Nominal Customer Offering

PARAMETER	DESCRIPTION	COMMENT
Total payload mass to lunar orbit	~60 kg	Assuming referenced mission architecture
Power interface	28-32V & 3-5V bus	During Transfer & for Hosted Payloads
Nominal Data interface*	CAN, RS-422, SpaceWire	During Transfer & for Hosted Payloads, *other options supported
Data Relay for Lunar Assets	UHF (CCSDS Proximity-1) (1 kbps -> 2 Mbps)	Use of CCSDS to allow cross-support to other assets. SDR card to be offered to customers.
Earth Link Data Relay	X-band for Earth link (5-10 Mbps)	To Goonhilly Earth Station
Comms availability	~10 hours per day, to be split between payloads on TBC basis	Definition of time sharing between payloads to be agreed
Ticket Price	target: £0.8M to £1.5M / kg	Includes: Interfacing of customer flight models at SSTL integration facilities, Guildford, UK Launch Fees and Transfer to agreed lunar orbit Provision of 10cm x 10cm plug-in CCSDS Prox-1 communications card interface First 6 months in-orbit communications services
Other notes	Passengers provided with power connections during transfer Passengers can be thermally controlled during transfer	

SSTL-12 Platform

- “CubeSat platform price with Microsat performance”
 - Scalable Nano/Microsat platform
 - Targeted at low cost, fast delivery missions
 - Based on constellation avionics
 - Partial redundancy in key systems
- E.g. Addition of 3-axis propulsion and the Prox-1 card would enable its use for lunar missions



Summary

- **We are looking for passengers to join our manifest:**
 - Commercial flight opportunities are available for interested parties, with a targeted launch date in 2020
- **Delivery into lunar orbit and communications service:**
 - Deployment of cubesats, nanosats and be-spoke ‘micro-payloads’
 - Case-by-case opportunities for hosted payloads on the communications orbiter
 - Payload data and telemetry/telecommand relay
- **We aim to bring lunar missions within budget levels of emerging space nations, universities consortia and small businesses**
- Details of the call and supporting documentation can be found on the Goonhilly Earth Station website (www.goonhilly.org/lunar)
- Enquiries about the mission can be sent to lunar@sstl.co.uk or please contact me directly (j.friend@sstl.co.uk)

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