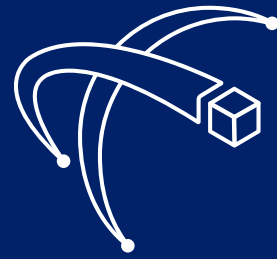


CLOUDS

**Outernet:**

**Development of a 1U Platform to Enable  
Low Cost Global Data Provision**

# Introduction



One of the UK's leading space companies, and the only wholly UK-owned Prime contractor.



ISO 9001:2008 accredited Quality Management



Broad space capability:

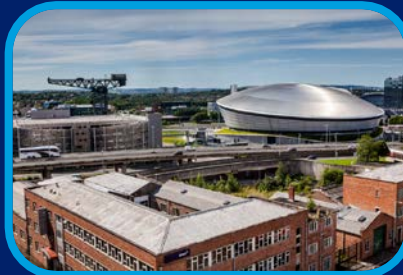
- Subsystems
- Platforms
- End-to-end missions
- Constellation design and implementation

Cleanroom will produce 60 spacecraft from mid-2015 to end of 2016, to service 5 unique missions.

Global leader in CubeSat technology, with hardware on c40% of CubeSat missions

Strategic partners for complex payloads.

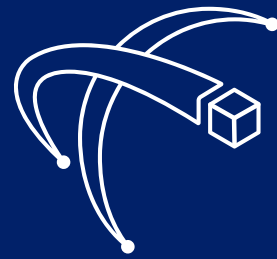
Over 10 years experience in spacecraft subsystems



World's leading supplier of small spacecraft power systems



# Pathfinder for Affordable, Space Based Telecom Network



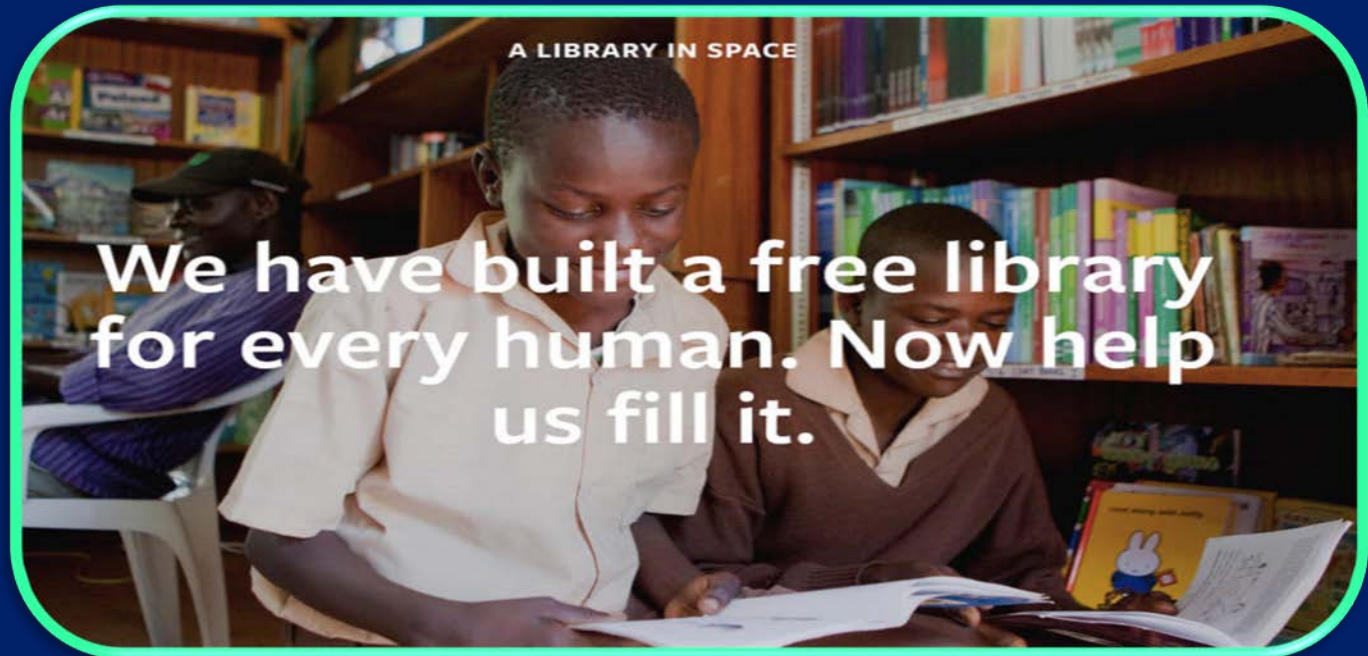
Outernet Nanosatellites being developed UK Space Agency, with support from the World Bank and Outernet

Outernet will broadcast updates from the internet across the entire planet, including areas traditionally lacking, or with restricted access to, the internet.

Outernet can broadcast Emergency data, and real time price data to farmers in remote locations; medical data, and educational content.

OUTERNET WILL PROVIDE A **FREE** SERVICE





# Objective of an *Operational* Outernet Nanosatellite Constellation



Provide **10MB** of useable, unique data:  
Per day,  
For free,  
To user anywhere on earth.

User Requested content on:

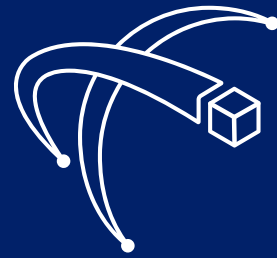
- Health Care Instruction.
- Educational Resources (Languages, Sciences).
- Disaster Recovery.
- Rural Communication.

**User requested information for  
National Library of Malawi includes:**

**Aquaponics Information.  
Computer Programming  
Advice.  
Food Security Research.**



# Clyde Space IOD Mission Considerations and Objectives



## Mission Parameter:

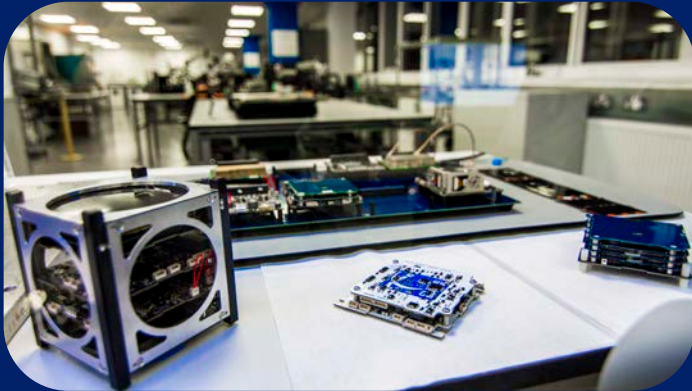
- Launch 3 x 1U CubeSats.
- Launch 1 x 3U Cubesats.
- Broadcast-only system in UHF and S-Band (3U), with GPS Scheduled User Content.
- Achieve extremely low production cost (to support Free Service).
- Develop a Global Satellite Communications System (in miniature).
- Engage with Department for International stakeholders to enhance Global Uptake.

## Clyde Space Approach:

- Investigate trade off's between data provision and power budgeting using In Orbit Test.
- Investigate low cost, automated production methodologies.
- Strict Enforcement of 'Standard Subsystem Use'.
- GPS/Galileo-Input Payload and system scheduling.
- Investigate Passive Orbit Phasing techniques and control modes.
- Promote Understanding of, and generate affordable, Space Based Solutions to Humanitarian problems.
- BETTER PREPARE CLYDE SPACE TO COMPLETE COMMERCIALY VIABLE NANOSATELLITE M2M MISSIONS.



## Standard Product Developments required for Commercially Operational Constellation:



- **Lightweight 1U Structure**
  - 130g.
  - Thermal Grounding of Primary Com. PA.
  - Facilitate rapid de-stack and re-harness.



- **Ensure highly available system**
  - Hard and Soft Watch-dog systems.
  - EDAC Scrubbed with SEC-DED fault monitoring.
  - MRAM Scalable in mass.
- Worst Case Analysis shows system-appropriate for commercial telecom missions in LEO over 4 year lifetime.
- Manufactured and tested in volume.
- High Performance:
  - 150MHz
  - 180DMIPS.
- Low power consumption
  - 350-400mW consumption
  - 4MJ per DMIP





# Volume Product to Achieve \$-per-Bit System Cost



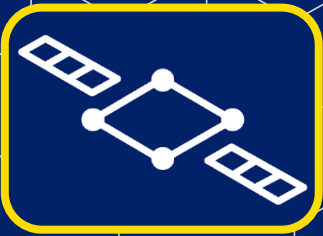
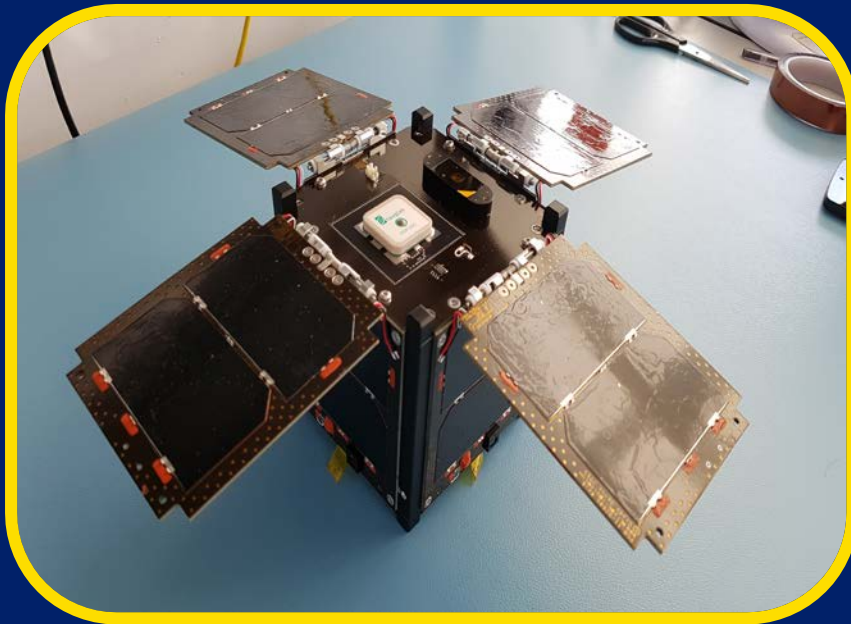
*“All Outernet Subsystems shall be manufactured using automated Production and Test techniques. This is a practical requirement to meeting Space Segment Cost requirements.”*

**Clyde Space have worked with a supplier to the UK MOD to aid volume production techniques.**



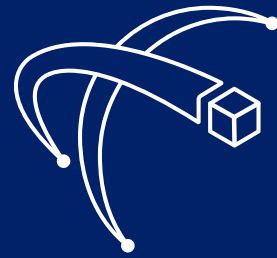


# 1U Outernet Space Segment

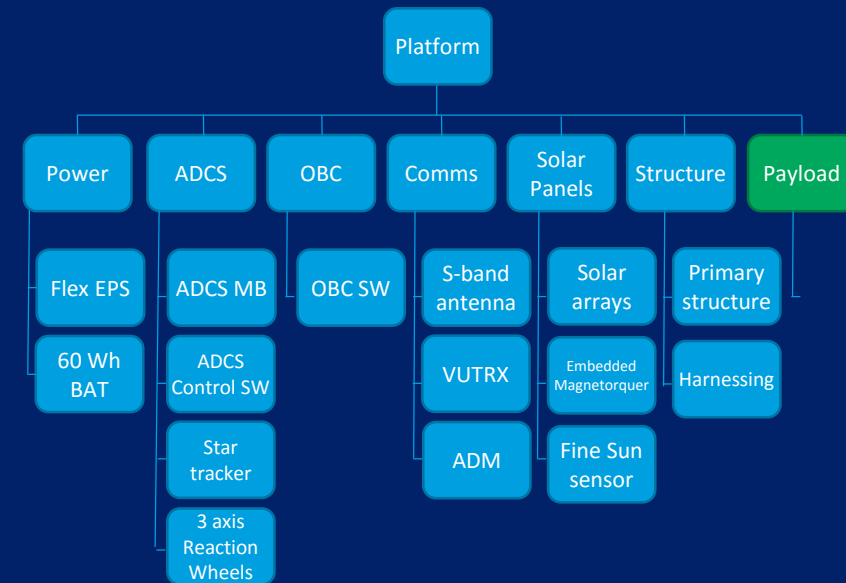


System Parameter	Value	Notes
Mass	1311g	
Peak Power Generation	4.6W	Not including Albedo.
Comms	Secure uplink; Broadcast Downlink in UHF (military band), 9k6 baud. S-band 3U Variant, 2Mbps.	
ADCS	Magnetic Control, Sun-Tracking, Spin Stabilised during mission mode.	
Power	Vbat, 3V3, 5V busses; 20Whr LiPo capacity battery (10% max. DoD).	
Orbit	TBC: 550km SSO; Inclination; 45-deg. Eccentricity; 0.03	Rocket Labs Electron Launch Vehicle.

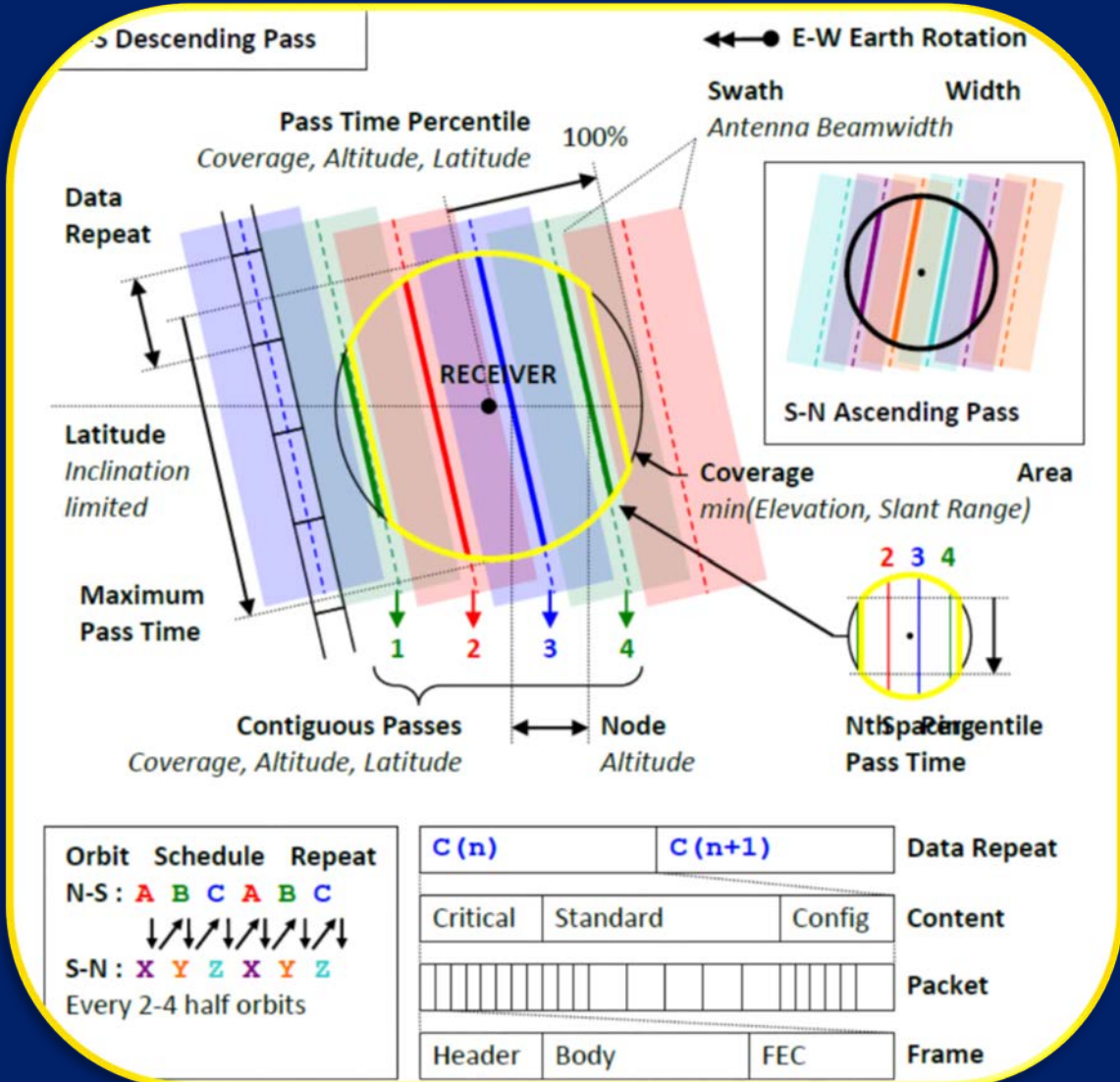
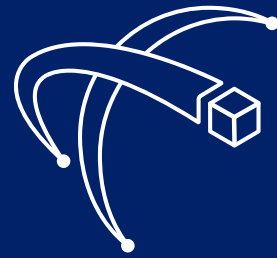
# 3U Outernet Space Segment



Subsystem	Configuration
Structure (STR)	3U Primary STR + harnessing.
Electrical Power System (EPS)	3 <sup>rd</sup> Generation (3G) Flex EPS
Battery (BAT)	Standalone 60Whr BAT module
Solar Array (SA)	Body Mounted SAs + Double sided 3U Deployable SA
On-board Computer (OBC)	Clyde Space OBC
On-board Software (SFW)	Bright Ascension Generation 1 SFW CMC VHF/UHF Transceiver (VUTRX)
Communications (COMMS) Primary	+ Omnidirectional VHF/UHF Deployable Dipole Antennas & Antenna Deployment Mechanism S-Band Transmitter (STX)
Communications (COMMS) Secondary	+ S-Band Patch Antenna ADCS Motherboard
Attitude Determination & Control System (ADCS)	+ Coarse & Fine Sun Sensors + 3 axis reaction wheels + SA Embedded Magnetorquers + OBC Integrated Global Positioning System (GPS) + Star Tracker



# Outernet Broadcast Strategy



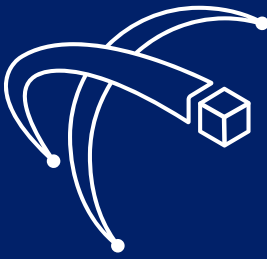
Downlink scheduling will be refreshed approximately every 24 Hours – enabling a full Earth rotation so that for any orbit geometry an orbit-orbit overlapped ground swath is assured.

Given the number,  $k$  of ground passes over a receiver,  $2k$  schedules will be repeated each 24 hours (1 for N-S descending passes, another for S-N Ascending passes).

Average pass time,  $t$  approx 210 seconds.



# Summary



3 x 1U Outernet Satellites, and 1 x 3U higher power variant shall be launched in late 2016 (December); Early 2017 (January).

Clyde Space has calibrated a production line of standardised, machine manufactured and tested components to enable rapid scaling of the Outernet Constellation post-IOD.

Clyde Space considers that Outernet mission concepts can be scaled to support many low-data-rate M2M concept applications.

**OUTERNET WILL PROVIDE A *FREE* SERVICE TO ENABLE HUMANITARIAN APPLICATIONS, WHICH CLYDE SPACE ARE PROUD TO SUPPORT>**



# Any Questions?



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