# CLYDE SPACE

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

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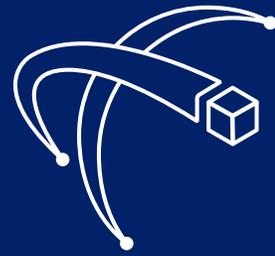
One of the UK's leading space companies, and the only wholly UK-owned Prime contractor.

Broad space capability:
- Subsystems
- Platforms
- End-to-end missions
- Constellation design and implementation

ISO 9001:2008 accredited Quality Management

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

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

Strategic partners for complex payloads.

Over 10 years experience in spacecraft subsystems
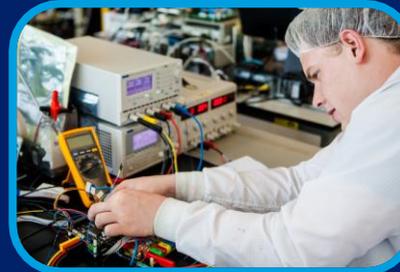
World's leading supplier of small spacecraft power systems

Pathfinder for Affordable, Space Based Telecom Network
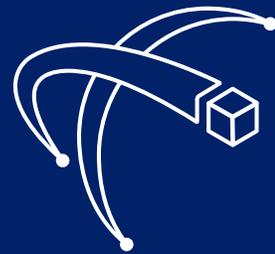
Outernet Nanosatellites being developed **UK Space Agency, with support from the World Bank and Outernet**

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**

OUTERNET
HUMANITY'S PUBLIC LIBRARY

THE WORLD BANK
Working for a World Free of Poverty

Cape Peninsula
University of Technology

A LIBRARY IN SPACE

We have built a free library for every human. Now help us fill it.
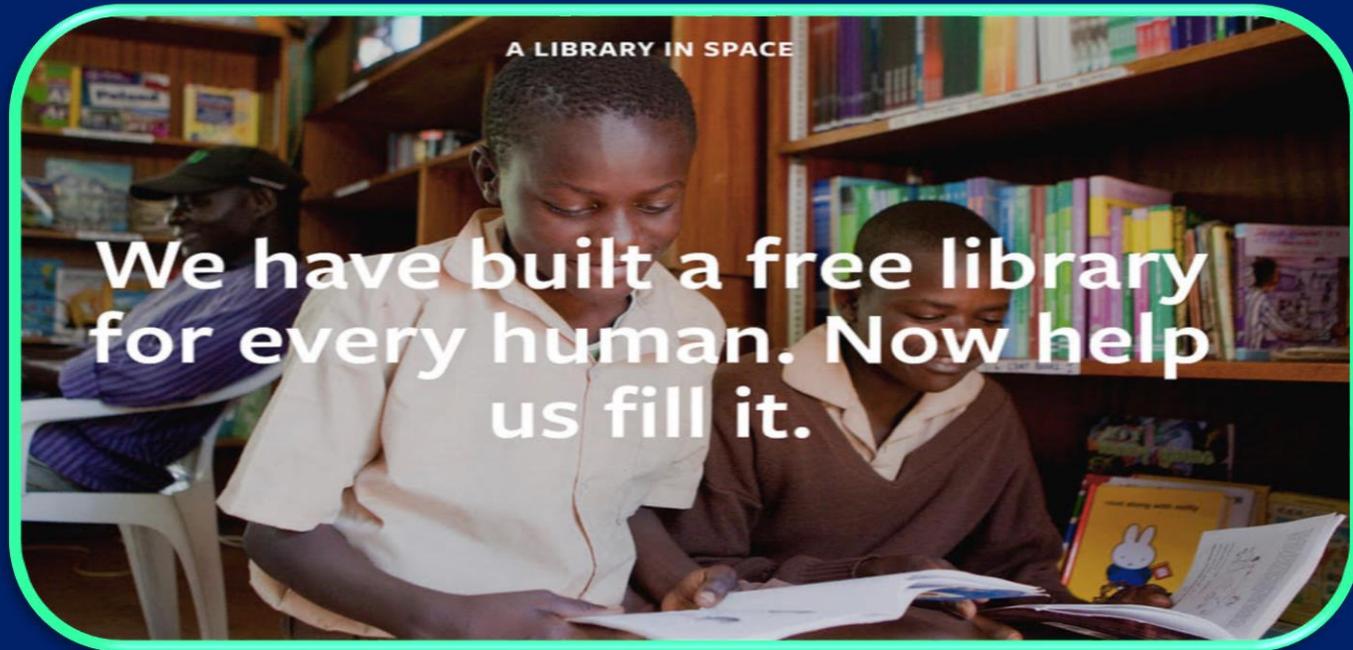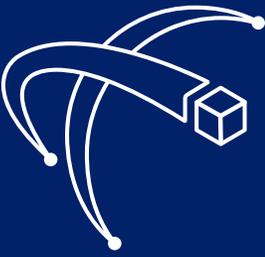
Objective of an *Operational* Outernet Nanosatelite Constellation
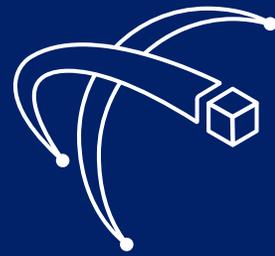
Provide 10MB of useable, unique data:
- Per day,
- For free,
- To user anywhere on earth.

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
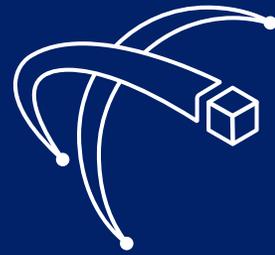
Mission Parameter:

- 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 COMMERCIALLY VIABLE NANOSATELLITE M2M MISSIONS.
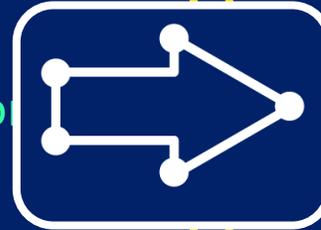
Standard Product Developments required for Commercially Operational Constellation:
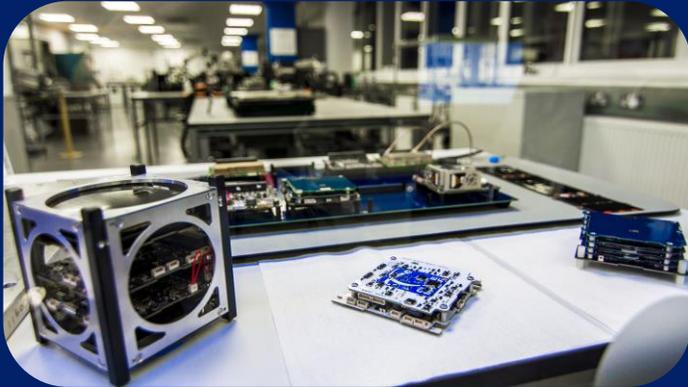

- Lightweight 1U Structure
  - 130g.
  - Thermal Grounding of Primary Com. PA.
  - Facilitate rapid de-stack and re-harness.

- 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
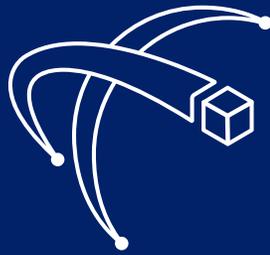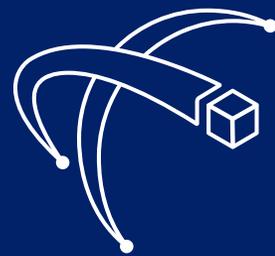
# Volume Product to Achieve $-per-Bit System Cost
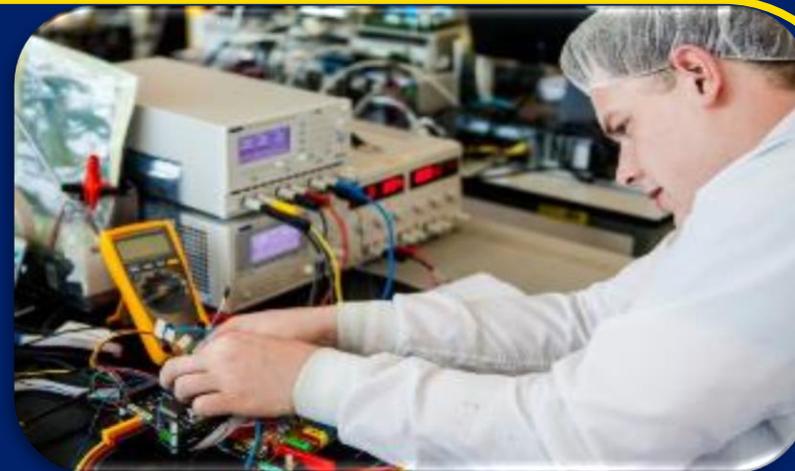
"All Outernet Subsystems shall be manufactured using automated Production and Test techniques. This is a practical requirement to meeting Space Segment Cost requirements."

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

1U Outernet Space Segment
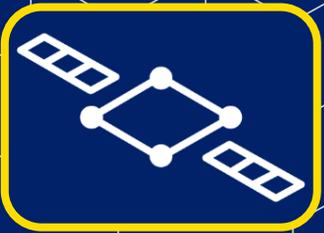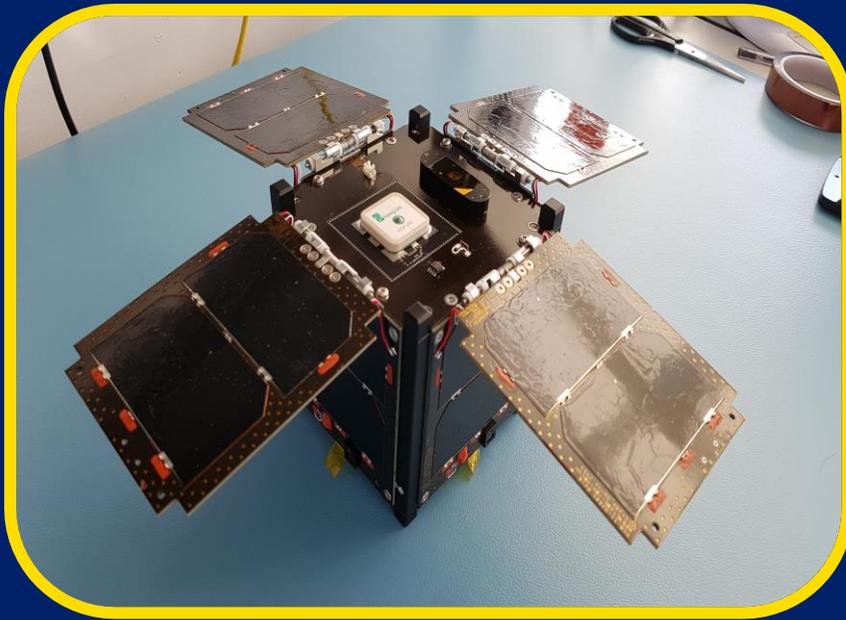
System Parameter	Value	Notes
Mass	1311g	
Peak Power Generation	4.6W	Not including Albedo.
Comms	Secure uplink; Broadcast Downlink in UHF (military band), 9k6 baud. S-band 3U Variant, 2Mbps.	
ADCS	Magnetic Control, Sun-Tracking, Spin Stabilised during mission mode.	
Power	Vbat, 3V3, 5V busses; 20Whr LiPo capacity battery (10% max. DoD).	
Orbit	TBC: 550km SSO; Inclination; 45-deg. Eccentricity; 0.03	Rocket Labs Electron Launch Vehicle.

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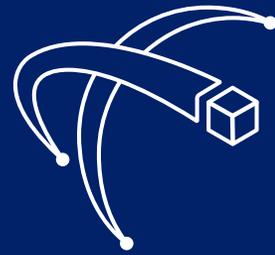
| Subsystem	Configuration
Structure (STR)	3U Primary STR + harnessing.
Electrical Power System (EPS)	3rd Generation (3G) FleX EPS
Battery (BAT)	Standalone 60Whr BAT module
Solar Array (SA)	Body Mounted SAs + Double sided 3U Deployable SA
On-board Computer (OBC)	Clyde Space OBC
On-board Software (SFW)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

Platform
- Power
  - Flex EPS
  - 60 Wh BAT
- ADCS
  - ADCS MB
  - ADCS Control SW
  - Star tracker
  - 3 axis Reaction Wheels
- OBC
  - OBC SW
- Comms
  - S-band antenna
  - VUTRX
  - ADM
- Solar Panels
  - Solar arrays
  - Embedded Magnetorquer
  - Fine Sun sensor
- Structure
  - Primary structure
  - Harnessing
- Payload
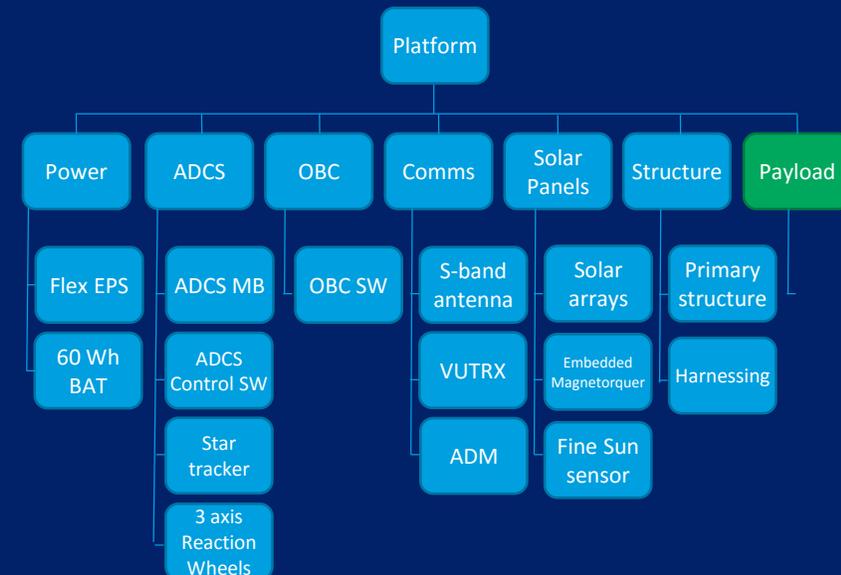
Outernet Broadcast Strategy
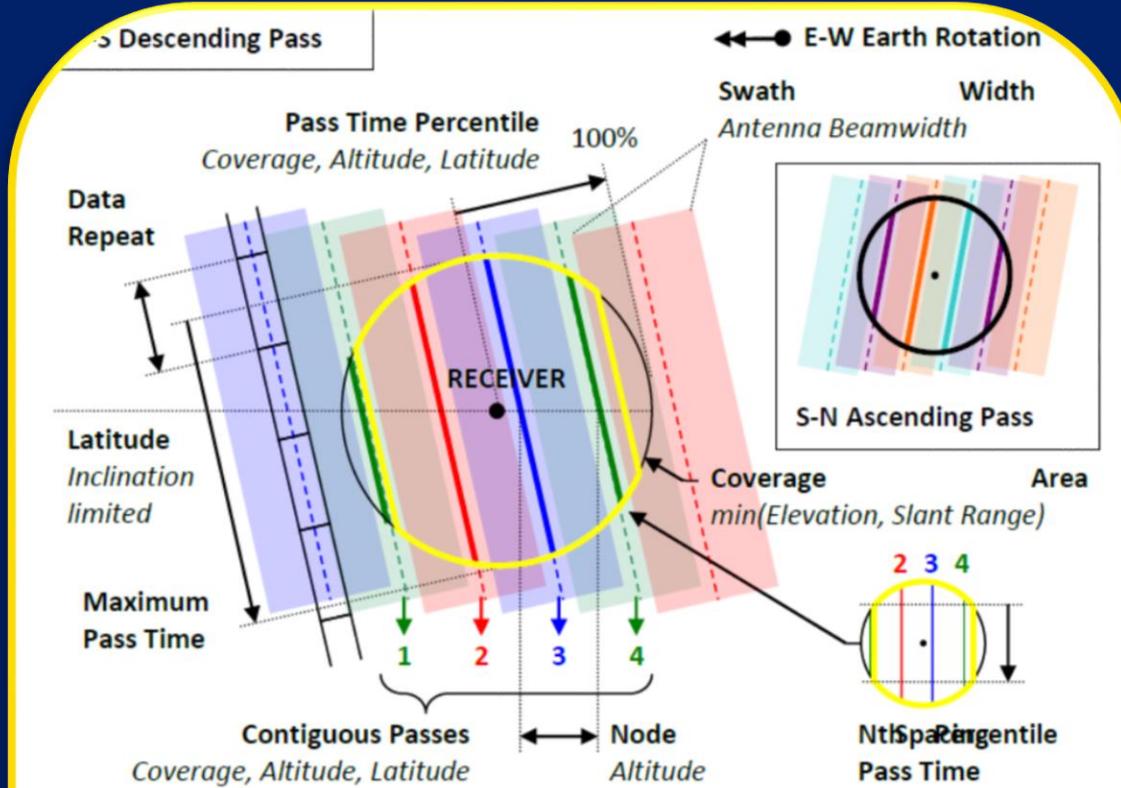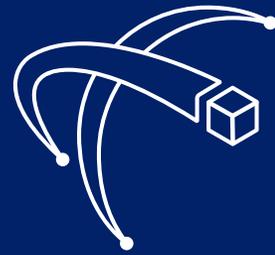
Downlink scheduling will be refreshed approximately every 24 Hours – enabling a full Earth rotation so that for any orbit geometry an orbit-orbit overlapped ground swath is assured.

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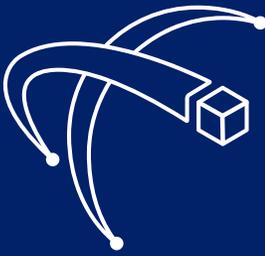
3 x 1U Outernet Satellites, and 1 x 3U higher power variant shall be launched in late 2016 (December); Early 2017 (January).

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>
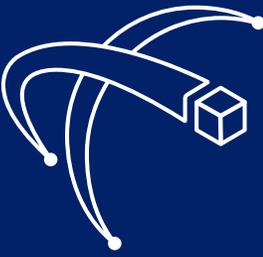
Any Questions?

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