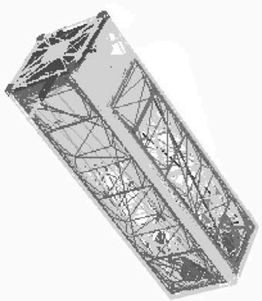
LSAT

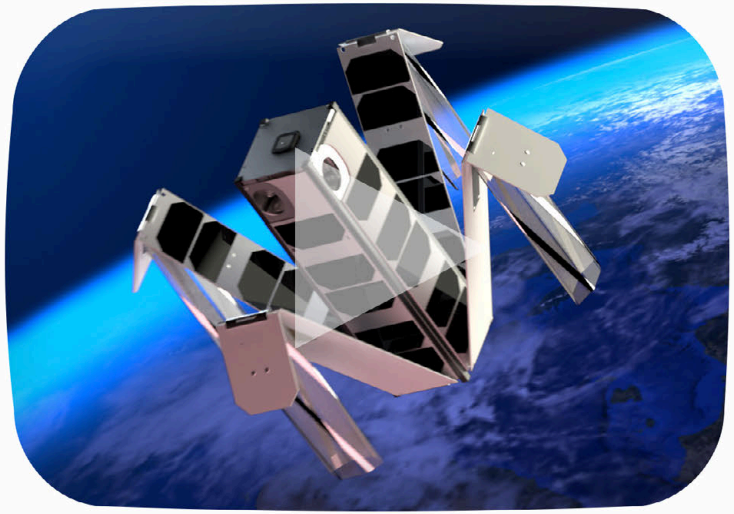
LOW SIGNAL ACQUISITION & TRACKING

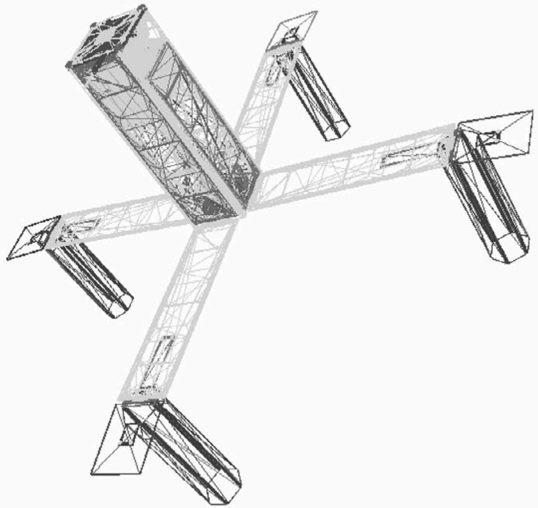
INTRODUCTION AND VIDEO DEMONSTRATION

LSAT is a high-gain, dynamic phased array antenna for UHF SATCOM. It features four hexagonal antennae that fold up into the solar panels as shown in the video demo below. The array can track co-operative targets, enabling high speed communication with small, disadvantaged terminals such as handheld radios, unmanned ground sensors and emergency beacons.

The array may also operate in RDF (radio direction finding) mode allowing it to determine the precise origin of UHF signals. This feature may be used to aid in search and rescue, as well as to identify and locate potential threats,



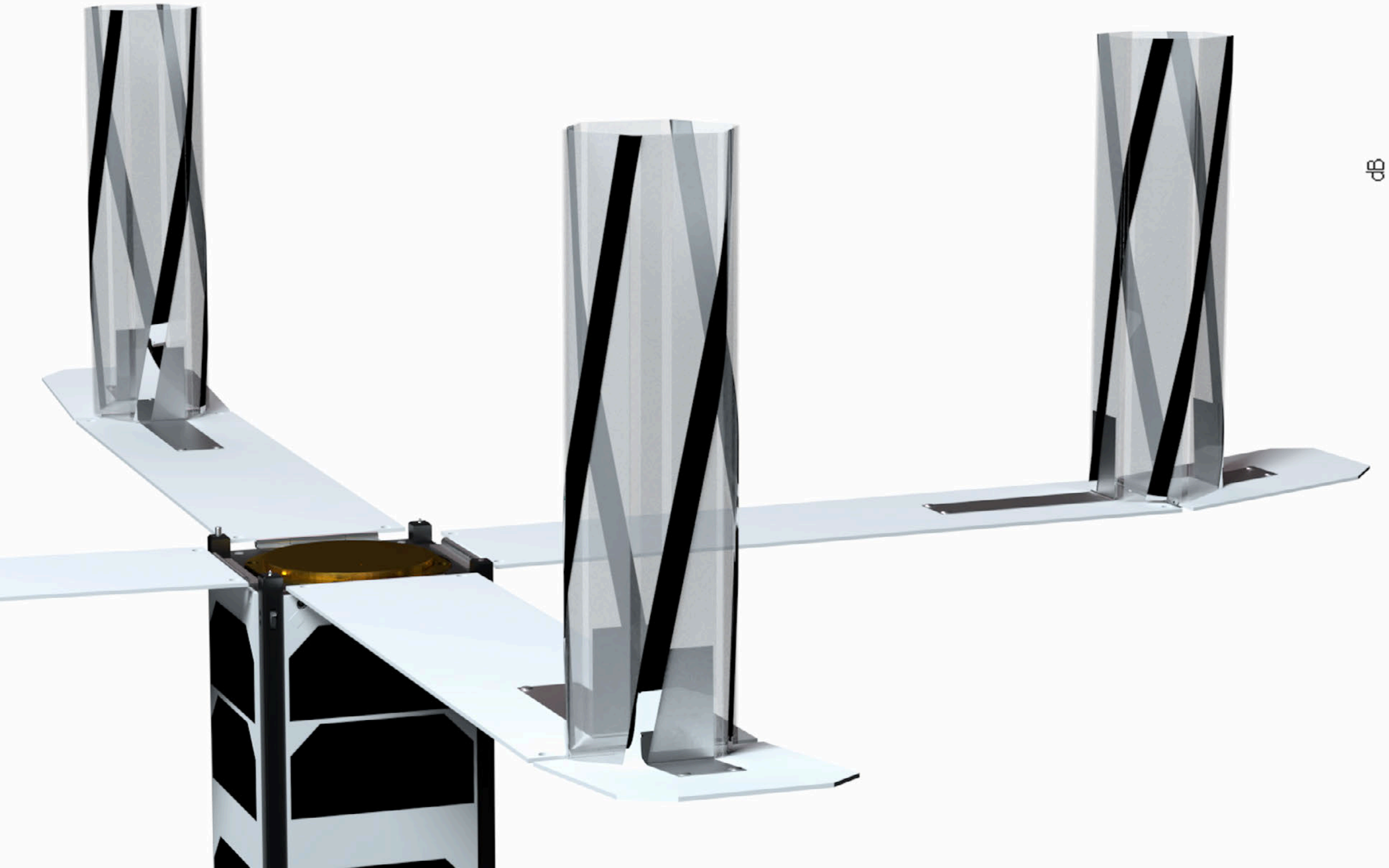


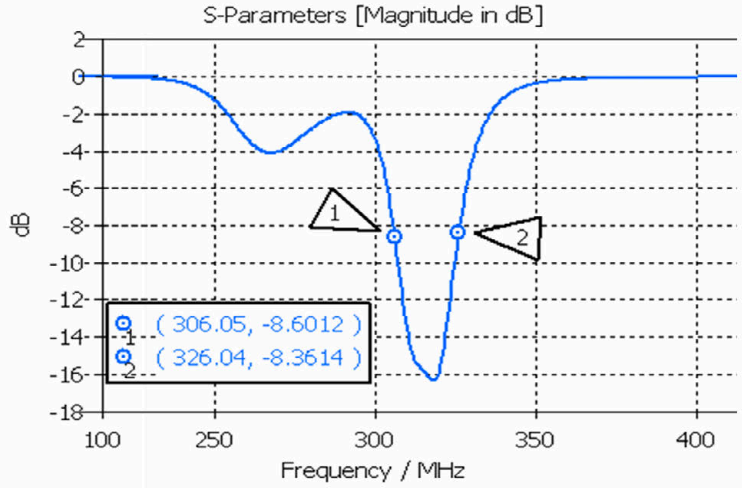


https://youtu.be/UfuUwajIvcU

PHASED ARRAY

ANTENNA DESIGN





Each antenna is an open-ended quadrifilar helix, bonded to a sheet of flexible dielectric film. The sheet is stiffened with 6 fibreglass panels to form a hexagonal tube that may be folded flat against the body of the satellite.

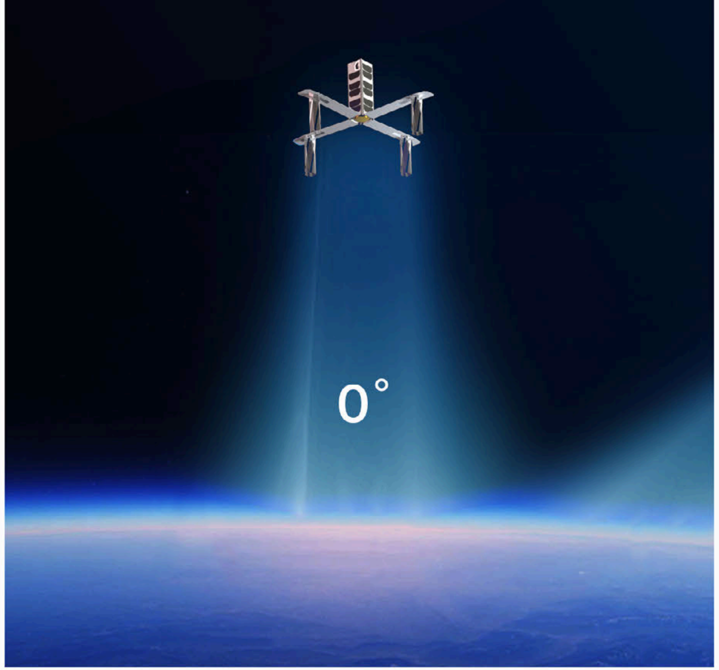
20Mhz bandwidth at UHF uplink frequencies is possible, as shown in our simulation results above. The antenna may be operated at down-link frequencies with the use of a duplexer.

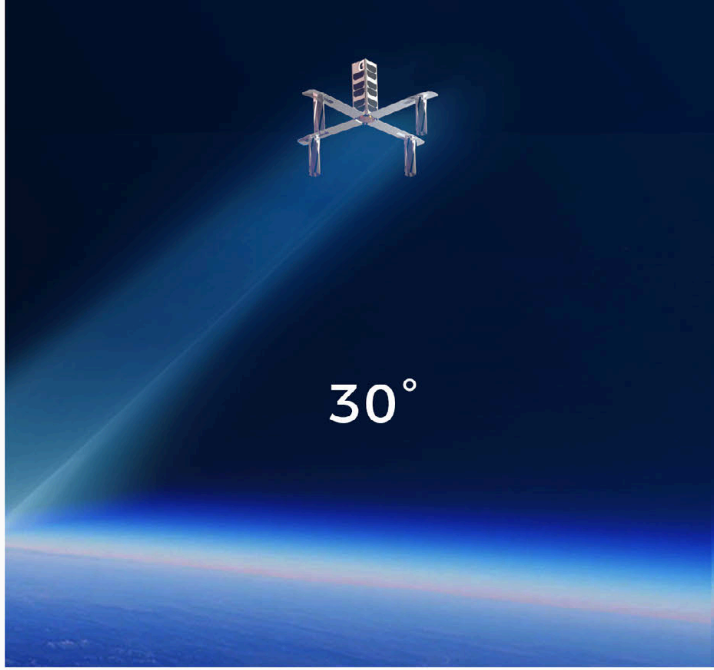
The simulation to the right demonstrates almost 7dBm of peak gain, a fivefold increase in gathering power over a standard UHF tape-spring antenna @ 0dBm. Radiation patterns at two example angles (0 and 30 degrees) are shown.

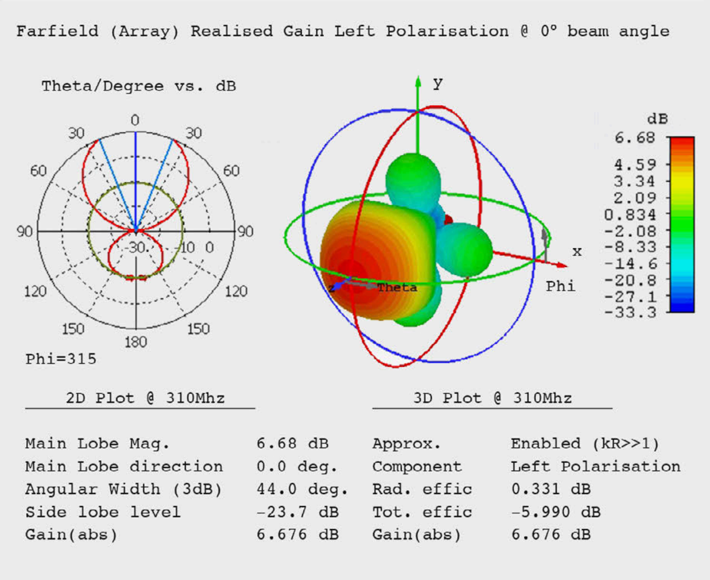
By adjusting the phase of the signal at each element, the beam angle may be changed without physically moving the cubesat. This allows us to keep the beam locked on to a mobile or static target as the satellite passes overhead, providing horizon-to-horizon communication for even the smallest ground terminals.

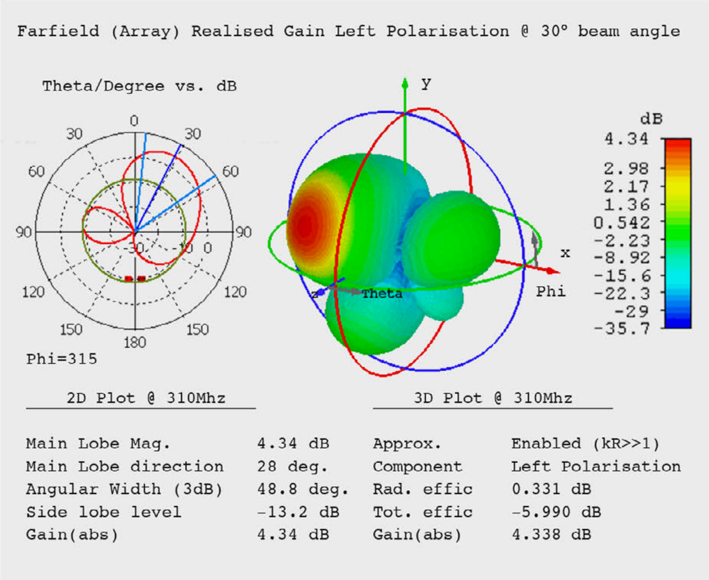
The LSAT system is incredibly versatile. Using standard flex-rigid PCB manufacturing it is possible to print and test a completely new conductive element without changing the shape of the hexagonal support structure or the method of deployment. L-band, S-band or higher frequencies are all possible. With only minor modification the antenna may be mounted on both 3U and 6U cubesats, including the 1.5U payload structure supported by the Prometheus cubesat bus.

The antenna itself occupies an estimated volume of only 15 cubic cm in a compressed state, expanding to 30 times this volume when deployed.



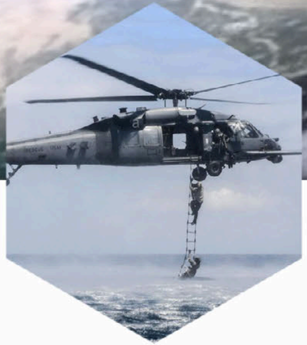


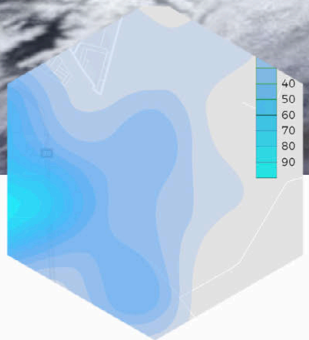




MISSION

APPLICATIONS





HANDHELD SATCOM

Achieve reliable communication using small, low power radios.

UNATTENDED SENSORS

Collect up to 0.5MB of data per pass from unattended ground sensors.

SEARCH AND RESCUE

Track standard issue radios or emergency beacons.

THREAT DETECTION

Determine the origin of UHF signals that may indicate a threat.

MINIATURE

HANDHELD SATCOM

Link budget when overhead

Cubesat altitude:	500km
Path distance	500km
Uplink frequency	310Mhz
Handheld EIRP:	7dBW
Array steering	0˚
Incident signal	0˚
LSAT antenna gain	6.8dB
LSAT noise temp.	1.5dB
Data rate	250kbps
Eb/No:	**31.4dB**

Link budget when at horizon

Cubesat altitude:	500km
Path distance	2574km
Uplink frequency	310Mhz
Handheld EIRP:	7dBW
Array steering	45˚
Incident signal	68˚
LSAT antenna gain	0.9dB
LSAT noise temp.	1.5dB
Data rate	250kbps
Eb/No:	**11.24**

The calculations above demonstrate that a robust communication link (Eb/No > 10) may be obtained with a transmitter EIRP of only 7dBW. This is within the capabilities (and safe limits) of a handheld radio with a dipole antenna, as shown in our concept design opposite.

If we estimate 90% standby, 8% receive and 2% transmit time, then a 23Wh battery would give us an estimated 10hr battery life.

A small cubesat constellation could operate as a backup in the event that the primary (MUOS) manpack radio fails or for missions that require ultra-lightweight equipment. These radios could also be issued to non-military personnel for support purposes or humanitarian use (such as disaster relief), providing a safe channel for communication in scenarios where there may be no cell service available.

Concept design for LSAT handheld terminal

MINIATURE

UNATTENDED GROUND SENSORS

The high gain and beamsteering abilities of the LSAT array make it ideal for capturing data from unattended ground sensors in remote areas. As the satellite passes overhead, it dynamically changes the beam direction to ensure the best possible link.

This minimises the power needed to communicate with the satellite, dramatically improving both the battery life and quantity of data that can be collected.

The table to the right demonstrates that a 25kb/s data link may be achieved even at low satellite elevations. With heavy usage (~250kb every 90 minutes) the radio may last for up to 9 months on a single Panasonic 18650 battery. With light usage, many years of operation are possible.

Overall sensor battery life will depend on power consumed by the sensor itself.

Cubesat altitude	500km
Path dist. @ horizon	2574km
Uplink frequency	310Mhz
Sensor Tx power	0.5W
Sensor EIRP	-3dBW
Data rate	25kb/s
Eb/No	**11.24**
Average pass time	180s
Data volume	250kb
Sensor system power	1W
Duty cycle	0.18%
Battery capacity	12.2Wh
Lifetime	**9 months**


Source: Wikimedia

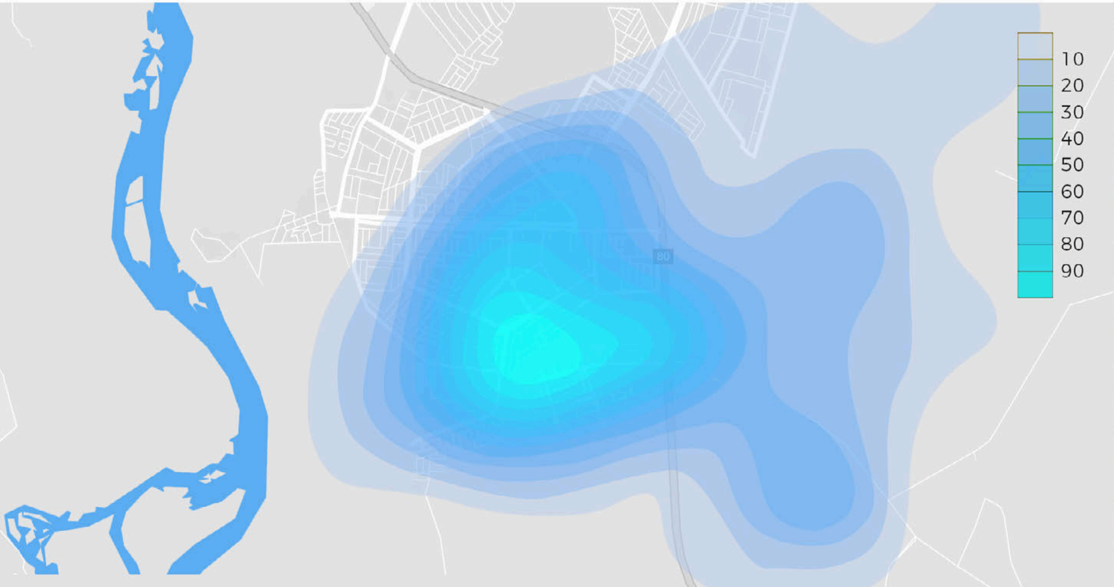

Source: Dakotalapse.com

THE APPLICATION OF LSAT TO

SEARCH, RESCUE AND THREAT DETECTION

The LSAT array may be operated in RDF (radio direction finding) mode. By using a combination of beamforming and Doppler processing techniques it is possible to determine the angle of arrival of UHF transmissions, and therefore their point of origin on the ground. This technique may be used to locate a standard-issue radio or specialised distress beacon.

RDF mode may also be used to locate the source of potential threats including jamming stations, UHF radar, areas of interference, etc. A constellation of cubesats could extend spectrum coverage if needed.



2D plot showing location of UHF source (artist impression)

LSAT render

TURNSTILE ANTENNA

GPS patch antenna + UHF turnstile antenna for telemetry while tumbling
Innovative Solutions in Space

EPS

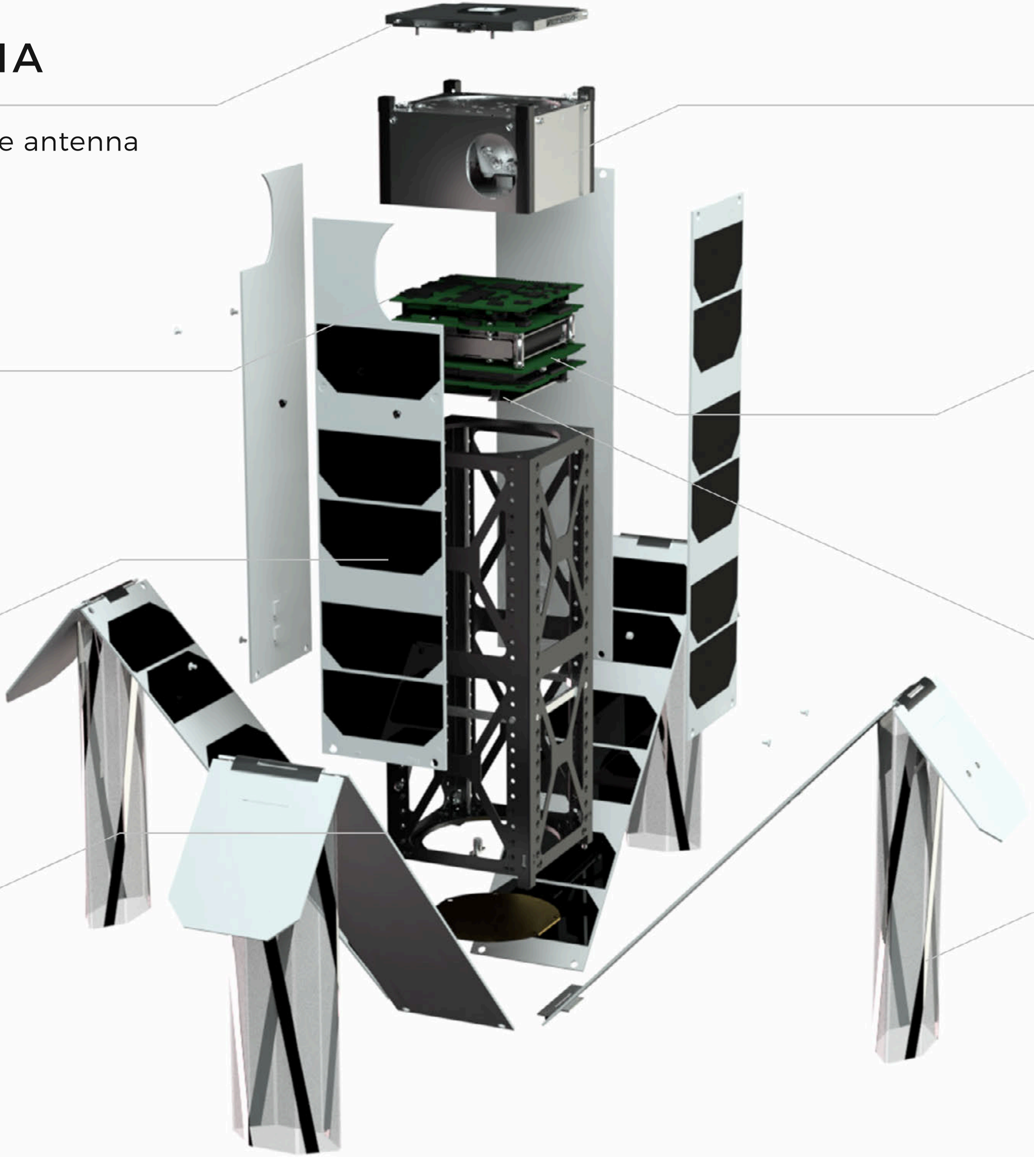
Electrical power system & battery
Clyde Space

SOLAR PANELS

3U solar panels (fixed)
Clyde Space

FRAME

Custom



ADCS

MAI-400 w/ 2 star trackers
Maryland Aerospace

OBC

On-board computer
Innovative Solutions in Space

LSAT RADIO

UHF radio & array driving circuitry
Custom

LSAT ANTENNA

Deployable phased array antenna
Custom

Example showing LSAT together with COTS components in a 3U configuration. LSAT is compatible with a variety of systems including 3U & 6U cubesats, and the 1.5U Prometheus bus.

LSAT in stowed configuration

THE TEAM

HUGO SHELLEY

System design

CATALIN EDU

Mechanical design

FERESHTEH ABASSI

Antenna simulation

DANI EPSTEIN

Animation

with thanks to

Clyde Space, Innovative Solutions in Space & Maryland Aerospace

for providing 3D models for some of their components