OXFORD SPACE SYSTEMS

DEVELOPMENT OF A NOVEL DEPLOYABLE CASSEGRAIN SPACE ANTENNA FOR SAR APPLICATIONS

4TH SEPTEMBER 2019

NCEO/CEOI ANNUAL CONFERENCE

NTU

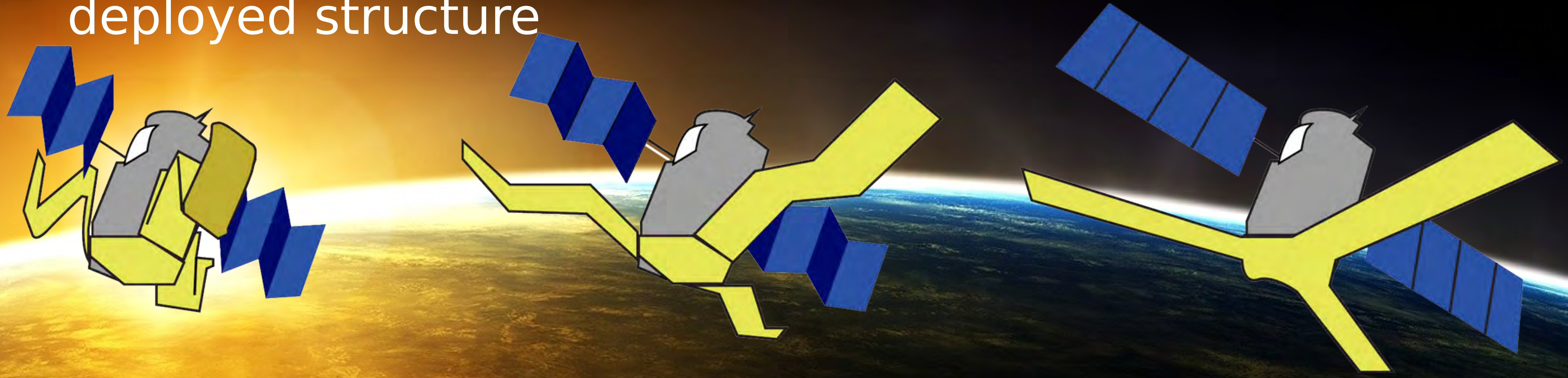
Oxford Space Systems | UK Space Cluster | Harwell OX11 0RL | United Kingdom

www.oxford.space explore@oxford.space

CONTENTS

Deployable structures for space

- To maximize performance and cost efficiency, critical systems are designed to deploy in orbit
- Larger structures typically => higher performance
- The higher the stowage efficiency, the larger the deployed structure



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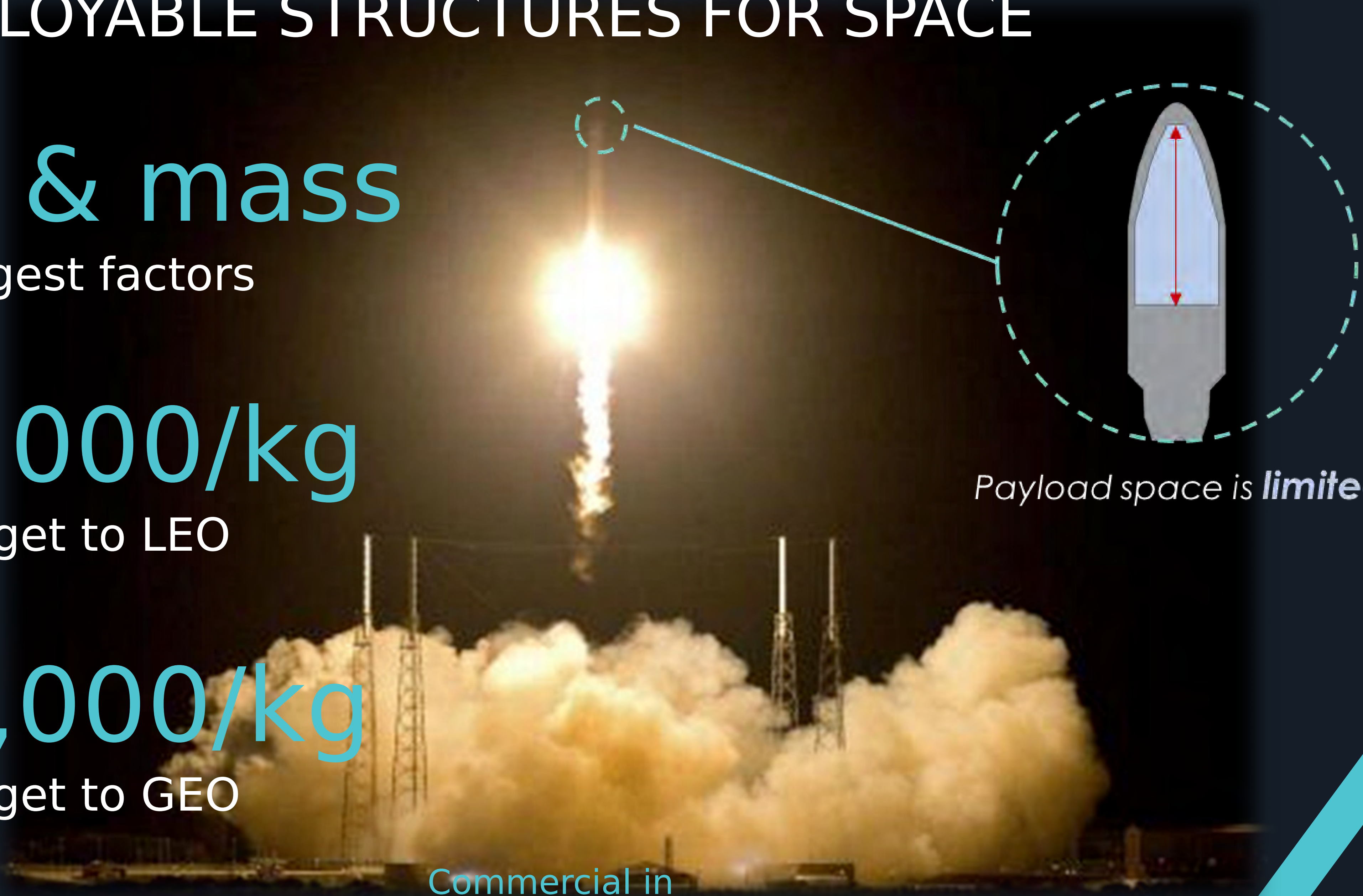
DEPLOYABLE STRUCTURES FOR SPACE



Size & mass

Two biggest factors

£10,000/kg

Cost to get to LEO

£50,000/kg

Cost to get to GEO

Payload space is ***limited***

Commercial in confidence

Deployable Structures at OSS

THREE KEY PRODUCT AREAS…..

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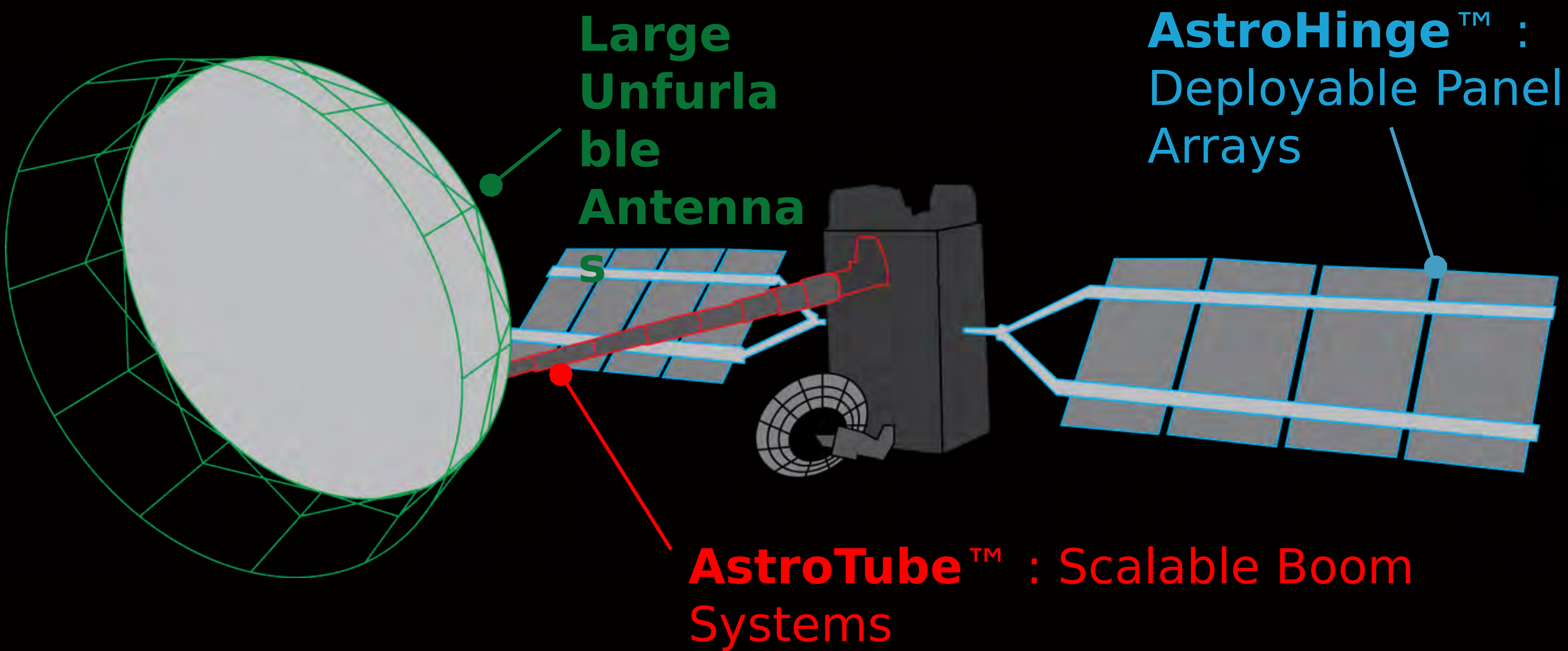
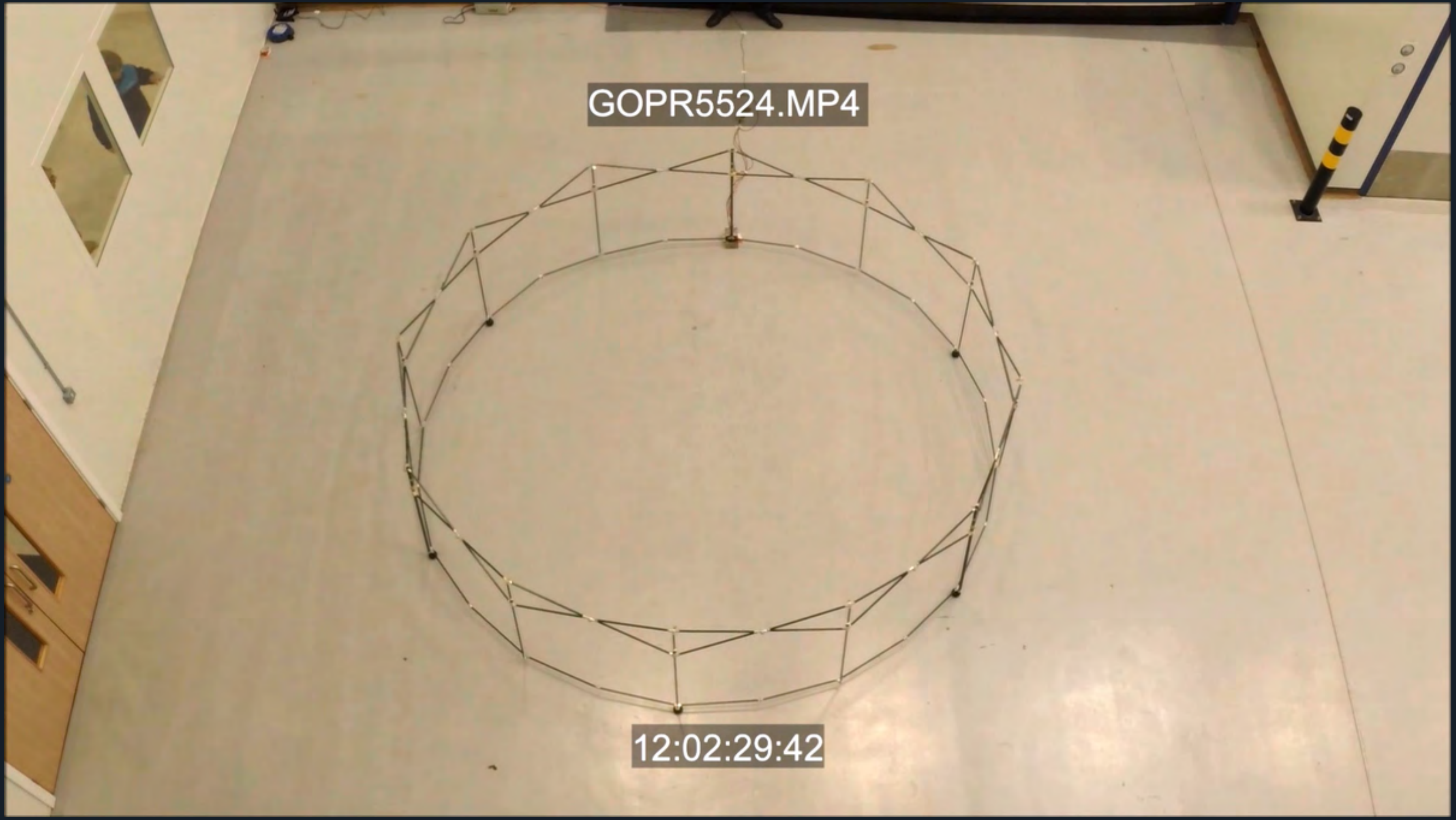


By using flight qualified proprietary materials OSS products are:

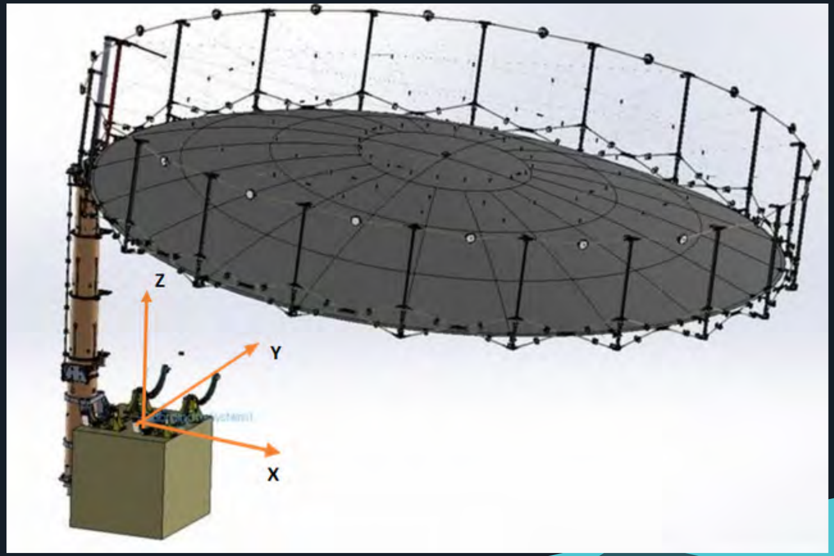
- ✓ **Lighter**
- ✓ **Less complex**
- ✓ **Lower cost**
- ✓ **More stowage efficient**

…than those in current commercial demand

OUTER RING DEPLOYMENT STRUCTURE FOR OFFSET REFLECTORS

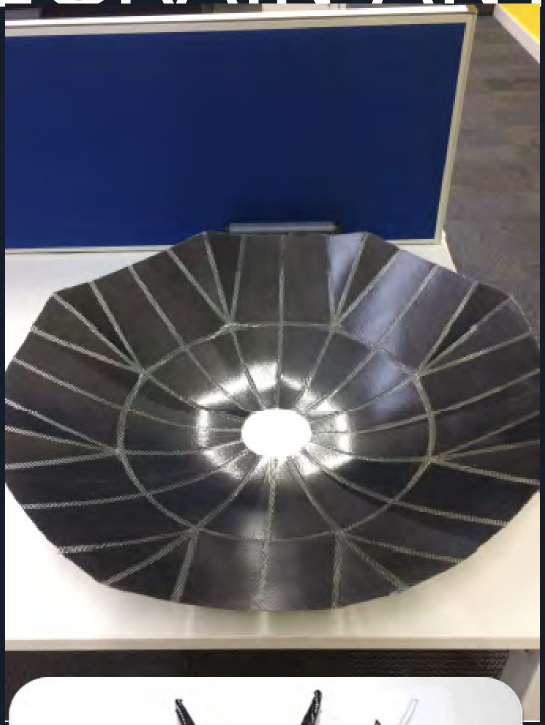


- Self-synchronised deployable structure for foldable parabolic offset reflectors



SMALL CASSEGRAIN ANTENNAS

- DM of a composite membrane to study the RF characteristics of a sub 1-m diameter antenna



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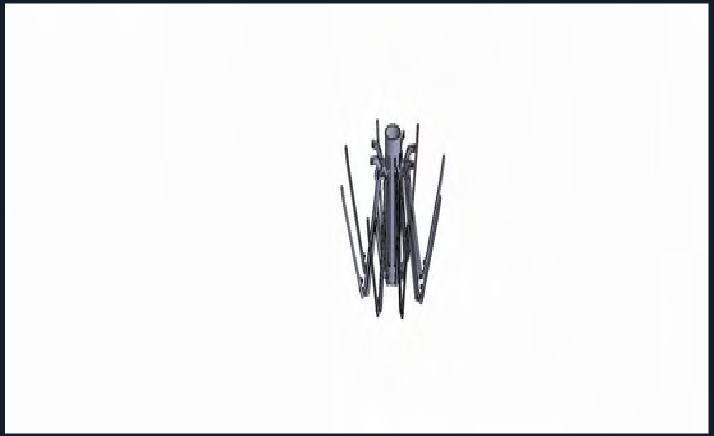
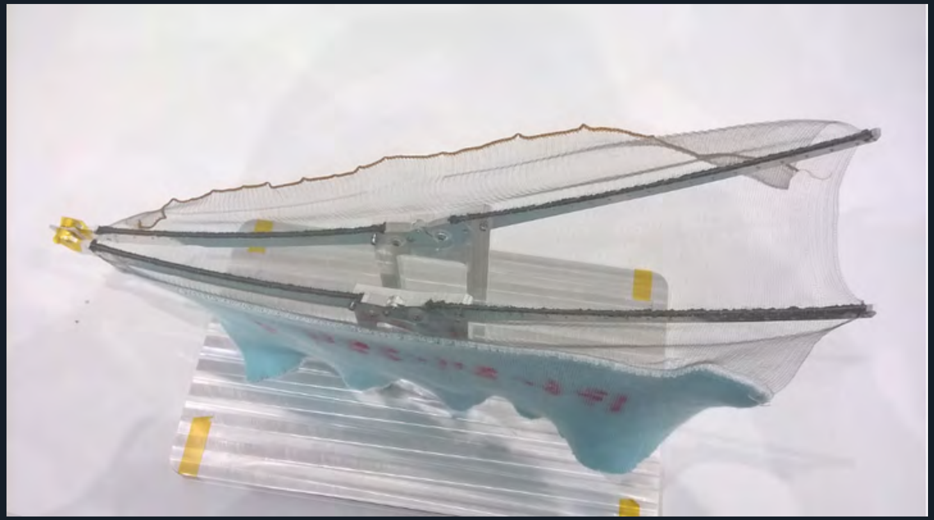


SMALL CASSEGRAIN ANTENNAS

- DM to study the integration of a metal mesh reflector to a deployment backing structure



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SAR Deployable Cassegrain Space Antenna Trade-Offs

Typical SAR applications

- **SAR Applications from Space**
- **Why SAR:**
  - Synthetic Aperture Radar: is a form of radar used to create 2-D images out of 3-D objects
  - EM waves penetrate clouds
  - It can discriminate moving targets against background
  - Day / Night illumination is possible
  - High Resolution, current target is sub 1m
  - Potentially low cost: can operate from small LEO platforms
- **Typical Applications:**
  - EO of
    - Cryosphere: ice /snow areas
    - Lands: vegetation/geology/tectonics/land use /change detection
    - Oceans: currents/ wind and waves/ maritime domain awareness

Typical RF Requirements for the DeCSA SAR antenna

- **Typical target RF SAR Requirements**
  - Frequency X-Band
  - Gain >49dBi
  - Bandwidth 2GHz
  - Sidelobes -20dB
  - Cross-polarisation -30dB

- **RF drivers (non-exhaustive)**
  - Primary reflector size
    - Larger diameter reflector → Higher antenna gain
  - Primary reflector shape
    - Low surface/ shape imperfections → Higher quality radiation pattern and higher gain (λ/30 typ)
  - Primary reflector material reflectivity
    - Ideally a perfect reflector e.g. solid Al plate
  - Secondary reflector positional accuracy
    - Higher → Lower reflector losses and higher efficiency

Typical RF / Thermo-Mechanical Trade-Offs for the DeCSA SAR antenna

RF target main drivers

- Primary reflector size
  - Larger diameter reflector → Higher antenna gain
- Primary reflector shape
  - Low surface/ shape imperfections → Higher quality radiation pattern and higher gain (λ/30 typ)
- Material type
  - Low RF loss secondary deployment mast materials →Higher reflector efficiency
- Primary reflector material reflectivity
  - Ideally a perfect reflector e.g. solid Al plate
- Secondary reflector positional accuracy
  - Higher → Lower reflector losses and higher efficiency

The implementation challen

- Larger Diameter:
  - Mass
  - Stowage volume
  - RMS surface accuracy
  - First natural frequency

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Typical RF / Thermo-Mechanical Trade-Offs for the DeCSA SAR antenna

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The implementation challenge

- Low surface /shape imperfections:
  - Ideal paraboloid is a continuous doubly-curved surface
  - Approximated by facets
  - Facets created by two adjacent ribs
  - “Facetting” introduces surface errors
  - High surface RMS errors =low gain
  - Number of ribs dictated by how many can be accommodated on entral hub
  - Also mass and stowage volume budgets

Typical RF / Thermo-Mechanical Trade-Offs for the DeCSA SAR antenna

- **RF target main drivers**
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- **The implementation challenge**
  - Perfect solid reflector:
    - Al plate is the datum
    - But Al plate not flexible
    - Primary reflector mesh /membrane:
      - Compliant enough to stow
      - Highly RF reflective in the frequency of interest
      - Once deployed: thermo-elastically and mechanically stable

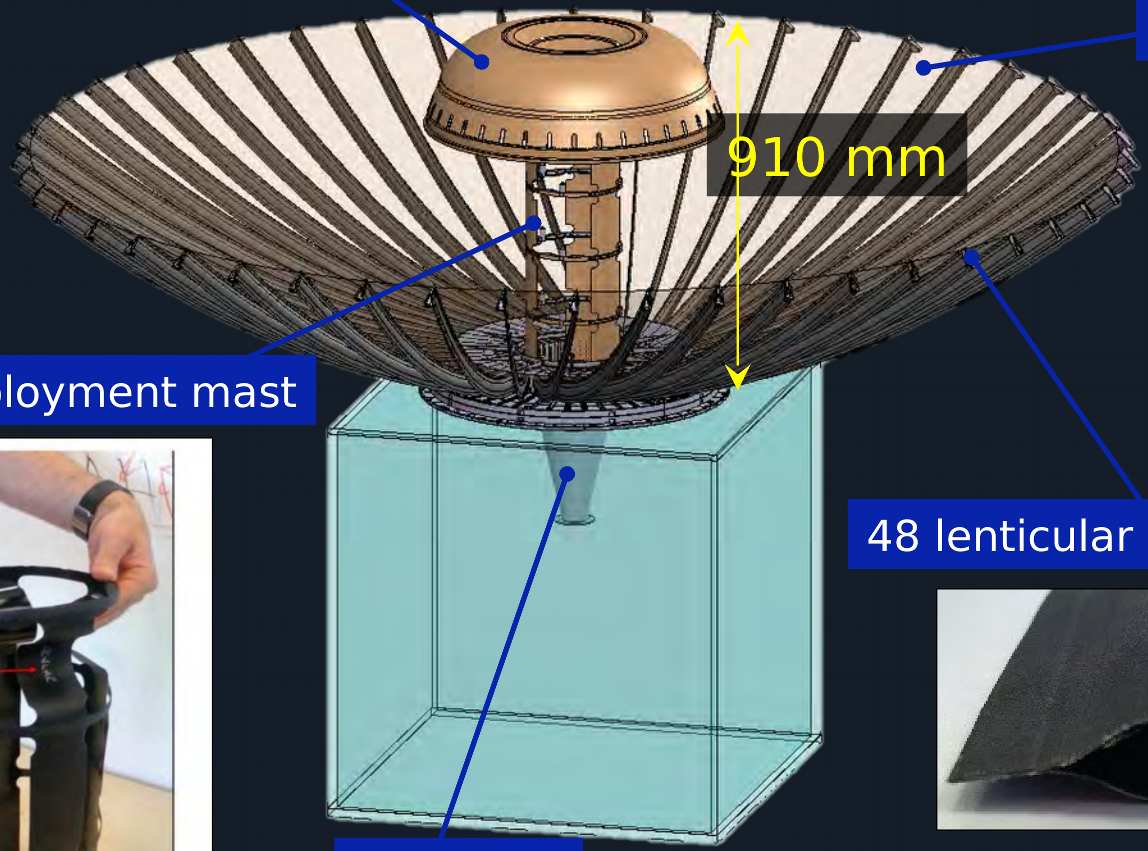
SAR Deployable Cassegrain Space Antenna Development at OSS

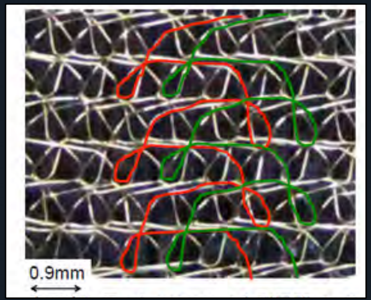
OVERVIEW OF DECSA PRODUCT DEVELOPMENT TO DATE

Secondary reflector & HDRM

2700 mm

Primary reflector membrane





630 mm

240 mm

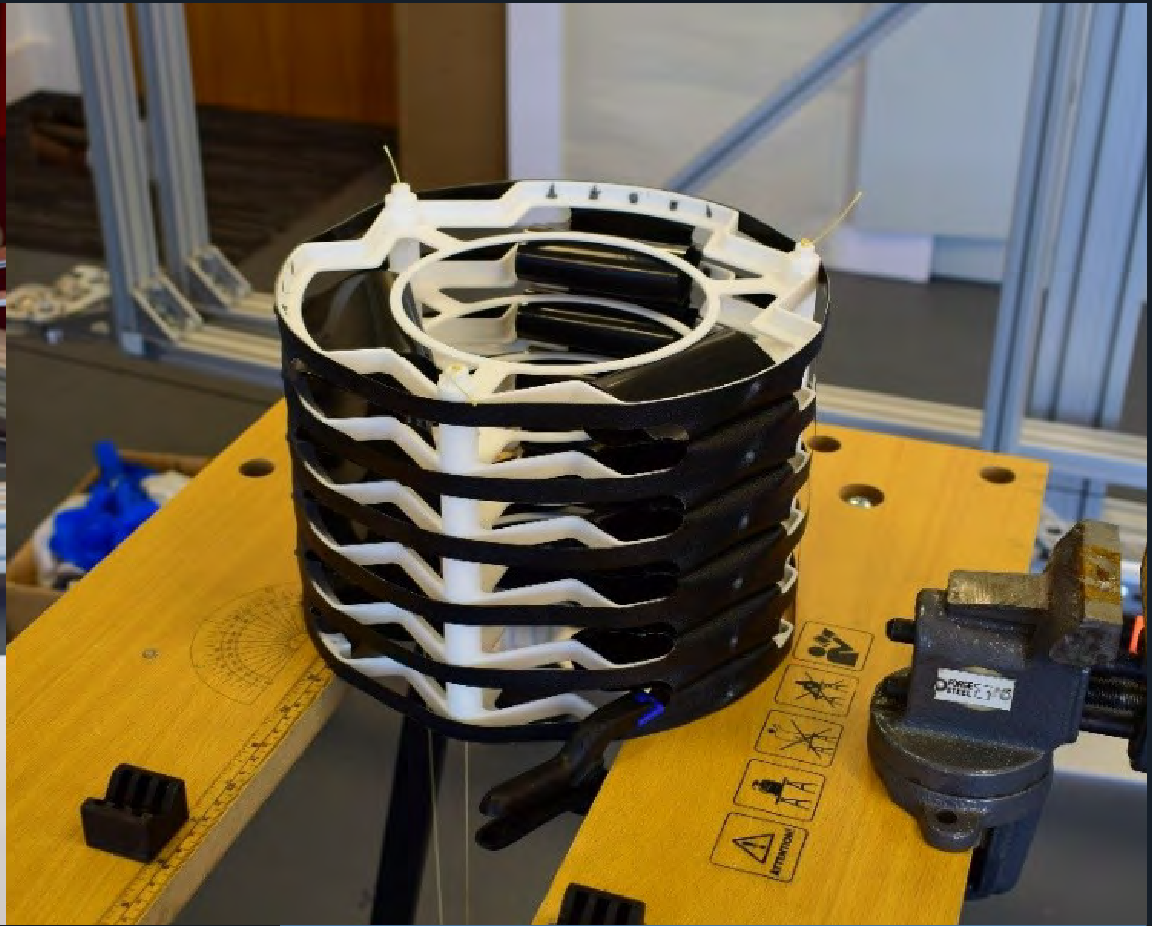
Collapsible deployment mast

48 lenticular cross-section ribs

Feed horn

SECONDARY REFLECTOR DEPLOYMENT MAST

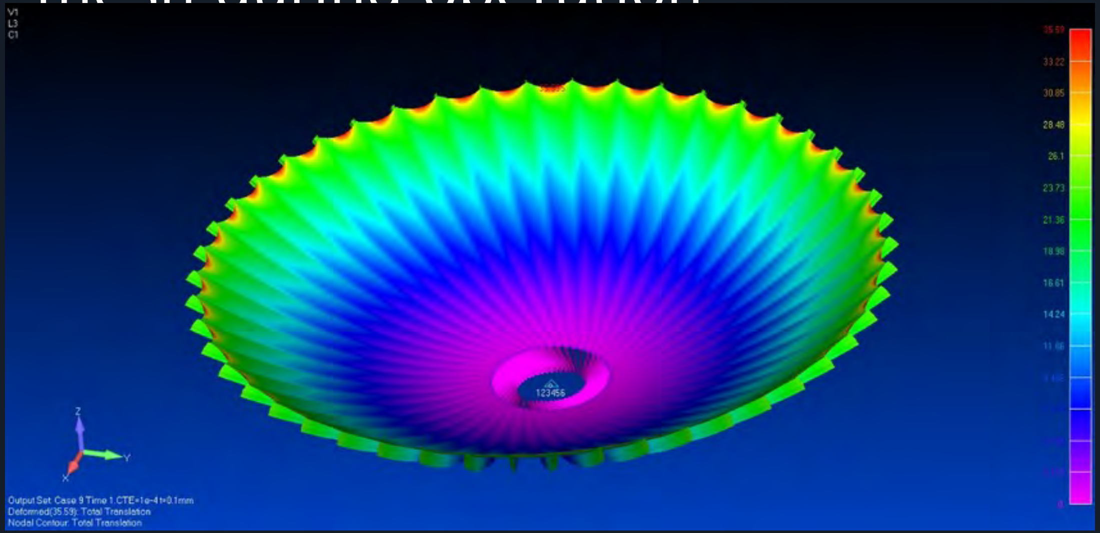
Secondary reflector deployment structure breadboard



- Low RF loss material used
- Compliant
- Thermo-elastically stable (low CTE)
- Still to be optimised

PRIMARY REFLECTOR BACKING STRUCTURE

- Primary backing structure uses CF lenticular cross section ribs
- Arranged radially or tangentially from a central hub
- Flexible but structurally stable when deployed
- Deploy using stored energy and then support the primary reflector mesh during operation



Mesh pretension analysis

Manufactured full-length rib

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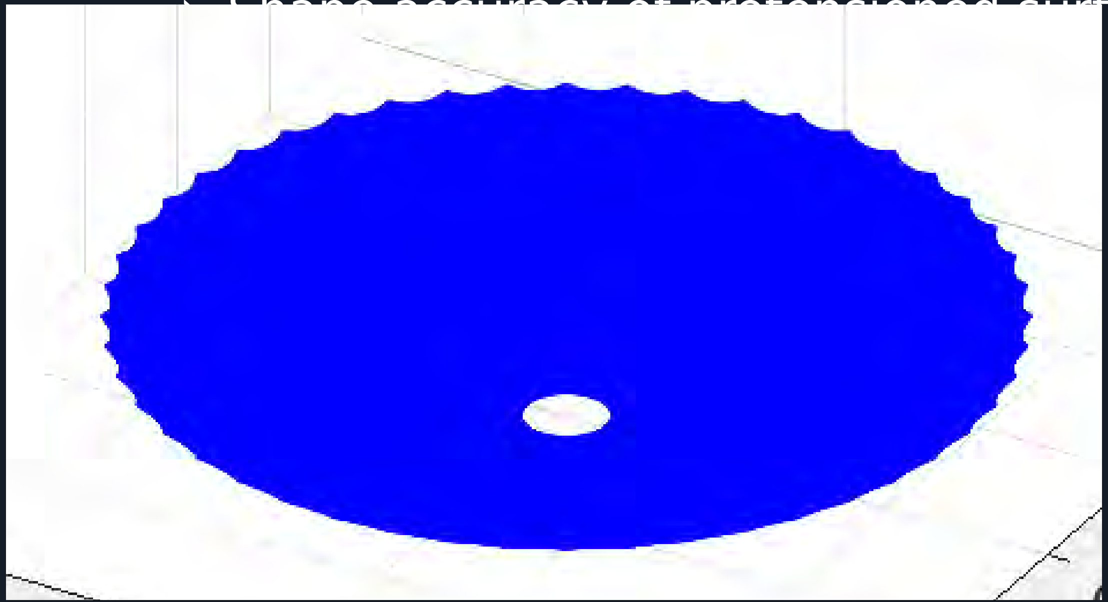
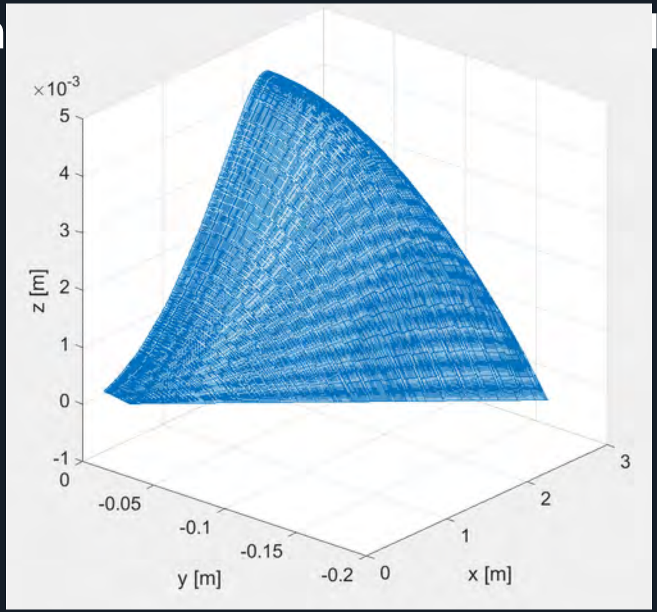
Determination of Surface RMS

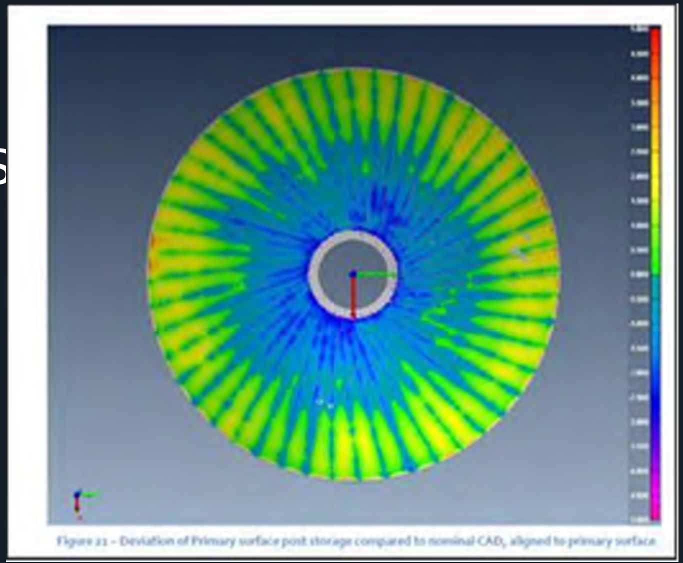
- A series of surfaces representing the primary reflector are generated for differing numbers of ribs:
  - 24, 30, 36, 42, 48, 54, and 72 ribs
  - Faceted surface (gore) is modelled as connected spring elements … pretension analysis was conducted.
  - Shape accuracy of pretensioned surfa… …S



PRETENSIONED SURFACE – 48 RIBS



DEVIATION FROM NOMINAL IDEAL SURFACE
48 RIBS, HALF GORE



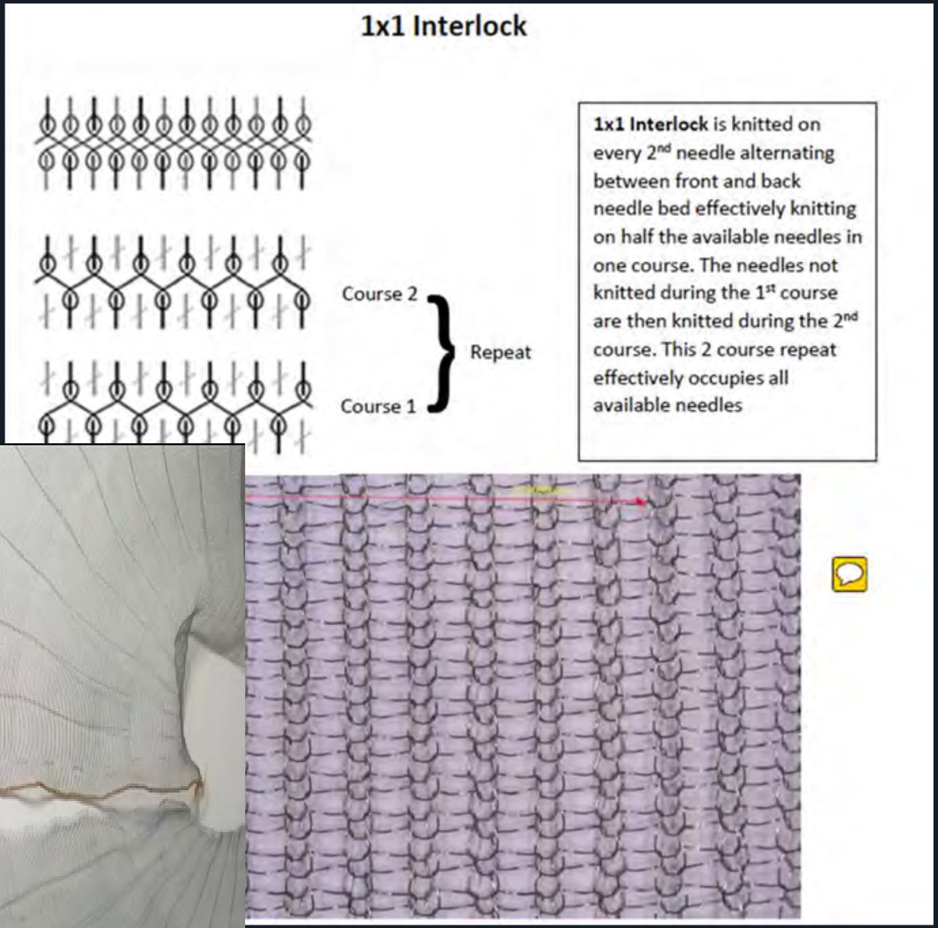
ACTUAL NON-CONTACT SURFACE ACCURACY MEASUREMENT

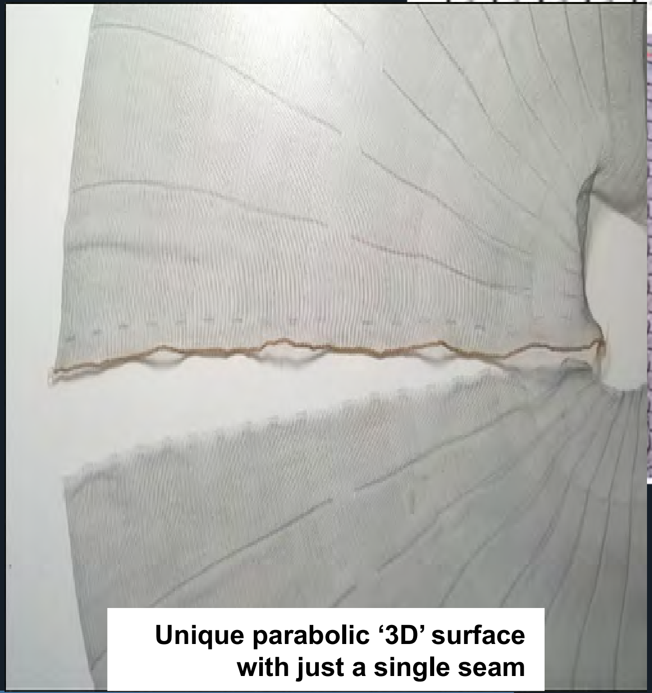
DECSA PRIMARY REFLECTOR BACKING STRUCTURE

- DM to study kinematics of deployment and mechanical attributes of the primary reflector backing structure

Metal Mesh Primary Reflector

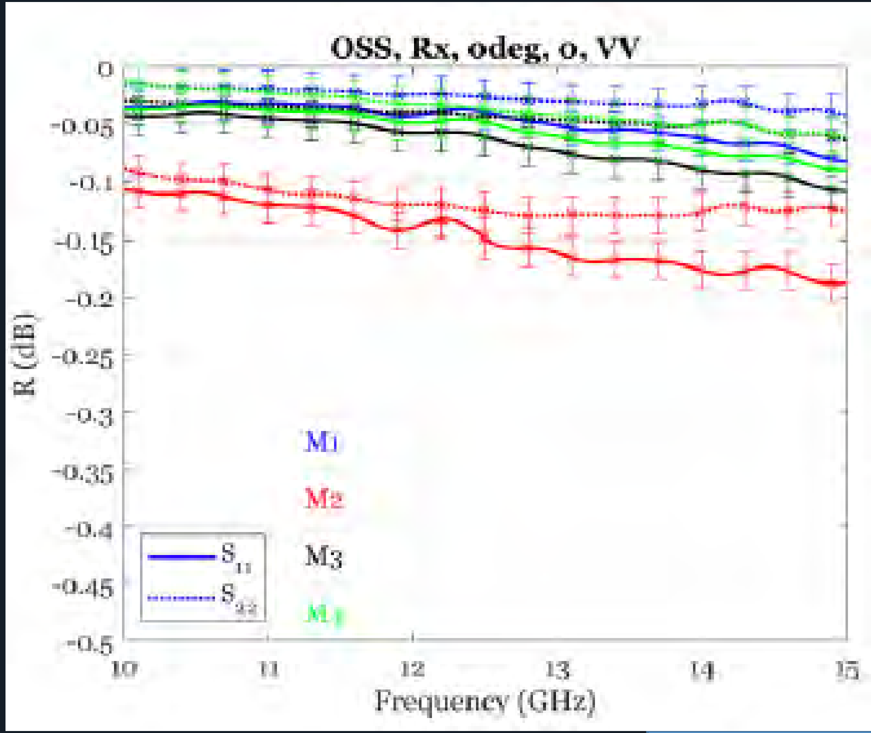
- Significant internally funded R&D work successfully completed to produce a variety of high performance mesh surfaces up to Ka-Band
- OSS is collaborating with a leading UK academic technical knitting research facility
- IP developed in knitting complete ‘3D’ parabolic surfaces with a single seam – significantly reduces labour required to join gores/’slices’ of the main primary reflector

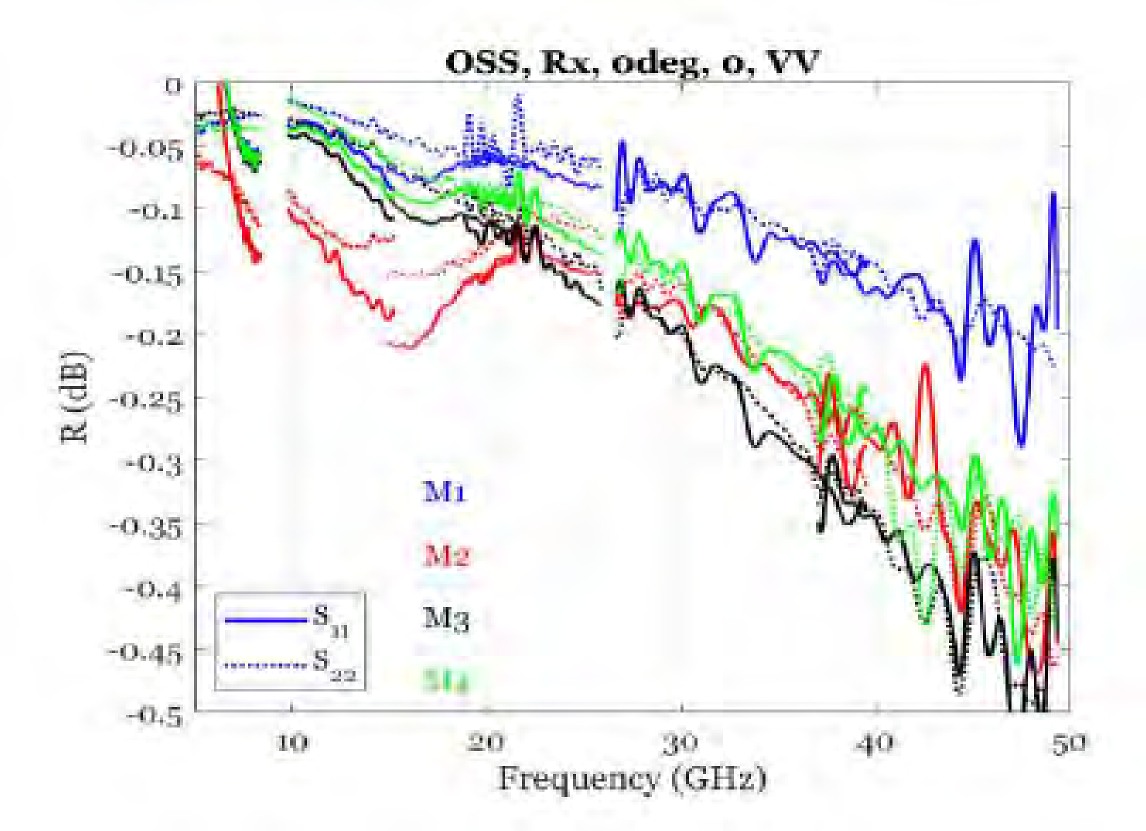



Unique parabolic ‘3D’ surface with just a single seam

Metal Mesh Reflector Surfaces

- Reflectivity testing by ESA ESTEC (6 – 50GHz) shows better performance than industry incumbents
- Targeting better than 0.3dB loss



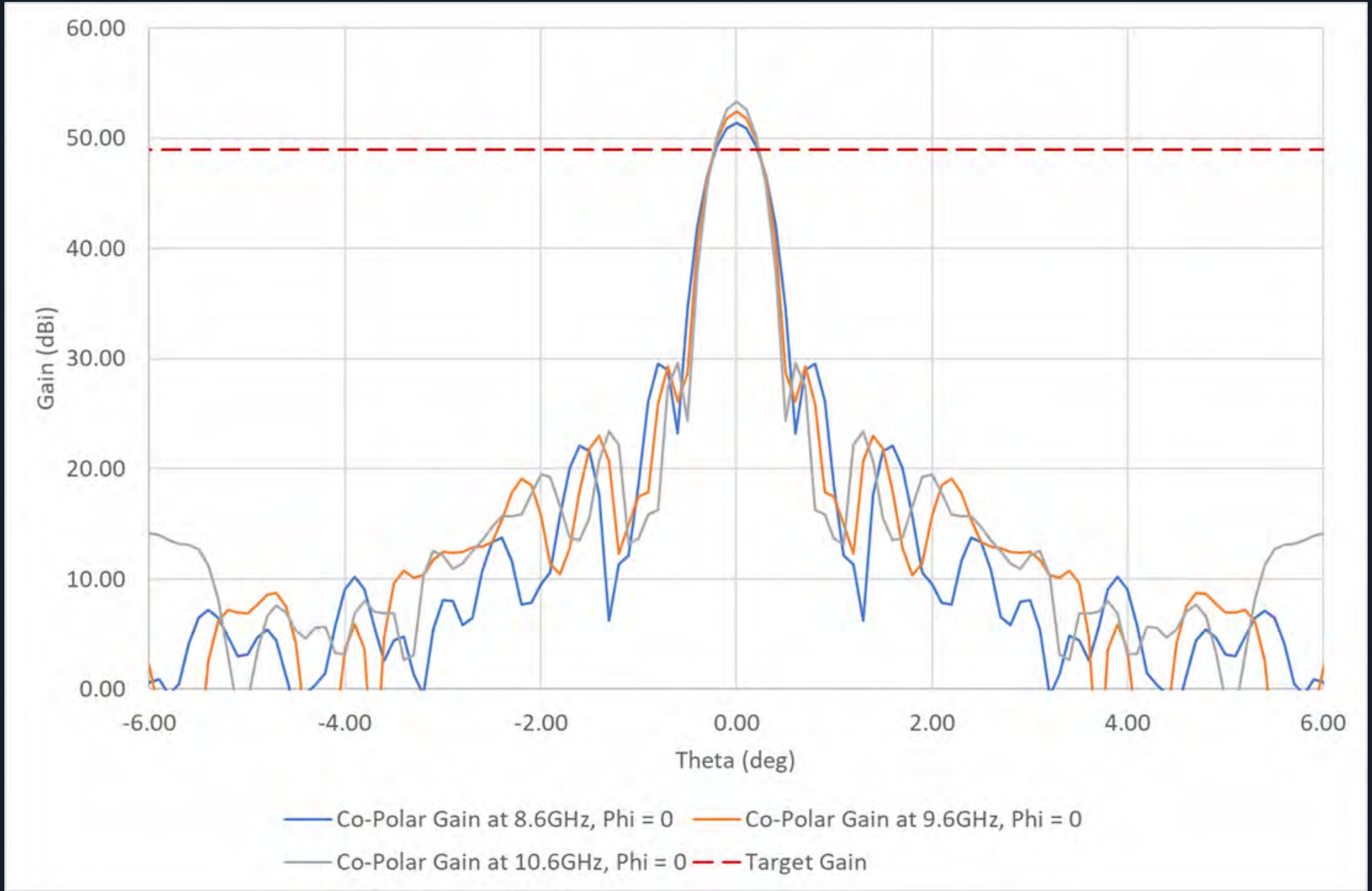


M1 OSS Mesh
M2 OSS Mesh (Low TRL Variant)
M3 Incumbent Mesh 1
M4 Incumbent Mesh 2
Note: S11 results illuminate mesh fixings

ESA TEST RESULTS

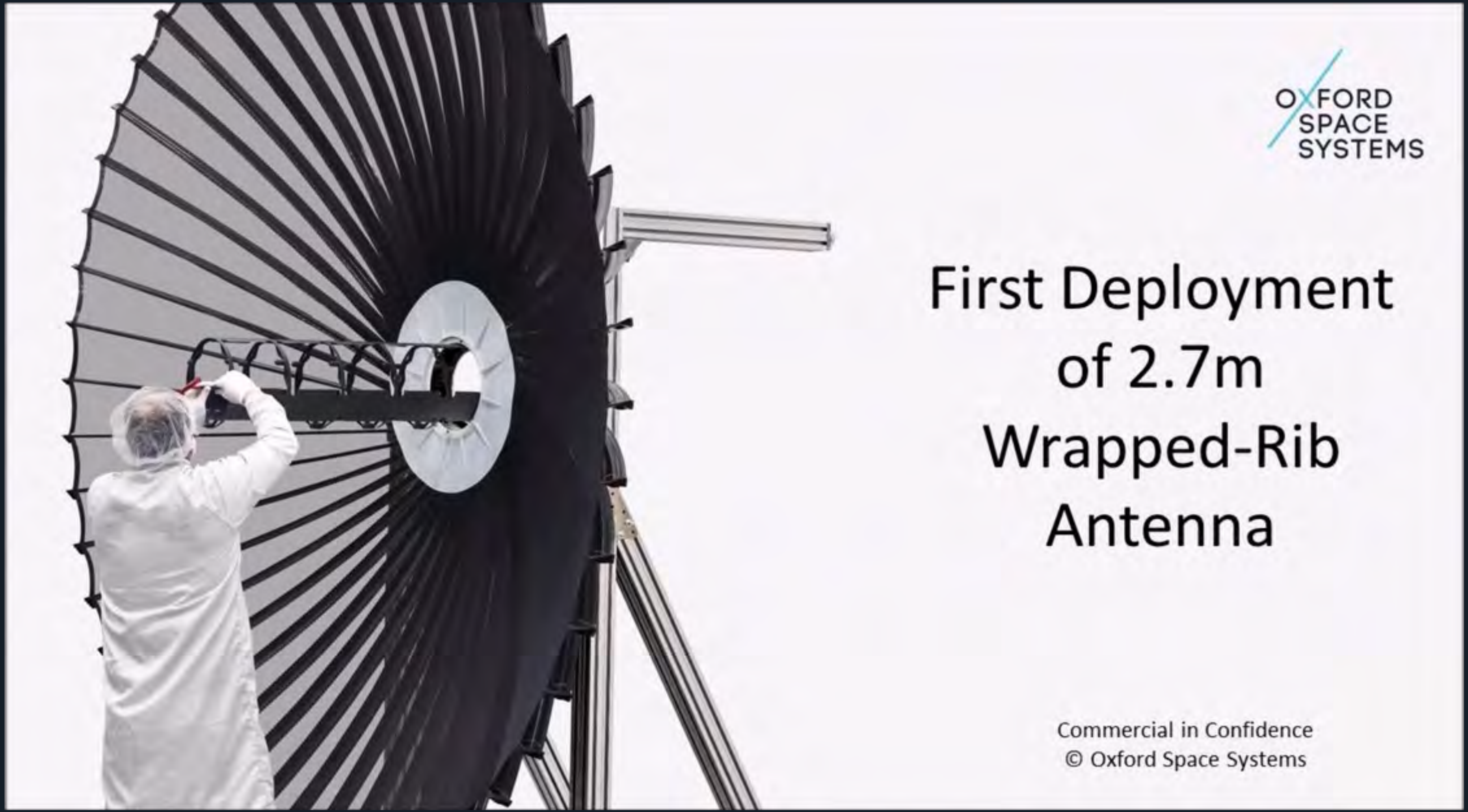
DeCSA Performance

- Example of achievable performance of a DeCSA SAR antenna



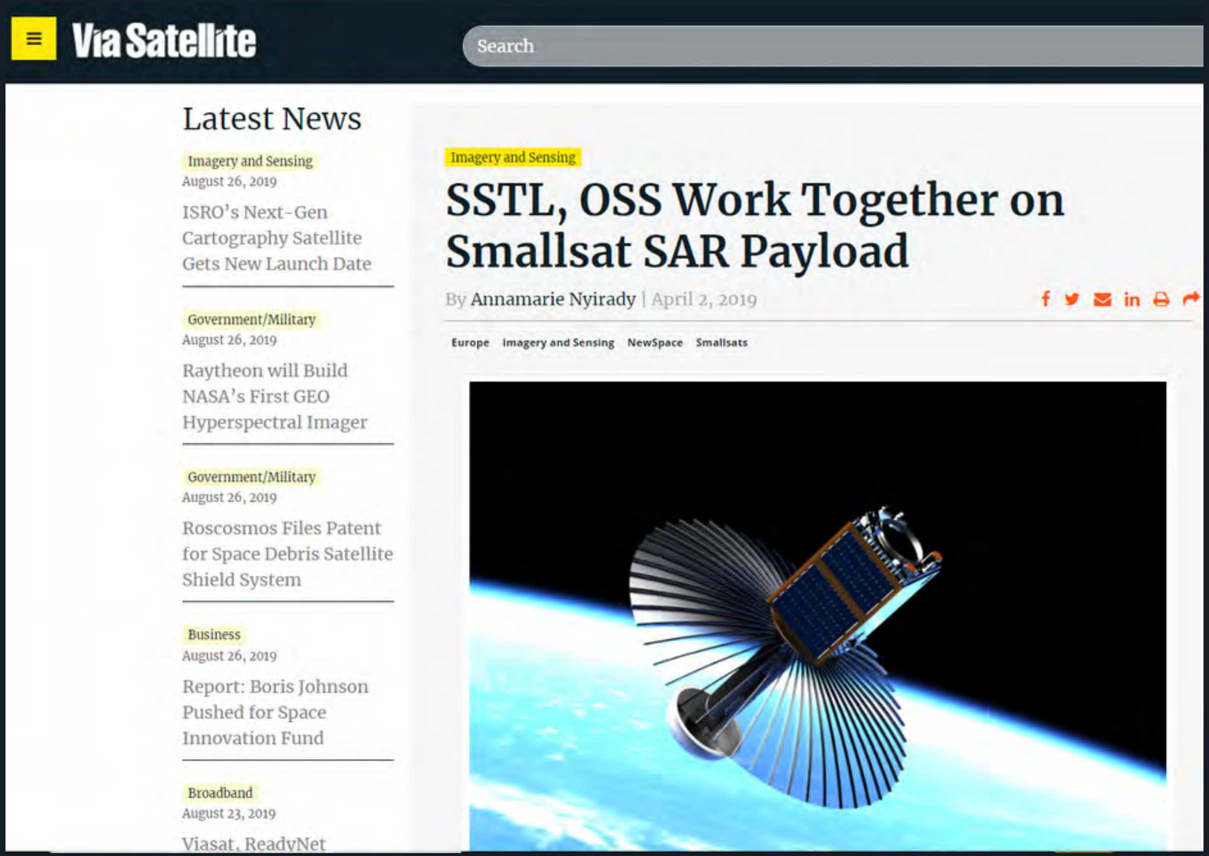
Putting it all together

FIRST DEPLOYMENT OF 2.7M RIB ANTENNA



- Based upon the now flight-proven flexible composite material, OSS is generating considerable interest in its very light weight, stowage efficient wrapped-rib antenna

The future



Via Satellite

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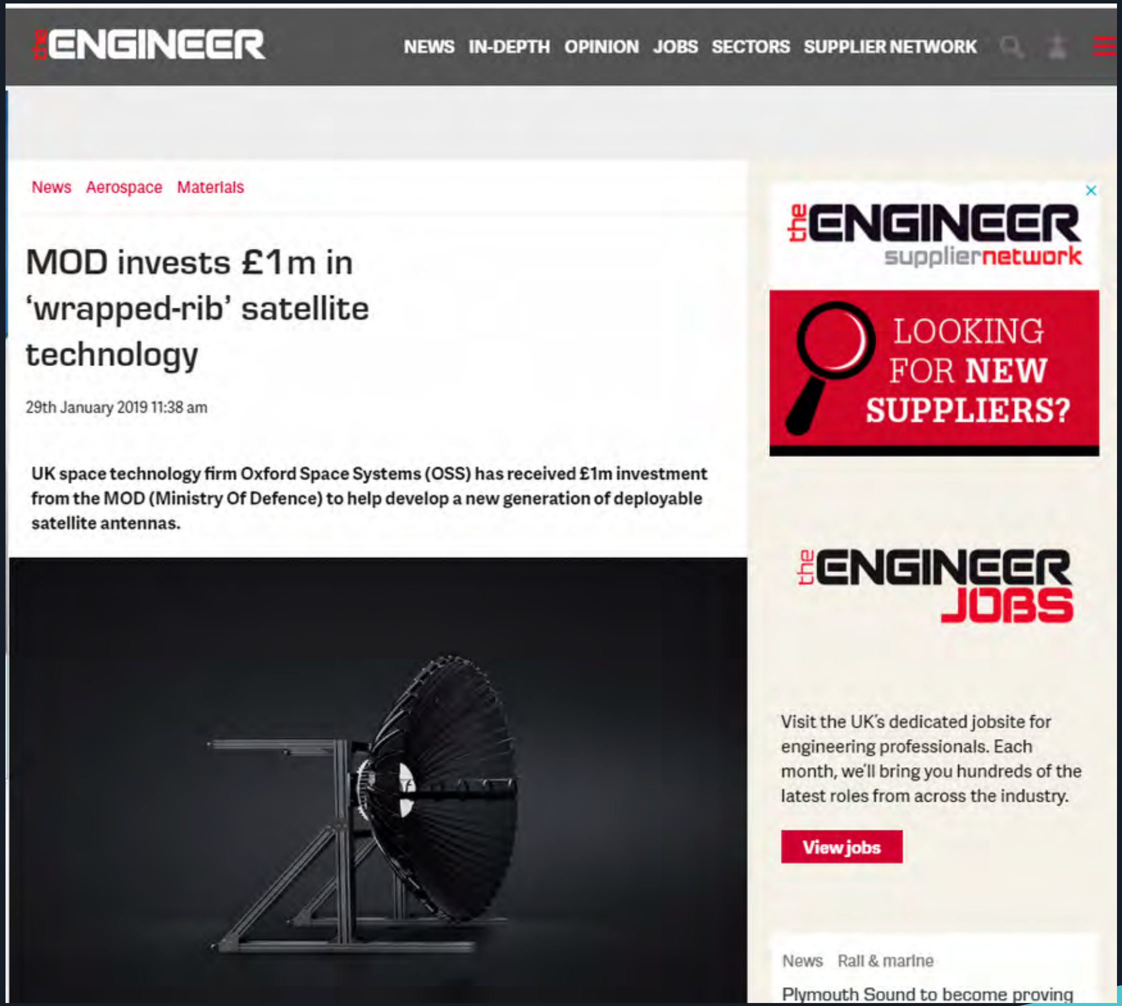

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News Aerospace Materials

MOD invests £1m in 'wrapped-rib' satellite technology

29th January 2019 11:38 am

UK space technology firm Oxford Space Systems (OSS) has received £1m investment from the MOD (Ministry Of Defence) to help develop a new generation of deployable satellite antennas.

News Rail & marine
Plymouth Sound to become proving

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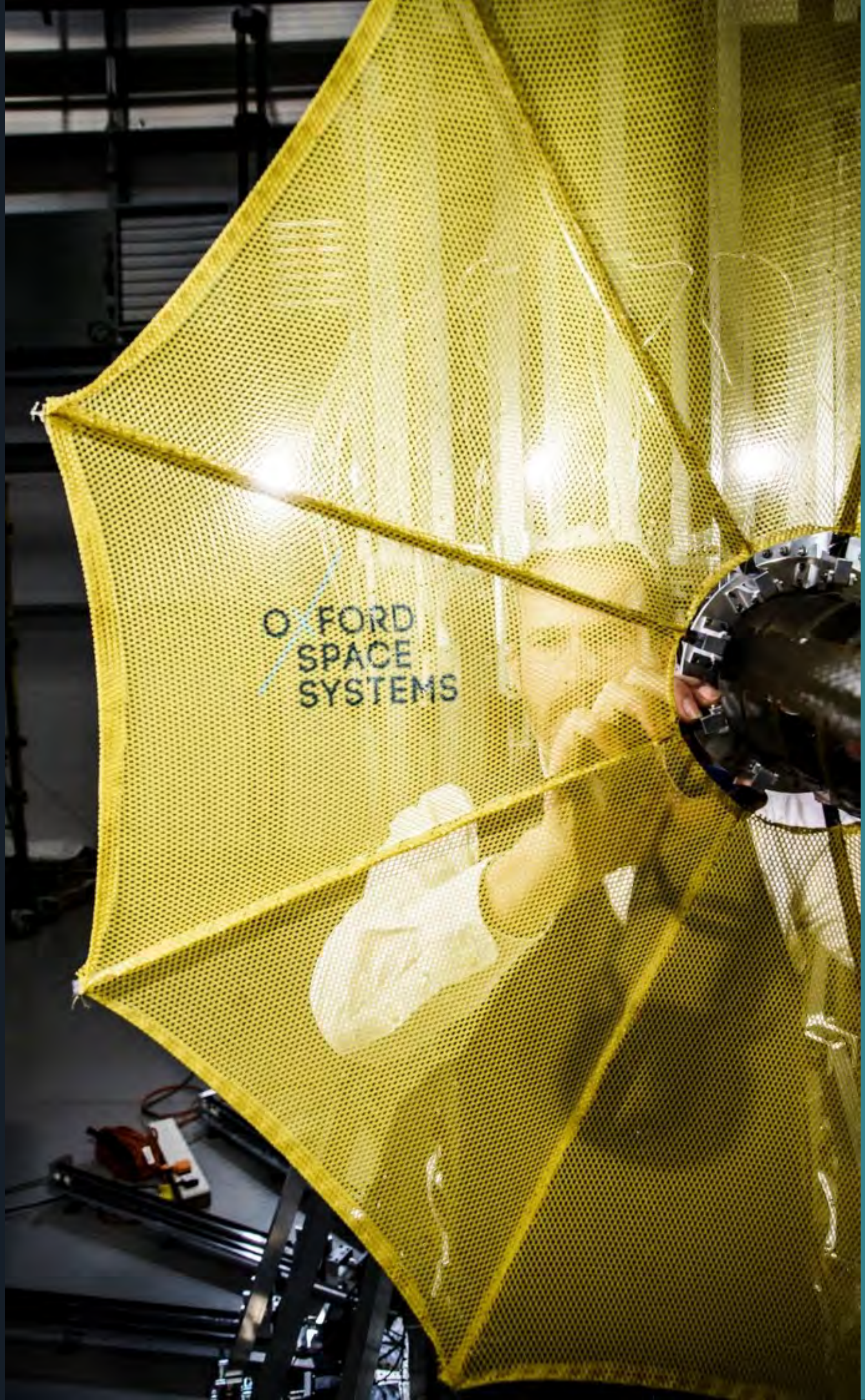

CONTACT US:

Oxford Space Systems
Zephyr Building
Harwell Space Cluster
Harwell OX11 0RL
United Kingdom

explore@oxford.space

+44 (0)1235 425 840

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