OXFORD SPACE SYSTEMS

Development of a Novel X-band Cassegrain Deployable Antenna for SmallSats Platforms

UK EARTH OBSERVATION WEEK 2021

MICROWAVE MISSIONS, INSTRUMENTS AND TECHNOLOGIES SESSION

6TH-10TH SEPTEMBER 2021

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CONTENTS

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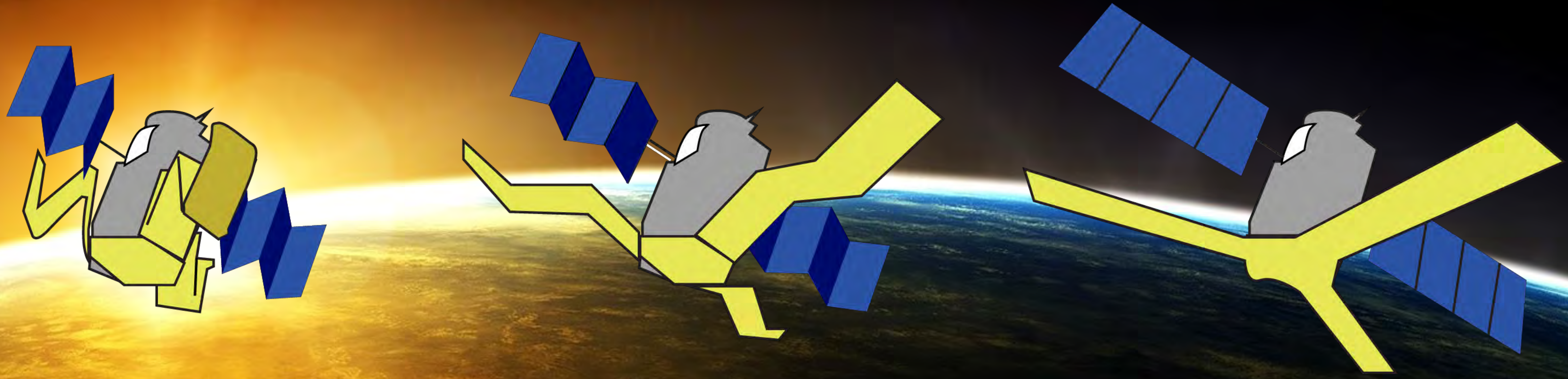
CURRENT FOCUS OF ANTENNA DEVELOPMENT

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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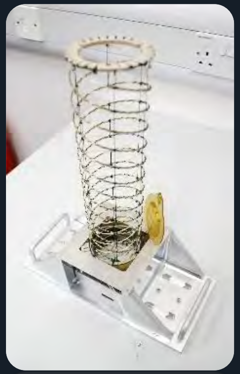
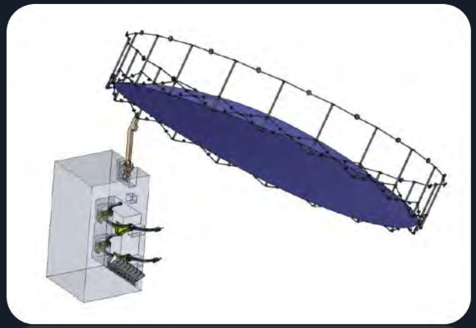
- A variety of deployable space antenna architectures have been explored at OSS ranging from low frequency applications (IOT and AIS) to high frequency offset reflectors for telecommunications
- The current focus is the development of SAR antennas, Synthetic Aperture Radar
- SAR has been used extensively for Earth Observation for more than 30 years
- It provides high-resolution, day-and-night, weather-independent images for applications ranging from Geoscience and Climate Change research to Security related imagery and Planetary Exploration
- The number of SAR systems operating from space have seen a significant rise in the past few years: 15 operational systems in 2013 to about 50 in 2021, many of them have been developed by private companies



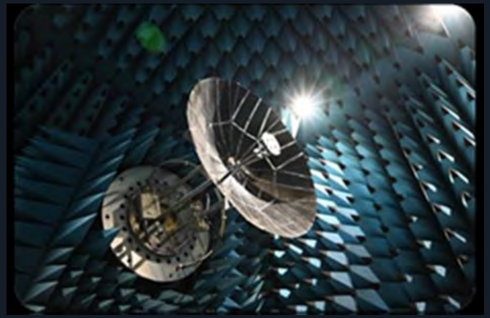
Helicals

Cassegrain WRA



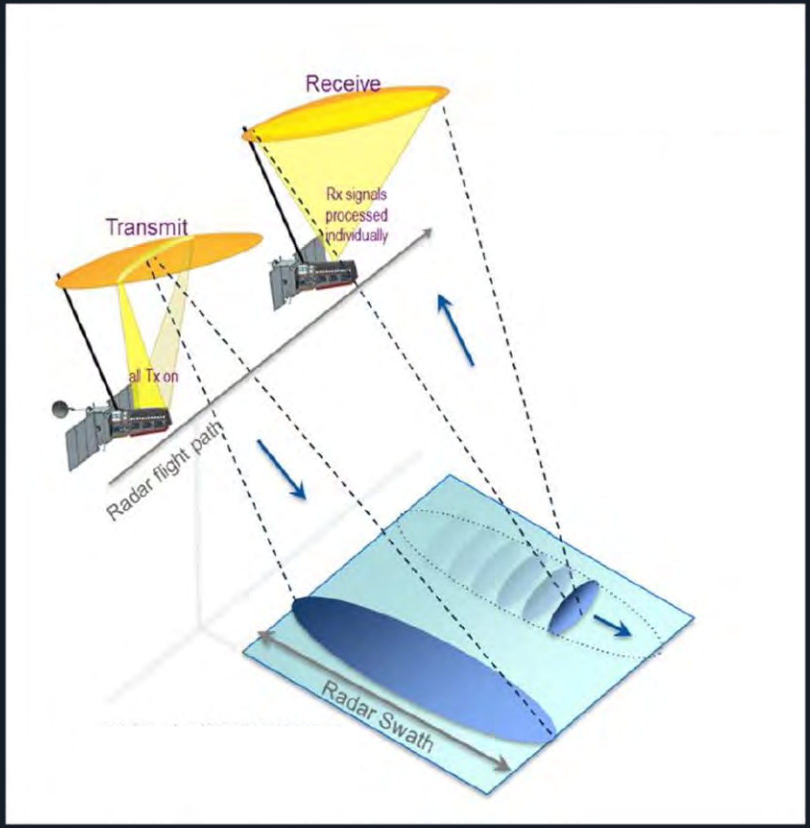
Offset Reflector

Yagi



Sub 1m Cassegrain

- Spaceborne SAR can monitor dynamics processes on the surface of the Earth in a reliable, continuous and global way
- It is based on a pulsed radar installed on a platform with a forward movement
- The radar transmits electromagnetic pulses of a given intensity and frequency and receives the pulses of the backscattered signal in a sequential way
- The swath on the Earth surface varies from 30km to 500km for spaceborne systems
- The backscattered pulse can be received by the same antenna in the case of monostatic SAR or by multiple receiving antennas in the case of a bi- or multi-static radar
- Amplitude and phase of backscattered signal depends on the physical and electrical properties of the imaged-object (eg roughness and permittivity)
- Penetration on the object depends on the frequency band



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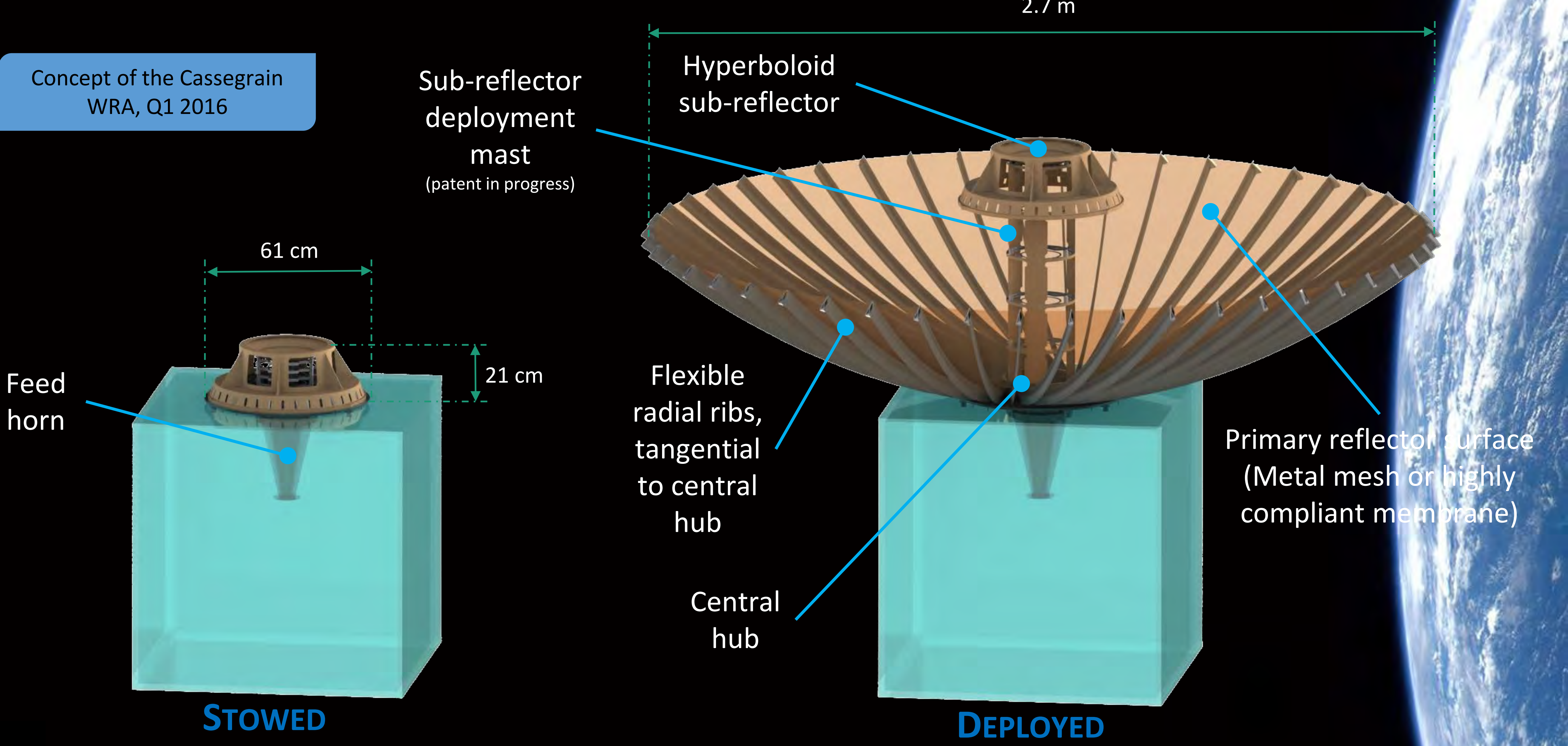
Frequency Band	Ka	Ku	X	C	S	L	P
Frequency [GHz]	40-25	17.5-12	12-7.5	7.5-3.75	3.75-2	2-1	0.5-0.25
Wavelength [cm]	0.75-1.2	1.7-2.5	2.5-4	4-8	8-15	15-30	60-120
SAR application							
Foliage penetration, subsurface imaging and biomass estimation						✓	✓
Agriculture, ocean, ice or subsidence monitoring			✓	✓	✓	✓	
Snow monitoring		✓	✓				
Very high resolution imaging	✓		✓				

SYSTEM DESCRIPTION

Wrapped-rib antenna for microsats: Cassegrain variant

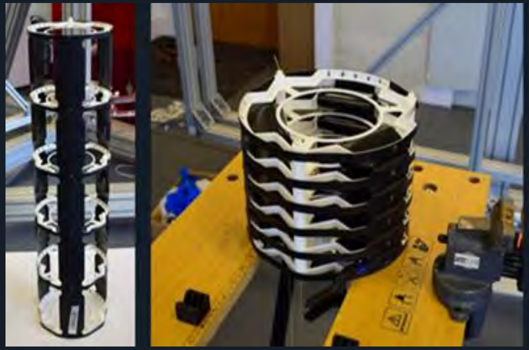
Concept of the Cassegrain WRA, Q1 2016



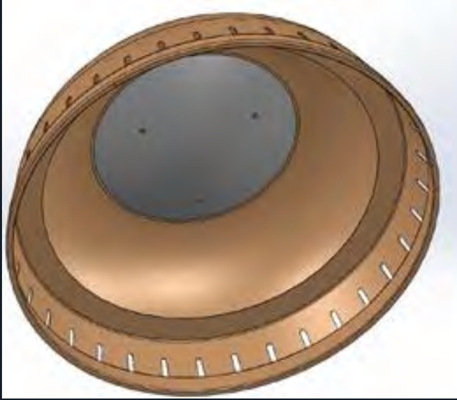
Wrapped Rib Architecture Components

- Cassegrain Reflector Antenna system description

Hub and backing structure

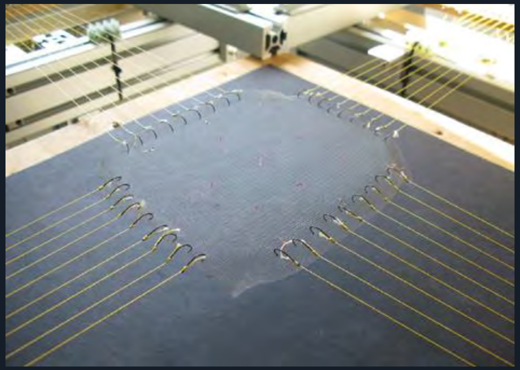


Secondary reflector deployment tower



Hold down and release + secondary reflector

Backing structure ribs



Primary reflector mesh

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Wrapped Rib BB Testing

Breadboard demonstrator complete :Q2, 2017

VIDEO 1

DESIGN, LAUNCH ENVIRONMENT AND IN-ORBIT PERTURBATION CONSIDERATIONS

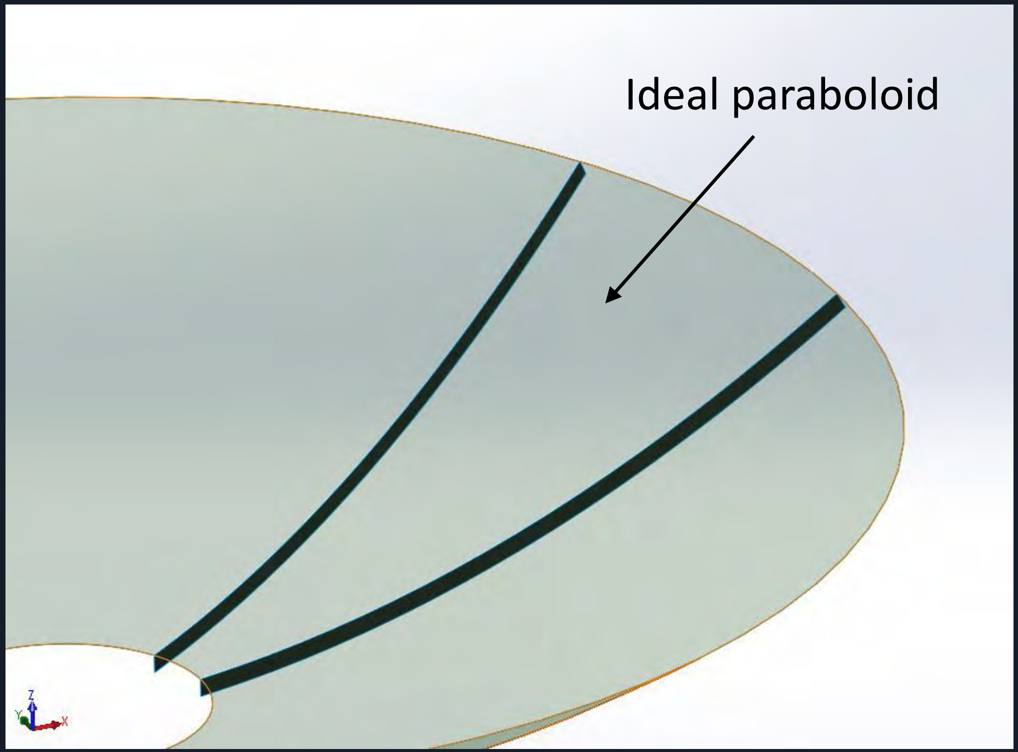
Primary Reflector Surface Inaccuracies

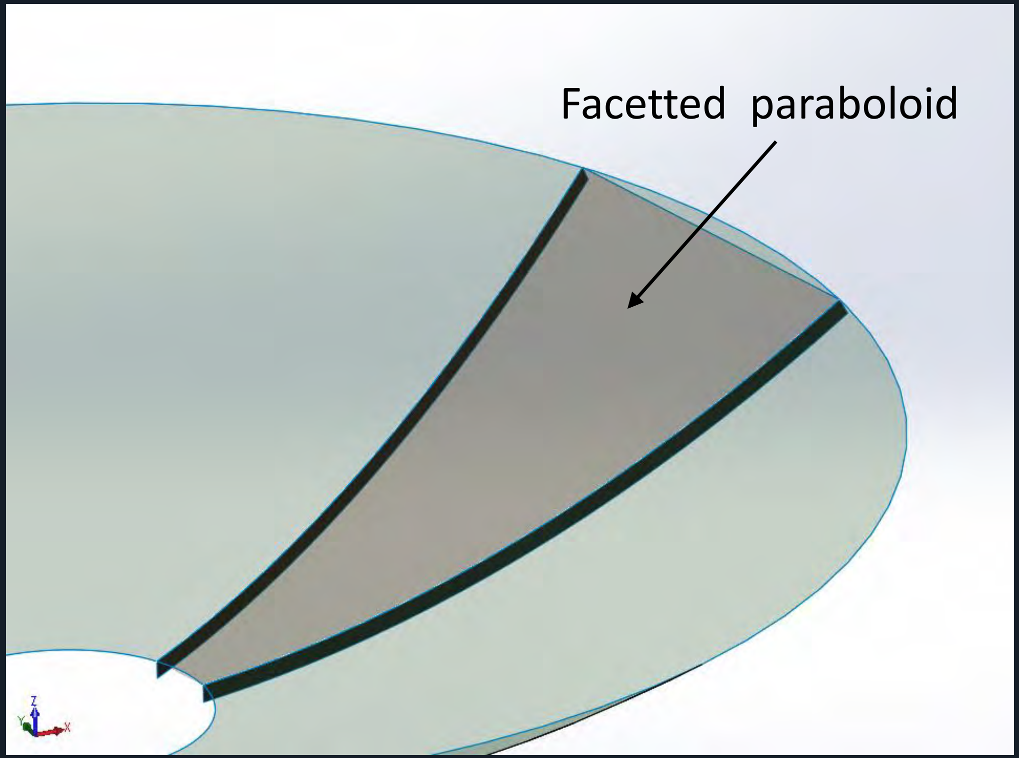
- **RF target main drivers**
  - Low surface and small shape imperfections
    - Higher quality radiation pattern and higher gain
    - Ideal paraboloid is a continuous doubly-curved surface

- **The implementation challenge**
  - Approximated by facets
  - Facets created by two adjacent ribs
  - “Faceting” introduces surface errors
  - High surface RMS errors =lower gain
  - Number of ribs dictated by how many can be accommodated on central hub

Origin of Primary Reflector Faceting

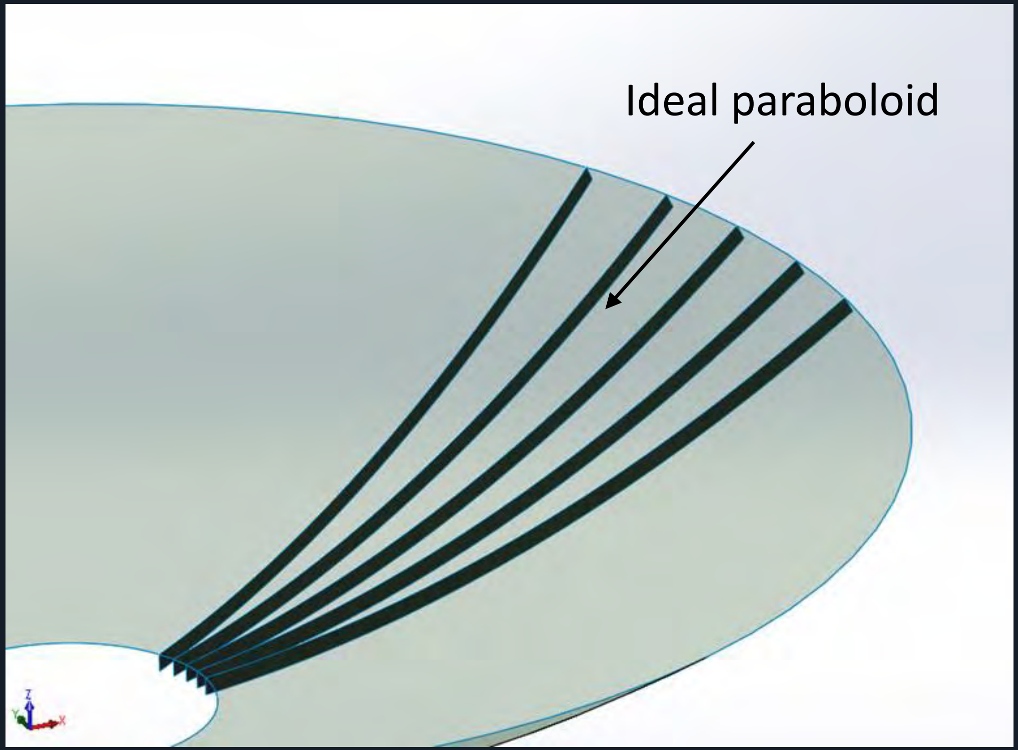
› Effect of backing structure architecture on RMS accuracy

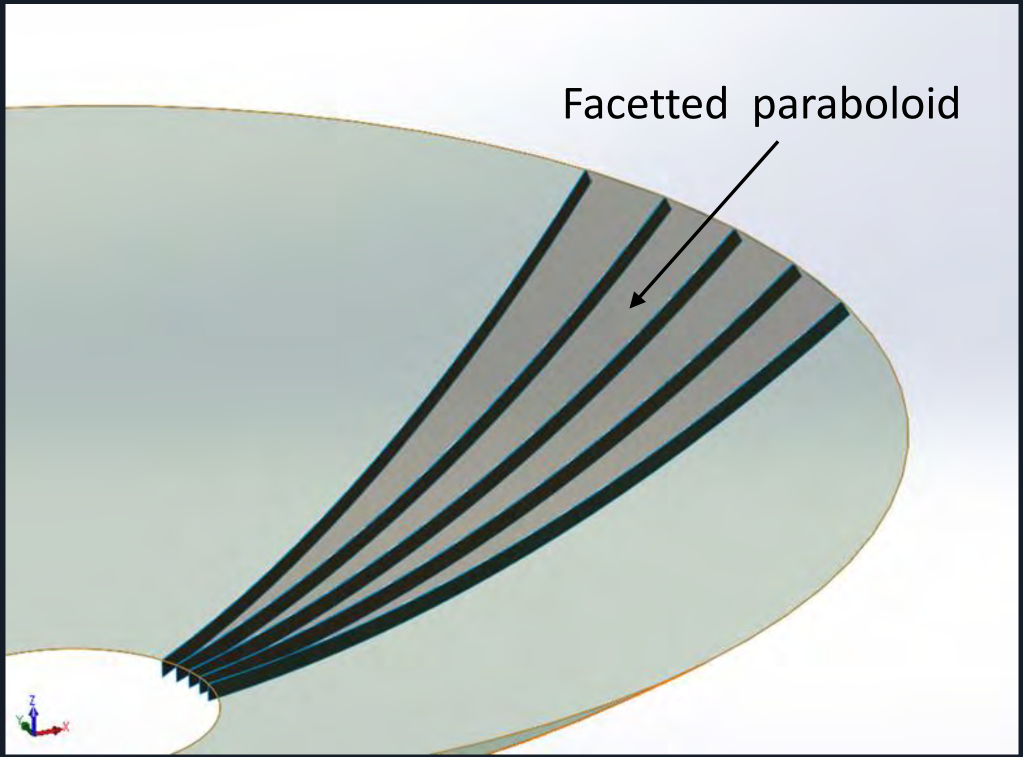




Origin of Primary Reflector Faceting

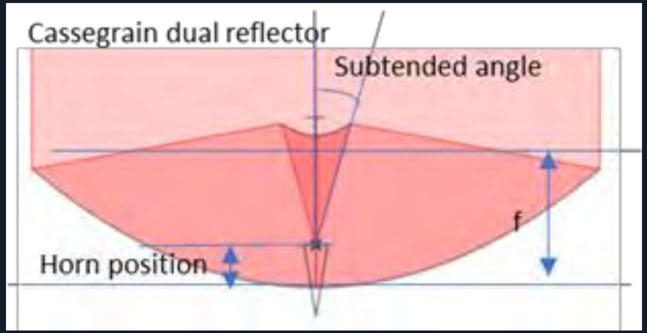
- Effect of backing structure architecture on RMS accuracy

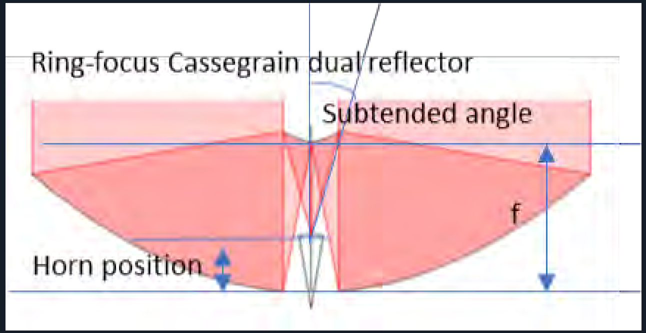


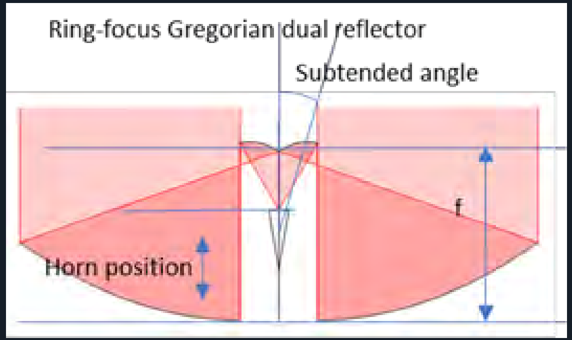


Secondary Blockage

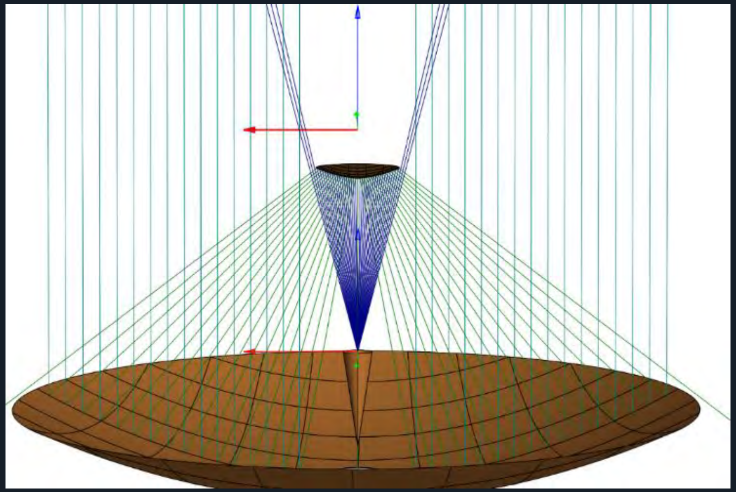
- Three main architectures considered:



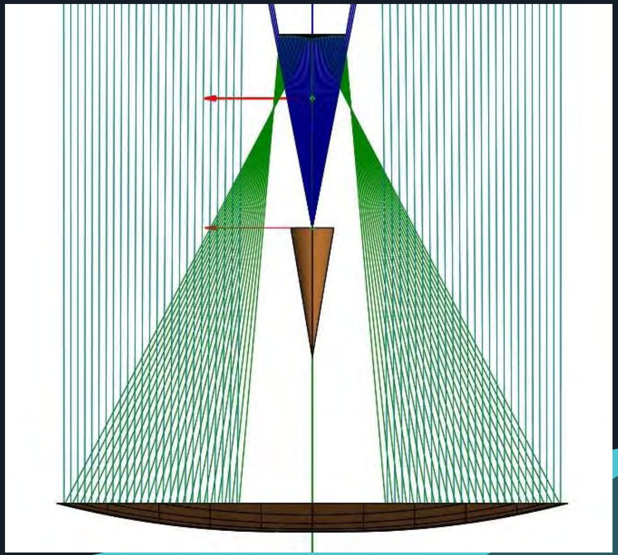




- Ring focused preferred as it minimizes reflection back to feed:



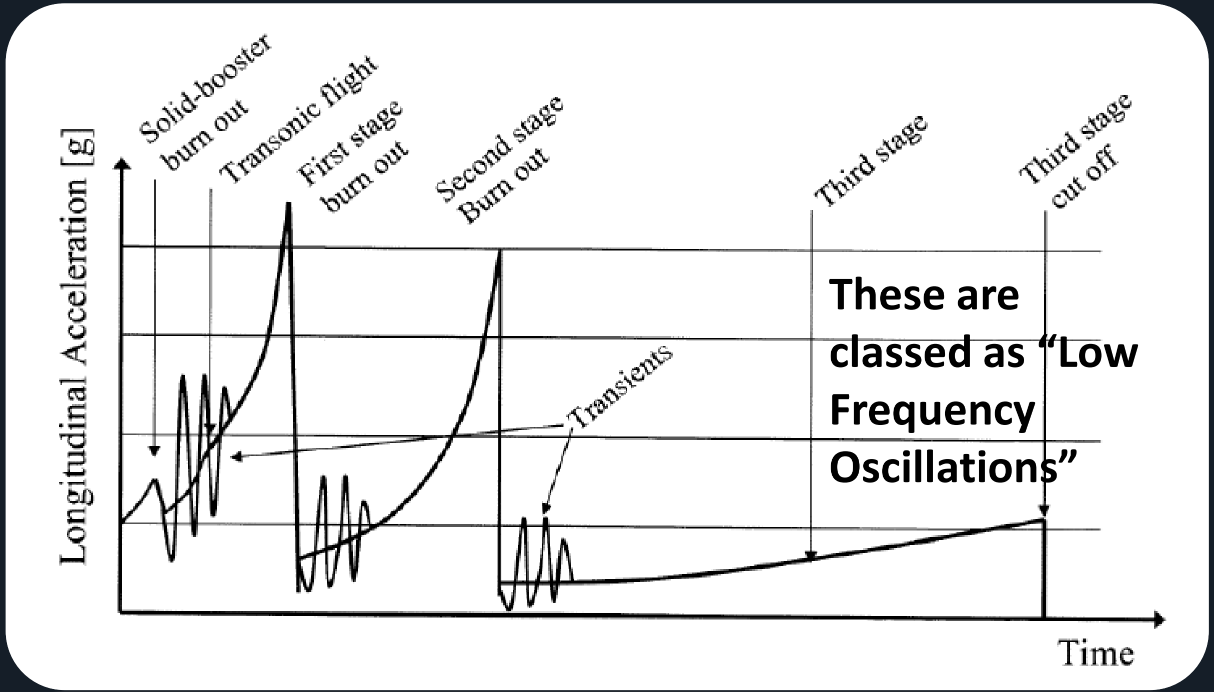
Ray paths in ring focussed Cassegrain (left) and Gregorian (right)



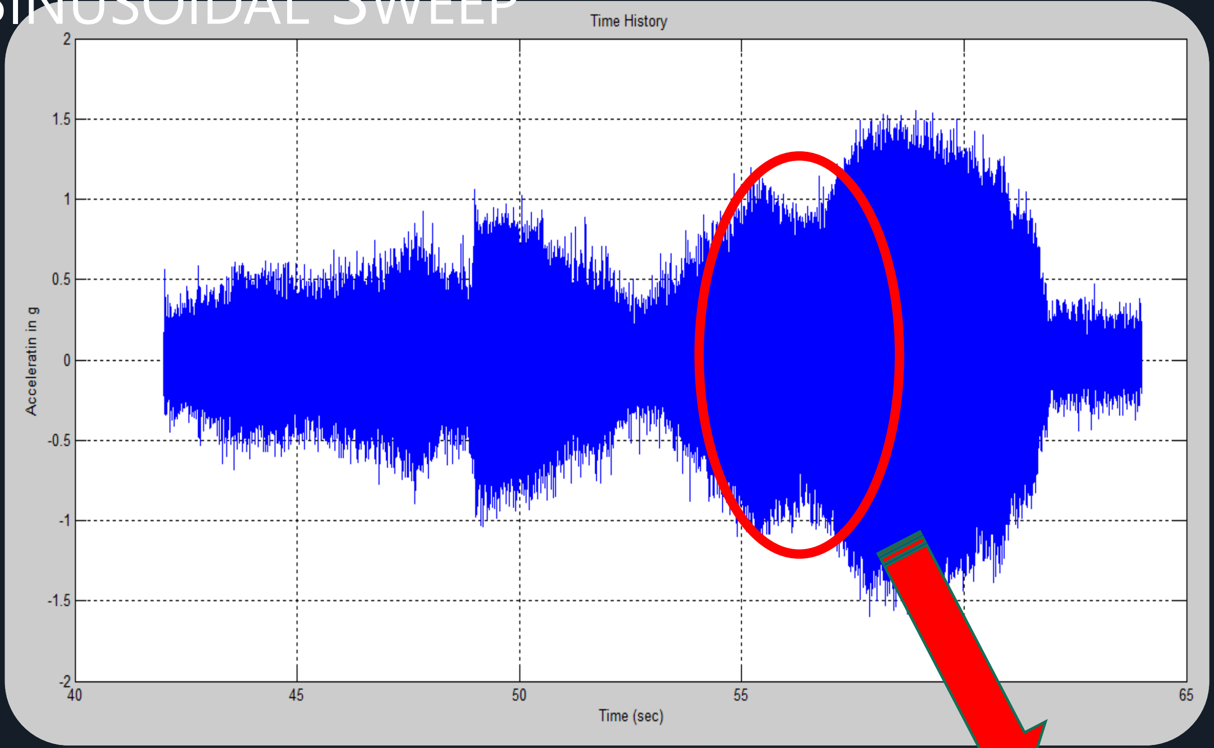
Low Frequency High Amplitude

Main engine cut-offs

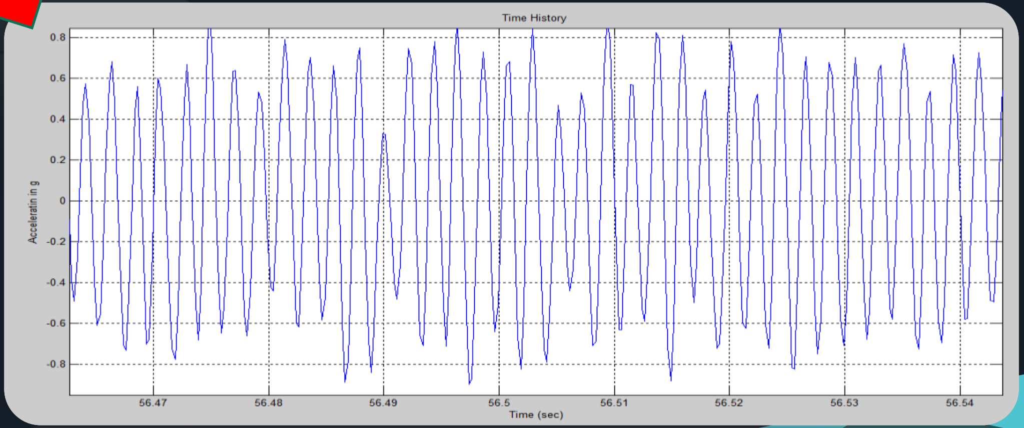
- For example in the Delta II rocket , cut-off produces a transient at 120Hz which translates into a high acceleration input to the antenna
- An example of engine cut-off-generated oscillations is shown in the following figure:



Sinusoidal Sweep

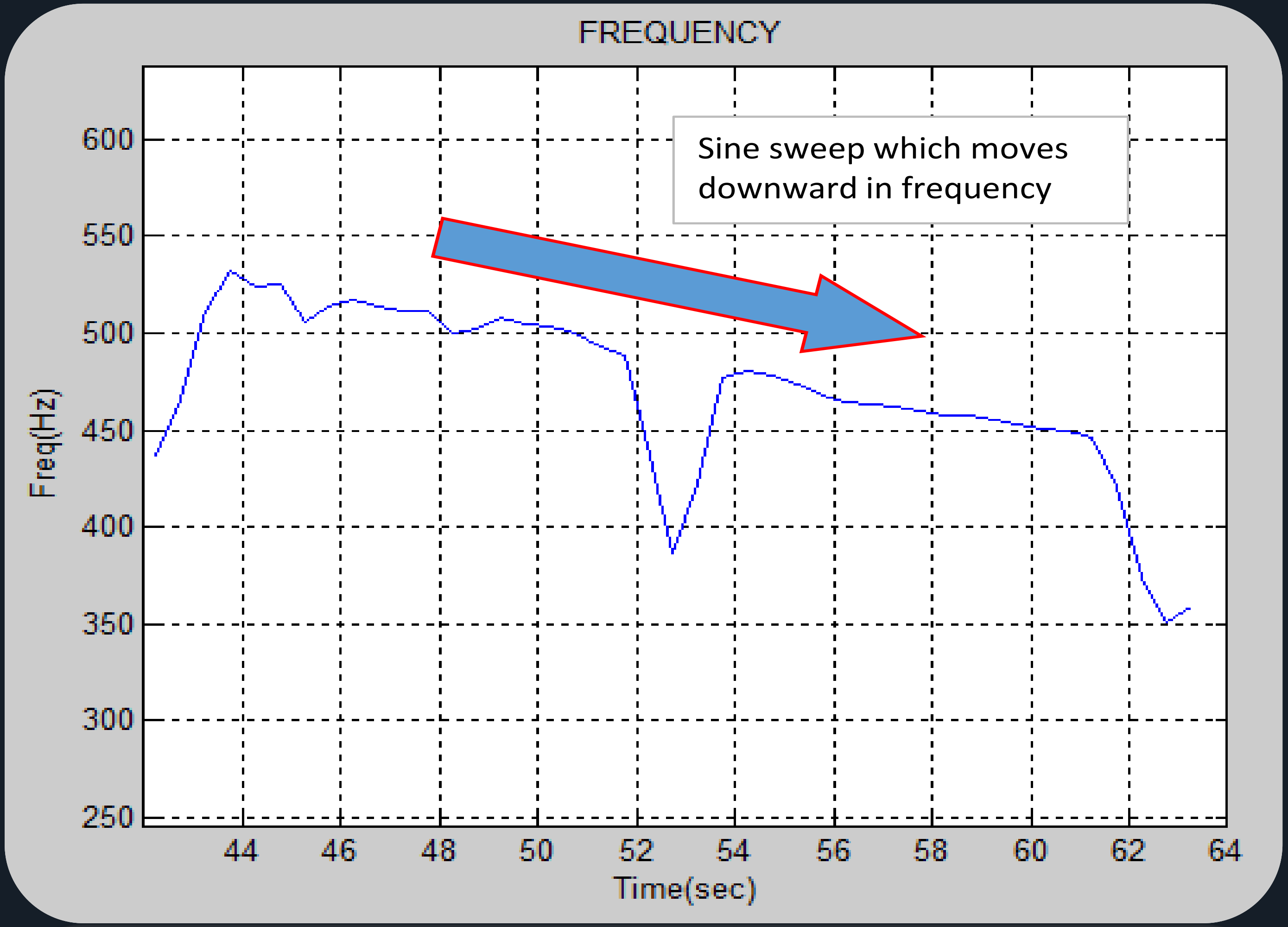


Acceleration vs time on a SRB at the rocket bulkhead



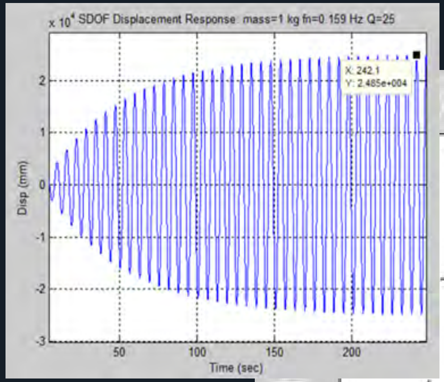
Zoom-in reveals mainly sinusoidal content in the signal (Sine sweep)

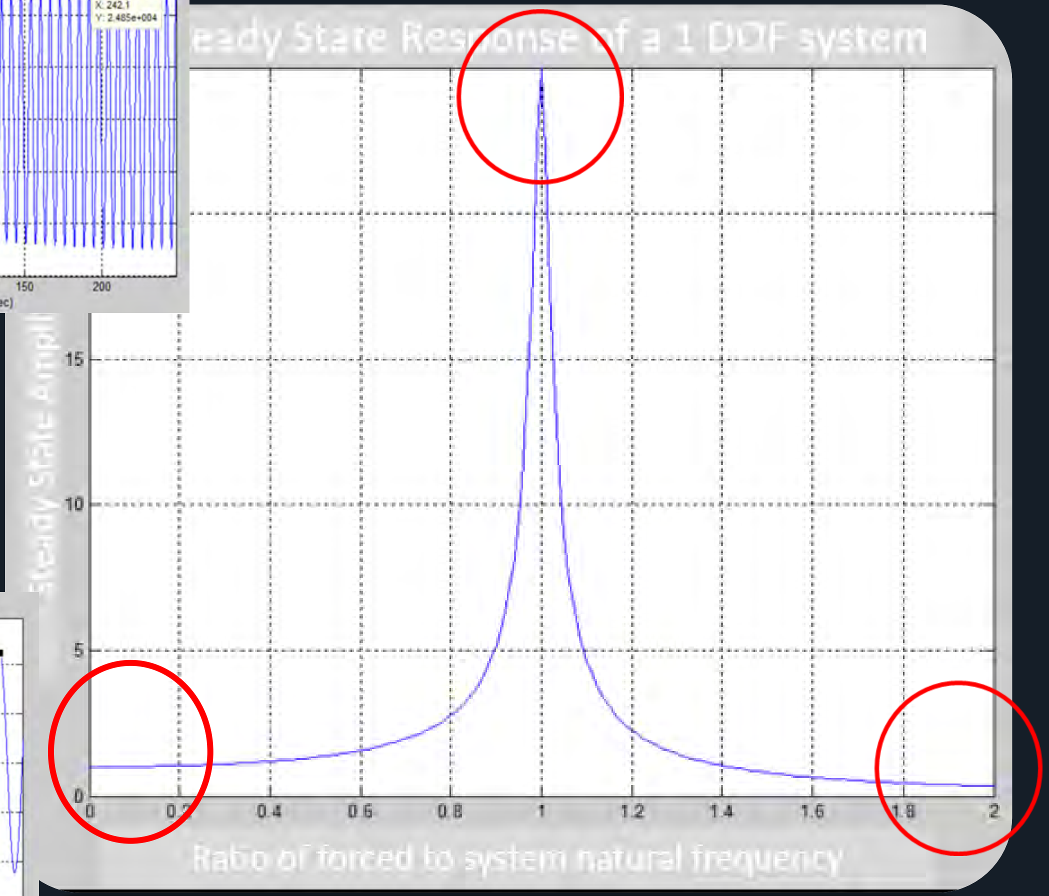
Sinusoidal Sweep

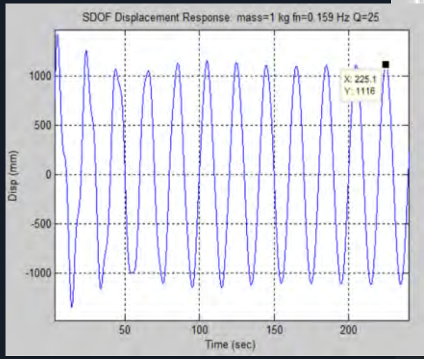


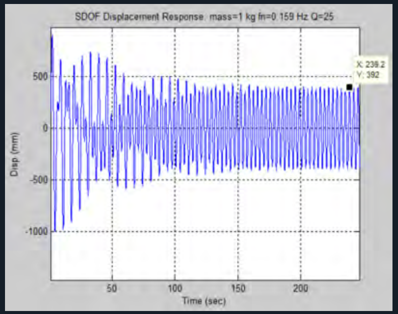
SINUSOIDAL SWEEP

VIDEO A,B,C









ENGINEERING MODEL TESTING

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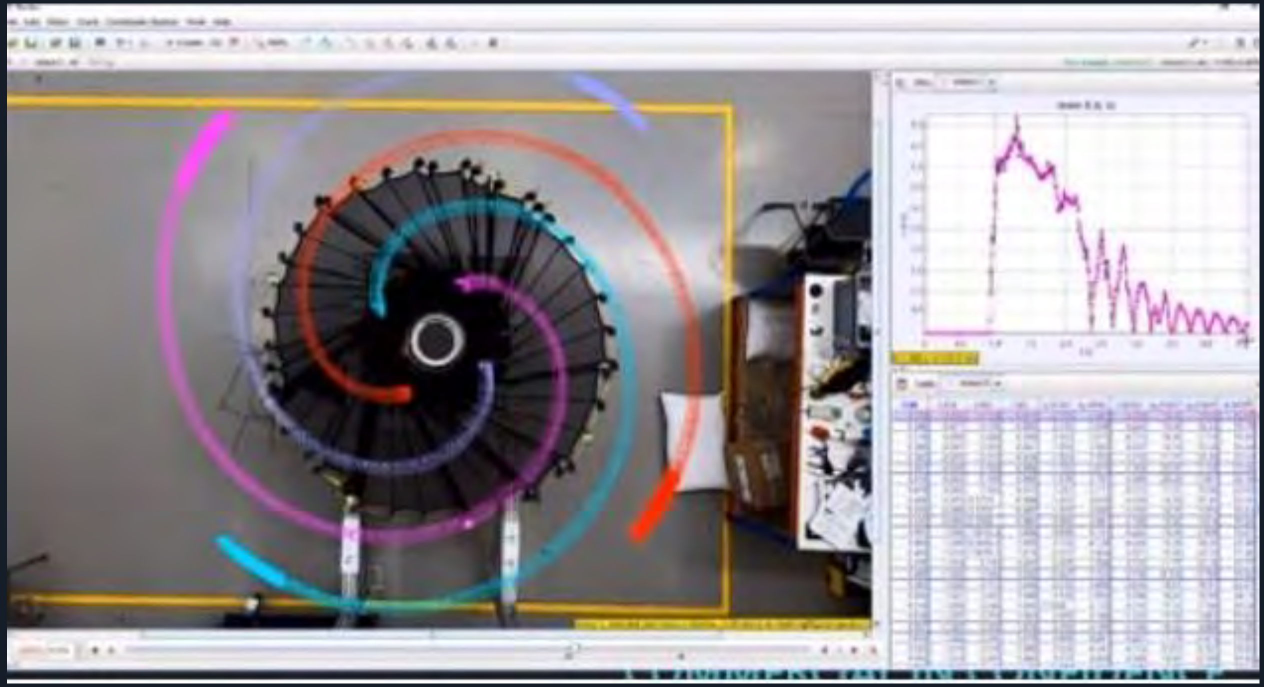
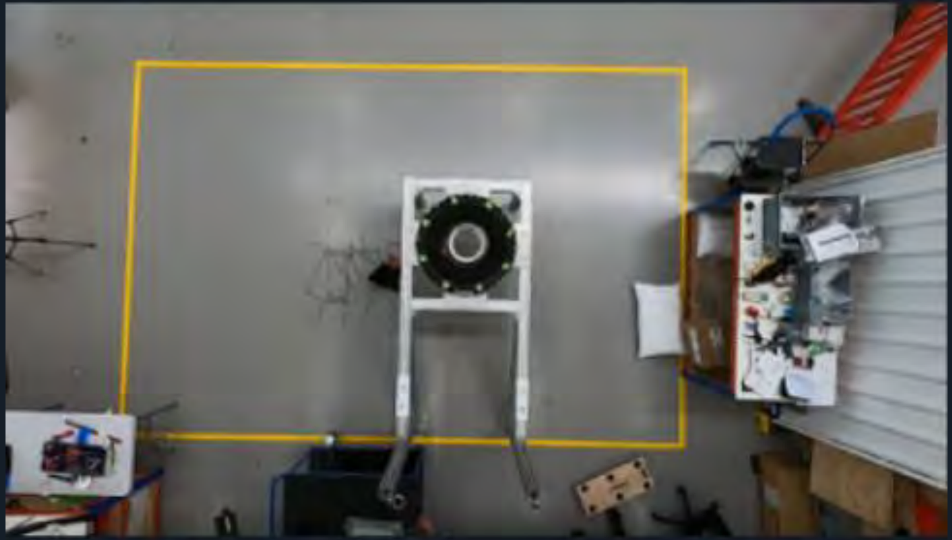
ENGINEERING MODEL TESTING-HDRM AND HDRM & PRIMARY

VIDEO 2





VIDEO 3

QUESTIONS?

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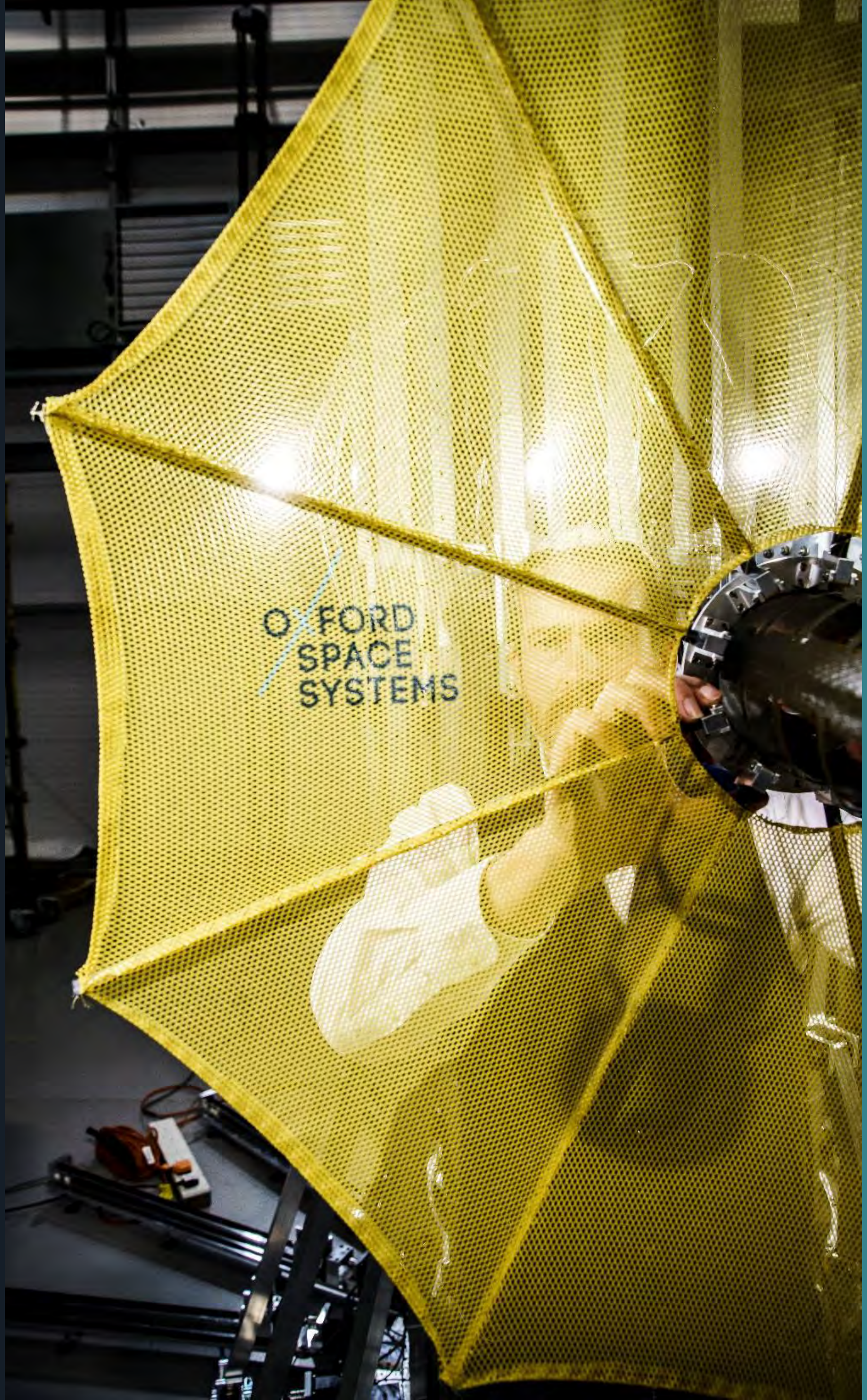

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