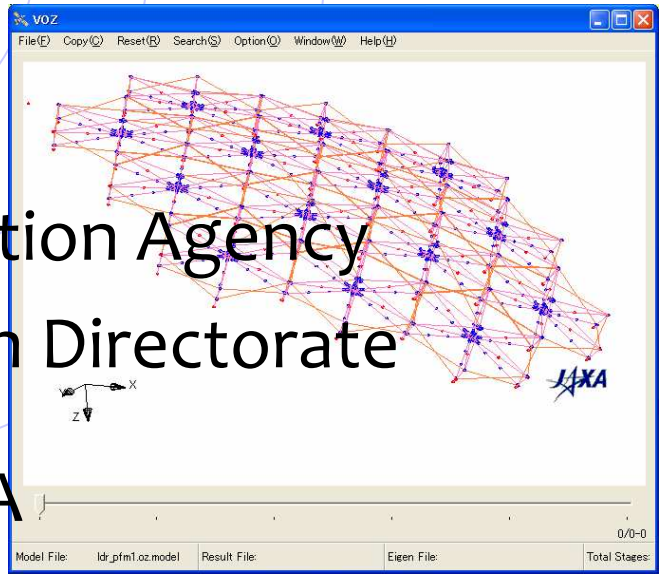
Large Deployable Reflector on Engineering Test Satellite VIII



Japan Aerospace Exploration Agency

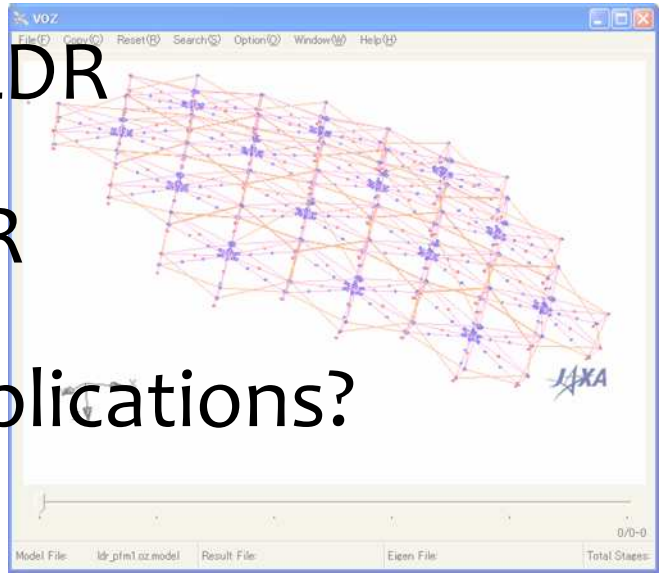
Space Applications Mission Directorate

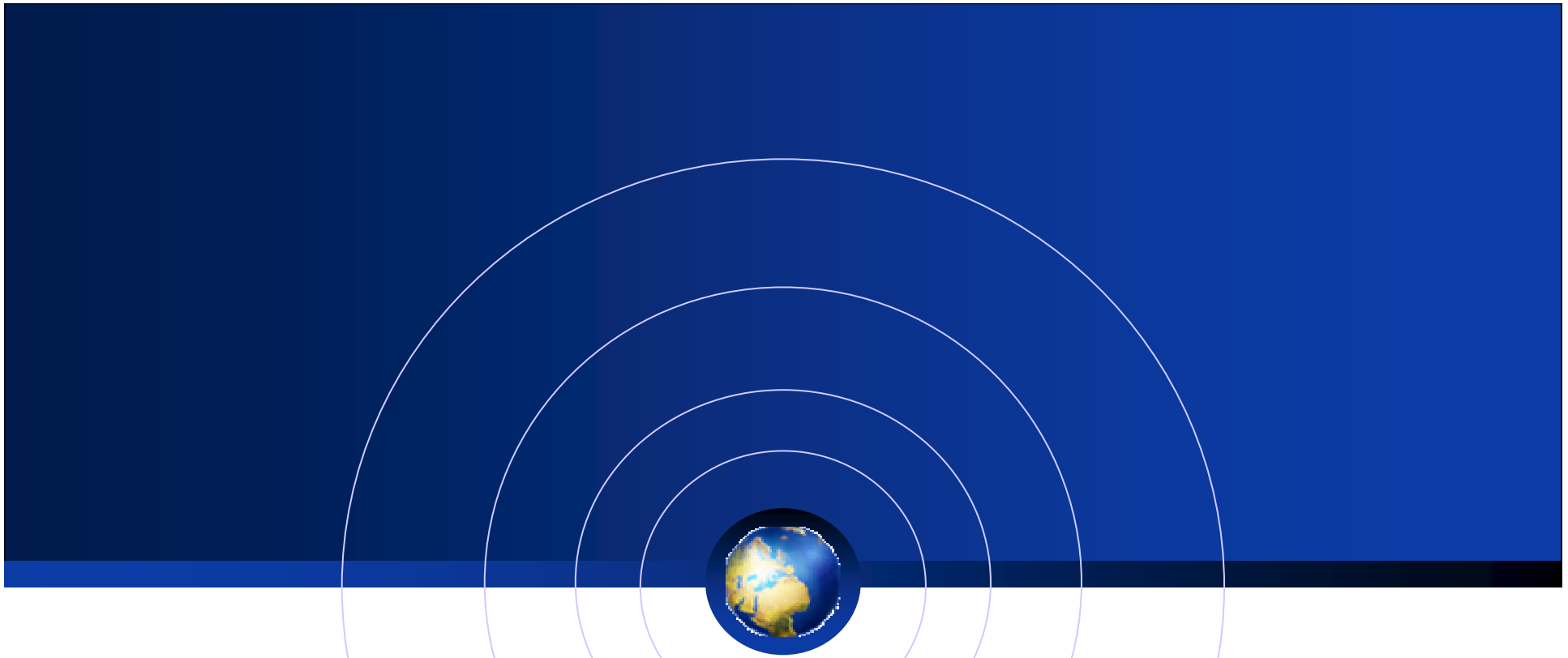
Satoru OZAWA

Today's Talk

Large Deployable Reflector (LDR)

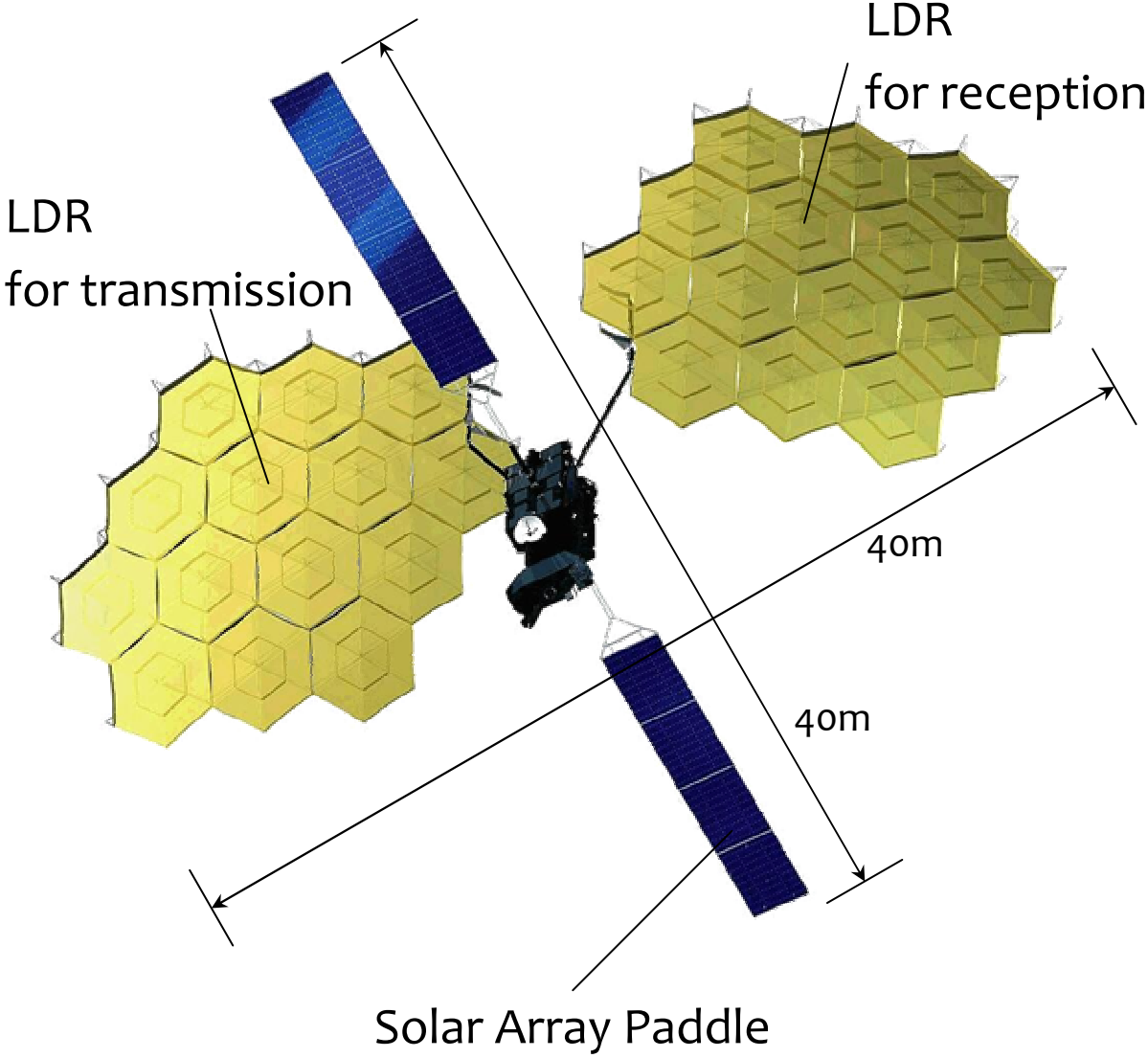
- What is Engineering Test Satellite VIII?
- What is Large Deployable Reflector?
- Development strategy of LDR
- In-orbit deployment of LDR
- What are Future Space Applications?





What is the Engineering Test Satellite VIII?

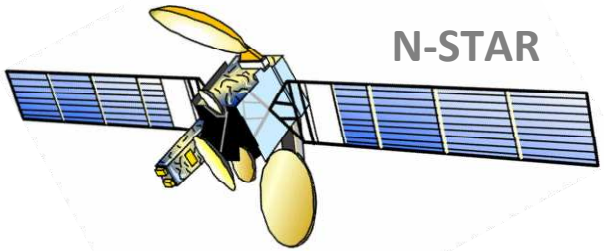
Overview of the Engineering Test Satellite VIII



Type	**Communication satellite**
Frequency band	**S band**
Mass	**3000 kg on-orbit at start of mission**
Electric power	**7.5 kW**
Orbit	**146° E longitude**
Design life	**10 years (s/c)** **3 years (mission)**

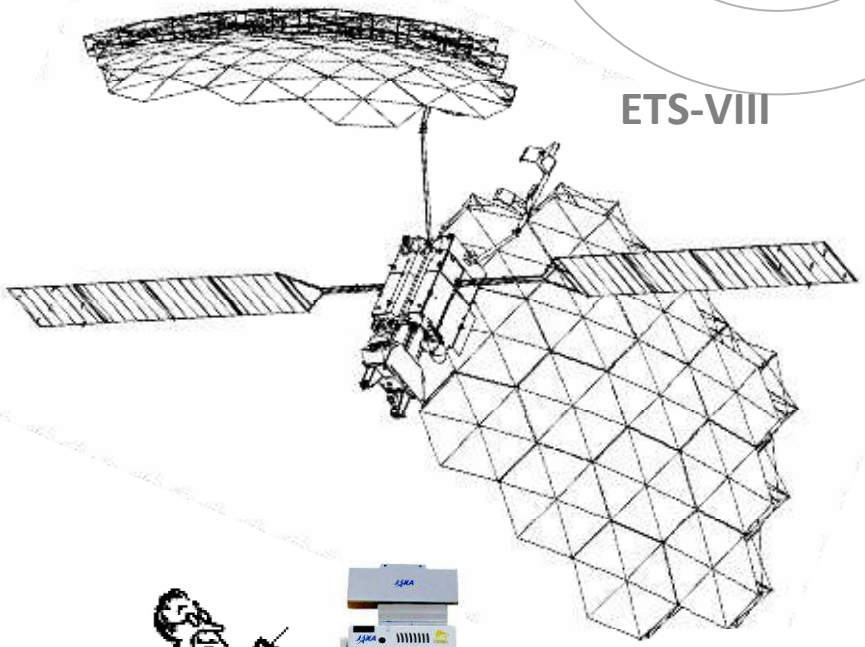
Objective of Engineering Test Satellite VIII

Mobile Communication Satellite

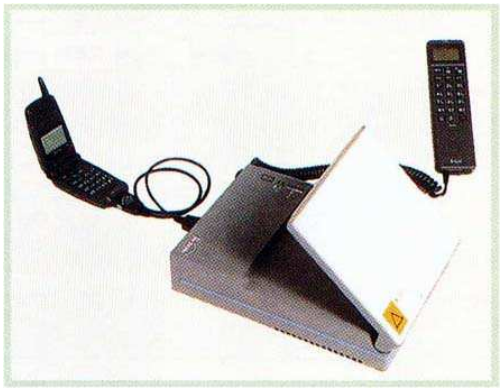


N-STAR

LARGE



ETS-VIII

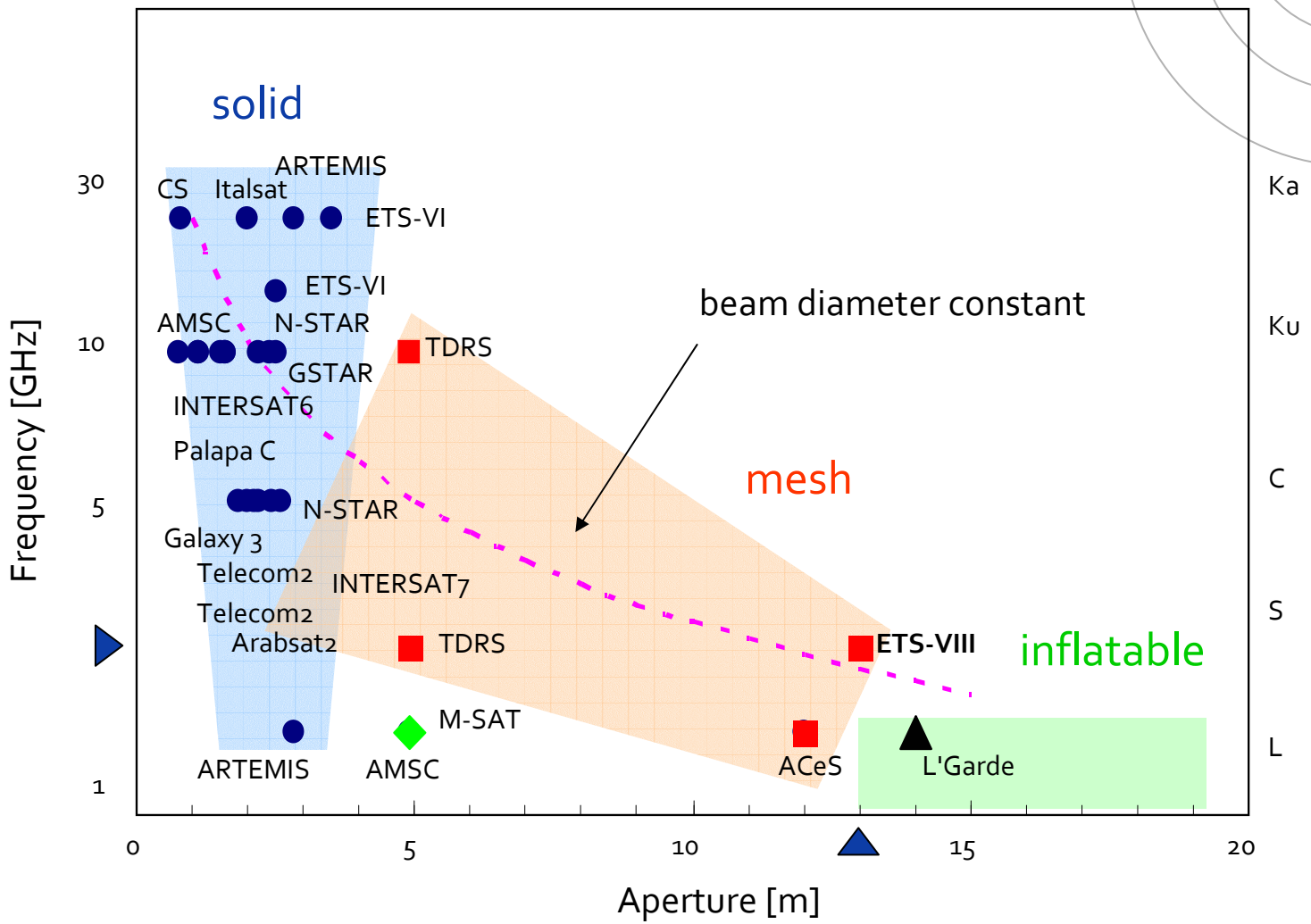


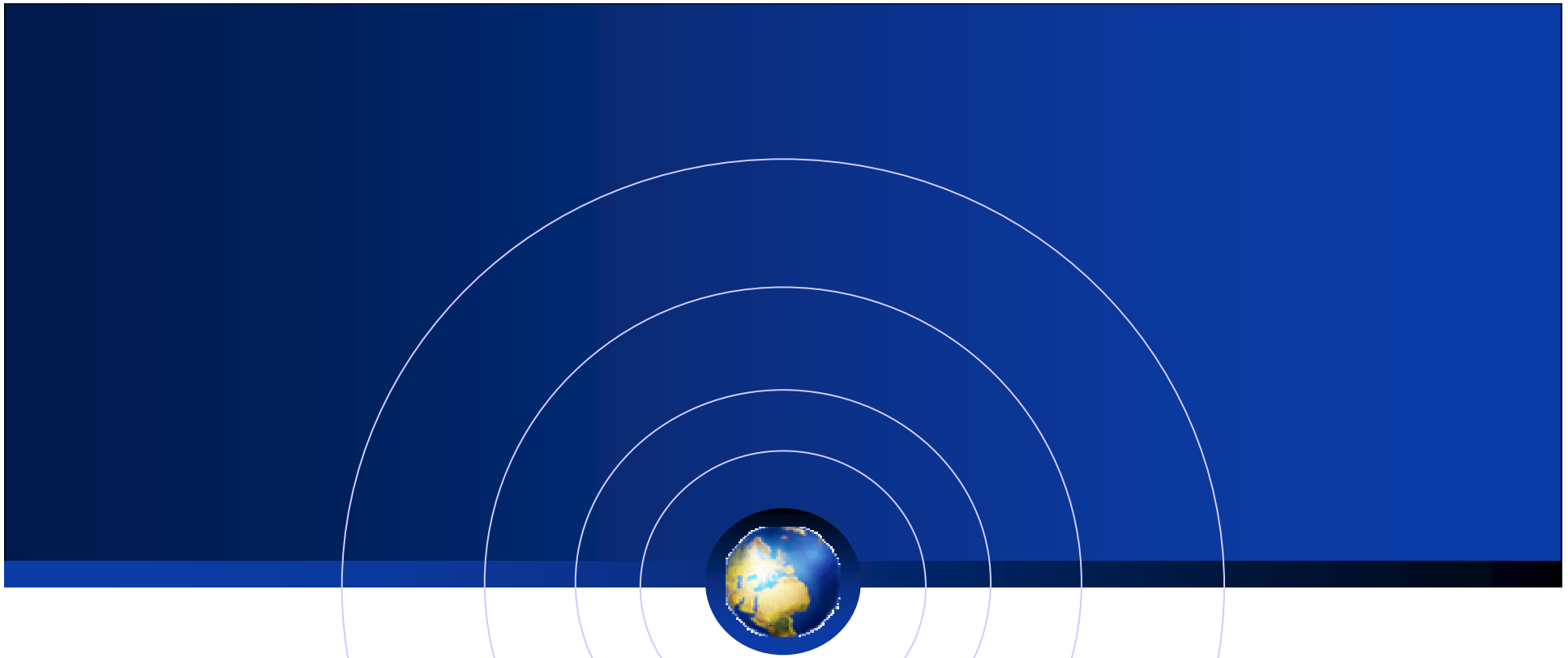
Portable size terminal

SMALL

Handheld size terminal

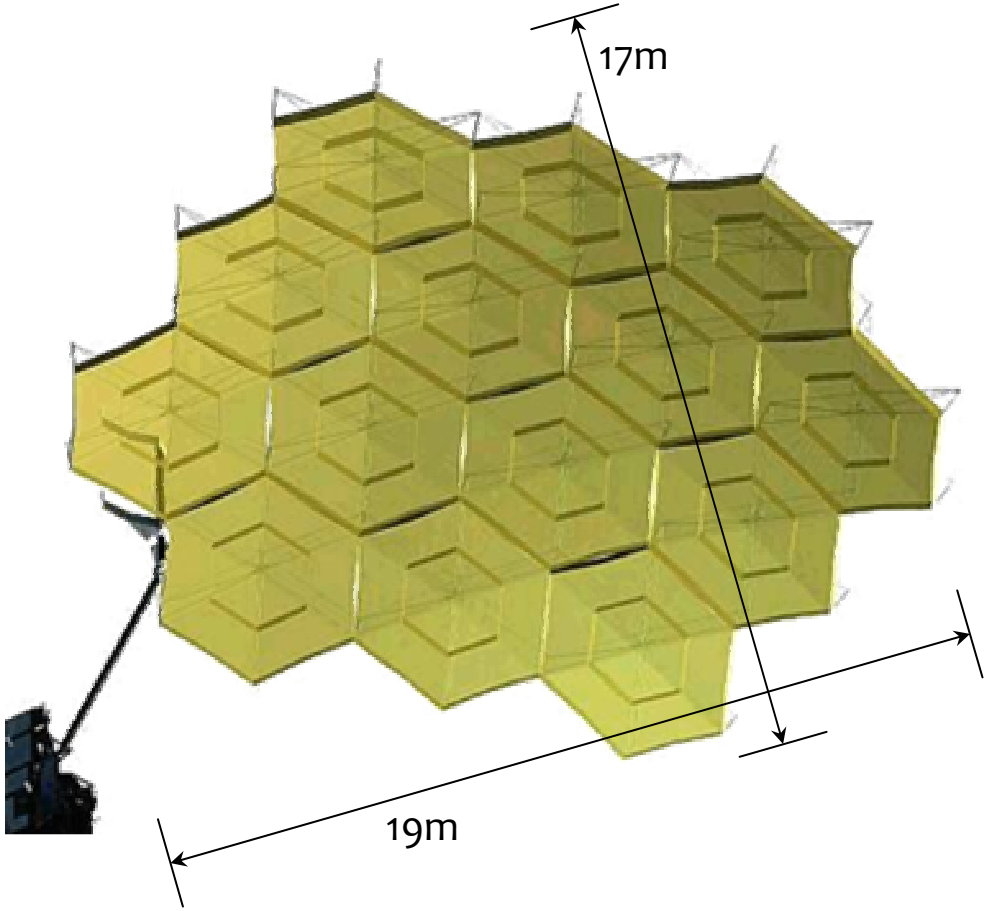
Target of Engineering Test Satellite VIII





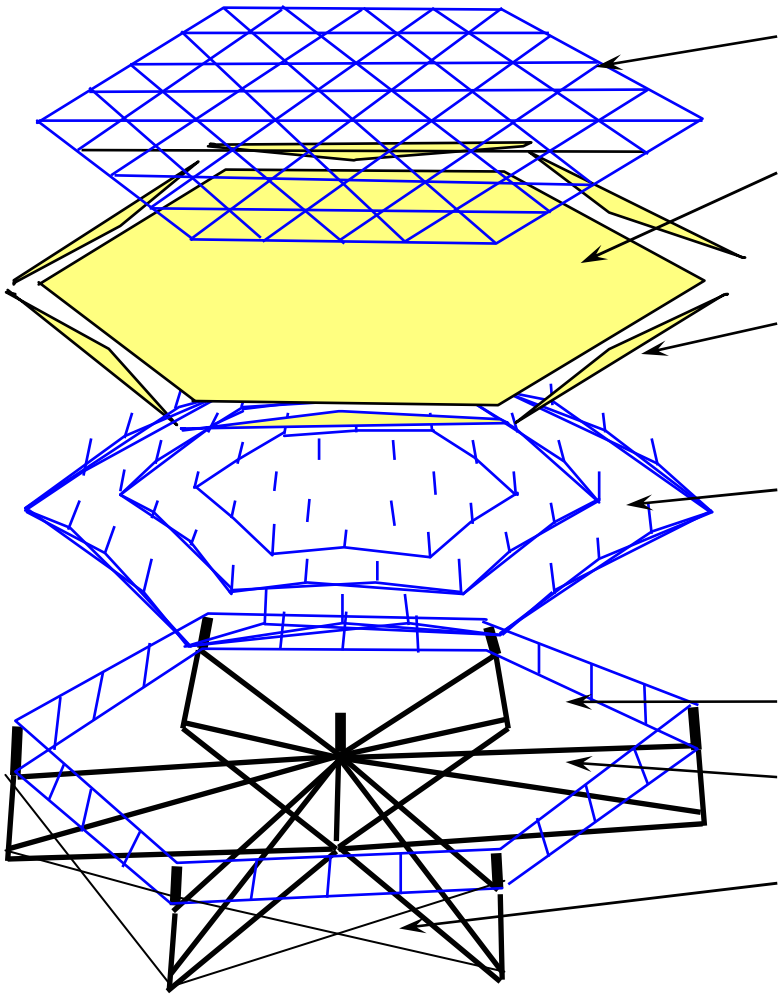
What is Large Deployable Reflector?

Overview



Type	Offset Parabola
Size	About 19m x 17m
Nominal aperture	13m (inscribed circle)
Number of modules	14
Offset angle	51.2°
Stiffness	0.09Hz or more
Accuracy	2.4mmrms or less
Weight Density	105kg (reflector) 650g/m²

Composition of each module



Surface cable
(Quartzel)

Surface mesh
(Gilded molybdenum)

Circumference mesh
(Gilded molybdenum)

Tie/Back cables
(Quartzel)

Reflector surface

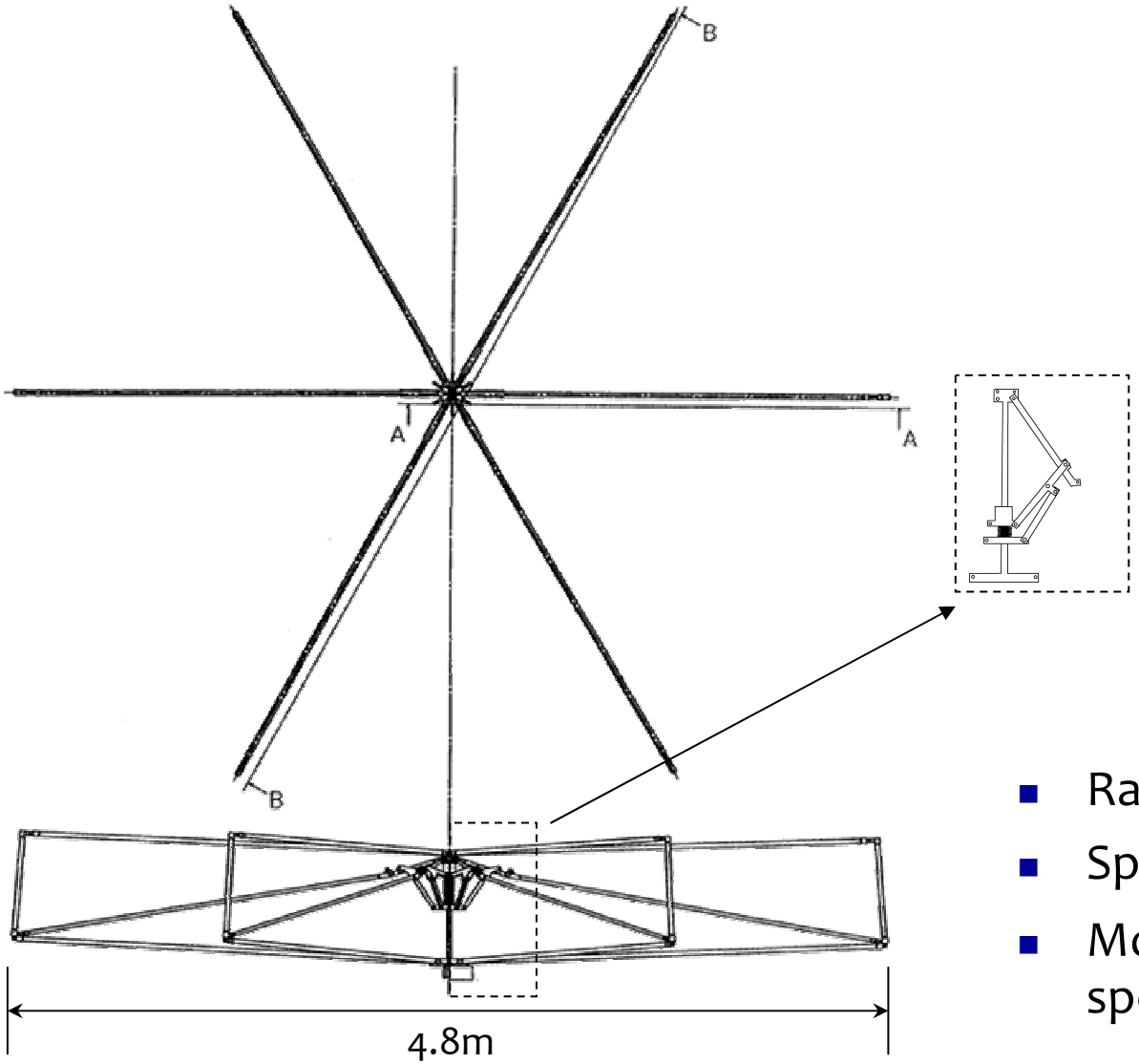
Circumference cables
(Quartzel)

Deployable truss

Tendon cable

Support structure

Support structure



- Radial truss structure.
- Spring deploys structure.
- Motor controls deployment speed and enables rewind.

Development strategy of Large Deployable Reflector

Development strategy of the Large Deployable Reflector

Strategy

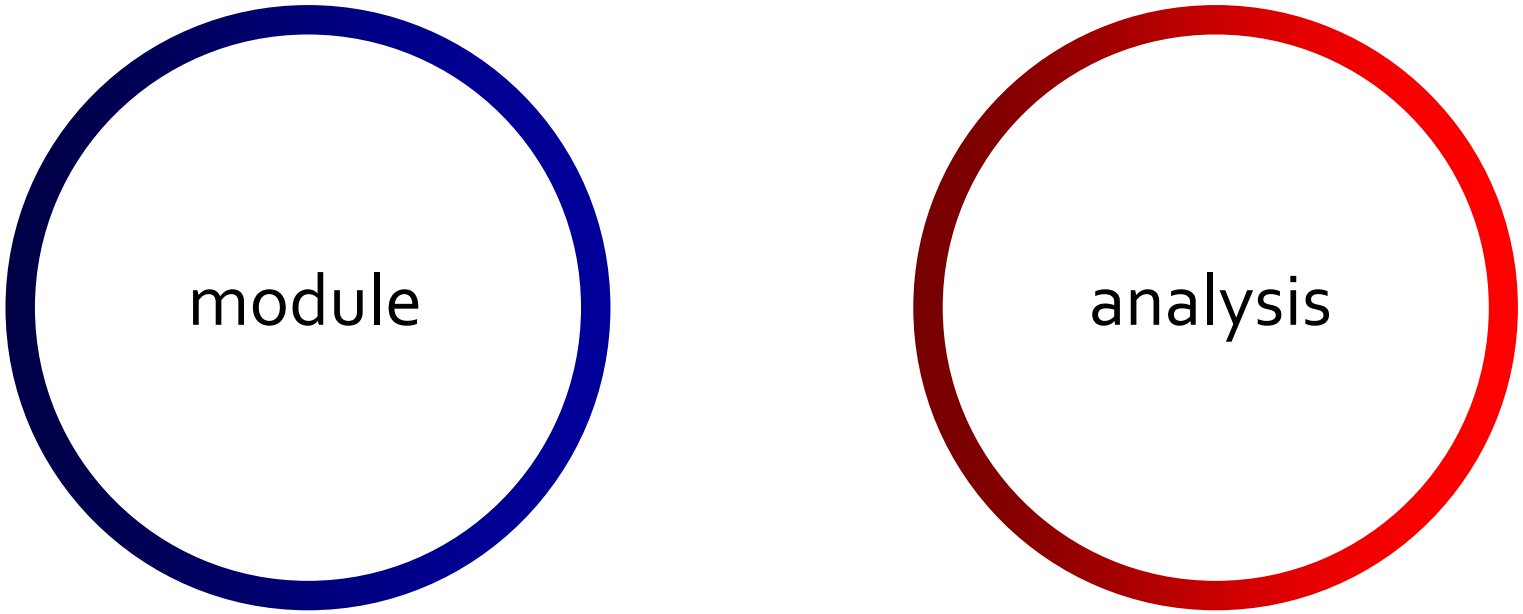
- Two main pillars:
  Module and Analysis
- Ground tests and Updating analysis model
- High accurate surface forming
- Analysis precision evaluation by LDREX-2
- Evaluation of Large Deployable Reflector

Two main pillars
Module and Analysis

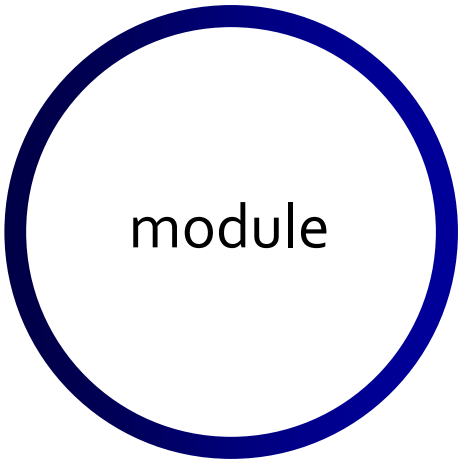
Strategy

- **Two main pillars:**
  Module and Analysis
- Ground tests and Updating analysis model
- High accurate surface forming
- Analysis precision evaluation by LDREX-2
- Evaluation of Large Deployable Reflector

Two main pillars

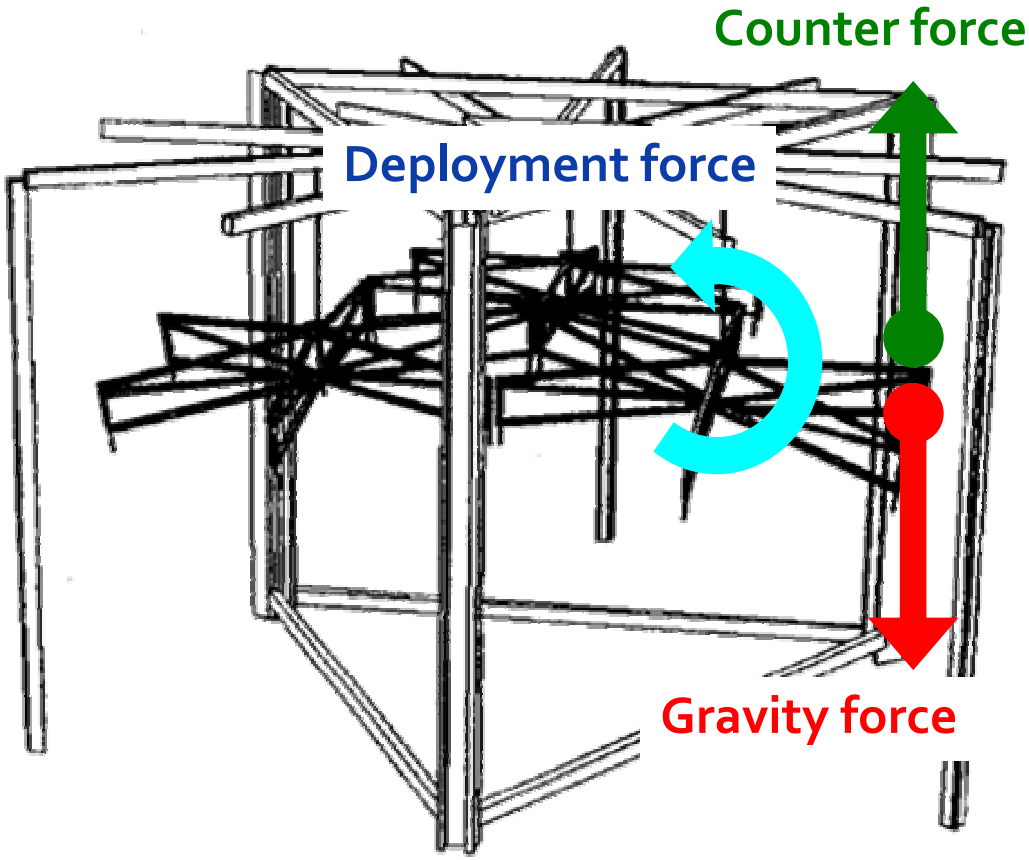


Modular mesh antenna concept



Modular mesh antenna concept

Deployment force vs. Gravity



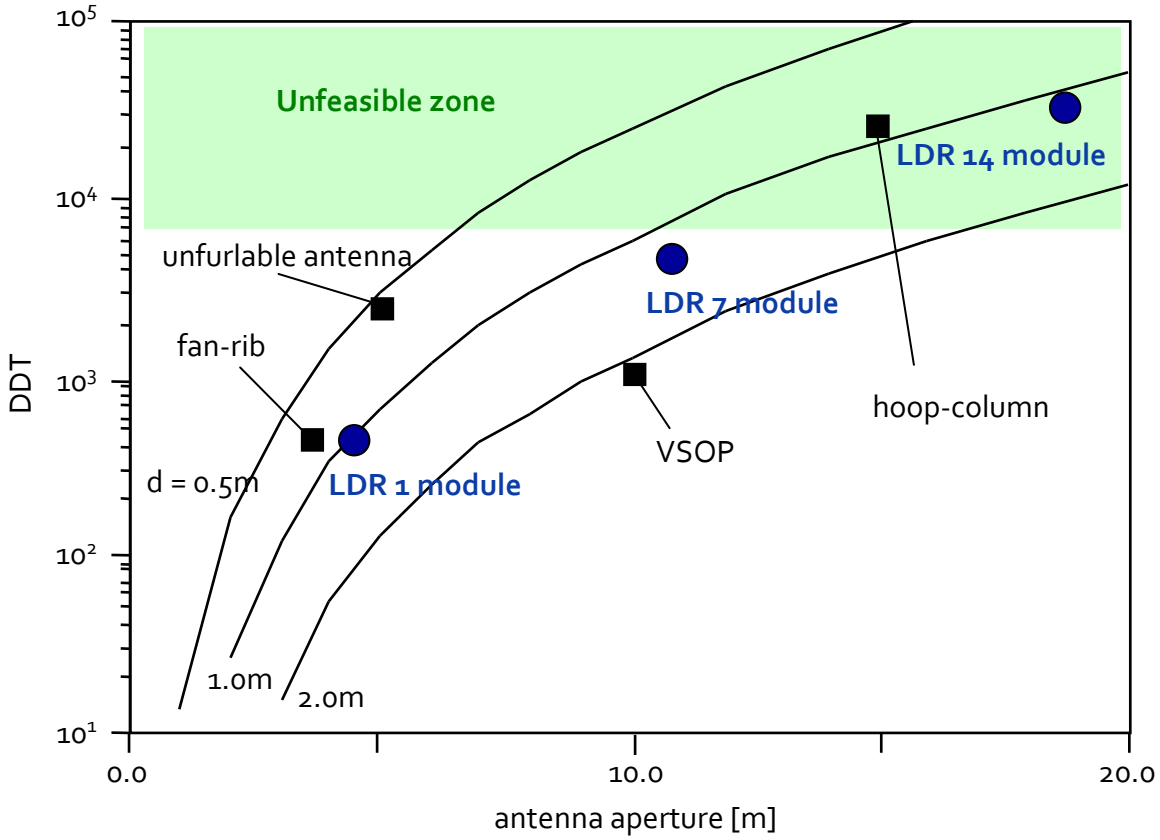
Large deployable structure

Gravity >> Deployment force

Errors >> Deployment Force

Unable to evaluate deployment force

Ground test difficulty evaluation



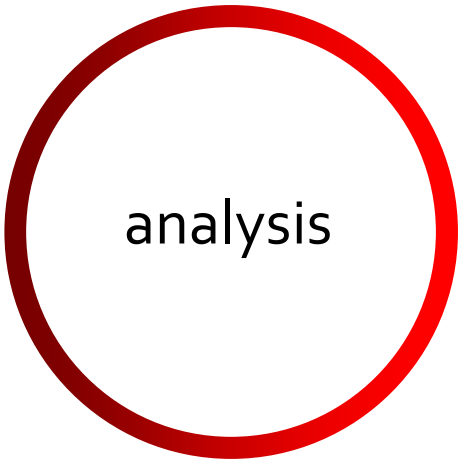
Difficulty of deployment test

$$DDT = \frac{gravity\ force}{deployment\ force}$$

- Small aperture for test/manufacturing.
- Large aperture for use.

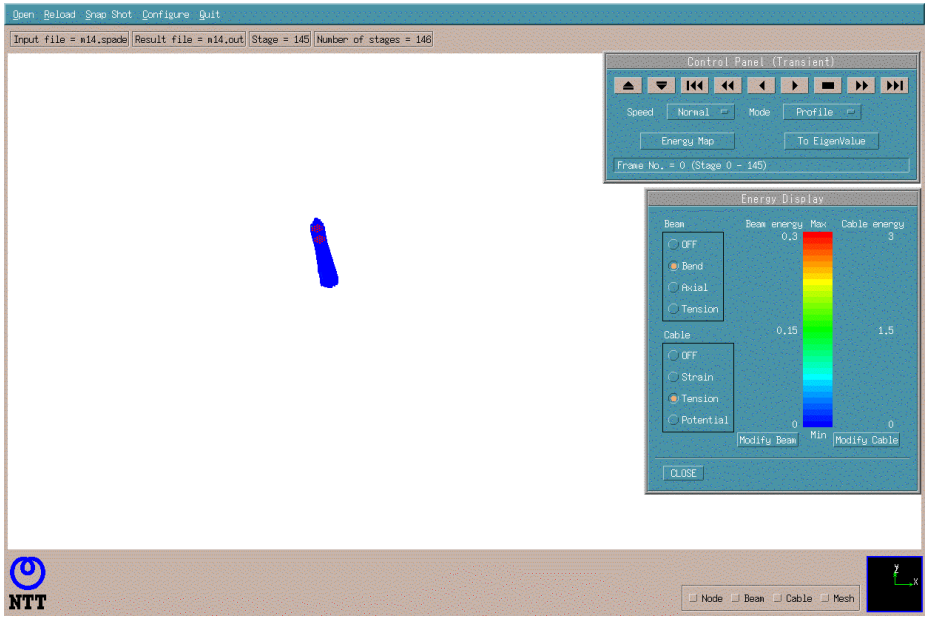
We apply the modular mesh antenna concept.

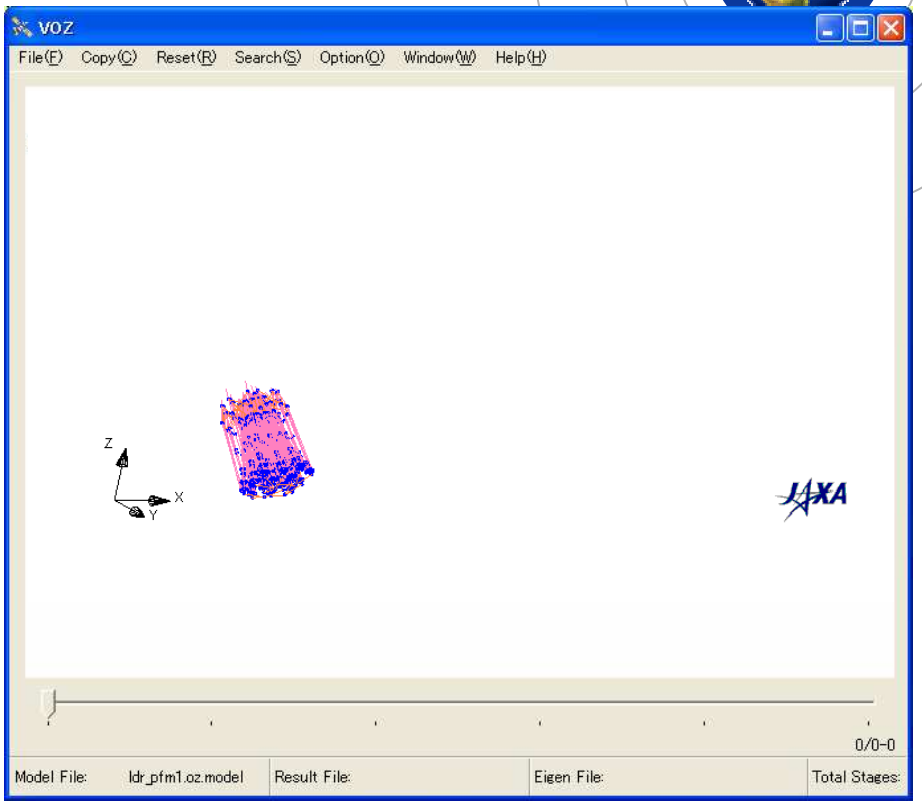
Development strategy of Large Deployable Reflector



High precision deployment analysis

Deployment analysis technology for high precision prediction





SPADE

Origami/ETS

SPADE was made for **high precision deployment analyses** by NTT (Nippon Telegraph and Telephone Corporation). Currently Orgami/ETS inherits its technology and is still being expanded by JAXA. These software contributed to LDR.

Update analysis model by ground tests

Strategy

- Two main pillars
  Module and Analysis
- **Ground tests and Updating analysis model**
- High accurate surface forming
- Analysis precision evaluation by LDREX-2
- Evaluation of Large Deployable Reflector

High accurate surface forming

Strategy

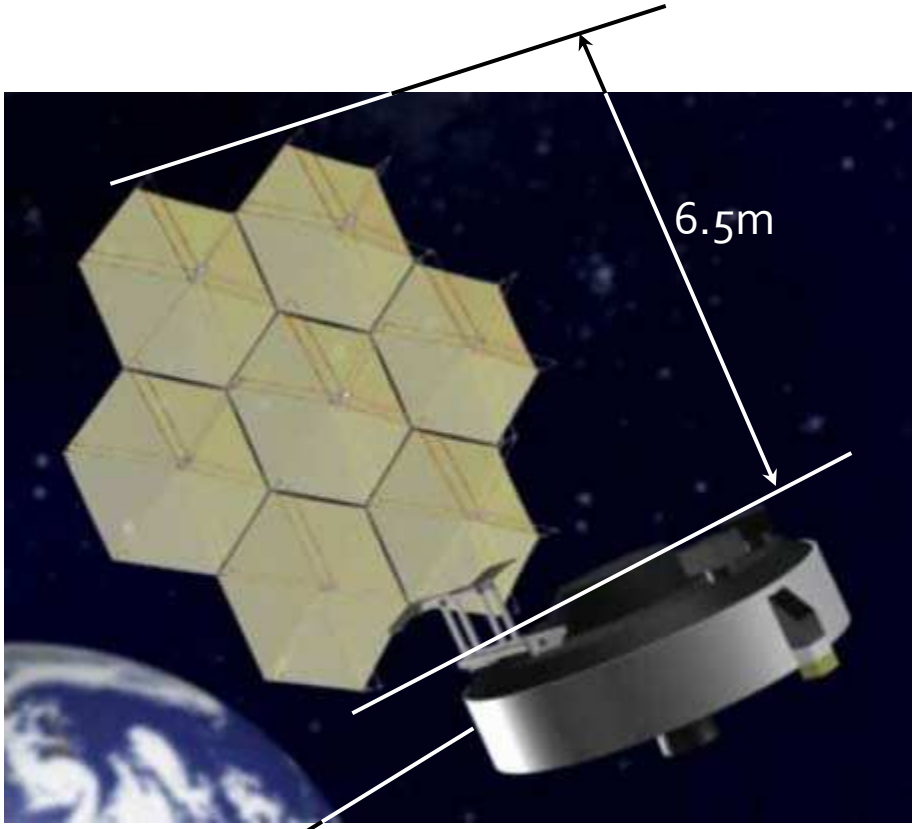
- Two important pillars
  Module and Analysis
- Ground tests and Updating analysis model
- **High accurate surface forming**
- Analysis precision evaluation by LDREX-2
- Evaluation of Large Deployable Reflector

Analysis precision evaluation by LDREX-2

Strategy

- Two main pillars
  Module and Analysis
- Ground tests and Updating analysis model
- High accurate surface forming
- **Analysis precision evaluation by LDREX-2**
- Evaluation of Large Deployable Reflector

Analysis precision evaluation by the LDREX-2 in-orbit experiment

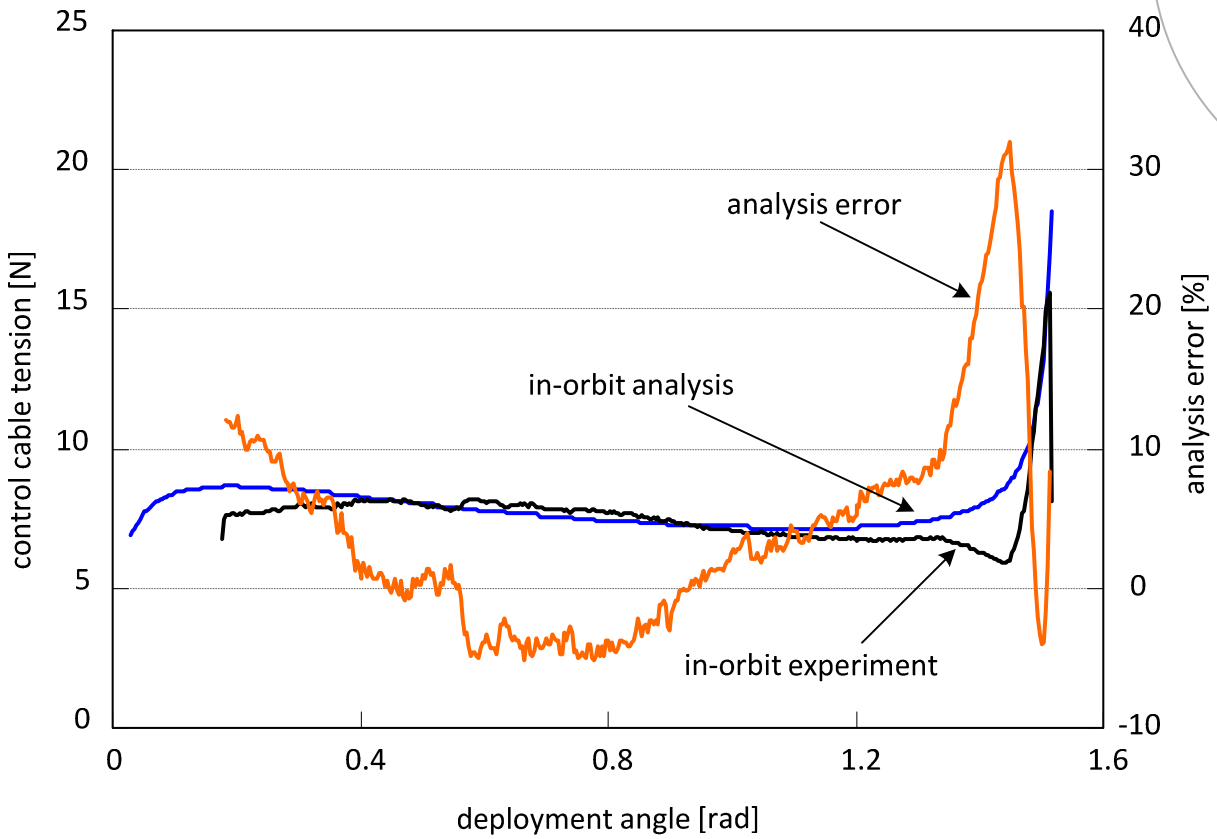


ASAP5
(ARINE5 Structure for Auxiliary Payload)

Mass	211 kg
Size	6.5m x 6.5m
Number of modules	7
Launcher	Ariane 5ECA
Orbit	GTO

LDREX-2 deployment procedure and result

Analysis precision evaluation by LDREX-2



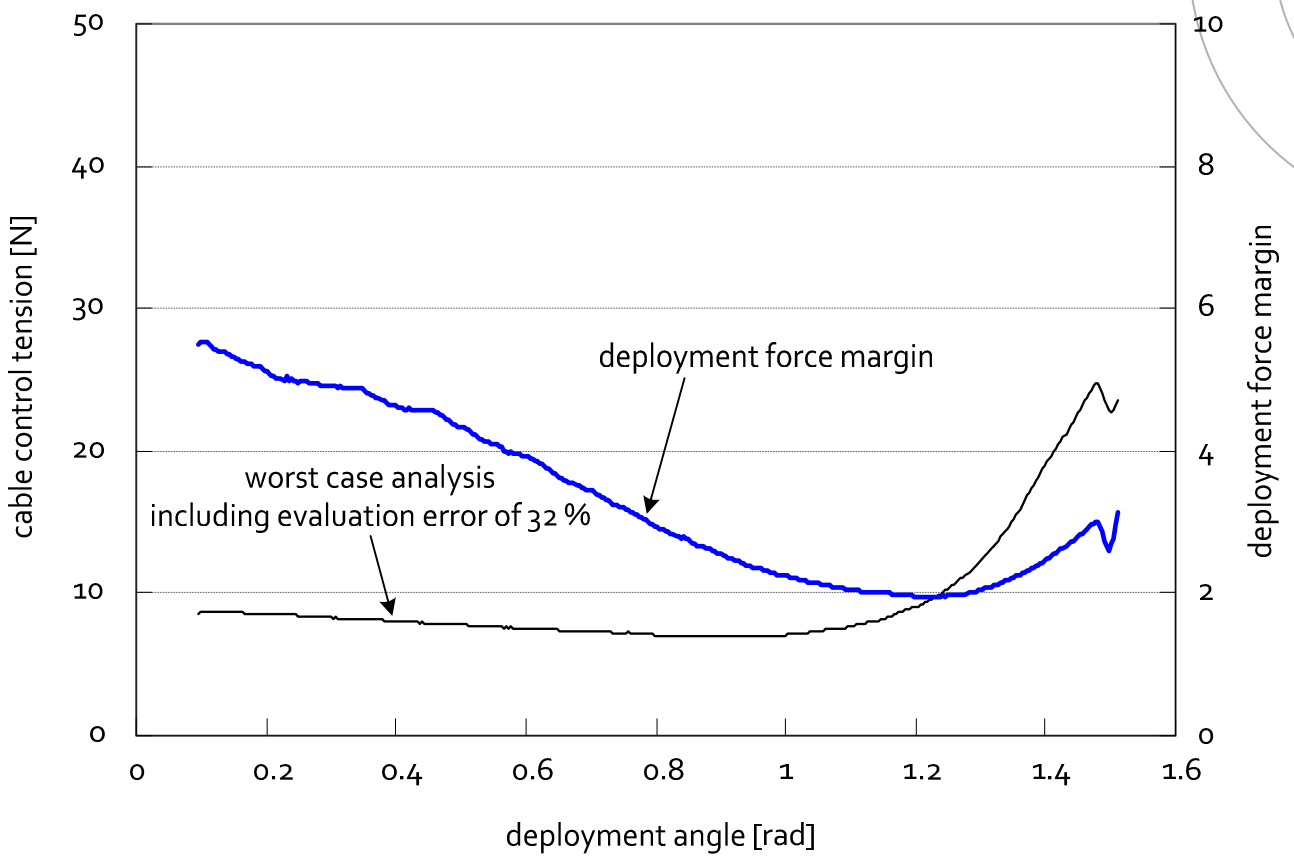
Analysis result agreed with experiment within 10% at almost every angle. The maximum error is 32% right before full deployment. Analysis simulates well and can be used for in-orbit prediction of LDR.

Evaluation of Large Deployable Reflector

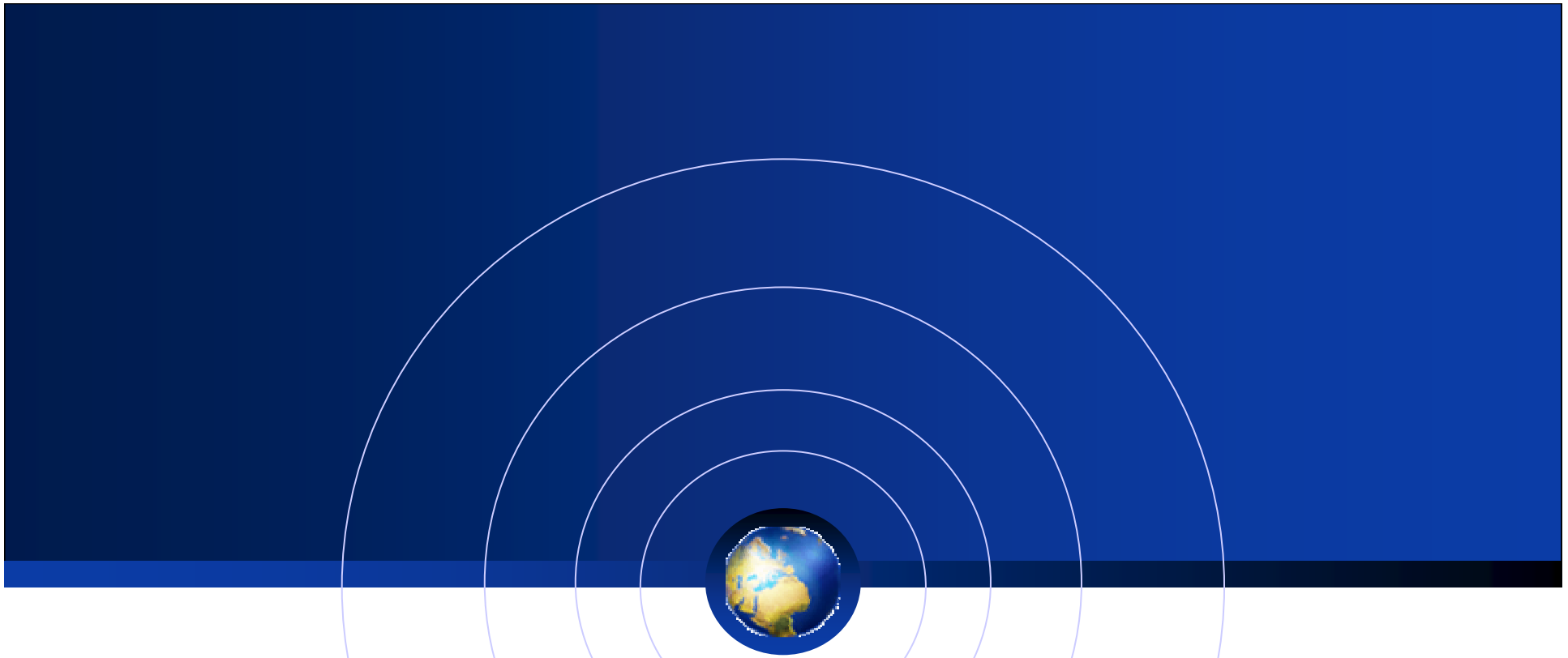
Strategy

- Two main pillars
  Module and Analysis
- Ground tests and Updating analysis model
- High accurate surface forming
- Analysis precision evaluation by LDREX-2
- **Evaluation of Large Deployable Reflector**

Worst case analysis results of the Large Deployable Reflector



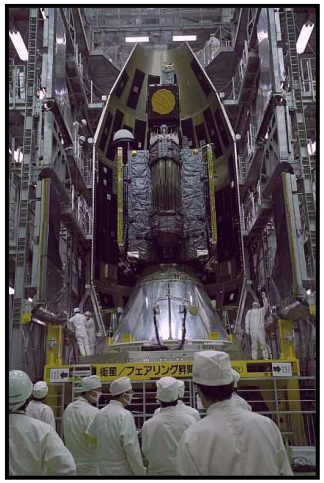
The evaluation of in-orbit deployment of LDR with maximum 32% error considered shows that the deployment force margin is greater than 2. The reflector is guaranteed to deploy through the analysis and LDREX-2.



In-orbit deployment of Large Deployable Reflector

Launch of Engineering Test Satellite VIII

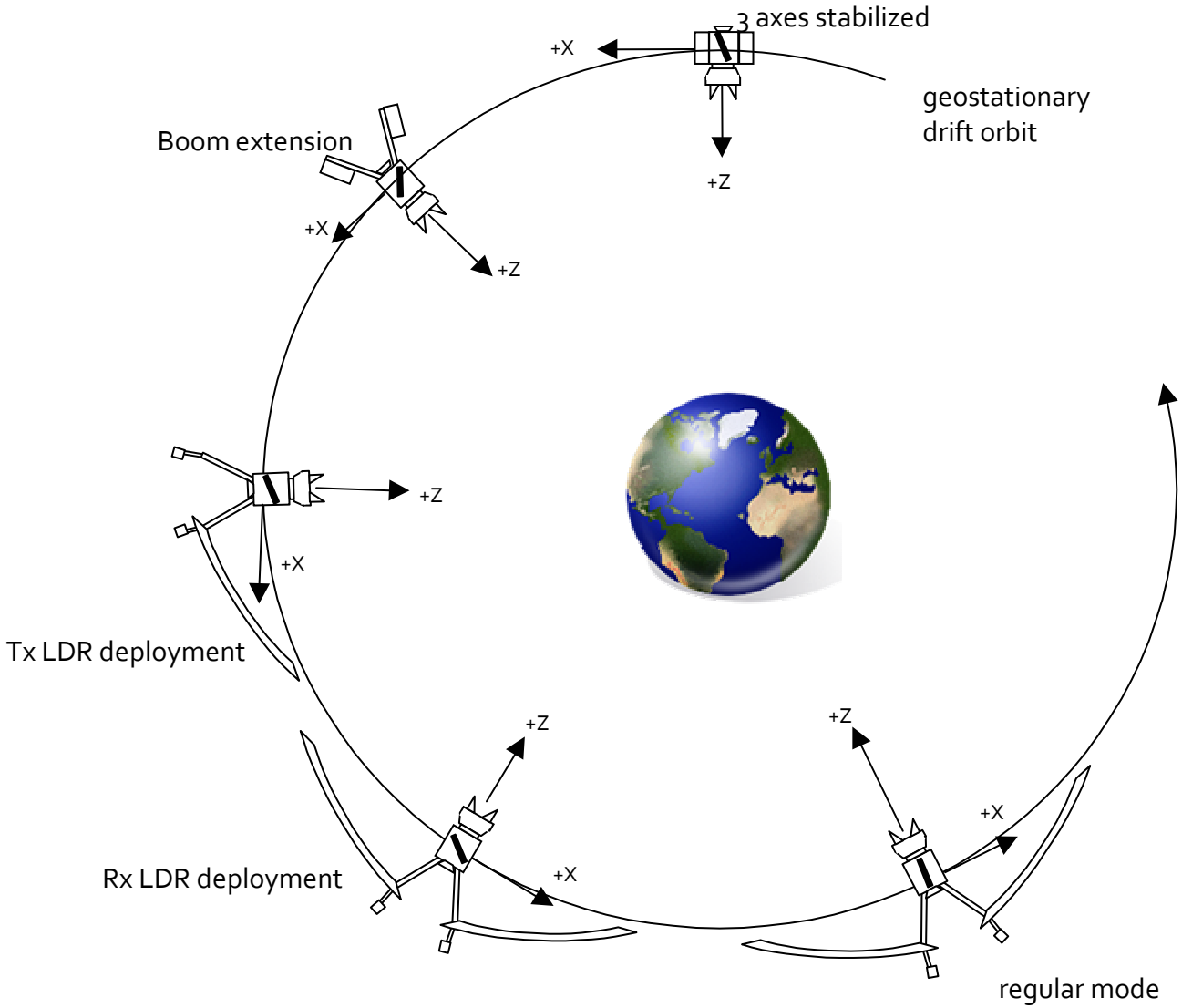
Final tests



Stacked on fairing

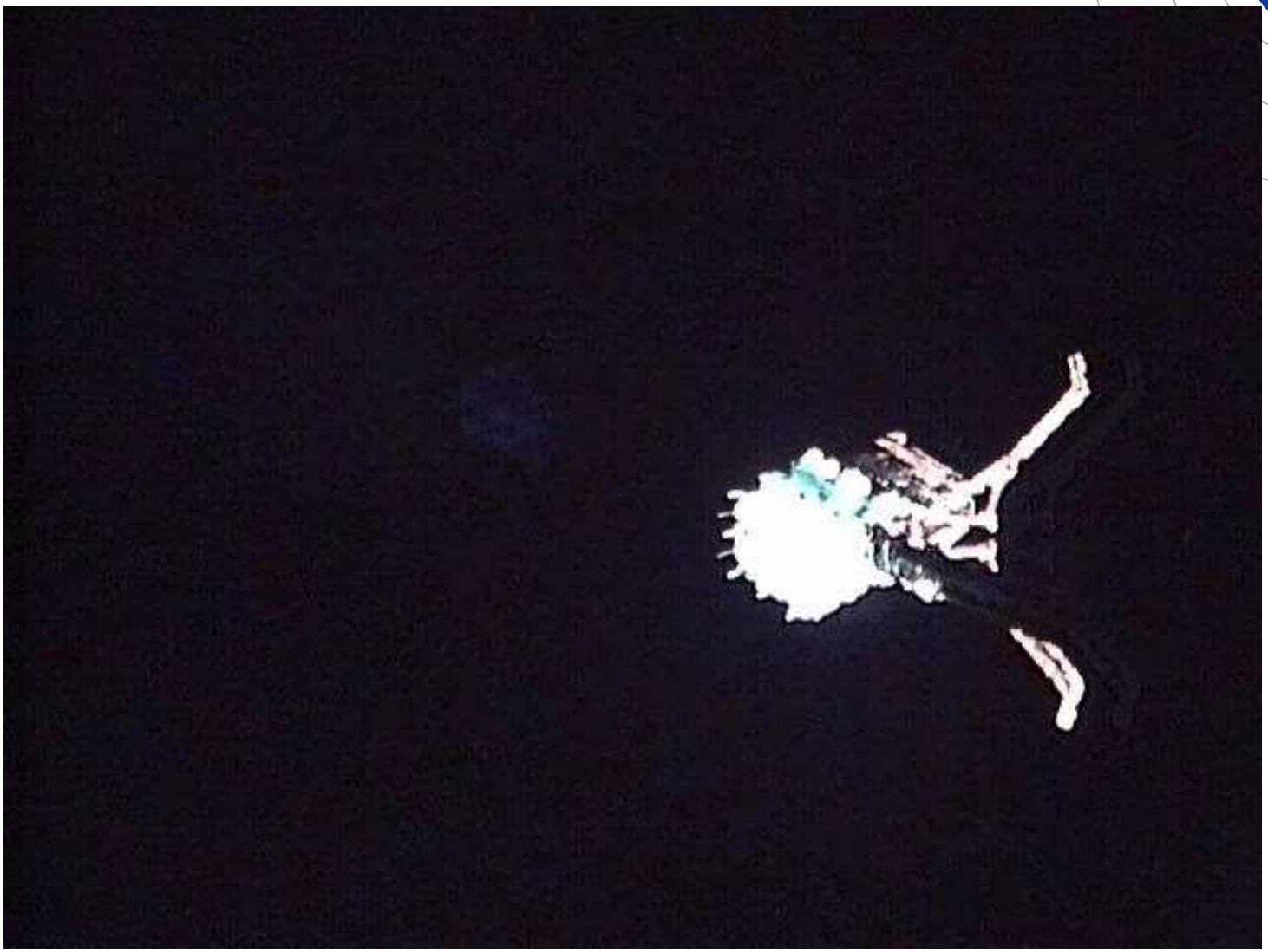
Launched on 18 Dec 2006

Events of Engineering Test Satellite VIII

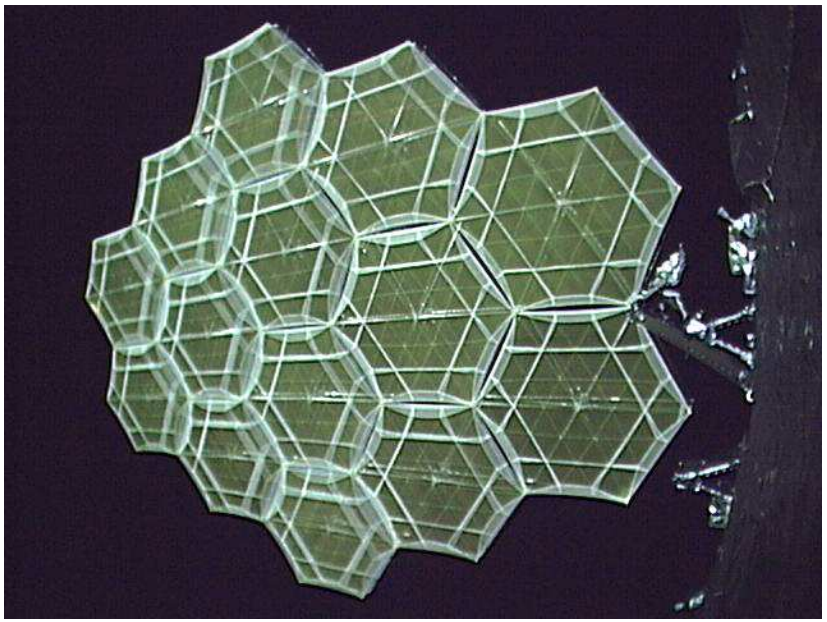


Deployment sequence

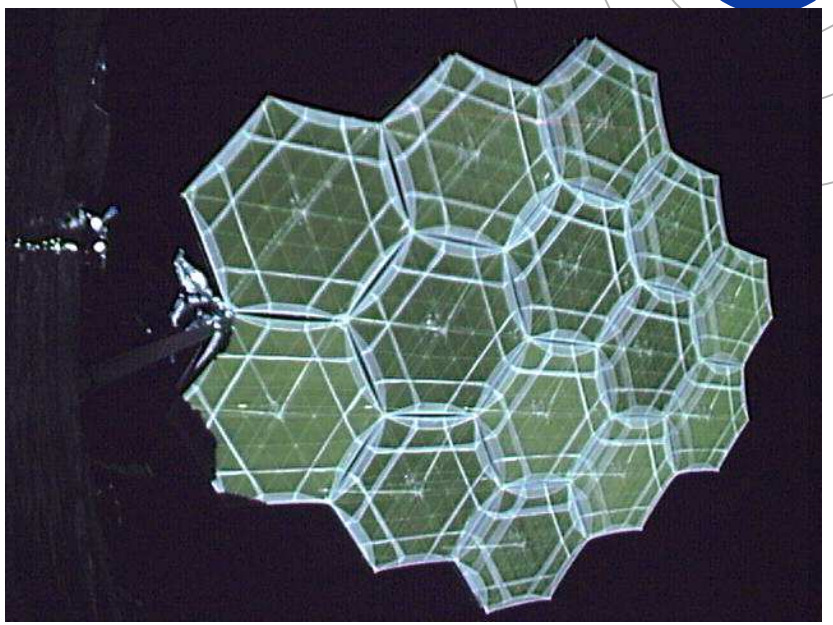
Deployment (1/2)



Deployment (2/2)

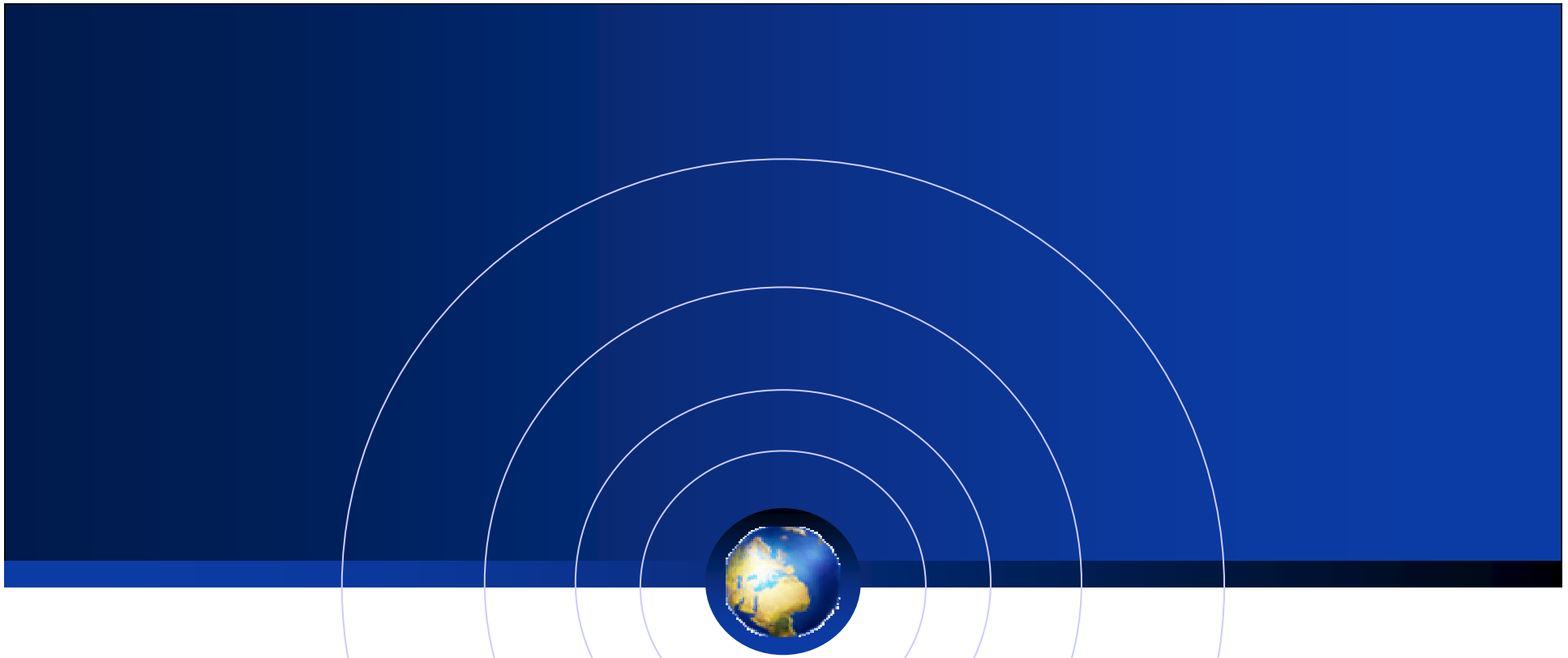


Deployed Rx LDR



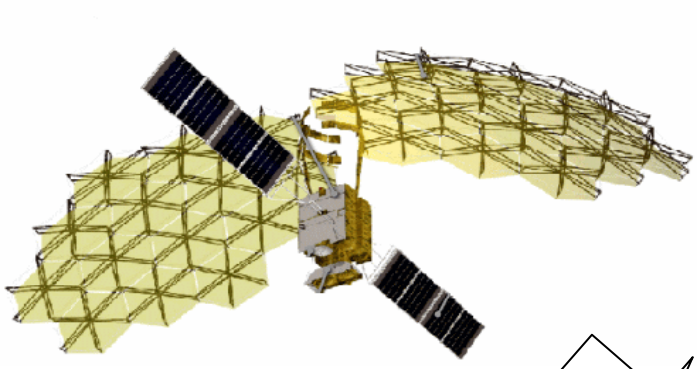
Deployed Tx LDR

The in-orbit deployment of Large Deployable Reflectors demonstrated that the modular mesh antenna concept and the high precision analysis technology are very effective. Furthermore, it is also confirmed that the surface accuracy satisfies the specification against thermal environments throughout the year. These methods can be used for various applications.



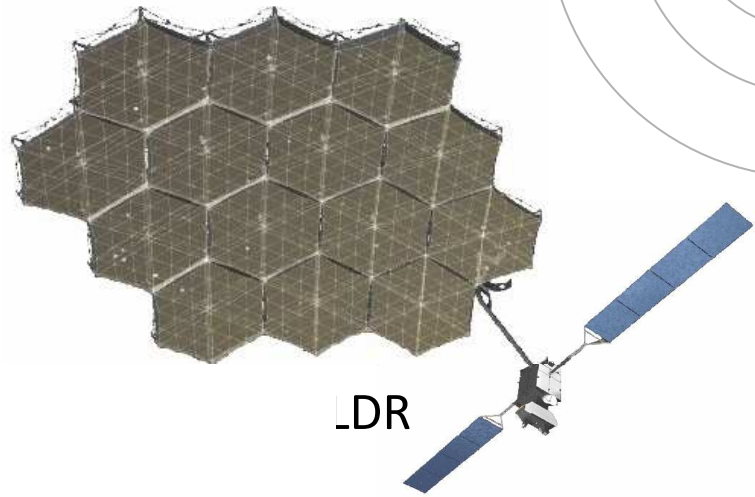
Applications of Large Deployable Reflector

Applications of the Large Deployable Reflector



ETS-8

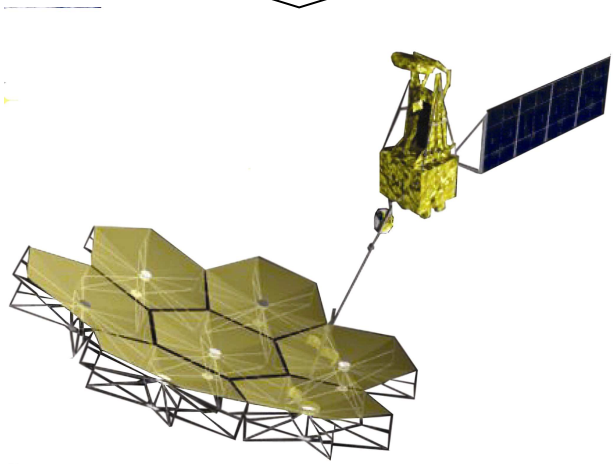
large



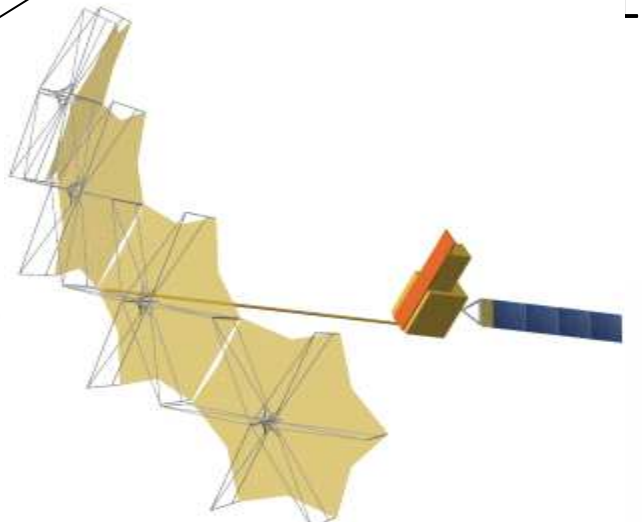
LDR

non ellipse

high accuracy

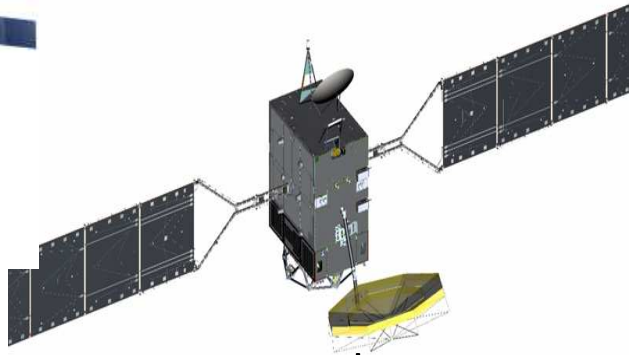


ASTRO-G



InSAR

one large reflector

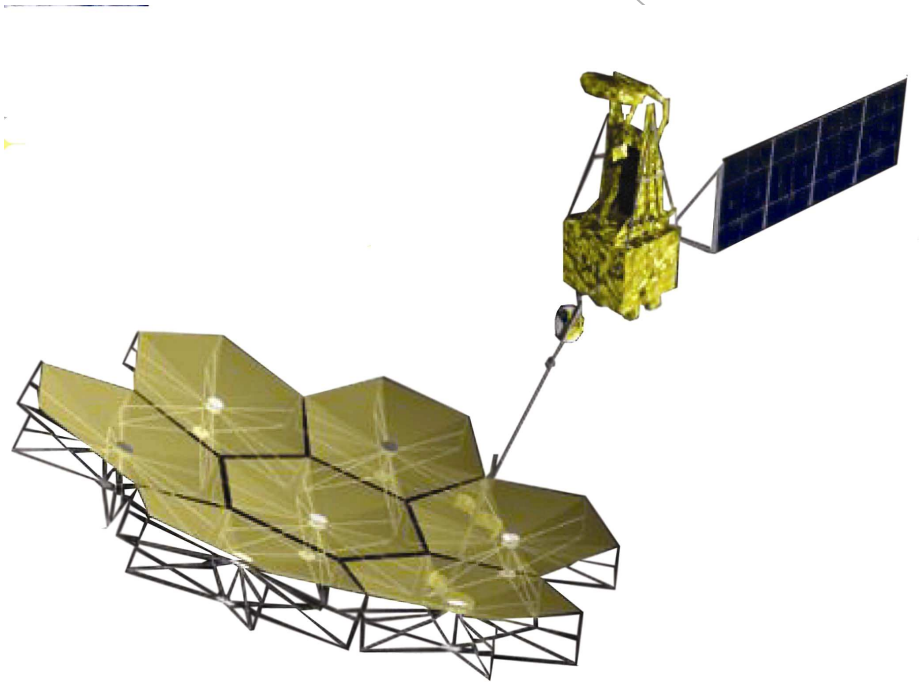


Data relay

Application to High accuracy reflector

ASTRO-G

- Radio astronomy
- 9.26m aperture
- 0.4mmrms surface accuracy for 43GHz observation

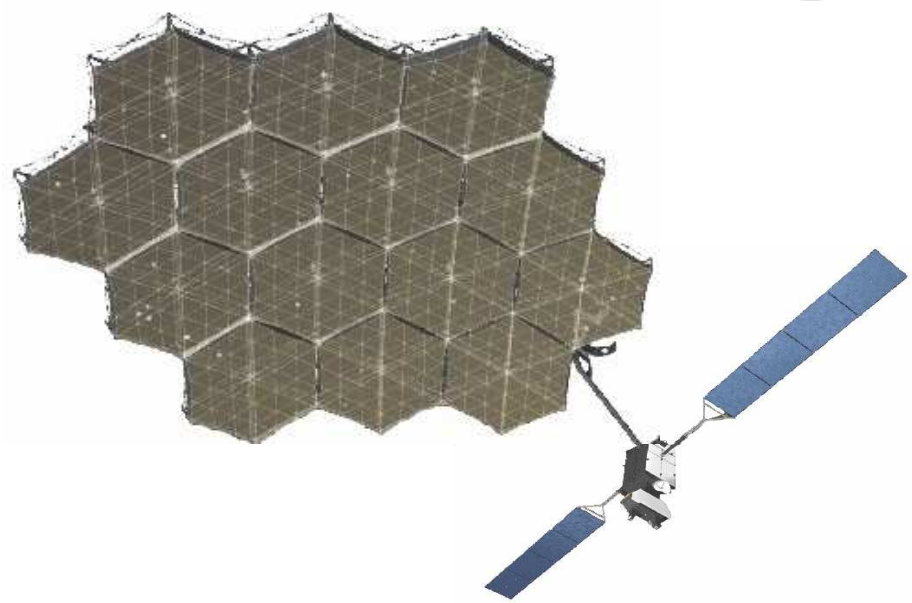


The modular mesh antenna concept can achieve the desired accuracy by the adjustment and measurement of its surface during the manufacture of each module.

Application to Very large reflector

30m class reflector

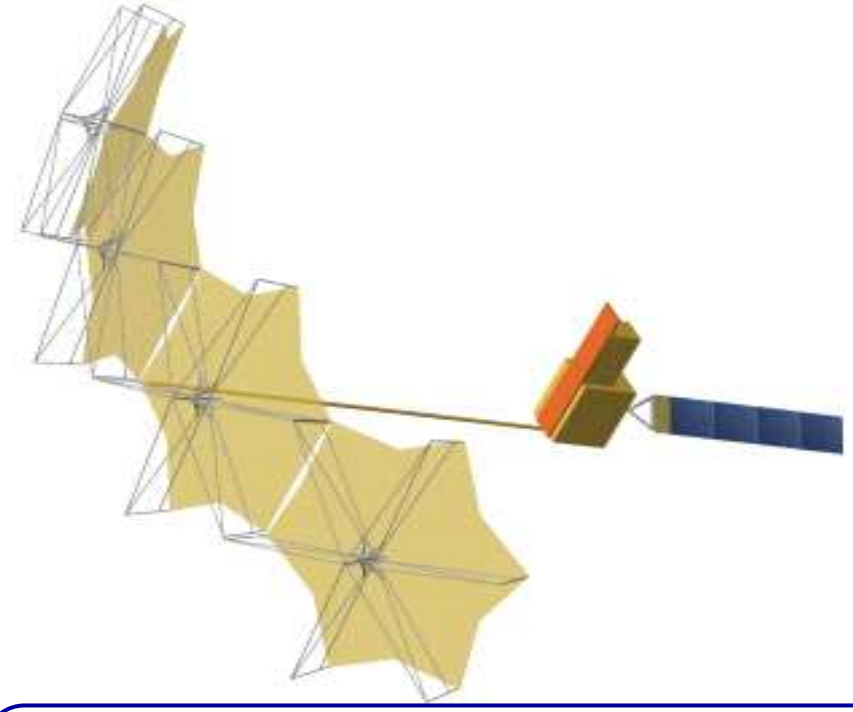
- Mobile communication
- 30m aperture
- S band



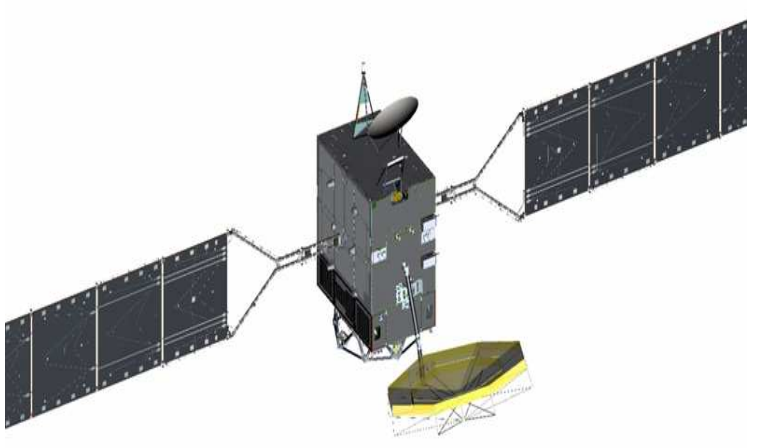
The modular mesh antenna concept can enlarge deployable reflectors by extending each module's aperture or increasing the number of modules.

Application to a variety of missions

InSAR



Data relay

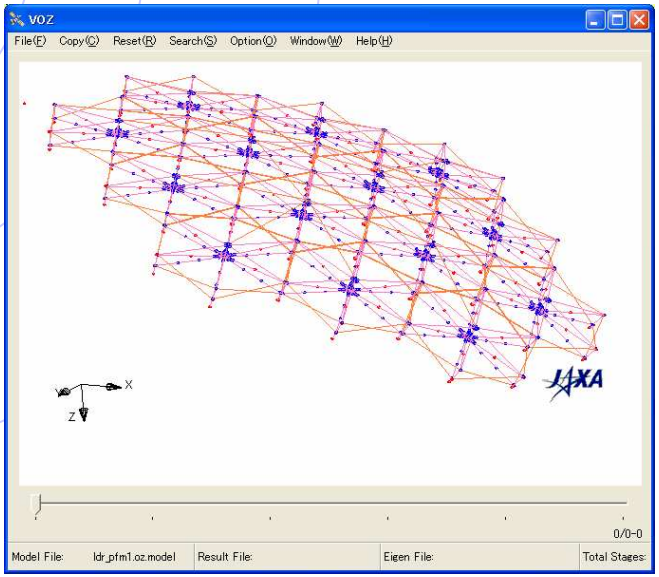


The modular mesh antenna concept can be applied to a huge variety of missions by changing the combination of modules, incorporating high precision modules, increasing the number of modules, and enlarging modules.

Concluding remarks

Concluding remarks

- **Large Deployable Reflectors mounted on Engineering Test Satellite VIII were successfully deployed.**
- **The two important pillars of Large Deployable Reflector are the modular mesh antenna concept and the high precision analysis technology.**
- **The modular mesh antenna concept can be applied to a huge variety of missions, such as radio astronomy missions, interferometeric synthetic aperture radars, communications and broadcastings.**


VOZ
File(F) Copy(C) Reset(R) Search(S) Option(O) Window(W) Help(H)
X
Z
JAXA
0/0-0
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Result File:
Eigen File:
Total Stages: