Indian National Society for Aerospace and Related Mechanisms
BANGALORE CHAPTER

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From the Editor

Dear Member,

It gives me immense pleasure to present you with this edition of E-newsletter. The second half of the year 2015 was a very significant milestone for our mechanisms community and in particular the members of Spacecraft Mechanisms Group at ISAC, as the team witnessed on-orbit deployment of six metre diameter Unfurlable antenna on-board GSAT-6 spacecraft. In addition several deployment mechanisms on-board the scientific satellite-ASTROSAT and deployment mechanisms of GSAT-15 spacecraft. The editorial committee congratulates the past and present members of Spacecraft Mechanisms Group, ISAC for this excellent achievement.

The first article entitled *"An Insight to the Deployment Mechanisms for ASTROSAT"* presents an overview of different deployment mechanisms like deployable covers for telescopes, steering mechanisms for payload and solar array deployment mechanism used in astronomical observatory satellite. The second article entitled *"Successful on-orbit deployment of 6m unfurlable antenna reflector on GSAT-6"* presents an overview of unfurlable antenna that was successfully deployed in orbit.

This newsletter is intended to be a platform for the exchange of information regarding the current developments, new ideas and novel concepts in the area of mechanisms and related field through active participation of members. I request all INSARM members to actively contribute technical articles related to mechanisms to enhance the technical value of the e-new letter.

With best regards,

Dr. B.P. Nagaraj

Chief Editor

CONTENTS

Quote:

"Dissemination of knowledge is the only way to renounce from one achievement and aim for the other..."

INSARM BANGALORE CHAPTER

Newsletter

AN INSIGHT TO THE DEPLOYMENT MECHANISMS FOR ASTROSAT

S.Narendra
DPD – Mechanisms, ASTROSAT
Spacecraft Mechanisms Group, ISAC Bangalore
Email id: naren@isac.gov.in

INTRODUCTION:

ASTROSAT is India's first space based astronomical observatory, which was launched successfully from Sriharikota on September 28th 2015. The spacecraft has been placed in a 650 km, 6 degree inclined circular orbit using the PSLV – C30 launch vehicle. The main mission objective is for providing a space based multi-wavelength observatory for scientists in the area of astronomy. In regards to this the spacecraft carries a set of five payloads which are sensitive over a wide spectrum of wavelengths covering visible, ultraviolet, soft x-rays and hard x-ray bands. The five payloads on ASTROSAT consist of 2 Ultra Violet Imaging Telescopes (UVIT), 1 Soft X-ray Imaging Telescope (SXT), 1 Sky scanning Monitor (SSM), 3 Large Area Xenon filled Proportional Counters (LAXPC) and 1 Cadmium Zinc Telluride array (CZT).

The spacecraft Mechanisms consist of 2 numbers of Solar Array Deployment Mechanisms, 2 Deployable covers for the UV Imaging Telescope, 1 deployable cover for SX Imaging Telescope and a Hold down Release and Steering Mechanism for SSM. The Figure 1 shows the spacecraft configuration with the mechanisms in the stowed and deployed configurations.

All the mechanisms have deployed successfully in-orbit and have performed flawlessly. The paper presents a brief insight into the mechanism and their performance in-orbit.

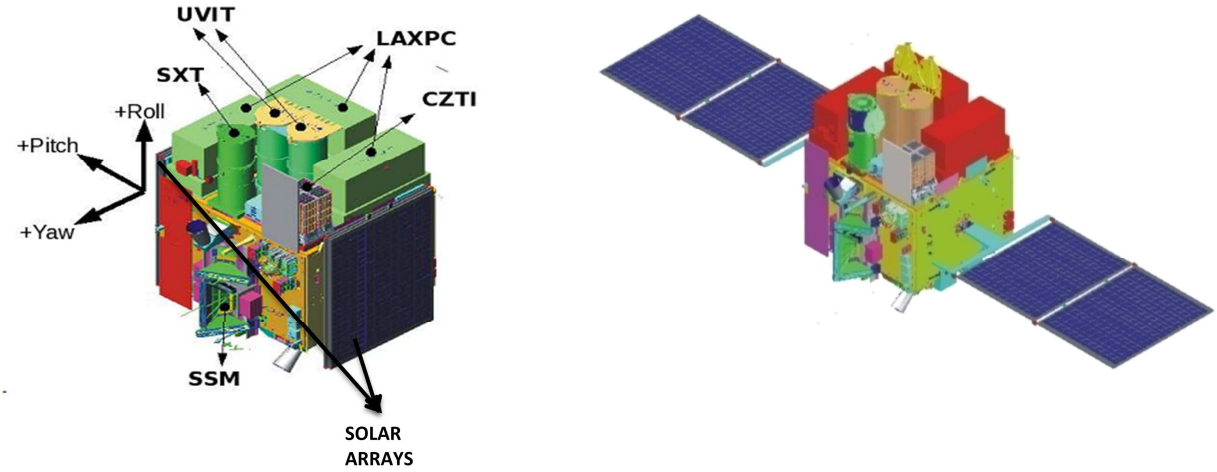

Figure 1: ASTROSAT spacecraft in stowed and deployed condition.

Solar Array Deployment Mechanisms:

Figure 2: Deployed Solar Array during ground tests.

The spacecraft consists of two deployable solar arrays consisting of 2 solar panels and a yoke in each array as shown in Figure 2. The solar panel size is 1.4 m X 1.8 m and is populated with improved triple junction solar cells capable of generating around 1600 watts of power. The solar arrays are stowed on the EP-02 and EP-04 side of the spacecraft.

The Solar Array Deployment Mechanisms (SADM) provides for the stowing of the solar arrays on to the spacecraft deck in the launch configuration by means of 4 hold downs and a pyrocutter based Hold down Release loop. The Figure 3 shows the typical two panel hold down assembly. The deployment hinges provide for the deployment energy required for the array deployment and also provide for the latching of the array in the end position. The deployment of the array on being injected into the orbit is by means of a SNAP related Auto program sequence in-built into the spacecraft, which commands the pyrocutter, releasing the hold downs and deploying the array.

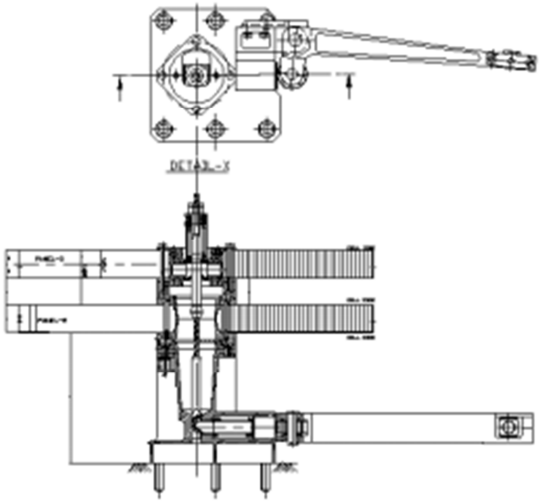

Figure 3: Two panel hold down assembly

In-orbit performance:
Both the solar arrays were deployed immediately after snap+80 sec by auto logic built into the spacecraft. The solar arrays deployed successfully and the functional parameters were all normal.

UV Imaging Telescope Cover Mechanisms:
There are two UV telescopes in ASTROSAT, which are mounted centrally in the spacecraft as shown in the Figure 1. The UV telescope optics have a stringent contamination control and thus two deployable covers are provided at the top baffle of the telescope, which protect the telescope optics from contaminants during the ground phase and initial 64 days of in-orbit phase of the spacecraft. The telescope covers also function as sunshades on deployment. The cover mechanisms consist of two spring driven hinges and a paraffin actuator based hold down and release mechanism as shown in the Figure 4. The cover is held in the stowed condition by means of the Hold down mechanism with a preload of 100 kgf. The two hinges provide for the energy of deployment and also provide for the centre of rotation for the cover and help in latching the cover in the final deployed position.

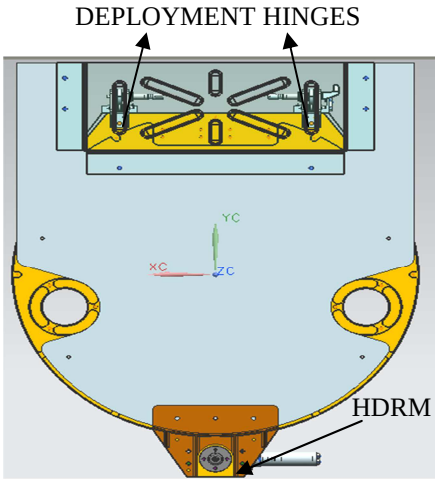

Figure 4a: Typical UV telescope cover Model


Figure 4b: UV Telescope cover Deployment in Lab

Soft X-ray Imaging Telescope (SXT) Cover Mechanism:
The SXT cover mechanism as shown in Figure 5 is similar to the UV cover mechanisms, except for the fact that the diameter of the cover is smaller and the angle of opening of the cover is different.


Figure 5: SXT Cover Deployed condition

The HDRM is identical to the UV mechanisms. The hinges are suitably designed to obtain the required angle of opening of 256 degrees. Unlike in UV telescopes the covers on deployment do not act as sun shades.

In-orbit Performance:
The SXT telescope cover was deployed on the 18th day from launch. The UV telescope covers were deployed on the 64th day from launch. All the cover deployments were as predicted and all the telemetry indications are nominal.

SSM Hold Down Release & Steering Mechanism:
The Scanning Sky Monitor (SSM) consists of three proportional counters, with coded masks which are mounted on a platform (Figure 6). The payload is mounted on the anti-sun side of the spacecraft as shown in the Figure 1. The complete platform should be capable of being rotated by ±175 degrees, continuously. Also during the launch the platform is to be held on to the spacecraft deck so as to provide the requisite launch frequency and withstand the launch loads. The mechanisms consist of two main assemblies namely

- The Hold Down and Release Assembly
- The SSM Steering Mechanism Assembly.

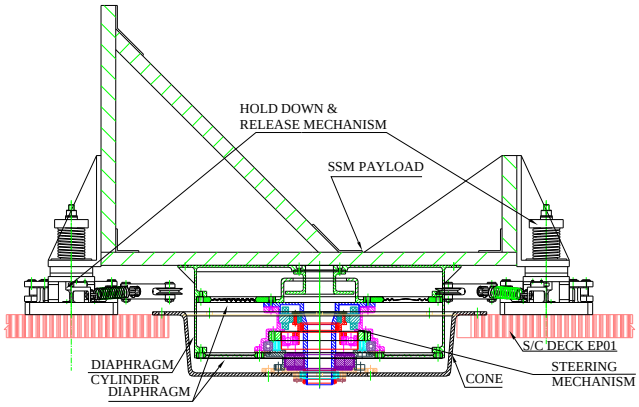

Figure 6a: SSM Steering and HDRM configuration

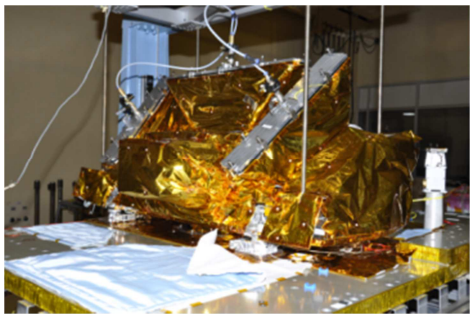

Figure 6b: SSM Payload on s/c Deck.

The Hold Down & Release Mechanism (HDRM):
The SSM platform is held down at 4 hold down locations to withstand the launch loads and is released in orbit to allow for the steering operation of the payload. At these hold down locations the platform is held on to the deck by means of preloaded bolts (Preload of 800 kgf). All the hold down bases are connected by a continuous hold down release loop which helps in retaining the preloaded bolt in position in the hold down bases. The hold down release loop is cut by means of a pyro cutter, which in turn releases all the hold down bolts simultaneously.

SSM Steering Mechanism:
The SSM steering mechanism as shown in Figure 7 consists of a stepper motor drive in conjunction with a harmonic gear drive. The motor is fixed to the housing which is connected to the payload platform through a pair of diaphragms. The angle of rotation is primarily obtained by means of the resolver.

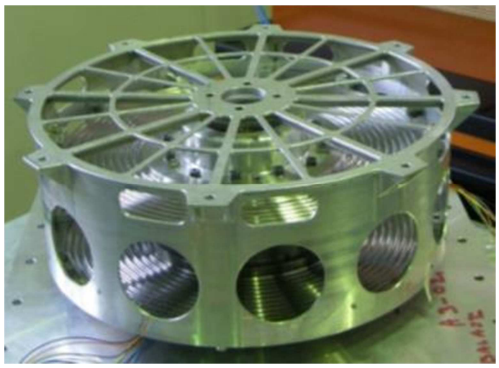

Figure 7: SSM Steering Mechanism

On release of the hold down mechanism the platform pops up by 3mm due to the release of strain energy of the diaphragms. The diaphragms also provide necessary deployed stiffness to the platform. The mechanism can be commanded to perform in the continuous open loop movement, step stare and Parking modes of operation.

In-orbit Performance:
The SSM hold down release was initiated immediately after the solar array deployment confirmation and the release operation was nominal and all the telemetry indications obtained for the release condition confirmation. Subsequently the steering operations of the mechanism were performed in the day 2 and day 3 operations and all the modes of operation were checked and found to be performing nominally. The payload steering operations are being carried out on a regular basis and are found to be satisfactory.

Conclusions:
The paper presents a brief glimpse of the various deployment mechanisms developed for ASTROSAT spacecraft. The successful spacecraft mechanisms performance in orbit has been presented in the paper.

SUCCESSFUL ON-ORBIT DEPLOYMENT OF 6M UNFURLABLE ANTENNA REFLECTOR ON GSAT-6

Subash Yadav, Milind Undale, Murali N S, Abdul Hameed and **B P Nagaraj**
Spacecraft Mechanisms Group
ISRO Satellite Centre
Bangalore

A 6m aperture Unfurlable Antenna reflector was successfully deployed on-orbit in September 2015. Developed by Spacecraft Mechanisms Group at ISRO Satellite Centre, Bangalore, the 6 m Unfurlable Antenna is the key element of GSAT-6 spacecraft which was launched on board GSLV- D6 on 27th August 2015. Post on-orbit deployment, In-Orbit Testing (IOT) confirmed that the deployed antenna reflector meets all the RF requirements.

Larger the aperture of the reflectors higher is the antenna gain. GSAT-6 unfurlable antenna having 6 meter aperture is an offset parabolic reflector with a focal length of 4.38m. The unfurlable antenna is stowed into small volume (0.4 m diameter) for launch and deployed on-orbit to its full size (7 m diameter) by remote command from ground. Figure 1 shows unfurlable antenna in stowed and deployed configuration. The reflector surface is made of gold plated molybdenum mesh which is shaped by a network of tensioned cables. The antenna consists of a peripheral deployable truss which is made of several four bar mechanisms that are connected by gears, converting multi degree freedom system into a single degree freedom mechanism. A miniature DC motor housed in one of the link of the deployable truss is energized to carry out the deployment. Prior to carrying out the unfurling of the reflector, the stowed stack is positioned away from the spacecraft body by operating a motor and latching in its final position. Unfurlable antenna is a unique technology, presently available with couple of nation's worldwide and we have been able to successfully develop, qualify and carry out successful on-orbit deployment in maiden attempt meeting all RF requirments

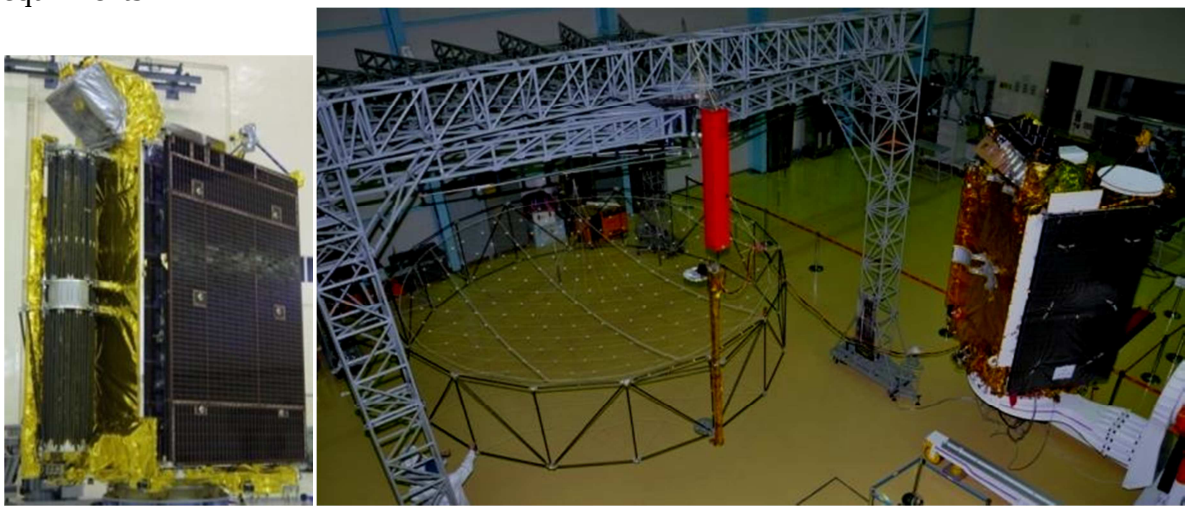

Figure 1 : Unfurlable Antenna Stowed (left) and Deployed configuration (right)

FORTH COMING SEMINARS

1) 10th National Symposium and Exhibition on Aerospace and Related Mechanisms
November 25-26, 2016, Organized by INSARM Bangalore Chapter, Thiruvananthapuram,Kerala
Wesite: *arms2016.vssc.gov.in*

2) International Symposium on History of Machines and Mechanisms
June 7-10,2016, Web page: http://www.uaq.mx/ingenieria/HMM2016

3) EUCOMES 2016,6th European Conference on Mechanism Science
20-23 September,2016, Nantes, France
http://eucomes2016.irccyn.ec-nantes.fr/index.php

INVITATION FOR ACTIVE PARTICIPATION

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enewsletter@insarm-bangalore.org

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