Indian National Society for Aerospace and Related Mechanisms

BANGALORE CHAPTER

INSARM Bangalore

E-NEWSLETTER

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From the Editor

Dear Member,

This has been an outstanding quarter for ISRO with the successful launch of Chandrayaan 1 spacecraft to the Moon. ISRO has joined the elite group of nations who have successfully managed the Moon missions. The Mechanisms fraternity in particular should be extremely happy for the flawless on-orbit performance of the canted solar panel system developed for the first time in ISRO programs and the Dual Gimbal Antenna mechanism with holddown & release system on this mission.

This has been a very significant quarter individually also to INSARM members. Sri NC Bhat, Group Director, Spacecraft Mechanisms Group (SMG), ISAC, was the recipient of the "Laurels of Team Achievement Award" for the year 2008 from the International Academy of Astronautics for his contribution to the Space Capsule Recovery Experiment mission. Sri KS Balan of SMG was the recipient of the ISRO Team Award for his contribution to INSAT 4CR project. Sri S Narendra of SMG was the recipient of the ISRO Team Award for his contribution to Indian Mini Satellite-1 project. The editorial committee congratulates the awardees for their stupendous success.

Several members have been active academically and have presented technical papers in International and national conferences in the last quarter. I was privileged to chair a technical session in the international symposium, IEEE-ISMCR 08. Sri HN Suresh Kumar of SMG was awarded a prize for his paper on interplanetary rovers in Kannada Kammata held at ISAC. The editorial committee congratulates the members for these recognitions.

This newsletter is intended to be a medium of information exchange regarding the state of the art developments and future directions in the area of mechanisms and related fields. The editorial committee welcomes your active participation in the form of technical articles and ideas which will certainly enhance the technical value of this e-newsletter.

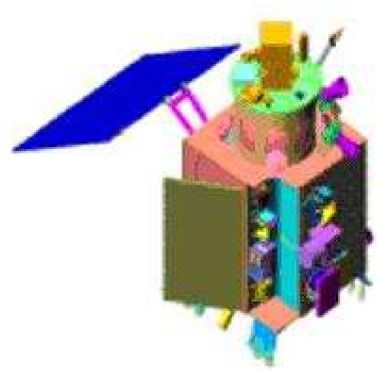
With best regards,

Dr. R Ranganath, FIE
Chief Editor

CONTENTS

FROM INSARM BANGALORE CHAPTER

CONGRATULATIONS
for the successful launch of Chandrayaan 1 spacecraft to the Moon



Shape Memory Alloy (SMA) Pin-puller*

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INTRODUCTION

During spacecraft launch, the drive modules of Dual Gimbal Antenna (DGA) mechanism (Figure. 1) are restrained from rotating using a launch restrained assembly. The launch loads are taken by mechanism bearings only but drive modules cannot be allowed to rotate freely during launch. If left freely, it can rotate under the influence of vibration causing possible damage to cables and hitting stoppers with high force. Hence, a launch restraint assembly is required to restrain both the drive modules from rotation during launch and release it in the orbit.

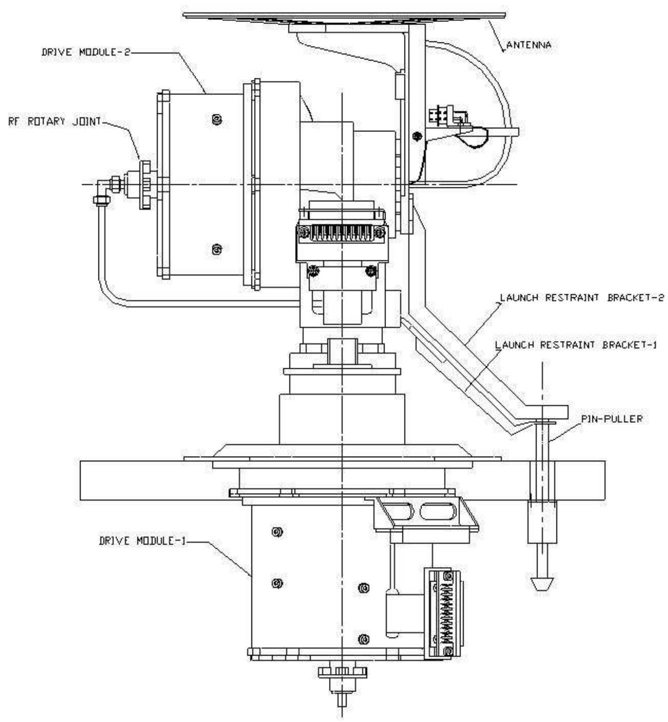

Figure.1: SMA Pin-puller holding drive modules through brackets

SMA PIN-PULLER

To restrain the rotation of drive modules and Antenna during launch, a Pin-puller has been designed. It basically functions with its pin inside a tapered hole during locked condition and pin coming out of the hole after actuation to release the restrained part of the mechanism. The design is based on the Shape memory alloy (SMA) wire actuation by direct electrical heating unlocking a pin loaded with a compression spring. This is a non-explosive, low shock, low mass release device. This can be used as a restraint device to prevent rotation/movement of any appendage during Launch and release it later in orbit.

SMA wire actuator is preferred for the following reasons:

1) Similar SMA has been used in INSAT-2E Flap drive mechanism.
2) In INSAT-2E SMA wire is qualified for thousands of cycles whereas in present design it is only one time operation in its life time.

SPECIFICATIONS:

Pull out force	:	12 kg
Pull stroke	:	8 mm
End force	:	6.0 kg (at the end of the stroke)
SMA Pull force	:	4 kg
Redundancy	:	2 independent SMA wires
SMA wire Dia./length	:	0.35 mm/140 mm
Actuation Current	:	2 Amps
Voltage	:	2.5 – 3.0 V
Actuation time	:	2-3 Seconds
Weight	:	100 gms
Overall size	:	100 mm L x 29 mm Dia.

Figure.2 shows SMA Pin-puller in locked condition. The schematic sectional view of Pin-puller is as shown in ***Fig.3***.

Figure.2: Shape Memory Alloy Pin-puller

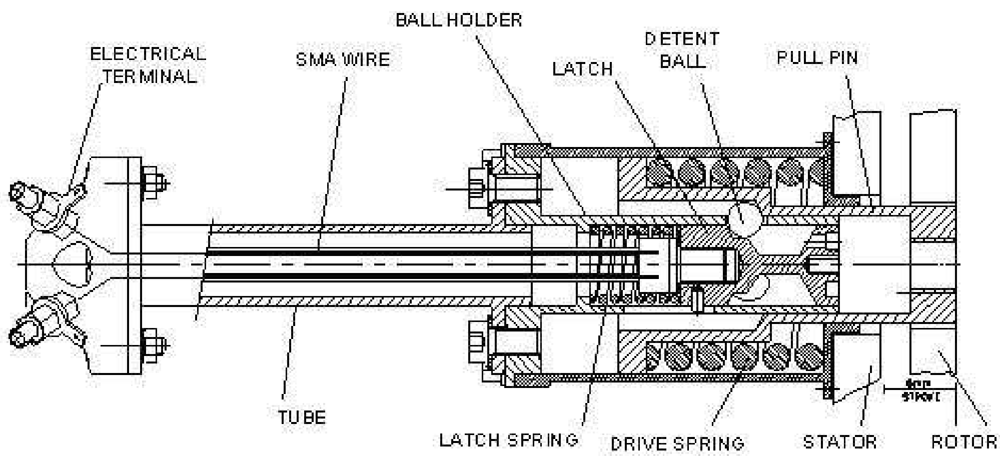

Figure.3: Pin-puller shown in locked condition

DESCRIPTION

In locked position of pin, drive spring is compressed and is restrained from release by balls and latch. The latch that can slide inside the ball holder rests against a latch spring to prevent it from sliding due to vibration or any inadvertent external load. The latch is connected to two SMA wire loops (one is redundant loop). To release the ball latch, SMA wires are heated electrically by passing direct current through it. SMA wires contract upon heating. This provides sufficient force to overcome latch spring resistance and detent balls frictional resistance. As SMA wires contract and pull the latch inside the ball holder, the vertical component of drive spring force on balls pushes them inward into the exposed latch groove. The fall of balls inside the groove triggers the release of drive spring to pull the pin from its locked position. The resetting of pin is done manually. The balls are removed from the latch groove, latch is pulled back, the drive spring is compressed and then the balls are repositioned to keep the pin remained in its locked position. In the process Latch simultaneously stretches the contracted SMA wires to its deformed shape. The Latch is provided with a Guide pin to prevent it from rotation. The Guide pin translates inside a slot provided in Ball holder. The SMA Pin-puller assembly is fixed with DGA deck of DGA mechanism support structure through its Housing. Fig.4 shows the locked and released positions of Pin-puller during performance testing.

Figure 4(a): Locked condition

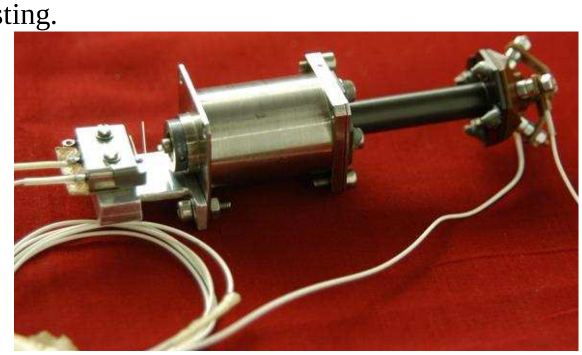

Figure 4(b): Released condition

Pin-puller is fully resetable and reusable and is having in built redundancy. It is tested and qualified to use on satellites.

CONCLUSIONS

Shape Memory Alloy (SMA) based Pin-puller with in built redundancy for restraining drive modules or similar mechanisms during launch or similar vibrating conditions is realized. It is resetable and reusable type. It is fully tested and qualified to use in orbital conditions. It is already flown on board Cartosat-2 & 2A spacecrafts and actuated successfully to release DGA mechanism.

"Success Quote"

"Remove failure as an option" - Joan Lunden
"Shoot for the moon. Even if you miss, you will land among the stars" – Les Brown
"Teamwork is the long word for success" - Jacquelinemae A. Rudd

VISUAL SPEECH RECOGNITION THROUGH LIP READING "I SEE WHAT YOU SAY"

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INTRODUCTION

The multi-modal nature of speech is often ignored in human-computer interaction. The lip deformation, and other body movement such as head and arm motion convey additional information. Speech cues can be integrated from many sources and this improves intelligibility, especially when the acoustic signal is degraded. This paper shows how this additional, often complementary, visual speech information can be used for speech recognition. A top-down approach is followed that fits a model of the inner and outer lip contours and derive lip reading features from a principal component analysis of shape.

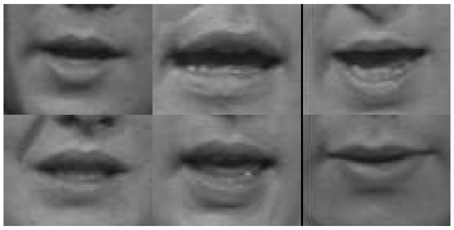
The use of Active Shape Models is described for extracting visual speech features for use by automatic speech reading systems, where the deformation of the lip model as well as image search is based on a priori knowledge learned from a training set. The goal is to combine the acoustic and visual speech cues so that recognition performance follows the human characteristic that bimodal results are always better than those from either modality alone. This problem has three parts:

1. Speech recognition from an audio signal;
2. Identification and extraction of salient visual features;
3. Optimal integration of the audio and visual signals.

The identification and extraction of visual features through lip reading is discussed here.

DATABASE

For this work I recorded my own aligned visual database of isolated letters called *ALIP*. The database consists of three repetitions by each of five talkers, 2 male (without moustaches) and 3 female, of the isolated letters A and O. Talkers were prompted using an autocue that presented each of three repetitions of the alphabet in non-sequential, non-repeating order. Each talker was requested to begin and end each letter utterance with their mouth in the closed position. No head restraint was used but talkers were provided with a close-up view of their mouth and asked not to move out of frame. The full face images were further cropped to a region of 80 x 60 pixels after manually locating the centre of the mouth in the middle frame of each utterance. Each utterance was temporally segmented by hand using the visual data so that each utterance began and ended with the talkers mouth in the closed position.



Sample images from ALIP Database

ACTIVE SHAPE MODELS

Active Shape Model (ASM) is a lip contour tracker which uses a (top-down) model of lip shape to constrain the tracker. They are flexible models which represent an object by a set of labelled points. It is a shape-constrained iterative fitting algorithm. The shape constraint comes from the use of a statistical shape model, also known as a point distribution model (PDM), that is obtained from the statistics of hand labelled training data. The PDM describes a reduced space of valid lip shapes, in the sense of the training data, and points in this space are compact representations of lip shape that can be directly used as features for lip reading.

A point distribution model is calculated from a set of training images in which landmark points have been located. Each example shape model is represented by the (x, y) co-ordinates of its landmark points. The inner and outer lip contour model used is shown in Figure 1 and has 44 points (24 points on the outer and 20 on the inner contour).

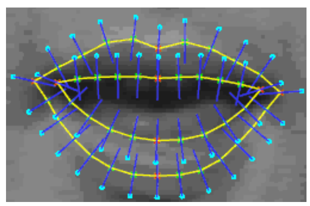


Figure 1 Inner and outer contour lip model.
Dots are landmark points. Lines indicate normals through each point.

If the ith shape model is, $\mathbf{x}_i = (\mathbf{x}_{i1}, \mathbf{y}_{i1}, \mathbf{x}_{i2}, \mathbf{y}_{i2,\ldots,} \mathbf{x}_{i44}, \mathbf{y}_{i44})^T$ then two similar shapes $\mathbf{x}_1$ and $\mathbf{x}_2$ can be aligned by minimizing , $\mathbf{E = (x_1 - M(s,\theta)[x_2]-t)^T W (x_1 - M(s,\theta)[x_2]-t)}$ where the pose transform for scale, s, rotation, q, and translation in x and y (t_x,t_y) is,

$$M(s,\theta)\begin{bmatrix} x_{jk} \\ y_{jk} \end{bmatrix} = \begin{pmatrix} (s\cos\theta)x_{jk} - (s\sin\theta)y_{jk} \\ (s\sin\theta)x_{jk} + (s\cos\theta)y_{jk} \end{pmatrix}$$

$$\mathbf{t} = (t_{x1}, t_{y1}, \ldots, t_{xN}, t_{yN})$$

and $\mathbf{W}$ is a diagonal weight matrix for each point with weights that are inversely proportional to the variance of each point.

To align the set of training models the conventional iterative algorithm is used. Given the set of aligned shape models the mean shape can be calculated and the axes that describe most variance about the mean shape determined using a principal component analysis (PCA). Any valid shape can then be approximated by adding a reduced subset, t, of these modes to the mean shape,

$$\mathbf{x}_s = \overline{\mathbf{x}}_s + \mathbf{P}_s \mathbf{b}_s$$

where $\mathbf{P}s$ is the matrix of the first t eigenvectors, $\mathbf{P}s$=(_$\mathbf{p}$1 _ $\mathbf{p}$2 _ _ _ _ $\mathbf{p}t$) _ and $\mathbf{b}s$ is a vector of t weights,$b_s=(b_{1\ldots\ldots}b_t)^T$. As the eigenvectors are orthogonal the shape parameters $\mathbf{b}s$ can be also calculated from an example set of points, $\mathbf{x}s$,

$$\mathbf{b}_s = \mathbf{P}_s^T(\mathbf{x}_s - \overline{\mathbf{x}}_s)$$

This allows valid lip shapes to be represented in a compact, statistically derived shape space. The number of modes of variation is are far less the number of landmark points used because the landmark points are chosen to clearly define lip shape and are highly correlated.

ADVANTAGES

Visual speech recognition technique uses image processing capabilities in lip reading to aid speech recognition systems in recognizing undeterministic phones or giving preponderance among near probability decisions Visual speech information from the speaker's mouth region can be used to improve noise robustness of automatic speech recognizers, thus promising to extend their usability in the human computer interface and in human robot interaction.

APPLICATIONS

Efforts to use visual information for automatic speech recognition have begun recently on experiments with small vocabulary letter or digit recognition tasks, dictation and medium vocabulary transaction processing tasks in relatively controlled environments. Speech Interface communication is used in human- robot interaction to command the robot to perform a particular task. Accuracy in the mobile robot domain can be improved through a knowledge based approach of speech systems using visual speech recognition sources especially under noisy environments.

CONGRATULATIONS TO AWARD WINNERS

Shri NC Bhat
Group Director, SMG,
ISRO Satellite Centre
President of INSARM Bangalore Chapter

Laurels of Team Achievement Award

for the year 2008 from the International Academy of Astronautics, Glasgow, Scotland, UK
for his contribution to the Space Capsule Recovery Experiment mission

Sri KS Balan
SMG, ISRO Satellite Centre, Bangalore

ISRO Team Award for contribution to INSAT 4CR project

Sri S Narendra
SMG, ISRO Satellite Centre, Bangalore

ISRO Team Award for contribution to Indian Mini Satellite-1 project

MECHANISMS for CHANDRAYAAN-1

HN Suresha kumar[#], S Narendra[$] and AV Nirmal[&]

[#] Deputy Project Director (Mechanisms), Chandrayaan-1

[$] Project Manager, Solar Array Deployment Mechanism, Chandrayaan-1

[&] Project Manager, DGA Mechanism, Chandrayaan-1

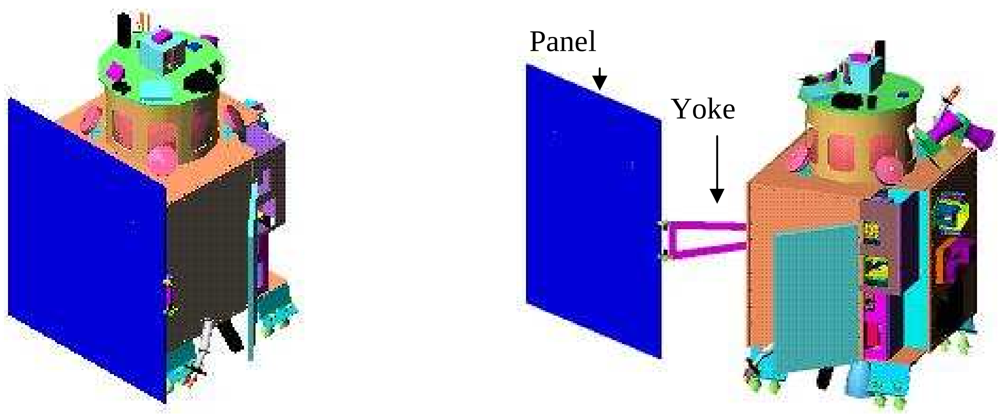
INTRODUCTION

CHANDRAYAAN-1 is the first lunar mission from INDIA, aimed at chemical and geographical mapping of the moon. The spacecraft, launched successfully on 22nd October 2008 has been orbiting the moon at 100 km polar orbit presently. This spacecraft carried mechanisms for the following,

1) Deployment of Solar Array : Single solar panel and Canted
2) Holddown-Release and pointing of Dual Gimbaled Antenna (DGA)

The solar array was deployed successfully on 22nd Oct 2008, immediately after spacecraft injection into the orbit. The on-orbit release of DGA has been accomplished successfully on 15th Nov 2008. The on-orbit performance of both the mechanisms has been normal. This paper presents briefly the details of these mechanisms.

SOLAR ARRAY DEPLOYMENT MECHANISM



a) Stowed solar array **b) Deployed solar array**

Figure-1 Configurations of solar array for Chandrayaan-1

The deployable solar array consists of a yoke and single solar panel mounted on the sun side deck of the spacecraft. The yoke is hinged to the spacecraft on one side and to the solar panel on the other side. The array is stowed on the spacecraft during launch and deployed on-orbit. The holddown-release and deployment mechanisms are used for the same. Additionally, the deployment of yoke and solar panel is co-ordinated by means of close control loop mechanism. After deployment and latch-up, the solar array is driven by Solar Array Drive Assembly (SADA) to track the sun.

The Solar array deployment mechanism is derived from corresponding mechanism of KALPANA-1 spacecraft. However, the Chandrayaan-1 configuration demanded the canting of the solar array by 30 deg about spacecraft pitch axis. The same has been accomplished through design modifications in the hinge mechanisms. Figures-1(a) & 1(b) show the stowed and deployed configurations of the solar array. The SADA-Yoke hinge has been designed to deploy through 60^0 and the Yoke - Panel hinge by 120^0. The array is deployed immediately after spacecraft injection through cutting of the hold down loop using a pyro cutter. The mechanism underwent detailed testing at unit level and at fully integrated spacecraft level.

The full loop deployment tests were carried out at different stages of hardware realisation to confirm the nominal functioning of the mechanism.

The mechanism has performed successfully on-orbit. Apart from direct indications from the microswitches, the indirect indications like variations in spacecraft body rates, reduction in solar panel temperature and increase in bus voltage confirm the nominal on-orbit deployment of solar array. Subsequent to deployment, the array has been successfully driven by SADA to track the sun.

HOLDDOWN/RELEASE AND POINTING MECHANISM FOR THE DUAL GIMBAL ANTENNA (DGA)

Chandrayaan-1 uses a 0.7m dia parabolic dish antenna for data transmission. The antenna is required to track the earth station when the spacecraft is in lunar orbit. Two orthogonal drive modules mounted on a support structure fixed on the anti moon viewing face of the spacecraft as shown in Figure-2, steer the antenna in two axes. The azimuth drive is attached to the support structure and the antenna is connected to the elevation drive using antenna bracket. An intermediate bracket connects the azimuth and elevation drives. The motors used are direct drive brush less DC torque motors. Redundant resolvers mounted in each drive module provide the absolute angle information for each axis. The motors are driven in open loop programmed mode.

During launch, the antenna is stowed towards negative roll axis by 110^{o} rotation of the elevation motor and is held down by use of hold down/release mechanism. On reaching the lunar orbit, the hold down is released by firing the pyro cutter.

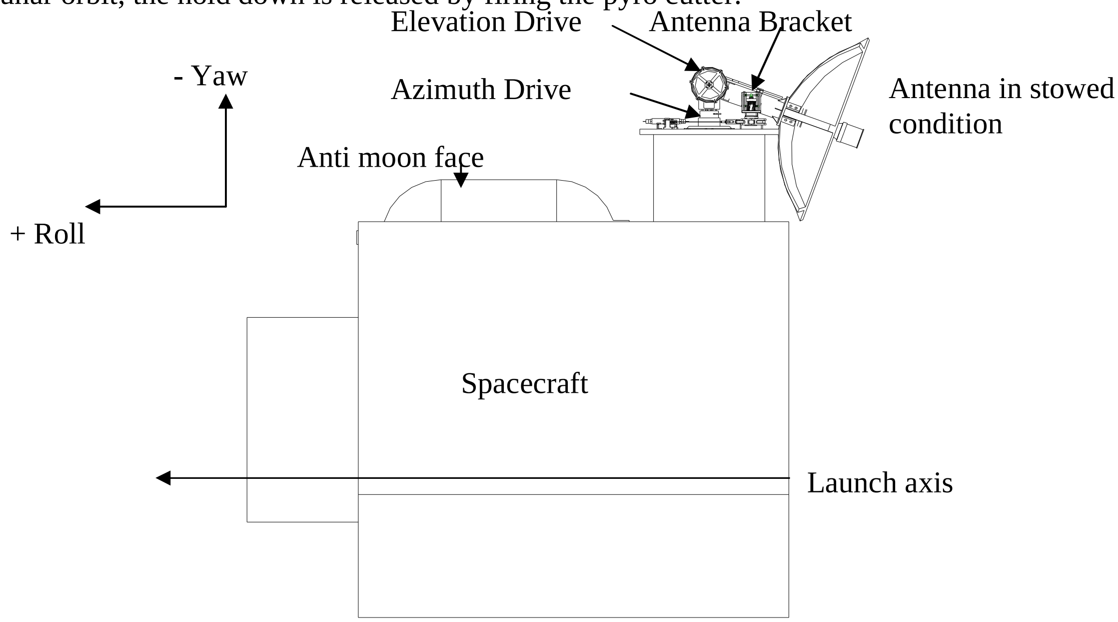


Figure-2 Launch configuration for the DGA system

The antenna pointing mechanism comprising of azimuth and elevation drives is identical to the successfully flown Dual Gimbal Antenna Mechanism (DGAM) of Cartosat-2. However, functional changes have been carried out to suit the requirements of Chandrayaan-1. The schematics of these mechanisms are presented in Figures 3 and 4.

During the course of the project, two models of the mechanism have been realised viz., the qualification model and the flight model. Both models have undergone the designated tests as per the test specifications document. The functional tests include, the holddown-release test and the drive test at ambient and under extreme temperatures. Additionally, the system has been subjected to vibration and acoustic tests to confirm the structural integrity of the system under the specified launch loads. The functional tests on the system conducted prior to and subsequent to dynamic tests helped to build confidence in the nominal functioning of the mechanisms on-orbit.

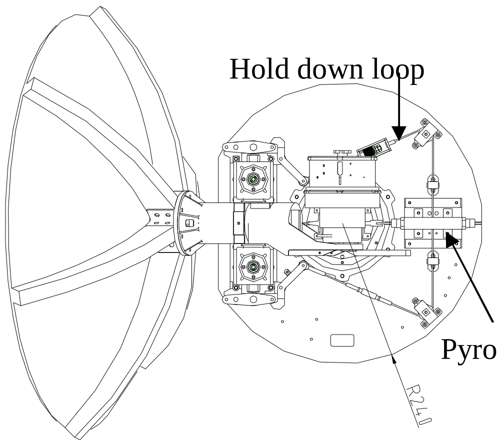


Figure-3 Schematic of holddown-release mechanism

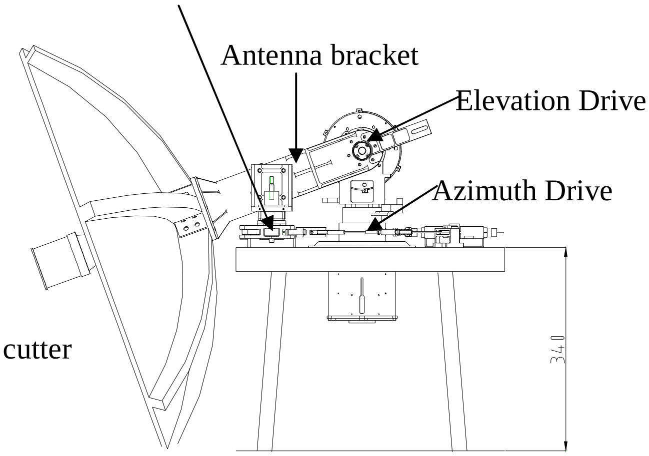


Figure-4 Schematic of Pointing mechanism

Figure-5 Chandrayaan-1 spacecraft during pre-launch operations at Satish Dhavan Space Centre (SDSC), Sriharikota

A photograph of the Chandrayaan-1 spacecraft during pre-launch operations at SDSC, has been shown in Figure-5. The stowed solar array and the DGA system are observable in this. The holddown-release of the DGA was commanded on 15th Nov 2008, after reaching the designated lunar orbit. Telemetry indications for the nominal release and movement of the antenna from its stowed configuration confirmed the successful functioning of the mechanism. Subsequent to release, the antenna has also been successfully driven using the antenna pointing mechanism. The on-orbit performance of both mechanisms is found to be nominal.

Conference/Seminars

International Conference on Research in to Design (ICoRD '09)
At IISc, Bangalore, on 07-09 January, 2009

IISc Centenary Conference,
At IISc, Bangalore, on 13-16 December 2008.

ISRO-DOS Workshop on Computer and Information Technology 2008 (WCIT-2008)
At VSSC, Thiruvanathapuram, on 10-12 December 2008
www.vssc.gov.in

International Conference on Advances in Armament Technology
At ARDE, Pune, on 20-22 November 2008.
www.icaat.in

22nd National Convention of Aerospace engineers on '**Present Status and Technological Challenges of Indian Aerospace Programme**'
At Ranchi, on 27-29 November 2008.
www.ieijsc.netfirms.com

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