Indian National Society for Aerospace and Related Mechanisms

BANGALORE CHAPTER

E-NEWSLETTER

Vol. 4, No. 1, February 2012

From the Editor

Dear Member,

In the year 2011, sixteen mechanism developed by the Spacecraft Mechanisms Group, ISAC were deployed in space from five different spacecrafts. The two solar array mechanisms each on RESOURCESAT-2, YOUTHSAT, GSAT-8, GSAT-12 and MEGHATROPIQUES spacecrafts, hold down release mechanism each on RESOURCESAT-2 and MEGHATROPIQUES, two antenna mechanisms of GSAT-8, one antenna mechanism of GSAT-12 and two ROSA antenna mechanisms of MEGHATROPIQUES. The editorial committee congratulates the past and present members of Spacecraft Mechanisms Group, ISAC for their commendable achievements.

This issue brings out an extended abstract of the article presented by the INSARM member on "Macro for automated simulation of spacecraft appendage deployment" presented at the conference on Computer Technology for Space-CTS 201, for the information of members.

I am happy to inform that the INSARM member Sri. C.D. Sridhara, Group Director, Spacecraft Mechanisms Group, ISRO Satellite Centre is the recipient of National design award in Mechanical engineering – 2011 from the Institution of Engineers (India) National Design and Research Forum for his outstanding contribution in the field of mechanical engineering design. The editorial committee congratulates for his outstanding achievement.

This news letter 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 contribute actively technical articles related to mechanisms to enhance the technical value of the e-news letter.

With best regards,

Dr. B.P. Nagaraj
Chief Editor

CONTENTS

Quote:

Sharing knowledge is not about giving people something, or getting something from them. That is only valid for information sharing. Sharing knowledge occurs when people are genuinely interested in helping one another develop new capacities for action; it is about creating learning processes.

By Peter M. Senge

FROM INSARM BANGALORE CHAPTER

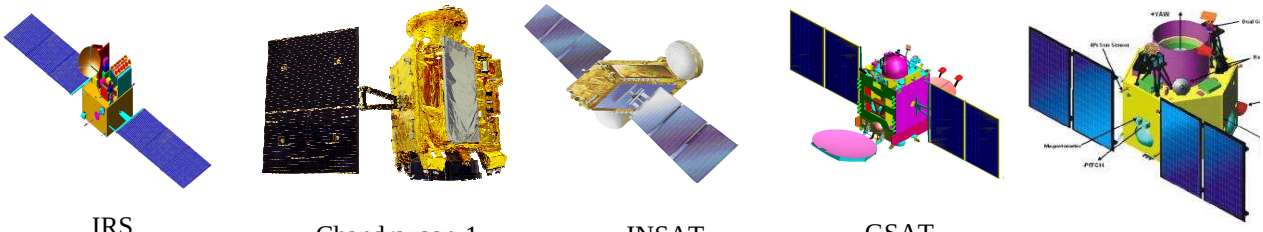
EXTENDED ABSTRACT OF CTS 2011 PAPER

MACRO FOR AUTOMATED SIMULATION OF SPACECRAFT APPENDAGE DEPLOYMENT

G.Srividhya[#], B.Lakshmi Narayana[#], H.N.Suresha Kumar[#], G.Nagesh[##] & C.D.Sridhara[###]
[#]Engineer [##]Division Head [###]Group Director
Spacecraft Mechanisms Group
ISRO Satellite Centre, Bangalore-560017
E-mail: gvidhya@isac.gov.in

Spacecraft appendages are nominally stowed during launch and deployed in the orbit. Figure-1 shows the configuration of various appendages like solar array, reflector in fully deployed modes. The energy for the deployment is provided by the preloaded torsion springs mounted at the hinges. In case of solar array, the deployment takes place in an accordion fashion, so that the different hinges latch up simultaneously. This minimizes the inter panel latch up moment because the momentum gets countered between the successive joints, due to change in the direction of rotation between successive joints. Close Control Loops provide direction control and help in converting a multiple degree of freedom system into a near single degree of freedom system. An eddy current damper limits the velocity of deploying panels to minimize the latch-up shock. The latch-up velocity of panels is an input for the estimation of shock loads at inter-panel hinges.

Mathematical models are developed to study the deployment dynamics of spacecraft appendages. Since the solar array configuration varies considerably among different spacecraft missions, it is customary to develop individual mathematical models for each of the different solar array. Such an activity is time consuming and is also prone for modelling errors.



IRS Chandrayaan-1 INSAT GSAT CARTOSAT

Figure-1: Various configurations of spacecrafts

Hence a general purpose macro has been developed in ADAMS software which is capable of generating the requisite mathematical model automatically. In case of solar array, the number and size of panels, the inter panel separation distance, torsion spring characteristics, damping rate, snubbers/ejectors, resisting torque due to friction, air drag, harness, the requisite angle of opening of yoke and panels etc are the salient input parameters for the macro. For reflector mechanism, the input parameters are the size of the reflector disc, mass and torsion spring characteristics. With the knowledge of these parameters, the macro is capable of developing the necessary mathematical model for any appendage .The macro provides the results of the analysis in terms deployment time, graphs and the model information as an output file.

A macro is a single command that is created to execute a series of Adams/View commands. The macro is designed to create the various elements of an appendage deployment like

geometry of the appendage, revolute joint hinges, deployment Springs, close control loops (CCLs), damper, snubbers and ejectors and harness torque. The deployment of any appendage like solar array, reflector/antenna can be simulated using the macro. The current article presents details of the general purpose macro, an add-on to ADAMS package, developed to simulate the solar array deployment for a given configuration.

The tasks that can be performed with the macro are, automate repetitive procedures, build general-purpose extensions to Adams/View, automatically create an entire model and quickly build many variations of a mechanism.

Detailed and complete mathematical model can be generated as said above. Post processing and the model information document are generated at the end of simulation automatically. The deployment simulation of GSAT-8 yoke and three panels are discussed in the present paper. The advantages of automating the modelling are the solution can be obtained quickly, modelling errors can be reduced as individual analytical models for appendages need not be developed and user friendly nature. In addition the deployment of the following appendages is simulated using the macro.

- GSAT-5P Reflector and Solar array (Yoke with 2 panels)
- GSAT-8 Reflector
- CARTOSAT Solar array (Two panels without yoke)
- IRNSS solar array (Yoke with single Panel)
- Chandrayaan (Yoke with single Panel and canted deployment)

Sensors are modelled to sense the latch up. Sensor is a built-in-statement available in ADAMS to monitor a particular parameter of the model. Once the parameter attains a particular value, simulation can be stopped. The angular opening of yoke and panels are monitored with respect to time. Simulation is stopped, once the yoke angle reaches 90 deg or inter-panel angle reaches 180 deg.

Model Information: The information about the model such as the size of the panel, inter panel gap, mass details and spring characteristics are written to a file using the macro. This helps to verify the generated model for its geometry and other details.Figure-9 shows the model information file generated by the macro for a typical IRS type of satellite.

Post Processing: Separate Macro has been developed for post processing and getting the model information. The following plots of the deployment analysis are generated automatically.

- Angle Vs Time
- Angular velocity Vs Time
- Harness torque Vs Angle
- Potential energy released by springs and kinetic energy attained by the panels

a. *Case Study:* Solar array containing yoke and three panels has been created using the macro. The physical parameters of deployment springs, close control loops, harness characteristics, ejectors and snubbers are considered corresponding to the given hardware. Analysis is carried out as explained in case study 1. Results of the analysis have been presented in the Figure-2 & Figure-3. First latching occurs at 7.0 secs which closely matches with the experimental data and also with results from earlier analysis.

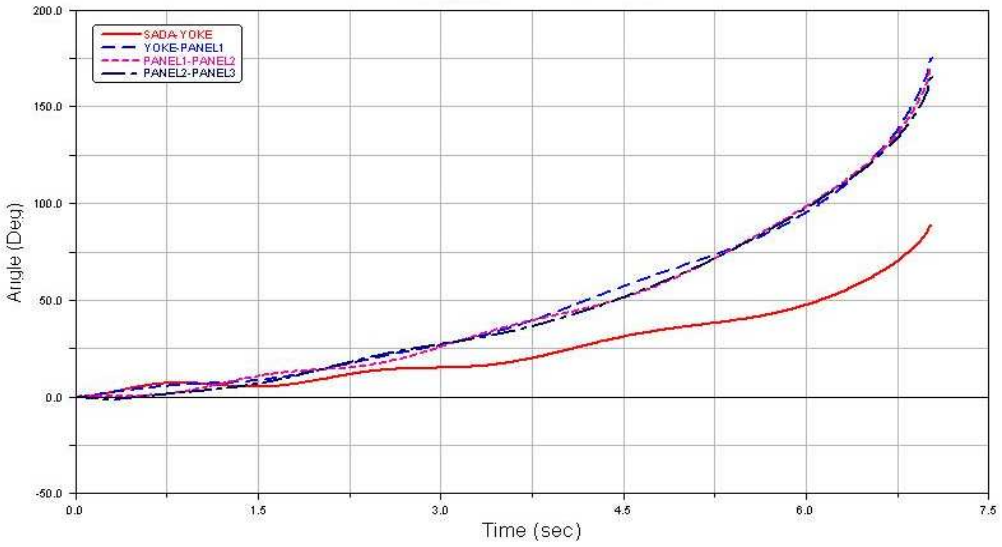


Figure-2: Angle of opening of Yoke and Panels with time

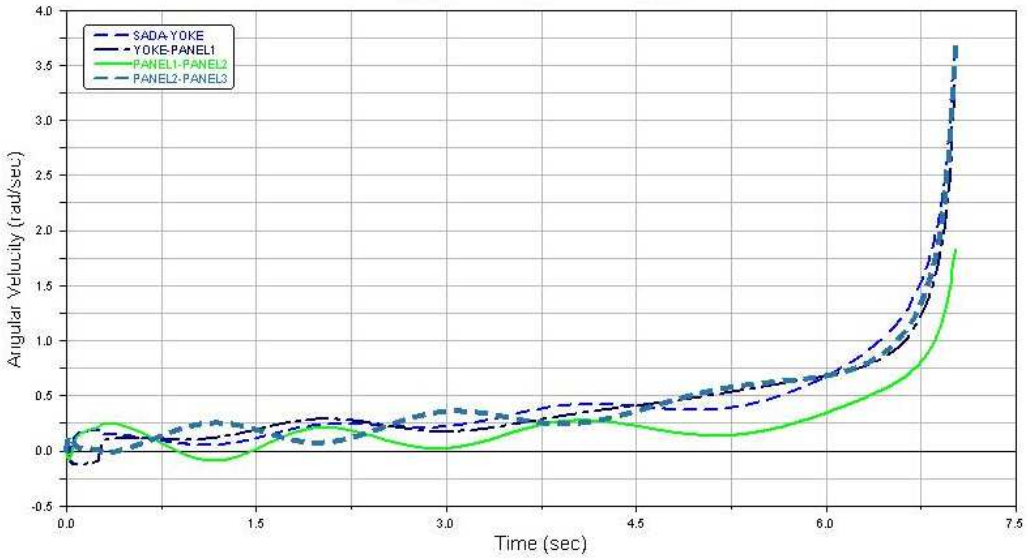


Figure-3: Variation of angular velocity with time

In this paper the details of a general purpose 'Macro' for the mathematical modelling and analysis of solar array deployment were presented. The advantages of the macros are

- ✓ Modelling of yoke and given number of panels has been automated using the macro. The definition of related hinges, the torsion springs is also carried out automatically.
- ✓ Separate subroutines for other elements like CCLs, snubbers and ejectors, damper have been developed and linked to ADAMS, as ADAMS does not support them as a standard features.
- ✓ As the modelling is automated, analysis can be carried out quickly for a variety of configurations and errors are minimized.
- ✓ Results obtained from the analysis are in good agreement with the earlier models.

CONGRATULATIONS TO THE AWARD WINNER

Sri. C. D. Sridhara, Group Director, SMG
ISRO Satellite Centre, Bangalore

National Design Award in Mechanical Engineering 2011 for the year 2011 from the Institution of Engineers (India) in National Design and Research Forum for his outstanding contribution in the field of Mechanical Engineering Design.

FORTH COMING SEMINARS

1. 2nd IFToMM Symposium on Mechanism Design for Robotics
   12-14 October 2012:Beihang University, Beijing, China
   Webpage: http://IFTOMM-SMDR.buaa.edu.cn
2. International Conference on Mechanical Engineering and Mechatronics
   15-17 August 2012: International ASET Inc., Ottawa, Canada
   Webpage: http://ICMEM2012.International-ASET.com
3. ASME 2012 International Mechanical Engineering Congressin ,Houston, TX
   Last date for abstract: February 27,2012
   Webpage: http://www.asmeconferences.org/congress2012

INVITATION FOR ACTIVE PARTICIPATION

We invite you to send technology news, technical articles, members' news and suggestions/comments on e-newsletter and the web contents to Chief Editor to improve the newsletter. The technical articles may be limited to 400 words only in MS Word format with two photographs. The direct extracts from references may be avoided. Kindly provide your e-mail & mail address to enable us to contact you.

enewsletter@insarm-bangalore.org

www.insarm-bangalore.org