Indian National Society for Aerospace and Related Mechanisms
BANGALORE CHAPTER

E-Newsletter
Vol.11, No.1, June 2021

From the Editor

My Dear Colleagues,

It is great pleasure to present before you the Newsletter of the Bangalore Chapter of INSARM after a brief period of dormancy. After the reconstitution of the board and council members in October 2020, reinvigoration of the activity of sharing through the Newsletter was emphasized and the new Newsletter committee was formed. Due to some unfavorable circumstances including the 2nd Wave of Covid-19, the issues of the Newsletter could not be released as planned. I personally request all the members of the INSARM Bangalore Chapter to accept my apologies and resume your contributions towards a successful and satisfying experience of sharing your knowledge and achievements of your teams through this media.

In this issue we share with you the constituent members of the new Executive Board and Council Members. Development of mobile systems for trans-planetary explorations is fraught with diverse technical challenges. A brief article from Mittal and Sharma of URSC presents insights into the importance of the "first touch" of the foot of a legged robot on the terrain of a distant planet. A series of Webinars that were streamed as an endeavor of continued engagement, sharing, and learning from the eminent members have also been listed for your record.

My special thanks of appreciation to all the members of the Newsletter Committee for their active support especially Mr. Akash Shetty for collecting and collating the material in this issue, and Dr B.P. Nagaraj for providing the template of the Newsletter.

With best regards,

Prof. Dibakar Sen,
Professor, CPDM, IISc-Bangalore
Chief Editor

CONTENTS

Quote:

"All knowledge that the world has ever received comes from the mind; the infinite library of the universe is in our own mind"

Swami Vivekananda

FROM INSARM BANGALORE CHAPTER

Election of New INSARM-BC Executive Board & Council

Annual General Body meeting of INSARM-Bangalore Chapter was held on 31st October 2020at Bangalore through Google Meet. The present Executive Board had completed two years in office and hence, as per the by-law, a new board was to be elected. Shri. K A Keshava Murthy, member of the executive council, presided the election of the new executive board and council members for the upcoming term (2021-22).All the executive board members were duly proposed, seconded by the members present in the GBM and elected as per the laid down procedure.

The newly elected board and council members are as follows:

EXECUTIVE BOARD:

President : Sri. G Nagesh, Ex-URSC, Bangalore
Vice President : Dr. B P Nagaraj, URSC, Bangalore
Secretary : Sri N S Murali, URSC, Bangalore
Treasurer : Sri H M Raghavendra Prasad, URSC, Bangalore

EXECUTIVE COUNCIL MEMBERS:

Sri. K A Keshavamurthy, Ex-URSC, Bangalore
Sri. H N Suresha Kumar, URSC, Bangalore
Sri. C A Prabhakar, Ex-URSC, Bangalore
Sri. Rajeev Rangrao Badagandi, URSC, Bangalore
Prof. Dibakar Sen, IISc, Bangalore
Sri. S N Sharma, HAL, Bangalore
Sri. A Shankara, URSC, Bangalore
Sri. A Louis, URSC, Bangalore
Sri. K Balaji, URSC, Bangalore

Analytical Models for Lander Footpad Impact on Soft Terrain

Dipanshu Mittal, Gaurav Sharma
Spacecraft Mechanisms Group, URSC

Legged landers are widely used for extra-terrestrial explorations and have been successfully employed for landing on Lunar and Martian terrain. The landers are typically three legged or four legged and are designed with cantilever type or inverted tripod type configuration. At the final descent of the lander, the lander soft lands on the terrain with residual touchdown velocity that persists after the firing of braking engines. Energy dissipation devices like honeycombs are used to absorb the impact energy thereby attenuating the loads and allowing stable landing without tip-over.

The first contact of the lander occurs at the footpad that is mounted at the base of the landing legs. The footpads provide wider base area of contact that reduces sinkage in the soil, thus ensures sufficient ground clearance between the engines and terrain. Footpads can have different geometrical shape and size like curved or flat surface at bottom, which influences the landing dynamics. Curved footpad tends to sink less and slide more; whereas cylindrical footpad sinks more, slides less and is a suitable design for incorporating honeycomb dampers. The contact force estimation at the footpad-terrain contact is crucial for design of the leg and the damping system. Rigid surface contact, typical to landing on a rocky terrain, is a classical contact problem between two elastic bodies and is modeled using Hertzian contact mechanics and Coulomb friction. Unlike rigid surface, soil is characterized by an elasto-plastic behavior. This article presents four different modeling techniques for footpad-soil dynamic interaction and compares them with respect to modeling effort and accuracy, experimental effort, and their range of applicability.

Various mathematical models have been implemented by different space agencies, ranging from a basic stiffness-damping based model to a completely experimental based model. Mathematical models use soil properties like bulk density, relative density, angle of internal friction and modulus of elasticity in addition to footpad geometrical and motion parameters like footpad diameter, impact velocity and penetration depth.

Numerical methods to simulate the footpad soil interaction like Finite element method and Discrete element method have not been discussed in this article but can be explored as an alternative to analytical methods for further study.A suitable model can be selected considering the modeling effort, experimental effort, accuracy and the range of applicability of the model to the soil and footpad under study.

The relative advantages and limitations of these modeling techniques are summarized below:

Sl. No.	Methodology	Inputs for modeling	Advantages	Limitations
1.	Elastic contact model [1]	Contact stiffness/ modulus of sub-grade reaction, damping, and contact friction.	Easy to implement. Good for low velocity impacts and small penetration.	Doesn't model elasto-plastic behavior of soil. Doesn't consider drag force by soil shear and increase in soil bearing strength with penetration depth.
2.	Elasto-plastic model based on empirical relations [2,3]	Bulk density, relative density, elastic modulus, angle of internal friction of soil, and footpad diameter.	Models elasto-plastic behavior of soil. Model validated with Test over specific range of soil properties.	Requires measurement of soil properties. Equations valid for curved footpad and lunar soils.
3.	Elasto-plastic model based on experimentally derived constants [4]	Coefficients to model normal and lateral force as a function of depth and penetration velocity.	Formulation based on footpad motion parameters and geometry only. Soil properties not required for modeling.	Can be used for a specific soil at a time. Accuracy of model depends on the order of equations.
4.	Elasto-plastic model based on correlation coefficients[5]	Bearing capacity at surface, contact stiffness and damping. Correlation coefficients derived from experiments.	Coefficients are function of footpad geometry. Model can be used for wide range of soils.	Uses large number of correlation coefficients requiring rigorous testing to develop generalized model.

References:

[1] Van Lai Pham et.al., Landing Stability Simulation of a 1/6 Lunar Module with Aluminum Honeycomb Dampers, International Journal of Aeronautical & Space Science, 14(4),356-368(2013).

[2] Dipling. Lars Witte, Touchdown Dynamics and the Probability of Terrain Related Failure of Planetary Landing Systems, University of Bremen, 2015.

[3] D.L. Brown, B. Holder, R.E. Schmidt, Final report on Lunar Module Soil Mechanics Study, Bendix Corp., 1968.

[4] George A. Zupp Jr., Harold H. Doiron, A mathematical procedure for predicting the touchdown dynamics of a soft-landing vehicle, NASA Technical Note, Washington D.C., 1971.

[5] Qing Lin, Zhiyu Kang, Jie Ren, Qilong Zhao, Hong Nie, Impact Analysis of Lunar Lander Soft Landing Performance Caused by the Body Gravity Centerline Shift, ASCE, 2014.

Highlights of Activities of INSARM-Bangalore Chapter

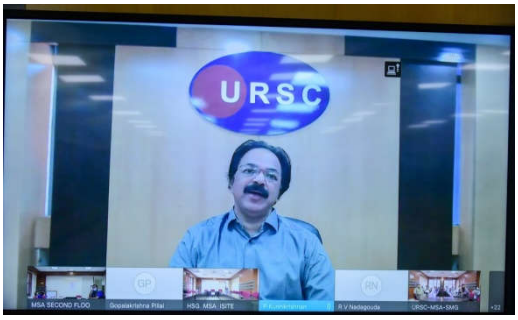
The INSARM-Bangalore Chapter has been actively involved in promotion of the Aerospace mechanism through technical talks and webinars. The chapter hosted 3 Technical Talks and a Webinar since Oct 2020. All the technical talks and seminar were on online mode because of the prevailing pandemic. The following Table provides the details of the Technical Talk organized by the chapter.

No	Date	Speaker	Topic
1	17-Oct-2020	**Prof. Dibakar Sen** Professor, Dept. of Mechanical Engineering, IISc	Mechanisms in Equilibrium – When forces do not move
2	12-Dec-2020	**Shri. C A Prabhakar** Former Project Director, URSC, ISRO	Realizing Reliable Space Systems
3	10-July-2021	**Shri. N Viswanatha** Consultant Principal Engineer, TMT Co-ordination Centre, IIA& Former GD, SMG, URSC	INDIA's contribution to Thirty Meter Telescope – A Mega Science Project

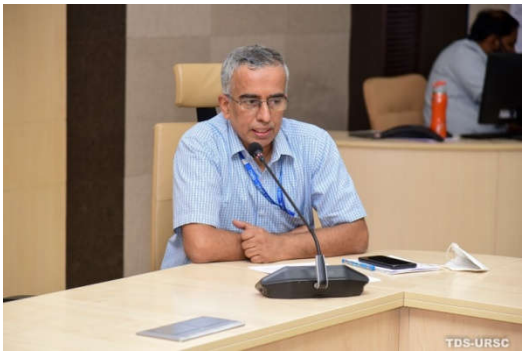
The Chapter also organized a half day seminar in web mode on the Topic "Metal Additive Manufacturing in Aerospace Mechanisms". The seminar was inaugurated by Shri. P Kunhikrishnan, Former Director, URSC. As part of the webinar, 3 sessions were organized where in experts from industry in the field of Metal 3D printing spoke about basics, design, and applications of metal additive manufacturing in aerospace engineering. More than 70 members of the chapter from various parts of the country attended the webinar.

Webinar on Metal Additive Manufacturing in Aerospace Mechanisms		
Date: 12-Feb-2021		
Session-1	**Shri. Srinivas Shastry,** Managing Director, M/s. SLM Solutions India Pvt Ltd	Basics of Metal 3D printing
Session-2	**Shri. Shibhashis Ghosh,** Sr. Technical Manager - Design & Manufacturing, M/s. Altair	Design for Additive Manufacturing with Metals
Session-3	**Shri. Saurabh Gupta,** Dy. Manager, DTDF, MFF, URSC/ISRO	Case studies of Metal 3D Printing applications with focus on Aerospace Mechanisms

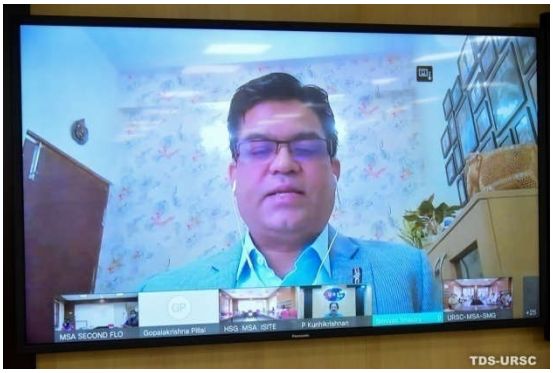
Photos of Webinar on Metal Additive Manufacturing in Aerospace Mechanisms



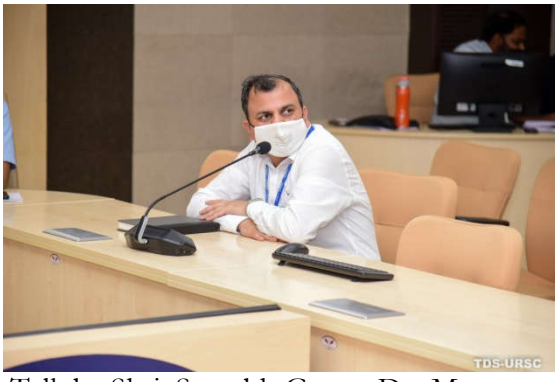
Inauguration by Shri. P Kunhikrishnan, Director, URSC



Welcome address by Shri. G Nagesh, President, INSARM-BC



Talk by Shri.Srinivas Shastry, MD M/s. SLM Solutions Pvt. Ltd



Talk by Shri. Saurabh Gupta, Dy. Manager, DTDF, MFF, URSC/ISRO

FORTH COMING CONFERENCES

1. 12th National Conference and Exhibition on Aerospace &Defense Related Mechanism - 2021, INSARM Pune Chapter.

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.

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