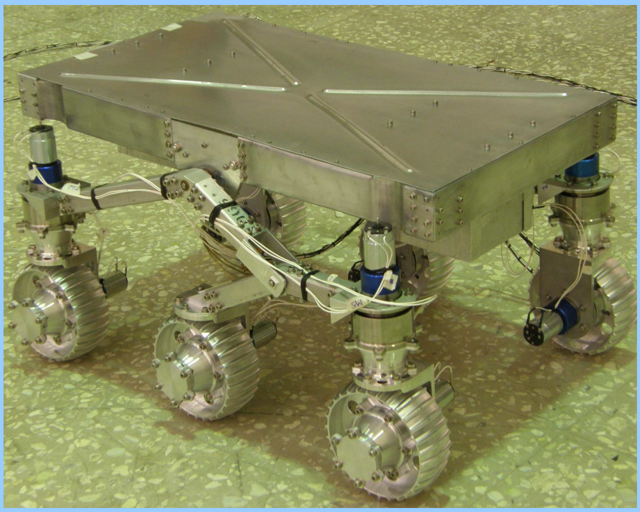
SYMPOSIUM ON AUTONOMOUS VEHICLES

SPECIAL EDITION E-NEWSLETTER



13th February, 2009

SPACECRAFT MECHANISMS GROUP
ISRO SATELLITE CENTRE
BANGALORE-560017

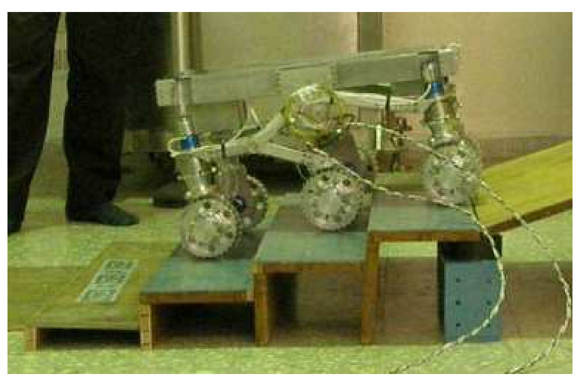
About Symposium on Autonomous vehicles

(Organized by INSARM Bangalore Chapter)

There is a great interest in the scientific community to explore other planets for various scientific studies. To minimize the cost of planetary exploration, autonomous vehicles are preferred to humans who require significant resources and supplies. They have high mobility and have the capability of providing in-situ data, which cannot be obtained by orbital or flyby mission. They can also transport scientific equipment which enables wide area imaging and identification of science sites, conduct spectroscope-based chemical analysis of surface terrain, collect loose soil and extract rock samples and perform other similar tasks. This data collection is fundamental to understanding the formative processes of planetary geology, a possible history of life, and the possible suitability of the Planet environment for future habitation. Thus, Autonomous Vehicles are an important asset for future scientific exploration of planetary surfaces.

This symposium is aimed at giving an exposure to the trends and the developments in the area of Autonomous Vehicles in the form of guest lectures by experts in this multi disciplinary area. This would provide a forum for researchers, industry experts & academia to exchange views, share experiences and interact on the above topic. It could also be helpful to identify and initiate collaborative efforts which could be useful in the realization of Autonomous Vehicles.

G. Nagesh
Organising Secretary
SMG, ISAC.



ISAC ROVER for Exploration of other planets
- First step towards development

Indian National Society for Aerospace and Related Mechanisms
BANGALORE CHAPTER
SYMPOSIUM SPECIAL EDITION
E-NEWSLETTER
Vol. 3, No. 1, February 2009

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From the Editor

Dear Member,

This has been an excellent quarter for ISRO capped by the stupendous success of Chandrayaan-1 spacecraft reaching the desired orbit around the moon. With the successful operation of the Moon Impact Probe, ISRO has joined the elite group of nations who have made their presence felt on the surface of the moon. The flawless on-orbit performance of the canted solar panel deployment mechanism developed for the first time in ISRO programs, the hold down release and subsequent performance of the Dual Gimbal Antenna and the separation mechanism of the Moon Impact Probe in this mission are notable achievements. This quarter has also witnessed successful deployments of solar arrays and reflectors in the W2M spacecraft.

Having reached the Moon, the next logical step would be to roam on its surface and explore for the presence of materials which will enable to plan and establish a manned presence in the long run. This exploration calls for the development of reliable autonomous vehicles with a host of payloads for experimentation. Towards this, INSARM Bangalore chapter is organizing a one day symposium on "Autonomous Vehicles". This symposium comprises of guest lectures from eminent people who will be sharing their invaluable experiences in this area. The editorial committee congratulates INSARM, Bangalore Chapter for this effort. As a token of appreciation, this issue of e-newsletter is brought out as a special edition consisting of abstracts of the guest lectures being presented in the symposium.

The members of INSARM may please note that 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 solicits your active participation to enhance the technical value of this e-newsletter.

With best regards,

Dr. R. Ranganath, FIE
Chief Editor

Challenges in Robotics & Automation

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Division of Remote Handling & Robotics of Bhabha Atomic Research Centre was created to provide remote handling and automation solutions for safe operation of our nuclear installations. The Division is primarily engaged in developing technologies that reduce exposure of operators to radioactivity. Use of Robot manipulators, mobile robots and automation systems forms an important component of many of these technologies.

Master Slave Manipulators – This is perhaps the most important item developed by this Division. These are the only means of handling radioactive materials in hot-cells. There are several categories of these manipulators.

Mechanical Master Slave Manipulators – Available in various payload capacities, these manipulators are being used in hot-cells in almost all units of Department of Atomic Energy (DAE).

Servo Manipulators – Installed in Waste Immobilisation Plant (WIP) of BARC, here the Master and Slave are electrically coupled, and thus can be positioned far apart. An advanced version of this, incorporating digital communication between Master and Slave, has also been developed. This permits motion and force scaling between the master and slave. It also allows the slave to be used optionally as a telerobot.

Reactor Control – Mechanisms have been designed, developed and perfected for Reactivity control in nuclear reactors in a reliable, time-bound and predictable manner.

An innovative scheme for automated direct fuel transfer from Spent Fuel Storage Bay to Fuel Reprocessing Plant has been worked out and verified in a miniaturized model.

Inspection – BARC Inspection System (BARCIS) has been developed and deployed for in-service inspection of Coolant Channels of PHW Reactors. An automated Gamma Scanning Unit has been developed for online inspection of Industrial Process Columns. A magnetic crawling Robot has been developed and tested for carrying EMAT probes for automatic inspection of Boiler tube thickness of NTPC Power Plants.

An underwater mobile robot has been developed for removing radioactive waste deposits from the floor of Spent Fuel Storage Bay.

Snake arm robot – This is being developed for probing areas that are difficult to reach with articulated manipulators.

Medicine – An indigenous Co-60 Teletherapy unit named ‘Bhabhatron’ has been developed, qualified, and installed in several Hospitals for cancer therapy. A Radiotherapy simulator for planning radiation therapy treatment is also under development.

An advanced microarrayer for making DNA microarrays have been designed and developed.

A robot assistant for interactive control of camera head in laparoscopic surgery is being developed in collaboration with Christian Medical College, Vellore.

Mobile Robots – The aim here is to develop technologies for remotely surveying hazardous (radioactive) areas.

***SmartROD* (Robot for Ordnance Disposal)** – This six-wheel-drive skid-steered vehicle was used for the safe removal and disposal of boxes containing explosive mine-fuzes from a storage room to the disposal site at Ordnance Factory Khamaria, Jabalpur.

ARMER (Automated Radiation Monitoring using Mobile Robot) – A small mobile robot, it is equipped with a detector for Gamma radiation. It is teleoperated from a host computer on which a radiation map is displayed.

AGV Based Automated Material Transfer System – This is being developed for automated distribution of materials of various kinds from a loading station to many delivery stations having different requirements of materials. The challenge lies in precise motion control of the AGV in the application area, as well as in automating all decisions regarding material transfer jobs to be assigned to the AGVs, their routing and scheduling.

National Status in Mobile Robotics – Important developments in the areas of autonomous vehicles and mobile robots in R&DE Pune, CAIR Bangalore, VRDE Ahmednagar, CVRDE Chennai, will be reported in conclusion.

"Autonomy" – Relevance to Space Exploration Rovers

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Till humans establish permanent settlements on other planets, robots are going to act as the extended arms and eyes for space exploration. Due to the enormity of distances involved in space, real time control of these robots from earth based stations is very cumbersome. Only gross motion commands and high-level goals can realistically be communicated to the robots. Beyond this, the robots will have to perform on their own; making decisions related to detailed path planning and defining sub-goals to achieve the high-level goals. Autonomy is therefore essential for the space exploring robots to make them effective and efficient agents in our quest for understanding this universe. This talk focuses on the implementation of autonomous navigation on mobile robotic platforms. This calls for development of specialized locomotion systems, localization system, perception system and path planning system. The achievements of CAIR in this field and the ongoing/pipeline projects relevant to this topic are also presented.

Estimating lunar terrain traversability using structured light and predicting mobility performance based on wheel slip and sinkage

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Lunar rovers sent for extraterrestrial surface exploration are required to safely navigate in highly uneven terrain with a significant degree of autonomy. The terrain can consist of loose sand, dust, craters, ash, rocky slopes, rifted stones, etc. which can cause wheel slippage and sinkage. Hence, terrain physical properties strongly influence rover mobility, particularly on uneven and sloped terrain. The focus of this presentation will be on the following two aspects (i) use of structured light to generate a map of the lunar terrain and detect obstacles or potential hazards for path planning of the rover and (ii) development of a kinematic model for coordinating the six wheels of a rover based on wheel and soil interaction, for different types of lunar soil and terrain conditions.

Vision cameras are the most reliable method of getting lunar terrain information required for path planning. In general, using only the information from two stereo cameras without lighting control is highly sensitive to mis-correspondence errors and is capable of generating highly noisy outputs. Prior information based approaches are usually attractive, but not particularly applicable for the lunar rover context, as no prior information is available. On the other hand, structured lighting (SL) provides a computationally light, yet adequately accurate solution. However, compared to the other approaches, it is slightly more expensive in terms of power consumption. In this method a sufficiently bright line of illumination is arranged using a laser source and cylindrical optics. The line is swept in a direction orthogonal to the line direction, with the current angular position of the sweep known at all times. The line is cast upon the terrain in the direction of the intended motion of the rover and the resulting image is captured by a camera for analysis, and the terrain response to the controlled lighting is extracted from the image. For each angular position of the line sweep, direct comparison of response data against calibration information yields distance and deformations of the terrain. If desired, the data generated may be used to construct a terrain shape map of the local region. With precise egomotion information of the rover (to be obtained through other means), the local maps may be properly mosaiced to generate maps of larger regions. A sweep and proceed protocol for the rover will allow the maintenance of high resolution as well as high accuracy, using post-facto accuracy and resolution updates. The system is capable of functioning in real time with reasonable computing resources. Several results already obtained in generating surface features obtained in our labs will be discussed.

The lunar rover is expected to consist of 6 wheels with a total of 10 or more degrees of freedom. It is expected that due to slip, sinkage, etc. of the wheels the rover may not function as desired and drift from its desired path or may even overturn. Hence an estimate of how much slip, slide etc. is expected on a particular terrain is essential for accurate path planning and also for correcting the drift of the rover to bring it back to its desired path. The unknown soil parameters (cohesion, internal friction angle, shear deformation modulus, lumped pressure sinkage coefficient and pressure sinkage exponential) will be identified using a wheel terrain interaction dynamic model and sensor feedback. An algorithm will be developed to use the terrain parameters for vehicle driving force prediction once they are identified. The predicted driving force will be employed for traversability prediction, traction control and trajectory following. Integration of terrain property information with traversability assessment methods will be used to attempt detection of soil trap hazards. Finally, such a theoretical model has to be correlated with experimental data and hence a wheel soil interaction test facility is currently being developed to create lunar gravity condition, for collection of real time data.

Unmanned Vehicle Development for IED Handling

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Future battlefield shall witness the proliferation of Unmanned assets for both offensive as well as support missions. Development of mobile robots or Remotely Operated Vehicles (ROV) have gained momentum world-wide in different application areas. Recent reports of deployment in Iraq and Afghanistan have demonstrated their efficacy and usefulness to work in hazardous environment.

The development of ground based ROVs at R&DE(Engrs), DRDO, Pune was initiated around 2002 and since then, the ROV-'Daksh' has been successfully realized, trial evaluated and shortly to enter into production. This was a pioneering work in development of a product based on requirement from the Army. The ROV-'Daksh' is primarily meant for Improvised Explosive Device (IED) handling wherein it can be controlled remotely from a distance of 500m and is equipped with a 6-axis manipulator arm capable of lifting 20kg at 2.5m. A Portable X-Ray Device supplied with the system can be integrated to scan the suspected object in-situ. On confirmation, an on-board Water Jet Disrupter can be used to diffuse the IED. In addition, a 12 bore shotgun is fitted on the ROV which can be remotely fired to break through locked rooms and automobile windshield. A Radiation Measuring device and a Portable Gas Chromatograph can be optionally attached to the ROV to scan radiation and chemically contaminated areas. The ROV can also be controlled by a fibre optic cable over a distance of 100m.

The ROV is controlled from a trolley based Master Control Station wherein a membrane keypad and joystick based Operator Control Unit (OCU) are provided for remote control. The ROV can also be operated by the touch screen interface on the display. The operator controls the ROV remotely by obtaining the video data on real time from three on-board cameras. The visual graphical user interface provided has been designed to enable the operator to exploit the features of the system effectively and with ease.

The ROV-'DAKSH' has also undergone comparative trials with the imported ROV of the same class and has emerged to have a number of features which are better than its counterpart. The ROV-'Daksh' can climb stairs and be deployed within buildings. The system comprises of 90% indigenous components hence being economical and easy to maintain.

The current focus of development at this establishment is to develop a standardized Communication Software Protocol for control of unmanned vehicles. This effort is aimed at development of the language and protocol for communicating to different unmanned vehicles and is being designed to reside on the topmost layer of communication. The protocol development is currently is at the implementation phase wherein it takes into account features related to packetisation, security, addressing and multi-robot collaborative scenario.

Designing for Lightweight Mobile Platforms

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Mobile platforms typically comprise both a vehicle and an arm for exploratory activities. The weight of the platform is a critical factor when the entire platform becomes a payload in a space application when it has to be lifted by a launch module, and the weight of the arm is a critical factor when it becomes a payload as in most applications for the vehicle.

The design of these arms differs greatly from the design of conventional arms used in stationary industrial shop floor applications. Payload, precision, workspace and cycle time are of primary importance in industrial applications. Of lesser importance is the weight of the robot arm in relation to its payload capacity. This weight to payload (w/p) ratio however is the most critical specification for an arm that is mounted on a mobile platform as every extra kilogram of platform payload capacity is a penalty on the mobility and endurance of the platform vehicle.

In designing arms to be mounted on mobile platforms the weight to payload ratio can be minimized by trading off specifications of precision, workspace and cycle time in a mobile platform scenario. Most often the mobility of the vehicle compensates for a smaller workspace of the arm, manual or supervisory control of the arm end-effector compensates for lack of precision, and operations are rarely under time pressure.

Lower W/P ratios can also be achieved by proper selection of the kinematic linkage that makes up the arm; a hybrid linkage rather than a pure serial or a pure parallel mechanism may offer the optimal solution. In addition is it important to use actuator and transmission components which provide a high torque to weight ratio and integrate them at the most primitive component level to eliminate unnecessary excess weight of housings and frames.

For space applications where the weight of the mobile platform with its associated arm become part of the launch payload the necessity for a low W/P ratio is even more acute. Some of the design strategies adopted for the arm design have to be migrated to the design of the vehicle too. For other applications in hostile environments (undersea, radiation, etc.), features that provide protection add to the weight of the arm and the vehicle but add more value than features that provide speed and precision.

On the Design, analysis and experimentation on control of autonomous (underwater) vehicles at IIT Kharagpur

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IIT Kharagpur has been involved in a national project on development of an autonomous underwater vehicle (AUV) for use in surveying the Indian Ocean economic zone. The vehicle is a 6 degree of freedom robotic system which is not guided by any remote control cables but by an autonomous controller built into the system. The vehicle is a thruster controlled device with 5 thrusters (under-actuated) and has its own navigation, control, communication and housekeeping systems – all in autonomous operations mode.

A test bed AUV has been designed and developed at IIT Kharagpur which takes into account various features like failsafe underwater systems design, mobility, sensor integration, battery energy management communications, navigation and control etc in addition to the mechanical assembly which facilitates the deployment of the system with reconfigurable options. The system has its own real-time computer control system with trajectory execution and recording facilities.

The mechanical system design is made in a manner that modules can be added seamlessly for underwater operation providing sealing as well as buoyancy. Sealing is critical for safety and buoyancy is useful for payload and control. A near neutral buoyancy (slightly positive) is designed for ease of retrieval in case of failures. The mechanical drive system is based on thruster forces to provide mobility for under water vehicles.

For terrain mobility vehicles–rovers and multi-legged mobility systems, the control and actuation systems will be different, but they too require autonomous control when in remote operating conditions. Motion control of such vehicles along with any application dependant interaction devices like manipulators, sensing devices etc will be specific to the mechanical design. However at the same time, these machines and mechanisms will have to be controlled either remotely (with telerobotic control) or autonomously or a combination of both.

Control of Autonomous Vehicles has been gaining very significant importance due to different considerations relating to communications in remote robotic applications. These include large time delay systems for distance applications like in space, deep space robotic systems where the communication propagation delays can be of the order of several minutes and such delays can make any online feedback control impractical and unstable. On the other hand, applications like in underwater robotic systems the communication systems are strongly influenced by poor signal propagation and excessive noise in the acoustic channels which severely limit the bandwidth of communication and thereby again contributing to delays in the control loops.

Motion planning and position as well as velocity control of robots inertial frames with sensory information relating to the states of the robot in the remote application is complex due to the delays and often large inaccuracies in sensing. Control schemes like time-delay control have been useful in such applications particularly when the remote system is an autonomous control system. Such control schemes can be used to linearize control actions which make motion control and planning easier.

Motion control schemes may also use models of the vehicle to estimate the states of the vehicle in situations when sensor data may be available with large uncertainties – as in inertial navigation, GPS aided navigation, ranging etc. The control schemes therefore will need to be reinforced with good models of the vehicle and environment. At IIT Kharagpur, the use of bond graphs in the development of such models has been found very suitable in many applications. Robust control of industrial robots, impedance and force control of robot manipulators with their environments and space robotic applications are few such areas where the model based control has been extensively used. In case of autonomous vehicles, the model of the vehicle and environment is being considered to aid and develop better predictions of the vehicle states in presence of uncertainties in measurements particularly from fused sensor data.

In this talk, I shall highlight the development of various robotic systems at IIT Kharagpur wherein the motion and force control strategies are implemented through model based approaches. In particular, I will describe in detail the development and control of an autonomous underwater vehicle with motion control, navigation and path planning integrated in the system. I will also briefly touch upon intelligent control application of such vehicles which may make use of developments in control of dynamical systems through recurrent neural networks, cellular neural networks, etc., which may aid in motion planning for autonomous vehicles. The objective is to make aware of an unified and integrated approach to autonomous vehicle development with all aspects of mobility, control, motion planning, navigation, sensor fusion etc being considered in the context of the application. Such an approach can easily be adopted for applications in space, planetary, moon rovers etc.

Autonomous Navigation of Mobile Robots

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SmartNav (Smart Navigator) – This differentially driven robot was developed by Zenn Systems, Ahmedabad under an MOU with IIT Kanpur. The control software was developed by us. We used this robot as well as a procured Pioneer robot for extensive experimentations in autonomous navigation in indoor environment. The building blocks of the navigation software are mapping & localisation, path planning, obstacle avoidance and finally path tracking. As a result, we developed deep familiarity with algorithms in these areas.

Mapping - Occupancy grid is a convenient way of mapping an area. Scan matching and error minimization methods are employed to correct poses of 2-D laser scans collected by the mobile robot while navigating through the area. Superimposing the pose corrected scans gives an occupancy grid representation of the area.

Path Planning – Navigation function is computed on all free cells of grid map starting from goal cell using the wavefront algorithm. A path joining the current position of the robot to goal is obtained by following the lowest value of navigation function among neighbouring cells, starting from the currently occupied cell. A concept of intrinsic function is used to label cells with inherent cost involved in travelling through them.

The path planned by Navigation function alone is jagged and not suitable for tracking. A smoothened path that takes care of the kinematic and dynamic limits of the robot and at the same time connects to goal is obtained by maximizing a suitable objective function in Real-time.

Path tracking – Once a path is planned, pure pursuit algorithm is used to issue corrective motion commands for tracking the planned path. This requires the knowledge of actual position and orientation of the robot at every instant. This is usually obtainable from a Laser Navigator, GPS etc., possibly in combination with IMU and odometry.

Areas of concern in the design of a mobile robot for planetary exploration – Although we have never worked towards space applications of robots, we realise that in the design of this robot low volume and weight is of the highest priority. A robot with wheel configurations appropriate for rough terrain locomotion needs to be built. Materials, actuators, battery or alternative power sources may be selected to ensure low weight.

Teleoperation of the rover through waypoints with local autonomy to respond promptly to events and observations, is the desired mode of operation of the rover.

Inertial navigation system fused with odometry can localise the robot. Optical proximity sensing may provide 3D profile of terrain which can be used for obstacle avoidance. Elevation data obtained from stereo cameras on Lander may be used for path planning or waypoint selection.

Our strength lies in a good understanding of Real Time Path Planning and Obstacle Avoidance algorithms. We also know and coordinate with almost all Robotics Laboratories in the country.

Essential Algorithms for Autonomous Robots

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Any autonomous robot for whatever application may be such as indoor surveillance, outdoor exploration, search and rescue, mine detection would require the following modules to be in place

1. SLAM (Simultaneous Localization and Mapping)
2. State Estimation (Global and Local)
3. Mapping or Estimating the State of the Environment
4. Exploration
5. Planning and Collision Avoidance

In this talk we will focus on 2 and 3 while also briefly touch up on 1 and 4. Towards the end of the talk we will show how all the five modules work in tandem with each other. Global State Estimation is the problem of estimating the state (pose) of the robot in a known map without an initial estimate of its state. The challenge is that in the absence of an initial guess, the problem cannot be modeled with unimodal probability distribution leading to a search over all possible poses or states of the robot. The search is inevitably exponential in state dimensions.

This contrasts with local state estimation where a guess of the robot's pose is made. Since this guess or prediction is corrupted due to system as well as measurement noise, local localization methods correct the prediction to a more reliable estimate through techniques involving Extended Kalman Filters and scan matching among others.

The popular global state estimation algorithms include the Markov and particle filter approaches. They model the state of the robot as a probability distribution function, one by discretizing the robot's state space into equally spaced configuration cells and the other by a set of particles. They both invoke properties of Bayes filter and update the probability distribution of the states whenever the robot senses the environment or when it moves. Through suitable combination of sensing and motion, the algorithms zero their probability distribution such that its peak coincides with the actual state of the robot. While highly popular, they have their share of the flaws. The Markov method becomes computationally intensive especially with motion updates while the particle filter methods suffer from the problem of loosing particles. We also talk about a fast global state estimation algorithm which is many times faster than the Markov and particle filter methods and which is based on reprojecting sensor readings from obstacle boundaries.

Local state estimation or position tracking is quintessential to most mobile robotic algorithms trying to overcome error in odometry and encoder feedback by making use of the map structure. Popular algorithms include scan matching and the Extended Kalman Filters. Scan matching involves estimating the robot error by correlating the robot's local scan with the global map structure.

Design and Development of a Mini UAV: Sharing of an indigenous experience

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The objective of this presentation is to share the experience of design, development and performance evaluation of a mini unmanned aerial vehicle (UAV). This UAV was designed in partnership with Snow and Avalanche Study Establishment (SASE), a premier laboratory of DRDO (Defence Research and Development Organization). The UAV has a moderate range of operation (15 Km) and is instrumented with an auto-pilot and a GPS (Global Positioning System) and on-board sensors such as gyros, pressure altitude, air speed etc.). The UAV carries a monochrome imaging sensor based on charge-coupled-device (CCD) technology and state-of-the-art digital signal processor (DSP) based electronics for image digitization, proprietary compression, telemetry data multiplexing, and forward error correction. This UAV uses a digital radio link with maximum data rate of 8 mbps to send the multiplexed image and telemetry data to the ground based equipment. The flight console on ground implements an innovative graphical user interface (GUI) to display the telemetry information along side the live video data. The flight console also offers post processing functions for digital image processing of the image data for detailed analysis of the image frames captured by the UAV.

The overall design of this UAV needed to consider a variety of performance parameters such as range, endurance, size, weight, resolution of imaging, field of view in imaging, sensitivity, image compression fidelity, ability to encrypt / decrypt, ability to multiplex telemetry to save additional radio link and power consumption. Additional challenges posed by the high performance expected from the electronics on-board are of EMI / EMC considerations of all the sub-systems.

This presentation will share the design and development experience for the UAV and also present results by way of sharing image sequences and other flight telemetry information. Internal block schematic of a complete UAV system will be elaborated during the presentation and critical parameters of performance for each block will be discussed.

Softlanding and Autonomous Rover for Lunar Exploration Mission

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With the scientific advancement, Man's quest for finding life in other planets has churned his imagination to find out more and more innovative inventions. In recent years there is much interest in the Space Community and Scientists to explore the moon and other planets. The interest may be to find out any specific resources available which can be used for humanity and also to develop the Space Tourism and Colony Settlement.

The use of robotic surface landers has become a standard tool for scientific exploration of celestial bodies. Some of the unmanned landing missions that has proved to be very successful are Lunakhod mission by Russia and Mars pathfinder, Spirit & Opportunity missions, to Mars by USA. It is recognized today that insitu measurements based on static lander only lead to a rather, strong restriction of scientific operations. Interesting scientific samples might be just out of reach of those instruments, even when being mounted on a manipulator arm, which can provide some degree of mobility in the range of few meters. Fully autonomous rovers can overcome these restrictions. Other than on Earth, unmanned mobile vehicles (rovers) have so far been successfully operated on Moon and Mars. In this presentation, the various Softlanding techniques, Rover Mobility Systems, types of Rovers, elements of Rover Systems are listed.

INDIAN NATIONAL SOCIETY FOR AEROSPACE
AND RELATED MECHANISMS
C/O SPACECRAFT MECHANISMS GROUP,
ISRO SATELLITE CENTRE, AIRPORT ROAD, BANGALORE (KARNATAKA)

APPLICATION FOR MEMBERSHIP

To

The National Executive Council of INSRAM

I hereby apply for admission to the grade of:

Life member	(Rs. 2000)	☐
Institutional Member	(Rs. 5000)	☐

STATEMENT TO BE SIGNED BY THE APPLICANT

I, the undersigned, do hereby declare that the statement made in this application are correct and that in the event of my selection, I will be governed by the Rules of the Society as they are now framed or as they may be altered hereafter under the powers of the said Rules, and that whilst a member of the Society, I will do all my best to advance the objective of the society.

Date   Signature

BIOGRAPHICAL AND PROFESSIONAL RECORD (In capitals)

Name in Full ……………………………………………………………………………………………….....................................

Date of birth ………………………………………….. Place of birth.. …………………………Nationality ……………….............

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Present occupation, stating precise duties……………………………………………………………………..........................

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Membership of other Societies…………………………………………………………………………………………………

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Titles and Honours………..

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Details of published work: Articles, Report, etc………………………………………………………………………………..

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PROFESSIONAL EXPERIENCE OF THE CANDIDATE:

Detail of positions held and specific details of work with dates must be given:

From	To	No. of years & Month	Designation & Organization	Details of Work

If the space is not sufficient, details may be given on a separate sheet

Having known the candidate personally for ……………years, I propose and recommended him as a proper person to belong to the society.

Signature of the Proposer …………………………….............Name (in capitals) ………………………………………….

Grade……………………………………………………………….Membership No……………………………………………..

Names and address of the persons to whom reference can be made. Persons whose names are given for reference, need not sign on this application form.

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Cheque/DD* No.:	Date:
Bank Name :	Branch :

The council, having considered this application, approved that …………………………………………… be accepted as a…………………………………………………………of Indian National Society for Aerospace and related Mechanisms.

* Cheque/DD to be drawn in favor of :
Treasurer, INSARM, Bangalore Chapter,

Date……………………….. Signed………………………..

General Secretary

NOTICE FOR THE GUIDANCE OF THE APPLICANT

Every candidate for selection should be proposed by a member who is upto-date in subscription.

A candidate for selection to Fellowship shall be proposed by a fellow.

Application completed in all respects may be sent to:

General Secretary,
INSARM, Bangalore Chapter,
Spacecraft Mechanisms Group
ISRO Satellite Center, AIR PORT ROAD
Bangalore 560017

"Interesting URLs on 'Autonomous Vehicles"

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www.chandrayaan-i.com/chandrayaan2/index2.html
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