Association for Machines and Mechanisms NewsBulletin

Volume 10, No. 2 April 2018

Objectives and Activities

The main objective of AMM is to contribute to mechanical design at all levels starting from academic research to industrial initiatives, thereby enhancing the quality and reliability of indigenous machines. With this in view, AMM organises the International & National Conference on Machines and Mechanisms, iNaCoMM, and the workshops on Industrial Problems on Machines and Mechanisms, IPRoMM regularly.

Inside This Issue

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Message from the Editor-in-Chief

Among the scorching sun and some threats of thunder storms at some parts of India, April 2018 issue is being published. The same old Editorial Board Members are still active and bringing out Bulletin of the Association for Machines and Mechanisms (AMM). The Editorial Board thanks the present Office Bearers for their active support to bring out the Bulletin of the AMM with **Prof. Pushparaj Mani Pathak** as the **Secretary.**

Bulletin of the AMM **Volume 10, No. 2, April 2018** issue is being published with **Dr. R. Ranganath, the Zonal Vice President (South)** taking positive steps to bring out this issue. Due to intense work pressure, the Editor-in-Chief could only take up the work of publication of this issue a bit late. He is sorry for the same.

April 2018 issue includes the interesting article bearing the title, **"Problems Encountered in Space Rendezvous and Docking- A Brief Study"** contributed by Sachin Barthwal, Shankar Narayan Y S, Ramkumar M S and Ranganath R of URSC, ISRO, Bangalore. Hope readers would find the article quite attractive with regard to the tit bit of successive space programmes.

A number of Brochures of forthcoming events is included in this issue as usual.

AMM members and others are requested to send contribute articles and technical briefs to the editorial team for July 2018 issue. Constructive suggestions, comments for improvement of the Bulletin of the AMM are most welcome.

On behalf of the Editorial Team of the Bulletin of AMM, I thank all concerned for their support, good wishes and suggestions for bringing out of this Bulletin.

Prof. Santanu Das
Editor-in-Chief

About the Association of Machines and Mechanisms (AMM)

The AMM headquarter is currently located at the Department of Engineering Design, IIT Madras. A new set of office bearers have taken charge of the affairs of AMM. AMM invites both individual and corporate membership from Indian academia, research organizations and industry. Membership benefits and other information about AMM are available at www.ammindia.org. The body of Zonal Vice Presidents (ZVPs) is active over the past several years with representations from the four corners of the country. They are playing the role of nodal agencies so as to decentralise the AMM official activities and to organise workshops under the aegis of AMM to popularise the mechanism science in their respective regions. They also form the editorial team of this news bulletin. AMM invites contributory articles from its members and others working in the various fields of mechanisms science for this quarterly news bulletin. Interested people can contact the editorial team.

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Our Greatest weakness lies in giving up. The most certain way to succeed is always to try just one more time.
--- Thomas Alva Edison

Contributed Article

Problems Encountered in Space Rendezvous and Docking- A Brief Study

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Abstract: Space rendezvous and Docking (RVD) is one of the complex space technologies and even small problems may result in failure of the mission. In this backdrop, it is crucial to study the problems encountered in other space rendezvous and docking missions and efforts needed to prevent them. This paper presents some of them, along with the possible root cause and ways to mitigate such problems.

1. Introduction

The study of problems encountered, ascertaining the root cause and their prevention are important in aerospace industries to improve performance. In this context, the review of the problems encountered & the lessons learnt in international Space rendezvous and Docking missions can be considered as one of the inputs while configuring and designing new rendezvous & docking experiments. This study has the following objectives:

- To identify the potential causes of failures.
- To build safety into designs.
- Verify and validate plans and procedures.
- Focus on high risk areas in design, development and testing.
- Risk assessment in acceptance of deviations and waivers.
- Identify and develop detailed remedial actions to correct mistakes, failures, accidents, mishaps and safety problems.
- Assist in prioritizing attention in areas particularly vulnerable to critical oversights and human errors.

2. Problems encountered in RVD missions

2.1. Gemini-IV, 1965 [1]

- **Problem:**
  Astronaut attempted to maneuver Gemini 4 closer to the inert Titan stage by pointing the nose of the spacecraft towards the target and firing short bursts of Gemeni maneuvering thrusters towards the target. This "eyeball" method of rendezvous only resulted in the increase in distance between the spacecraft and stage over time. This resulted in unsuccessful rendezvous and docking.

- **Root cause:**

- Wrong estimation of orbital mechanics thrusting of spacecraft with eyeball method changes orbital altitude and velocity relative to the target. Same action, made Gemini-IV to move away and downward with low orbit and increased speed.
- The spent Titan-II stage (target) was dumping its residual propellant, causing it to move around in various directions relative to the Gemini.
- There were only two running lights on the Titan-II stage (target), which made it hard at times for astronaut to determine its orientation.
- There was no radar on board Gemini 4 to give a precise range to the target, so the astronauts had to rely on their visual depth perception to estimate the range, and this differed for the two men.

2.2. Gemini IX-A, 1966 [2], (Figure-1).

- **Problem:**
  The conical nose shroud failed to separate from Augmented Target Docking Adapter (ATDA), the two pieces hanging agape at the front like a giant, open jaw (Figure-1).

- **Root cause:**
  The shroud's explosive bolts had fired but, because the quick disconnect lanyards that were designed to unlock the electrical connectors to the explosive bolts had not hooked up, the electrical wiring to the bolts held the two 1-1/2-inch-wide steel shroud retaining bands together.

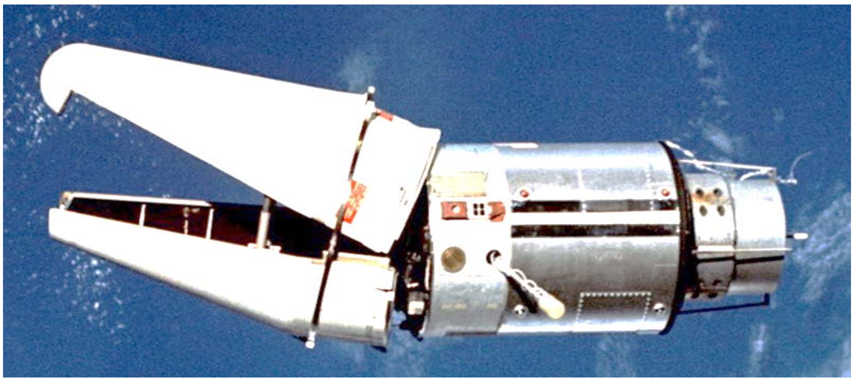

Figure-1: The Augmented Target Docking Adapter, or ATDA, as seen from the Gemini IXA spacecraft during one of their three rendezvous in Earth orbit. Failure of the docking adapter protective cover to fully separate on the ATDA prevented the docking of the two spacecrafts. ***Credits[15] [NASA[14]]***

The reason for the lanyards' condition was soon discovered: the shroud to be attached to the Agena second stage, but the Air Force decided at the last minute that Atlas could achieve the desired orbit without NASA's second stage. This dropped NASA out of the launch and meant that the ATDA and fairing would be installed directly on Atlas not Agena. These last-minute changes brought errors and dangling straps taped under the small fairings that protected the explosive bolts.

2.3. Soyuz-6/ 7 / 8, 1969 [3], (Figure-2).

- **Problem:**
  Soyuz—8's docking approach to Soyuz-7 began at 250 km, with a series of orbital manoeuvres that let to Igla rendezvous system onboard both spacecraft acquiring the opposite spacecraft's signals. Unfortunately, at 1 km the Igla system onboard Soyuz-8 failed to lock on its Soyuz-7 target.

- **Root cause:**
  It was suspected that due to unstable temperature, disparity between the frequencies of the transmitters and receivers (stabilized by special quartz resonators) this failure would have occurred. The piezocrystals were supposed to be in thermostats at a strictly constant temperature.

2.4. Soyuz 10, 1971 [4], (Figure-3).

During the docking and undocking of Soyuz-10 with Salyut-1 two failures happened. These resulted in unsuccessful docking.

a) Soft docking failure:
During soft docking computer sensed an abnormality in the spacecraft's alignment and began firing the attitude control jets to compensate. The automatic control system failed during approach due to a

serious design oversight. With Soyuz 10 being pushed to one side by the attitude control system, it became impossible to achieve hard dock and large quantities of propellant were expended in doing so.

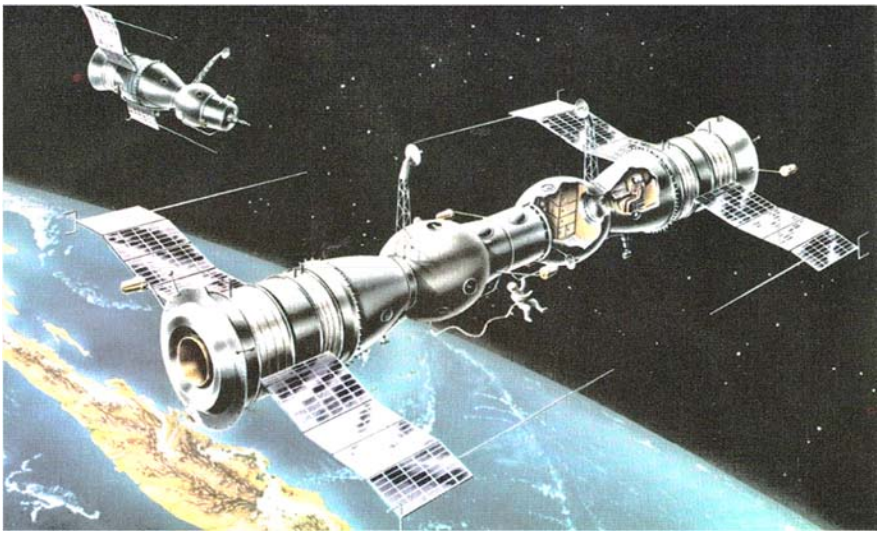

Figure-2: Pictorial view of Soyuz 6 taking photographs of docking of Soyuz-7 & Soyuz-8. ***Credits: Spacefacts [16]***

- **Root cause:**
  Investigative commission found that the likely cause of Soyuz 10's failure to dock was a dented sleeve on the active part of the docking mechanism. It was found that the sleeve gets bent at 130kg force (60% of design). However, the real force of docking was estimated 160 to 200 kg.

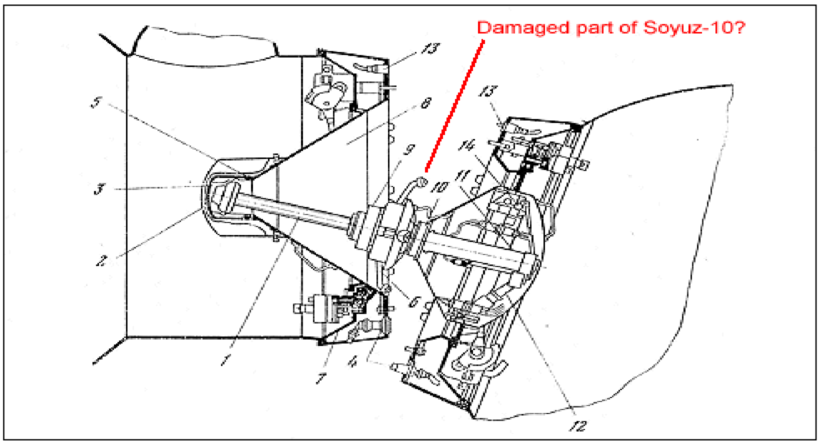

Figure-3: View of damaged part of Soyuz 10 probe and drogue mechanism **Credits*: Sven Grahn [17]***

b) Undocking failure:

A spacecraft first initiates a soft dock by making contact and latching its docking connector with that of the target vehicle. Once the soft connection is secured they may proceed to a hard dock where the docking mechanisms seal together (air tight), enabling interior hatches to be safely opened so that crew and cargo can be transferred.

Soft docking was successfully achieved however, unsuccessful attempts of hard docking made cosmonauts to start undocking procedure. The probe stuck in docking cone of space station and did not come out.

- **Root cause:**
  Undocking procedure can start only after successful hard docking. which was not achieved.

2.5. Apollo-14, 1971 [5] , (Figure-4).

- **Problem**:
  Five attempts were made to dock Command Service Module (CSM) with Lunar Module and all got failed. The sixth attempt was a success.

- **Root cause:**

- The first possibility is that of a side load being introduced into the torque shaft by the torsion spring or by other means; this may cause the ball end of the torque shaft to bind against the cam. This failure occurred on another probe during acceptance tests and it was possible to demonstrate this same failure on the Apollo 14 probe by applying a side load, but the failure did not occur consistently.

- The second possibility is that some small foreign material may have been lodged in the probe in a manner that prevented operation of the mechanism. Burrs from an unknown source were discovered in the bore of the tension-tie plug between the plunger and the plug and may have caused the problem. A foreign particle might have got inadvertently lodged.

2.6. Soyuz 15, 1974 [6]

- **Problem:**
  During rendezvous firings, engine was performing exactly opposite to what was intended.

- **Root cause:**
  The reason for failure was found to be failure of Igla system and initiating false commands. When Soyuz was 350 meters from Salyut, Igla thought it was 20km away and turned on the engines as it would on a long-range approach. Consequently Soyuz, when passing Salyut at a distance of 7 meters was travelling at a relative velocity of 72 kmph. Had the vehicle stuck Salyut it would certainly have killed the crew; but this did not happen, because at 20km the approach pattern had induced a small amount lateral drift which misaligned the two spacecrafts. After the two failed automated approaches, the crew were ordered to shut down Igla and return to the earth.

2.7. Soyuz-23,1976 [7]

- **Problem:**
  At 4.5km from the Salyut station Soyuz reported strong lateral fluctuations and with further movement Soyuz started moving away from Salyut.

- **Root cause:**
  It was a docking system electronic failure. Sensors indicated an incorrect lateral velocity, causing unnecessary firing of the thrusters during rendezvous.

2.8. Salyut-7, 1985 [8], (Figure-5 & 6).

- **Problem:**
  a surge of current in the electrical system, which led to the tripping of over current protection and the shutdown of the primary radio transmitter circuits. The backup radio transmitters were automatically activated. Instead of understating the situation and review by specialists mission controllers decided to reactivate the primary radio transmitter. Considering the over current protection had tripped accidentally, and if not, then it should still be functional and should still activate if there really was a problem. The controllers, acting against established tradition and procedures of their office,

sent the command to reactivate the primary radio transmitter. Instantly, a cascade of electrical shorts swept through the station, and knocked out not only the radio transmitters, but also the receivers. An entirely new set of docking techniques were developed as a repair mission, and this was done under a project titled “docking with a non-cooperative object”.

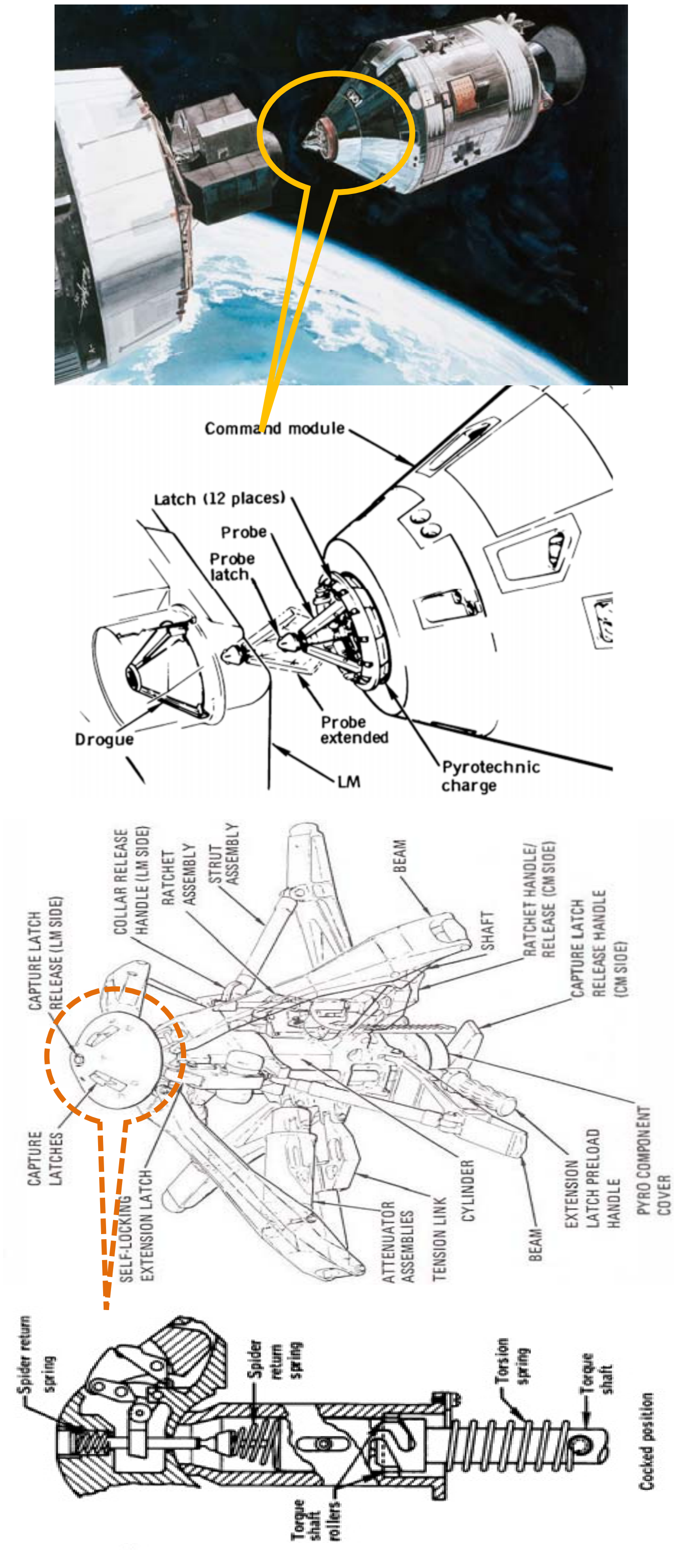

Figure-4: View of Probe and drogue docking mechanism of Apollo-14, ***Credits: Wikimedia [18]***

- **Root cause:**
  A single faulty sensor was determined to be the cause of the station's descent into a frozen darkness. It was a sensor which monitored the state of charge of battery number four. The sensor was designed to shut down the charging system when the battery to which it was connected was full, in order to prevent overcharging that battery. Each of the seven primary batteries and the single backup battery had such a sensor and any one of the sensors- primary or backup- had the authority to shut down the charging system. Single backup battery had such a sensor and any one of the sensors - primary or backup - had the authority to shut down the charging system.

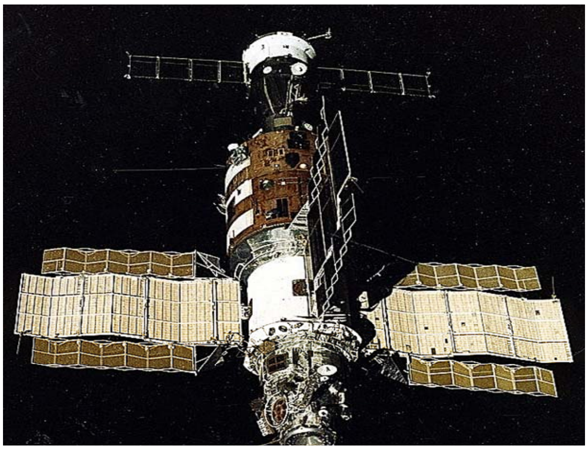

Figure-5: The view of Salyut 7 from Soyuz T-13 (rescue) after undocking and beginning the journey home, ***Credits: Spacefacts [19]***

2.9. Kvant-1, 1987 [9], (Figure-7).

- **Problem:**
  Kvant-1 achieved soft docking without any incident, but hard docking failed. For some reason the docking probe retraction system failed to engage the capsule latches to pull. Kvant-1 was into dockin ring of Mir's aft port. Looking out of the viewing ports of Mir, the cosmonauts were unable to find the anything obviously wrong

  Root cause:
  The crew conducted an emergency EVA to investigate the problem. The crew found a piece of debris, probably a trash bag, which might be left by Progress 28. This has caused jamming inside of docking mechanism.

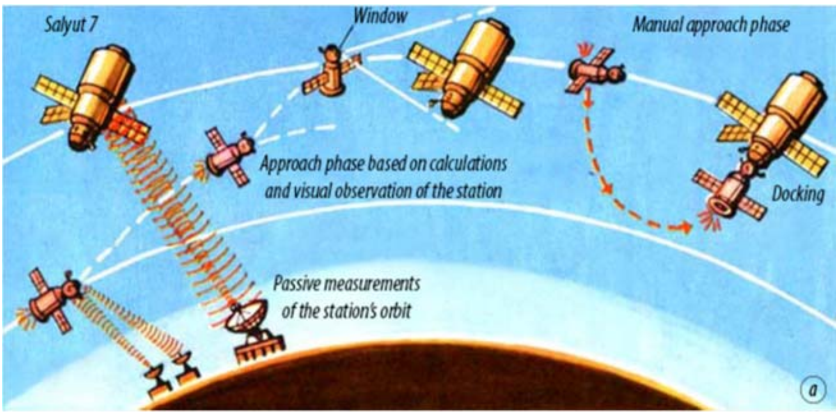

Figure-6: A depiction of the rendezvous and docking with a non-cooperative object procedure employed for SoyuzT-13***: Arstechnica [20]***

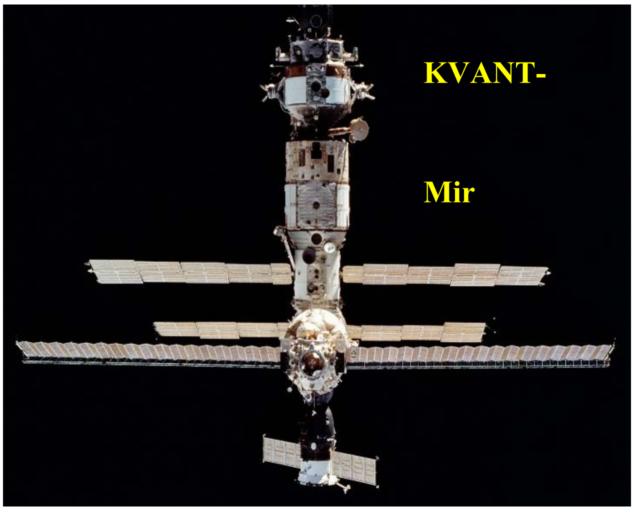

Figure-7: The view of Kvant-I attached to Mir space station, ***Credits: NASA [21]***

2.10. Progress M-34, 1997 [10], (Figure-8).

- **Problem:**
  The spacecraft Progress-M-34 re-approached Mir under manual control, Tele Operated Rendezvous Control System (TORU), in a test intended to establish whether Russia could reduce the cost of Progress missions by eliminating the Kurs automated docking system. the crew began the TORU test under remote control conditions. Progress slammed into a solar array and ricocheted into the *Spektr* module, rocking the entire station.

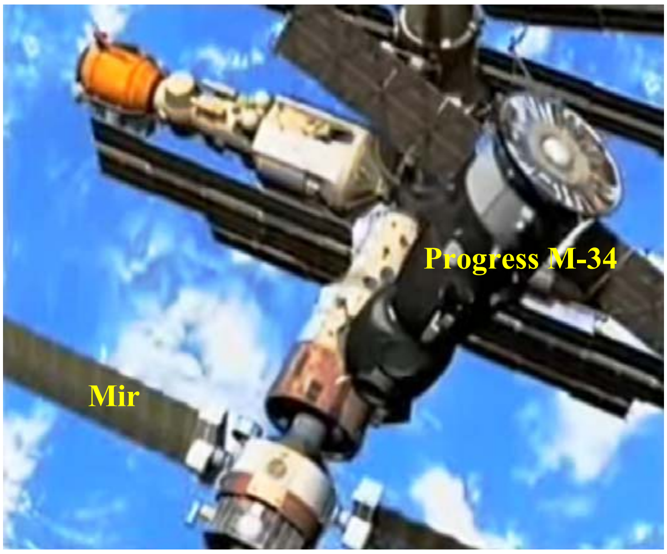

Figure-8: View of Progress M34 colliding with Mir space station, ***Credits: Youtube [22]***

- **Root cause:**
  NASA astronaut Thomas Stafford headed an investigation (known as the Stafford Commission) whose findings showed *Mir*'s crew had done all that it could. The Stafford Commission concluded following root cause for this failure

- Manoeuvre were performed outside of radio contact with the ground, making it impossible for the Russian Federal Space Agency Mission Control Centre (TsUP) to use its controls or data readings to assist the crew.
- *Mir* was not equipped with docking simulators, so Tsibliyev had not rehearsed the docking in more than four months, leaving his docking skills degraded.
- The poor lighting conditions resulted Progress's camera difficult to differentiate *Mir* from the background of Earth's clouds.
- Progress-M 34 had been overloaded, thus displacing its centre of gravity. The spacecraft's response to Tsibliyev's commands therefore differed from the responses TsUP had predicted.

2.11. Progress M-06M, 2010 [11], (Figure-9).

- **Problem:**
  The spacecraft aborted the docking procedure after a critical communications error.

- **Rootcause:** The most likely cause of the aborted docking was traced to the activation of the TORU "Klest" TV transmitter, which created interference with TORU manual rendezvous system, causing a loss of the TORU command link between spacecraft and the ISS that triggered the abort of the Progress docking. The Russian flight control team later confirmed that the KURS system operated normally during the aborted docking attempt and did not fail, as was initially believed.

Figure-9: View of Progress M-06M approaches the ISS again for docking, ***Credits: NASA [23]***

Figure-10: View of Progress M-15M spacecraft moving away from the International Space Station, ***Credits:***

2.12.Progress M-15M, 2012 [12], (Figure-10).

- **Problem:**
  Progress M-15M undocked from the Pirs Docking Compartment and tried to perform a re-rendezvous to test the new Kurs-NA navigation antenna. The re-docking was aborted after equipment aboard the Progress spacecraft failed a self-test.

- **Rootcause:**
  A likely cause for the aborted rendezvous was pointed at lower than expected temperatures on Progress M-15M's Kurs-NA system.

2.13. Soyuz TMA-19M, 2015 [13], (Figure-11).

- **Problem:**
  Just few meters from the station, the Kurs automated rendezvous system suddenly aborted the approach and fired attitude-control thrusters, forcing the ship away from the station.

- **Root cause:**
The investigation narrowed down a culprit in the failure of the DPO-B No 20 attitude-control thruster for the aborted automated rendezvous between the Soyuz TMA-19M. This small engine is a part of the two independent engine clusters known as Circuit 1 and Circuit 2. Distributed around the ship's instrument module, both groups of small engines are used to fine-tune the spacecraft's orientation in space and to conduct low-thrust manoeuvres. The particular engine provides a sideway thrust along-Y axis in the ship's coordinate system.

2.14. Dragon, 2017 [14], (Figure-12).

- **Problem:**
A SpaceX Dragon cargo ship packed with nearly three tons of supplies aborted its rendezvous to the International Space Station due to a navigation glitch.

- **Root cause:**
The Dragon spacecraft's navigation system works by comparing position data derived from the GPS satellites to determine the range, direction and closing rate between the visiting supply ship and the space station.

The spacecraft ran into trouble processing GPS navigation data due to an incorrect value in the spacecraft's Relative Global Positioning System which basically tells Dragon's computers, for its burn plan, where it is in the sky relative to the International Space Station. So, rendezvous was called off and reattempted on next day.

Figure-11: View of moments before docking, the spacecraft's automatic docking system ***Credits: NASA [25]***

Figure-12: View of moments before docking, of Dragon with ISS, ***Credits: NASA [26]***

3. Conclusion

Several problems encountered in RVD missions have been presented. In hindsight, these problems are eminently preventable with robust design, meticulous planning, detailed testing, elaborate simulations and precise execution. The following observations can be useful towards achieving successful RVD mission.

3.1. Contamination

The Apollo-14, 1971 & Kvant-1, 1987 faced problem in docking due to jamming of docking mechanism by foreign material. So, to prevent contamination, covers were provided on critical and moving parts of mechanism during ground operations and removed before flight.

3.2. Thermal

Some of unsuccessful docking attempts have pointed out that the thermal expansions/ jamming/distortions of moving elements may lead failure of docking mechanism as in Progress-15M & Apollo-14.

To avoid jamming between two moving elements of docking mechanism, the following preventive measures may be considered:

- Thermal analysis of docking mechanism under extreme anticipated temperatures and thermal gradients.
- MOS_2 (Molybdenum disulphide) coated for all moving elements to prevent any cold welding
- Functional test at sub system level at extreme anticipated temperatures
- Functional test of docking mechanism at thermo vacuum conditions

3.3. Centre of Gravity off set

One of causes for unsuccessful docking of Progress-M 34 was identified as variation in centre of gravity of docking spacecraft. This resulted unaccounted couples and forces during docking.
Efforts are to be done to keep Centre of Gravity within permissible limits.

3.4. Androgyny

Many of the international dockings failed due to failure of one out of two docking mechanism/ spacecraft. The target and chaser spacecrafts had Probe and drogue docking type of mechanism for docking. Failure in anyone will lead to unsuccessful docking.

To avoid this, androgyny is being considered in recent docking mechanism designs. Chaser and target will have same docking mechanism. Any one will play active part. Even in case of failure in anyone, docking can be re attempted with making it passive and other one active.

3.5. Sensor failure

Soyuz 23 mission could not proceed with docking because of large lateral distance caused by failure of one of rendezvous sensor failure.

To make rendezvous more reliable following checks should be ensured
- Testing of all rendezvous and docking sensor with simulation of hold points
- Identify the failures modes for all sensors.

3.6. Over look of assembly procedures and non-conformances

Gemini IX-A, 1966 could not start rendezvous as the conical nose shroud failed to separate.

To make rendezvous more reliable, following checks may be looked into:

- Strict adherence to procedures and any changes/deviation to be implemented only after due acceptance procedure.

➢ All non-conformances to be reviewed by respective review boards for acceptance

3.7. Interference of transmitters and sensor measurement

Docking TV transmitter, which created interference with manual rendezvous system, causing a loss of the command link between ProgressM-06M spacecraft and the ISS that triggered the abort of the Progress docking

To avoid similar anomalies in any rendezvous and docking mission, the validation of sensors for rendezvous from far range to close range in flight simulated conditions need to be carried-out.

3.8. Contingency plan

Soyuz TMA-19M and Dragon, 2017 faced rendezvous problems due to anomalies in mission but achieved success later because of systematic execution of contingency plans. This alerts us to the requirement of drawing up detailed contingency plans for all phases of the mission.

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[23] **Figure-9:** https://spaceflight.nasa.gov/gallery/images/station/crew-24/hires/ iss024e007404.jpg
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Forthcoming Events

The XXIV International Conference on Robotics

ROBOTICS 2018

September 20 - 21, 2018, Iasi, Romania

Conference Website: www.robotics2018.tuiasi.ro

General information:

It is our pleasure to invite you to ROBOTICS 2018, organized by "Gheorghe Asachi" Technical University of Iasi, Romania, during September 20 - 21, 2018. The conference aims at bringing together under a unique forum, scientists from academia and industry to discuss the state of the art and the new trends in robotics and to present recent research results and prospects for development in this rapidly evolving area.

All materials must be written in English. Submitted papers will undergo a peer review process, coordinated by the International Program Committee. **All the selected and presented papers will be published in IOP Conference Series: Materials Science and Engineering (ISI Web of Science)**.

Organized by:

”GHEORGHE ASACHI” TECHNICAL UNIVERSITY OF IASI
FACULTY of MECHANICAL ENGINEERING
FACULTY of AUTOMATIC CONTROL AND COMPUTER ENGINEERING

With the support of:
ROBOTICS SOCIETY of ROMANIA - SRR

Important deadlines:

March 18, 2018:	Submission of papers
May 15, 2018:	Notification of acceptance
June 15, 2018:	Final camera ready manuscript and registration of at least one of the authors
September 20 – 21, 2018:	Conference

For any questions please contact the organizers at robotics2018@tuiasi.ro

FIRST ANNOUNCEMENT AND CALL FOR PARTICIPATION

IFToMM

4th Students International Olympiad on
MECHANISM AND MACHINE SCIENCE
October 24-26, 2018, Lima, Peru

SIOMMS 2018

www.olimpiada.pucp.edu.pe/siomms/

PUCP

The **Pontificia Universidad Católica del Perú** is pleased to invite university teams to participate in the 4th Students International Olympiad on Mechanism and Machine Science (SIOMMS) that will be held on October 24-26, 2018. This fourth global Olympiad will be arranged following the decision of the Executive Council of International Federation for the Promotion of Mechanism and Machine Science (IFToMM). It will follow the previous ones in Izhevsk State Technical University (ISTU), Izhevsk, Russia in 2011, Shanghai Jiao Tong University (SJTU), Shanghai, China in 2013 and Universidad Carlos III de Madrid, Spain in 2016.

PROBLEM TOPICS
- Structural analysis and synthesis of mechanisms
- Kinematics of flat mechanisms
- Force analysis of mechanisms
- Kinematic analysis of cam mechanisms
- Gearings (kinematics, geometry, efficiency)
- Adjustment of dynamic characteristics, mechanical governors
- Balancing of rotating masses

LANGUAGE
The working language of the Olympiad is English.

TEAMS
Teams consisting of three (3) bachelor and master students and one (1) or more tutors are invited to take part in the Olympiad. Each university may send only one team. The choice of students for each university team may be conducted on the basis of its own local selection competition.

LOCAL ORGANIZING COMMITTEE
Pontificia Universidad Católica del Perú
- Jorge Rodríguez Hernández (Chair).
- Jorge Alencastre Miranda (Vice-Chair).
- Kurt Paulsen Moscoso.
- David Berrios Bárcena.
- Pedro Flores Álvarez.
- Daniel Lavayén Farfán.
- Mario Torres Melgarejo.

SCIENTIFIC COMMITTEE
- Jorge Rodríguez-Hernández (Chair) Perú
- Marco Ceccarelli, Italy
- Cristina Castejón, Spain
- Eduard Krylov, Russia
- Lena Zentner, Germany
- Yukio Takeda , Japan
- Emilio Bautista, Spain
- Osvaldo Penisi, Argentina
- Juan Carlos García-Prada, Spain
- Andrés Kecskemethy, Germany
- Carlos Alberto de Almeida, Brazil
- Paulo Flores , Portugal
- Jorge Alencastre, Perú
- Dante Elías, Perú
- Klaus Zimmermann, Germany

CONTACT PERSON
Jorge Rodríguez Hernández.
Mechanical Engineering section
Av. Universitaria 1801,
San Miguel, Lima 32.
Peru
crodrig@pucp.edu.pe

REGISTRATION FEES
The registration fee is 150 USD for each participant, which covers the participation in the Olympiad, meals and social program. The accommodation has to be covered by the participants extra. The payment will be detailed by website.

IMPORTANT DATES
Submission of electronic application form: March 28, 2018.
Registration fee payment: June 30, 2018.

APPLICATION
The application will be via website.

TRANSPORTATION
Lima is the capital city of Peru and is one of the most important cities of Latin America. Lima is located in the central coast, along the Pacific Ocean.
Lima has excellent public transport within the city and has a very modern airport in the port of Callao.

HOST CITY
Peru's capital has more than 10 million people, made up of different races of the world.
The historic center of Lima was declared World Heritage Site by UNESCO. Lima is a city with great cultural diversity that is why there are a large number of museums.
In Lima you will find everything you are looking for as cultures, adventures, beaches, dining, entertainment and everything you can imagine.

T 626 2000 www.olimpiada.pucp.edu.pe/siomms/
Campus principal: Av. Universitaria 1801, San Miguel - Lima 32, Perú

Second Call for papers

Asian MMS 2018 is the fifth in the series of biennial conferences held under the patronage of International Federation for the Promotion of Mechanism and Machine Science (IFToMM) and Association for Machines and Mechanisms (AMM) to bring together researchers, industry professionals, and students, primarily from the Asian countries but also world at large. Previous conferences were held at Taipei ('10), Tokyo ('12), Tianjin ('14), and Guangzhou ('16). The conference focuses on all topics related to mechanisms and machines.

Dates to note

Abstract	Apr. 10, '18
Acceptance	May, 1, '18
Full paper	Jul. 1, '18
Acceptance	Sep. 1, '18
Final paper	Sep. 15, '18

Call for special session proposals from Oct. 15, 2017 to Feb. 1, 2018

Pre-conference workshops	Dec. 17, 2018
Conference [Plenary talks; invited talks; oral presentations;	Dec. 18, 2018
interactive poster sessions; and more]	Dec. 19, 2018
Conference picnic [A trip to scenic and historic places]	Dec. 20, 2018

Topics

Plan to submit a paper, organize a special session, and attend the conference, right now!

- Theoretical kinematics
- Computational kinematics
- Machine elements
- Actuators and sensors involving mechanics
- Gearing and transmissions
- Linkages and cams
- Mechanism design
- Dynamics of machinery
- Tribology
- Vehicle mechanisms, dynamics, and design
- Reliability in machines and mechanisms
- Experimental methods in mechanisms
- Robotics and mechatronics
- Biomechanics
- Micro/nano mechanisms and systems
- Medical/heathcare devices
- Nature and machines
- Compliant mechanisms
- History of mechanism and machine science
- Education in mechanism and machine science
- Reconfigurable mechanisms
- Parallel and serial manipulators

Registration (opens on Sep. 1, 2018; 20% early-bird discount until Oct. 15, 2018)

Regular	INR 12,000
Students	INR 5,000
Pre-conference workshops	INR 2,500
Conference picnic (Dec. 20, 2018)	INR 2,500

About Bengaluru

Bengaluru, known as the science city of India because it has numerous educational and research institutions and as garden city because of its cool climate and greenery, is a major metropolitan city. It is also an IT hub with thriving start-up companies and major industries, public and private.

About Indian Institute of Science

Indian Institute of Science (IISc), established in 1909, is India's top-ranked university and is in the top 10 of world's small universities. Its vibrant and verdant campus with world-class infrastructure is one of the finest university campuses in the world.

Accommodation

IISc has guesthouses on campus and there are 3-star hotels around IISc.

Travel

Bengaluru International Airport is well connected to all major cities in the world. Bengaluru has good public transportation system and taxi service.

www.iisc.ac.in/conf/AsianMMS2018

Conference Chair G. K. Ananthasuresh, Indian Institute of Science
Conference Secretariat Safvan Palathingal
Email: asianmms2018@gmail.com

Symposium on Machines & Mechanisms for Agriculture and Rural Applications

(an IPRoMM initiative)

Event: Pre-conference Symposium during IFToMM Asian Mechanism and Machine Science (Asian MMS 2018)
Date: December 17, 2018
Venue: J. N. Tata Auditorium, Indian Institute of Science (IISc), Bengaluru – 560012, India

CALL FOR PARTICIPATION

A one-day symposium is planned as an initiative of Industrial Problems on Machines and Mechanisms (IProMM) during Asian MMS 2018. The theme is related to the usage of machines and mechanisms for agriculture and rural applications.

Mechanization and modernization of methodologies followed in farming are steadily improving over the years. These aim to attain improved productivity and reduce efforts by human workers. Similarly, a lot of rural technologies have been developed to improve the livelihood of people. A lot of scope is still there to improve these scenarios.

A typical workflow of a product related to agriculture/farming equipment and rural technologies is as follows:

- Identification and formulation of problem statements
- Ideation
- Systematic design of proposed ideas/concepts
- Fabrication/development of equipment
- Testing and deployment
- Feedback and redesign

The symposium comprises a keynote lecture followed by several talks/sessions by researchers working in the aforementioned topics and also from industries. They discuss how a product could be developed and deployed. In addition, they will also share their success stories.

Registration

The attendees can be students pursuing engineering (undergraduate, postgraduate or doctoral), researchers, faculty, and personnel from industries working in the related fields.

The registrants of Asian MMS 2018 will have free access to attend the symposium. The registration charges for attending only the symposium is Rs. 2,500.

About Asian MMS 2018

Asian Conference on Mechanism and Machine Science (Asian MMS 2018) is an international conference organized under the patronage of IFToMM during Dec 17-20, 2018. The aim of the conference is to bring together academic researchers, industry professionals, and students in the fields of mechanism and machine science. The first Asian MMS 2010 was held in Taipei. This conference is the fifth in the series after Tokyo in 2012, Tianjin in 2014, and Guangzhou in 2016. The Asian MMS 2018, although primarily intended for Asian countries, serves as a global platform for the participants to exchange ideas and present their research in the following topics.

About IPRoMM and AMM

IProMM (Industrial Problems on Mechanisms and Machines) is an initiative under the aegis of Association for Machines and Mechanisms (AMM), a member organization of International Federation for the Promotion of Mechanism and Machine Science (IFToMM).

AMM India was formed in 1981 as a group of researchers, both academic and industrial, working in the field of mechanisms and machine sciences. AMM has been instrumental in organizing National Conference on Machines and Mechanisms (NaCoMM) held every alternate year. The last three versions of NaCoMM have been made international and hence renamed as International and National Conference on Machines and Mechanisms (iNaCoMM). The year in between iNaCoMMs, efforts are made to conduct IProMM as a National Workshop.

This symposium is being organized as an IProMM initiative, along with the Asian MMS 2018 conference.

Steering Committee

- Prof. C. Amarnath
  IIT-Bombay (Retired)
  AMM President
- Prof. G. K. Ananthasuresh
  IISc, Bengaluru
  AMM Vice President
- Prof. Ashitava Ghosal
  IISc, Bengaluru
- Prof. Subir K. Saha
  IIT-Delhi

Symposium Coordinator

Mr. Rajeevlochana G. C.
Amrita School of Eng., Bengaluru
rg_chittawadigi@blr.amrita.edu

Organized by:

AMM India   IISc Bangalore

http://www.iisc.ac.in/conf/AsianMMS2018/

Forthcoming Events

Call for Session proposals

Asian MMS 2018 is the fifth in the series of biennial conferences held under the patronage of International Federation for the Promotion of Mechanism and Machine Science (IFToMM) and Association for Machines and Mechanisms (AMM) to bring together researchers, industry professionals, and students, primarily from the Asian countries but also world at large. Previous conferences were held at Taipei ('10), Tokyo ('12), Tianjin ('14), and Guangzhou ('16). The conference focuses on all topics related to mechanisms and machines.

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Acceptance	Sep. 1, '18	interactive poster sessions; and more]	Dec. 19, 2018
Final paper	Sep. 15, '18	Conference picnic [A trip to scenic and historic places]	Dec. 20, 2018

Submit a proposal for organizing a special session
The call opens now and ends on Feb. 1, 2018

Proposals for organizing special sessions on emerging topics in mechanism and machine science are invited from interested researchers from academia, government research organization, and industry. The proposals will be evaluated by the programme committee and the decision will be communicated to the proposer. The proposal should contain the following information:

1. Name of the proposer:
2. Position and affiliation:
3. Theme of the session:
4. Description of the theme (100-200 words):
5. A tentative list of potential authors (at least five):
6. Contact information of the proposer (email, telephone, and postal-address):
7. Curriculum vitae of the proposer

The proposer is expected to contact potential authors whose work aligns with the chosen theme of the proposed special session, before submitting the proposal. Additional papers are likely to be submitted under the proposed session, if it is accepted. Hence, papers submitted to a special session will also be reviewed like any other papers.

www.iisc.ac.in/conf/AsianMMS2018

Conference Chair G. K. Ananthasuresh, Indian Institute of Science
Conference Secretariat Safvan Palathingal
Email: asianmms2018@gmail.com