Experiences in student capacity-building in the area of space engineering and technology

UNOOSA Workshop on Human Capacity-Building in Space Science and Technology for Sustainable Social and Economic Development

30 Oct. - 2 Nov. 2017

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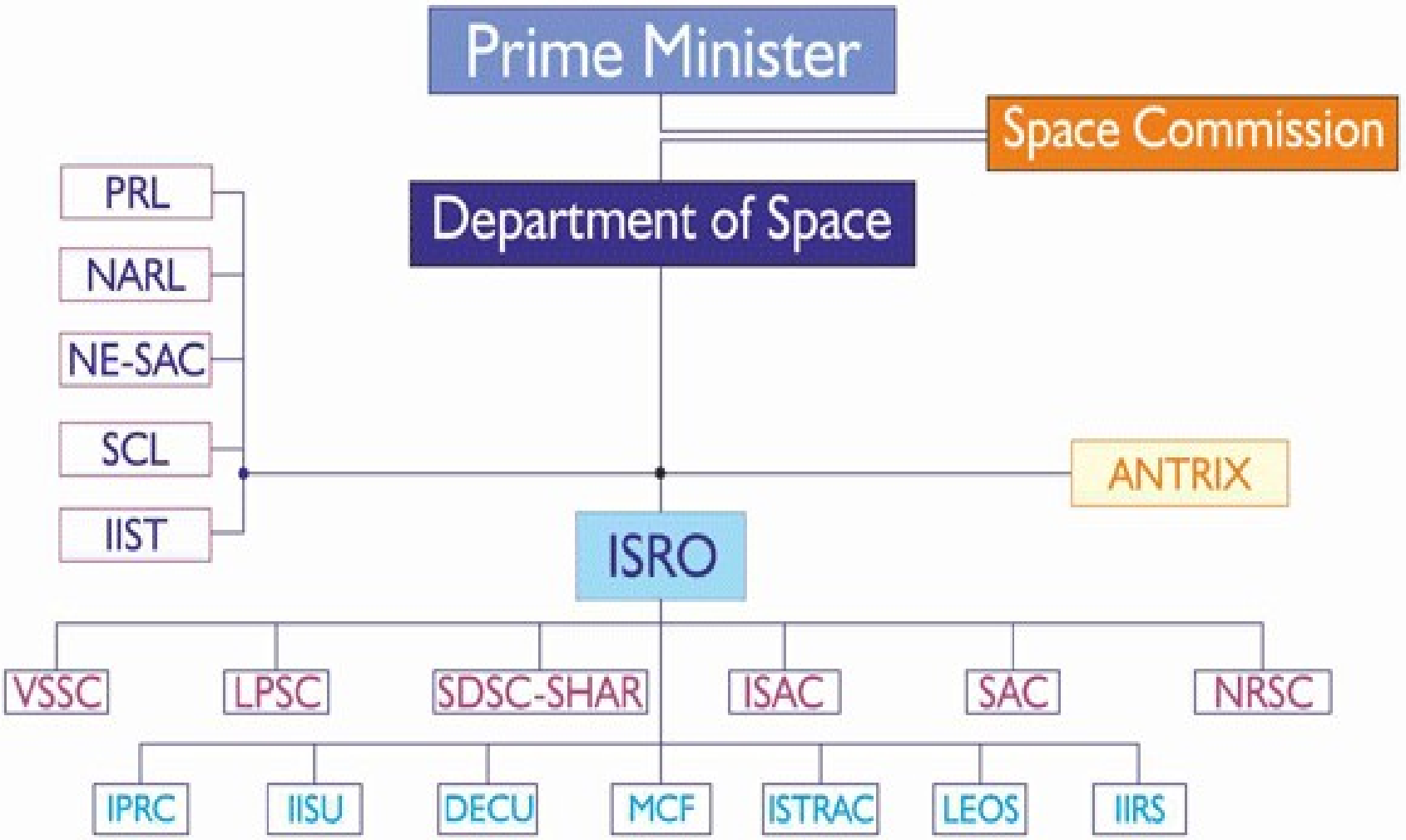
Organisation



PRL: Physical Research Laboratory **NARL:** National Atmospheric Research Laboratory **NE-SAC:** North Eastern Space Applications Centre **SCL:** Semi-Conductor Laboratory **IIST:** Indian Institute of Space Science and Technology **ISRO:** Indian Space Research Organisation **Antrix:** Antrix Corporation Limited **VSSC:** Vikram Sarabhai Space Centre **LPSC:** Liquid Propulsion Systems Centre **SDSC:** Satish Dhawan Space Centre **ISAC:** ISRO Satellite Centre **SAC:** Space Applications Centre **NRSC:** National Remote Sensing Centre **IPRC:** ISRO Propulsion Complex **IISU:** ISRO Inertial Systems Unit **DECU:** Development and Educational Communication Unit **MCF:** Master Control Facility **ISTRAC:** ISRO Telemetry, Tracking and Command Network **LEOS:** Laboratory for Electro-optic Systems **IIRS:** Indian Institute of Remote Sensing

India's first and only space institute IIST

- Autonomous institute under DOS Deemed to be University (Est. 2007)
- **Mission**
  - **Create a unique learning environment enriched by the challenges of the Space Programme.**
  - Nurture the spirit of innovation and creativity.
  - Establish Centres of Excellence in niche areas.
  - Provide ethical and value based education.
  - **Promote activities to address societal needs.**
  - **Network with national and international institutions of repute.**

IIST Master Plan

Programs Offered

- Bachelors in Technology (B. Tech)
- Masters in Technology (M. Tech)
- Dual Degree (B. Tech + MS/M. Tech)
- Doctoral and Post doctoral research

Departments

- **Avionics**
- **Aerospace Engineering**
- Earth and Space Science,
- **Physics**
- Chemistry
- Mathematics
- Humanities

Bachelors in Technology (B. Tech)

- 4 year program
- Admission through all India Joint Entrance Examinations (1.3 million took exams in 2017)
- Out of 20,000 qualified candidates 140 were chosen (2017)
- Areas and number of students per year
  - Avionics (60)
  - Aerospace Engineering (60)
  - Engineering Physics (Dual Degree) (20)

Masters in Technology (M. Tech)

15 Masters program, admission through all India Graduate Aptitude and Technical Examinations (GATE)	
Avionics (5)	Control Systems, Digital Signal Processing, RF and Microwave Engineering, VLSI and Microsystems, Power Electronics
Aerospace Engineering (3)	Aerodynamics and Flight Dynamics, Structures and Design, Thermal and Propulsion
Chemistry (1)	Material Science and Technology
Physics (2)	Optical Engineering, Solid State Physics
Mathematics (1)	Machine Learning and Soft Computing
Earth and Space Science (2)	Astronomy and Astrophysics, Earth System Sciences, Geoinformatics

Research

- Around 100 Research Scholars from all the departments

Student Satellite Program Objectives

- To set a small-satellite standard for the Indian education institutes
- Hands-on experience on the design, fabrication and realization of small satellites
- Mentorship provided by ISRO scientists and IIST faculties
- Continuous activity of developing and launching small satellites for TDP and science missions

Satellite related Activities at IIST

- **Present activities**
  - IISTnSAT-1
  - INSPIRESat-1
  - AAReST
  - RPA for ISRO MOM-2
  - Multiband Ground Station
- **Future Missions**
  - Proposed RPA and nanosatellite for Venus Mission
  - TDP for nano-propulsion systems
  - Close range cluster formation
  - Docking

Mission Specifications	
Dimension	100 x 100 x 300 mm3
Total Mass	< 3 kg
Power Consumption	< 10 W
Orbit Type	Polar
Altitude	400 – 800 km
Communication Link	Uplink : 435 MHz band Downlink : 135 MHz band
Stability Requirement	3-axis stabilized; earth pointing (<10^0)

Sub System	Description	Status
Payload	Objective is to count radiations and estimate effect on human exposure	Breadboard Model completed
Structures and Thermal	Aluminium alloy T60 or T70 series used for rails	Dynamic simulations
Power System	Power Buses : 3.3 V at 5 A and 5 V at 4 A	Prototype – 2 completed Prtotype – 3 design completed
On Board Computer	Flash based FPGA SoC with data acquisition.	Porotype-3 completed
ADCS	Sensors : Magnetometer, sun sensors; Actuators : 3-axis magnetorquers	Simulations complete; Prototype-1 complete Test beds
Communication	Uplink : FM-FSK modulation Downlink :Raised cosine BPSK Antenna : Directional monopole	Receiver :RF front end porotype testing in progress Transmitter & Antenna : Design in progress

INSPIREsat1

- **Main Collaborators**
  - LASP, University of Colorado, Boulder
  - National Central University, Taiwan
  - Indian Institute of Space Science and Technology

INSPIREsat1 Work Distributions

Sl. No	Subsystem	Short Description	Institute
1	Payload	Compact Ionosphere probe - CIP, Custom Built	NCU
2	C&DH and Flight Software	Custom Build	IIST
3	EPS - Power	Custom Build	IIST & NCU
4	Structure & Thermal	Custom Build	LASP
5	ADCS	XACT system from Blue Canyon Technology, COTS	LASP
6	Commuication	Space Quest, COTS	NCU

Autonomous Assembly of Reconfigurable Space Telescope (AAReST)

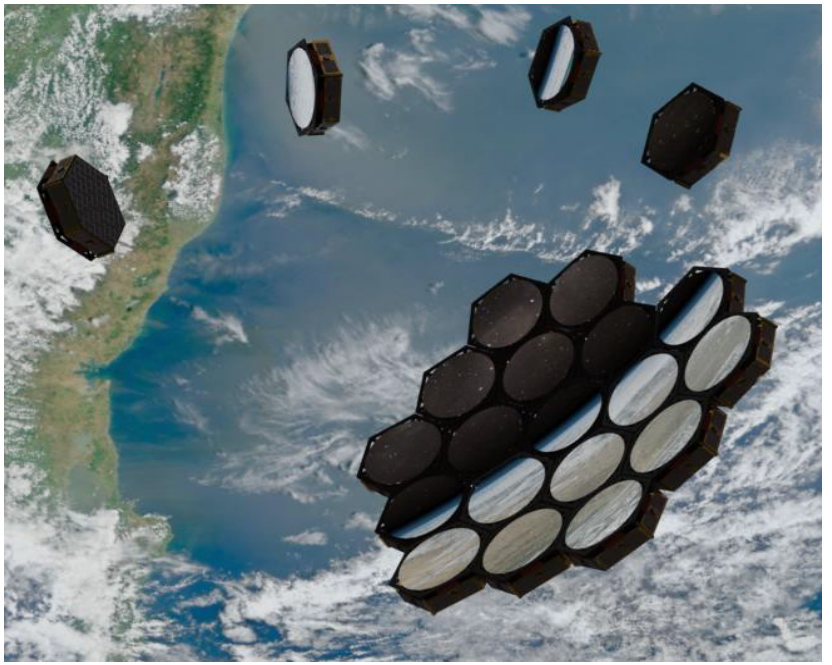
- **Main Collaborators**
  - Caltech/JPL, USA
  - University of Surrey, UK
  - Indian Institute of Space Science and Technology

AAReST

Mission Objective

- Demonstrate key technologies:
  - –Autonomous assembly and reconfiguration of modular spacecraft carrying mirror segments
  - –Active lightweight deformable mirrors (modular and robust – relaxed tolerances for assembly)
- Gather engineering data to enable development of the next system

Image Courtesy:
AAReST PDR,
Caltech University



AAReST TDP

Image Courtesy: AAReST Payload CDR, Caltech University

AAReST

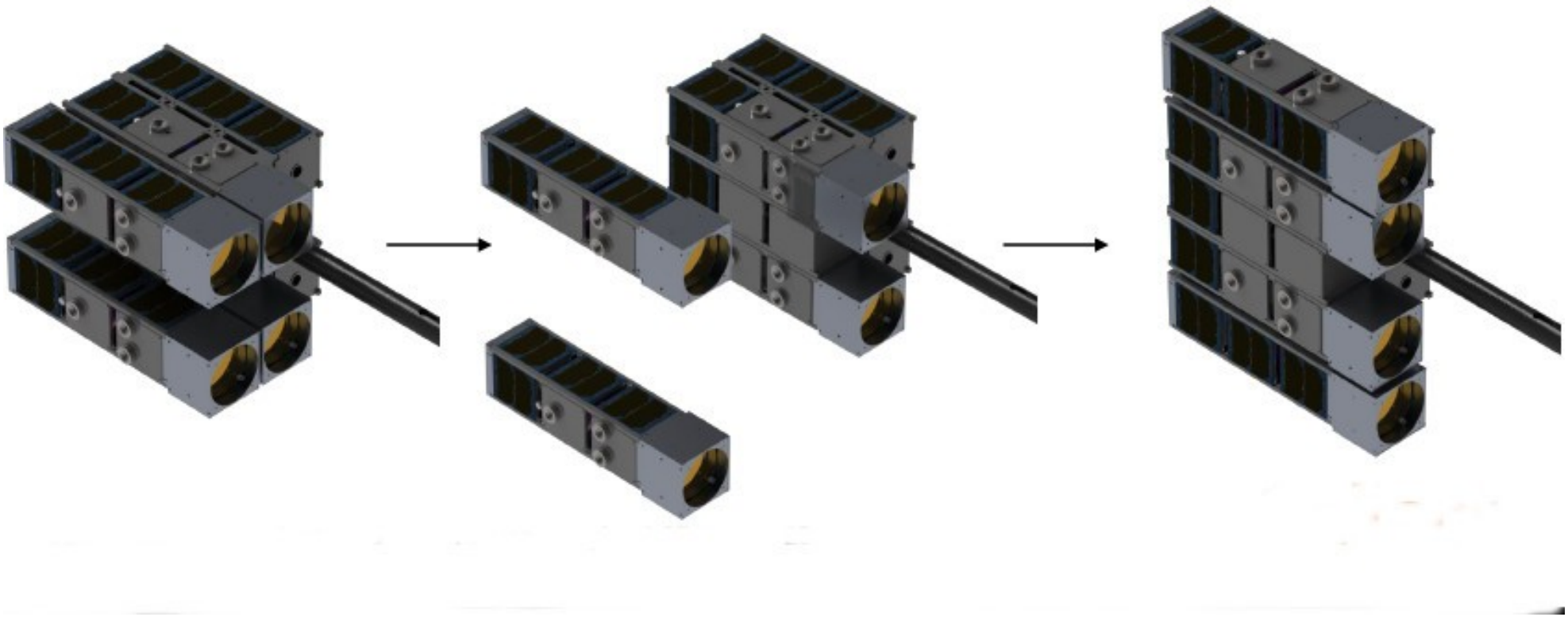
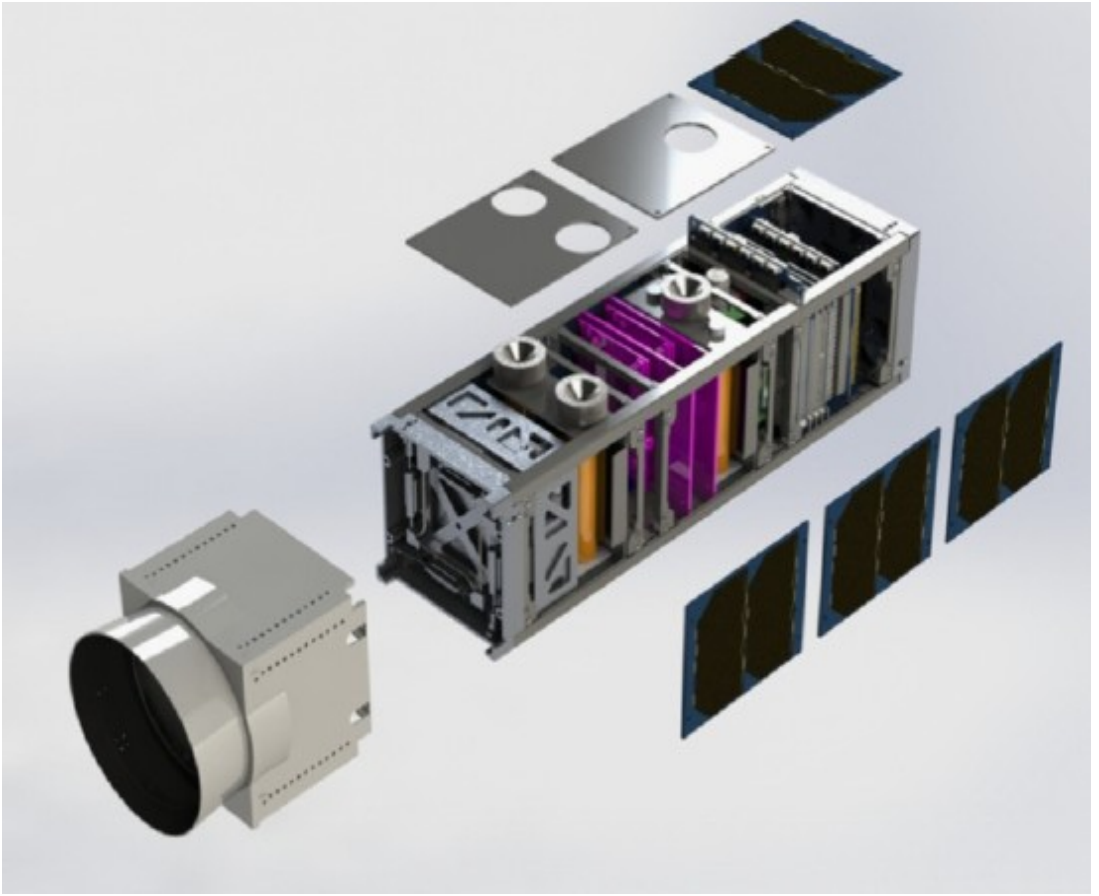


Image Courtesy: AAReST Payload CDR, Caltech University

AAReST IIST MirrorSat

- One full Mirror satellite consisting of the sub-systems including, Electrical Power System, ADCS, Propulsion System, Structures
- Docking Structure and OBC – by UoS
- Ground station with VHF/UHF/S-band capability at IIST

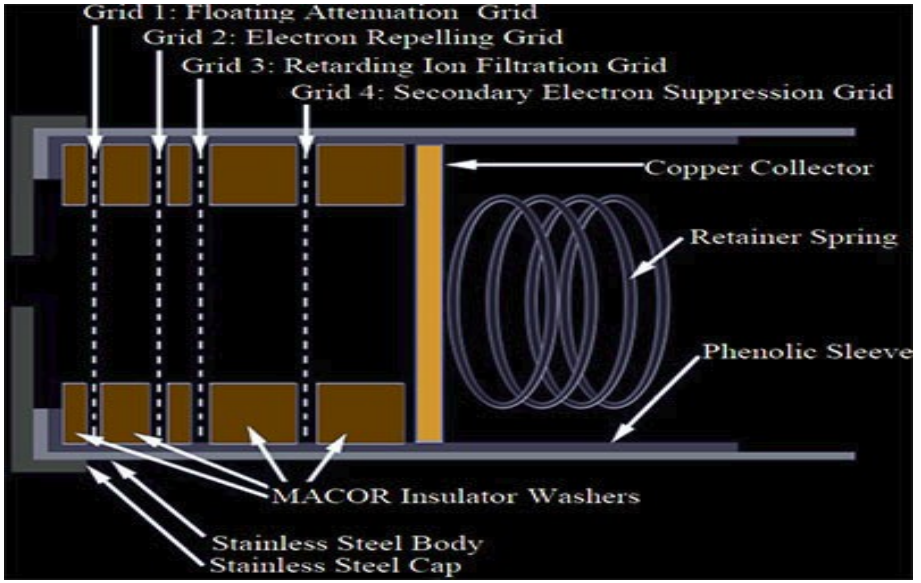
Image Courtesy:
AAReST CDR,
Caltech University



MOM-2 Payloads

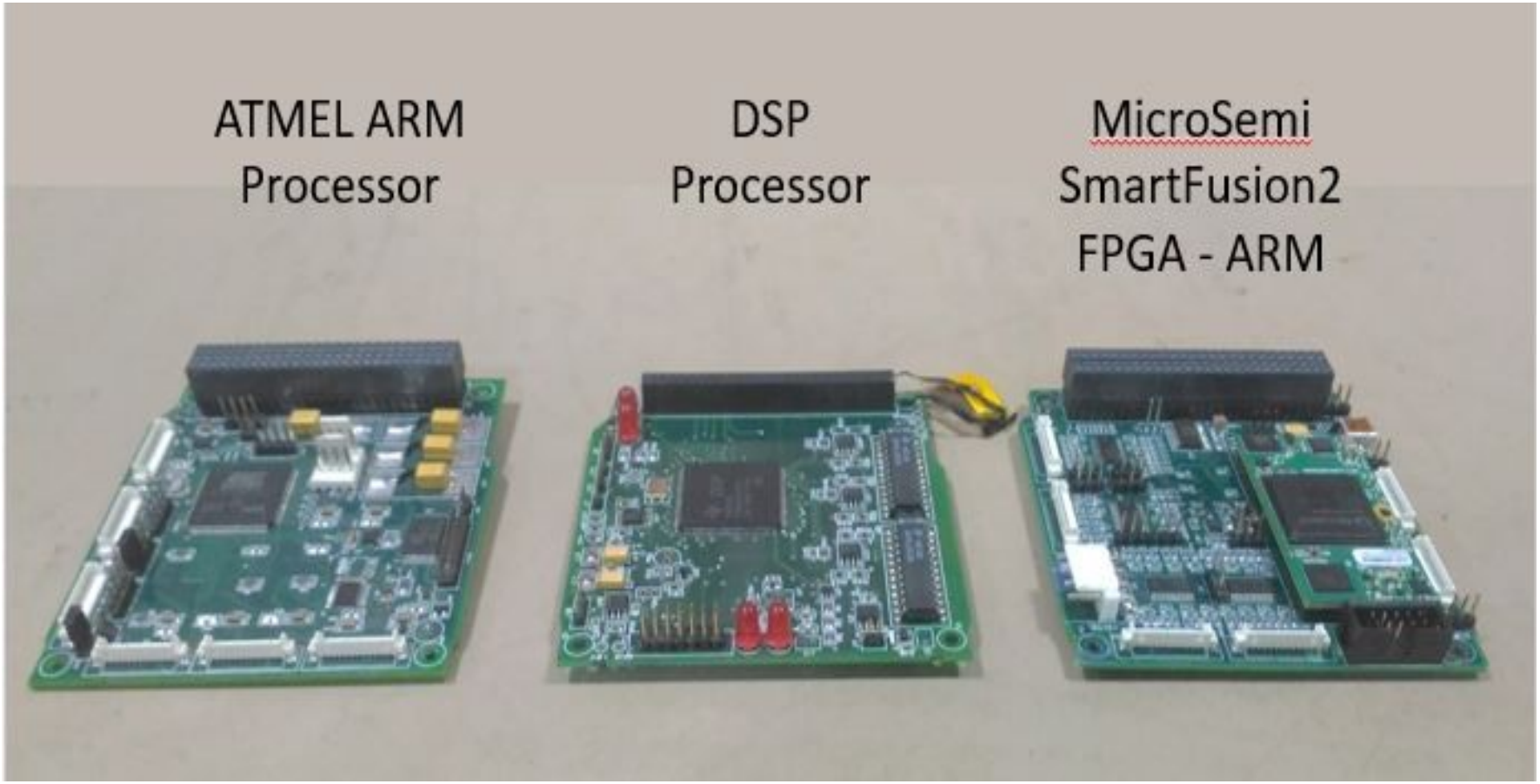
1. Retarding Potential Analyzer on Main Orbiter

-Study of Mars ionosphere – ion energy distribution

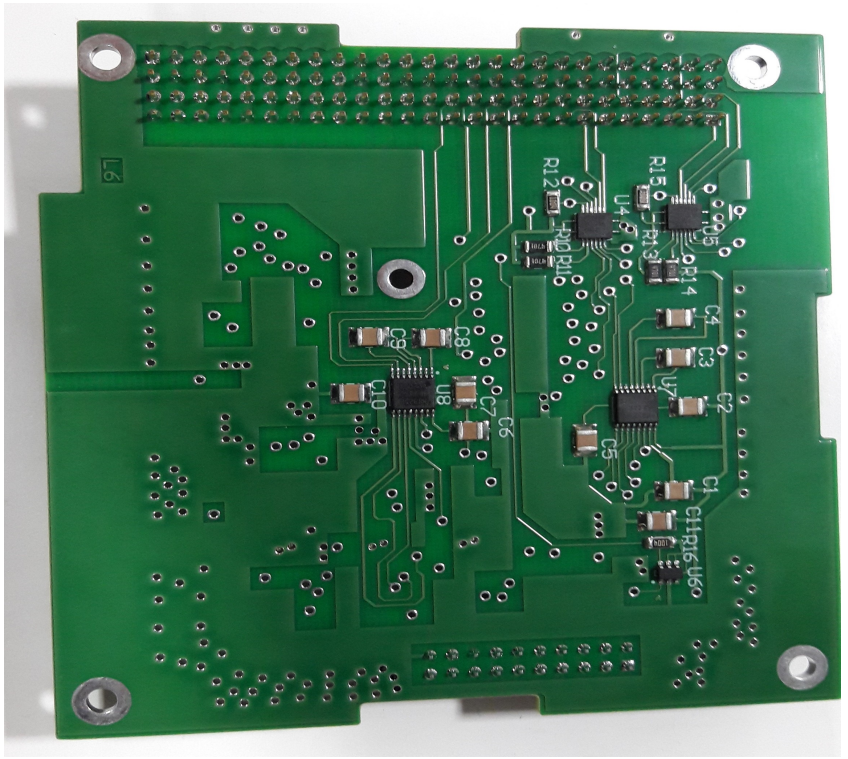


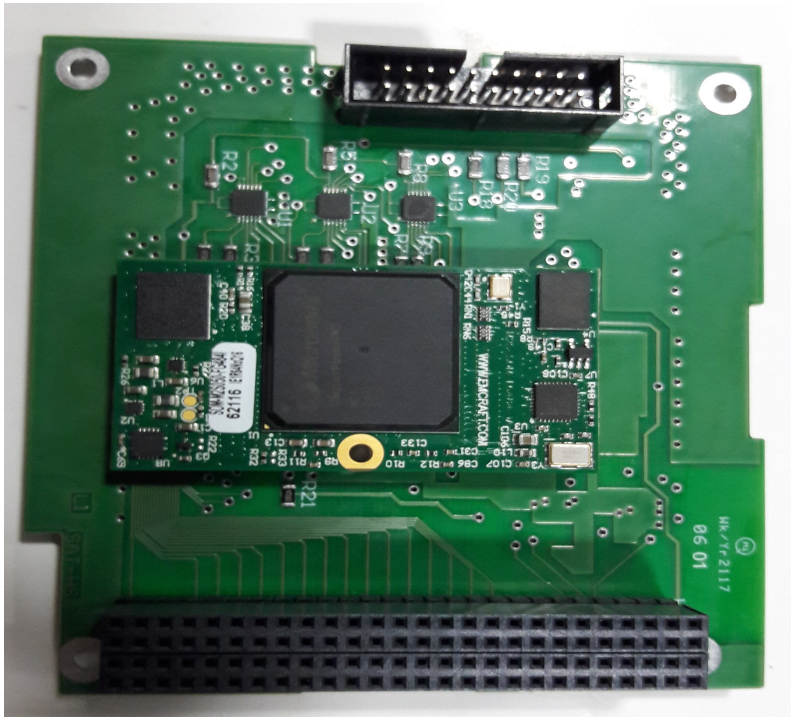
Lemmer, K. M., "Use of a Helicon Source for Development of a Re-Entry Blackout Amelioration System," Ph.D. Dissertation, University of Michigan, 2009.

Prototypes at IIST – OBC

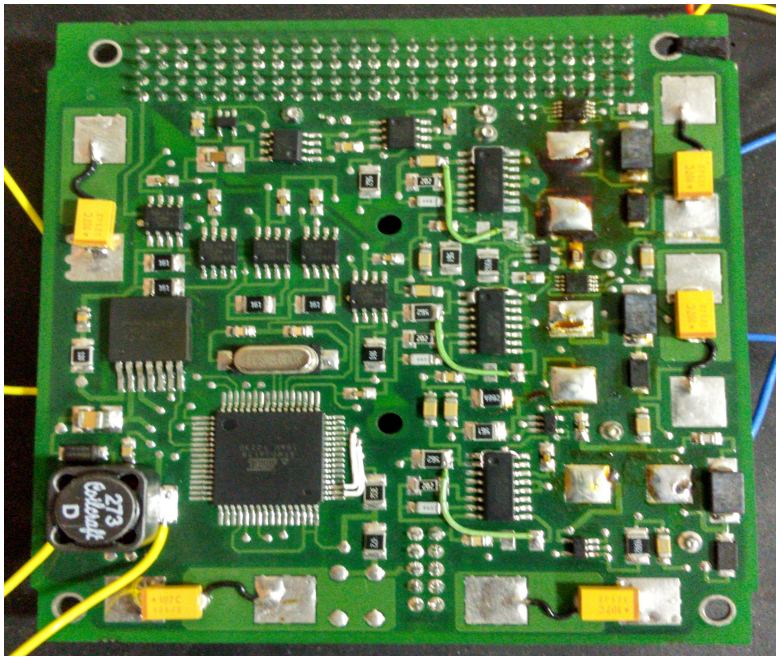


OBC ver1 for INSPIREsat1

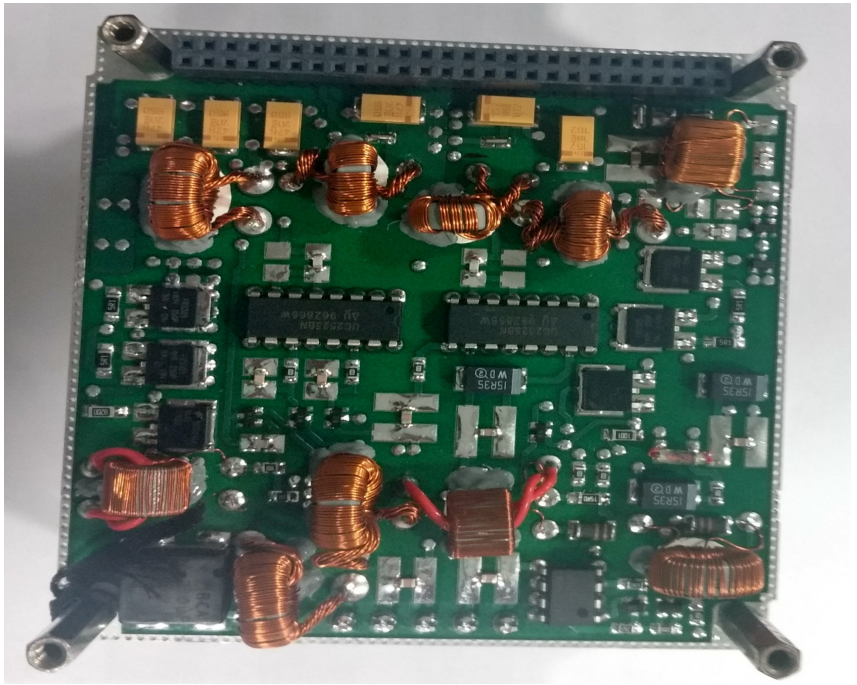




Prototypes at IIST – EPS

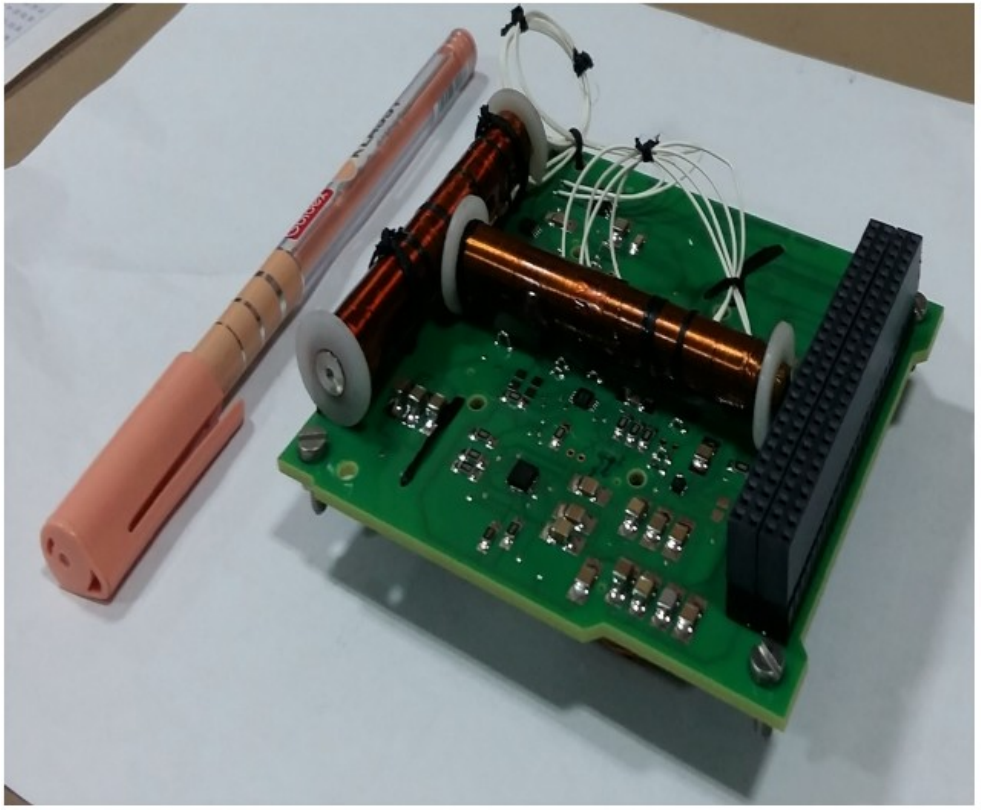


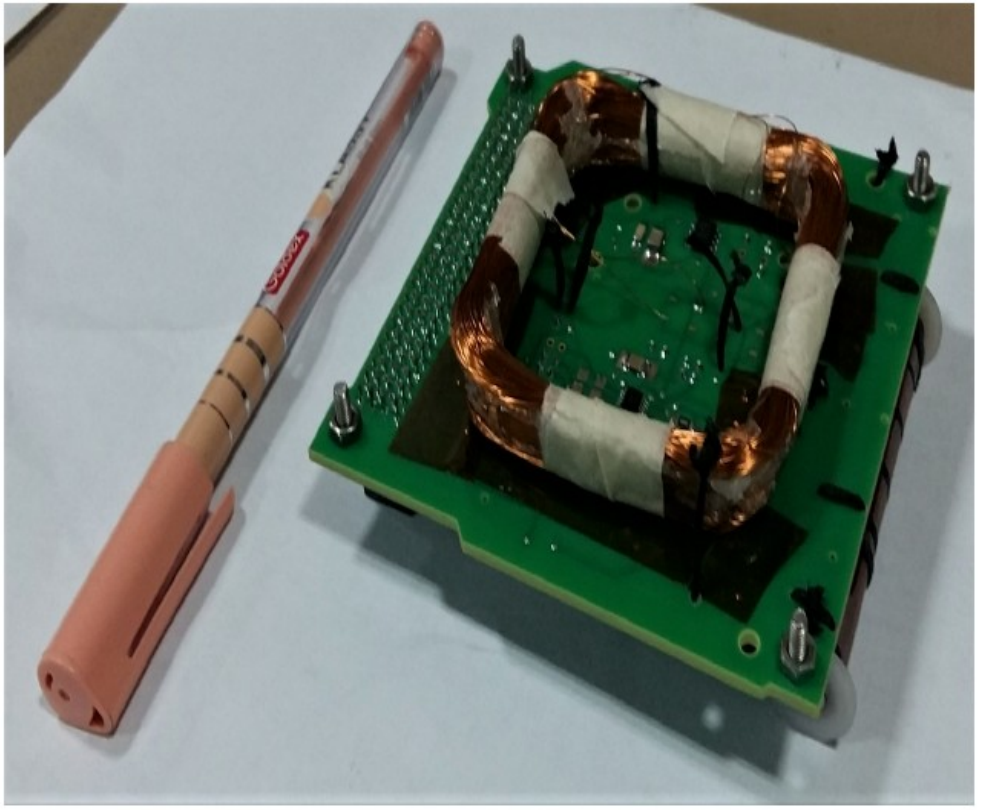
EPS ver 2



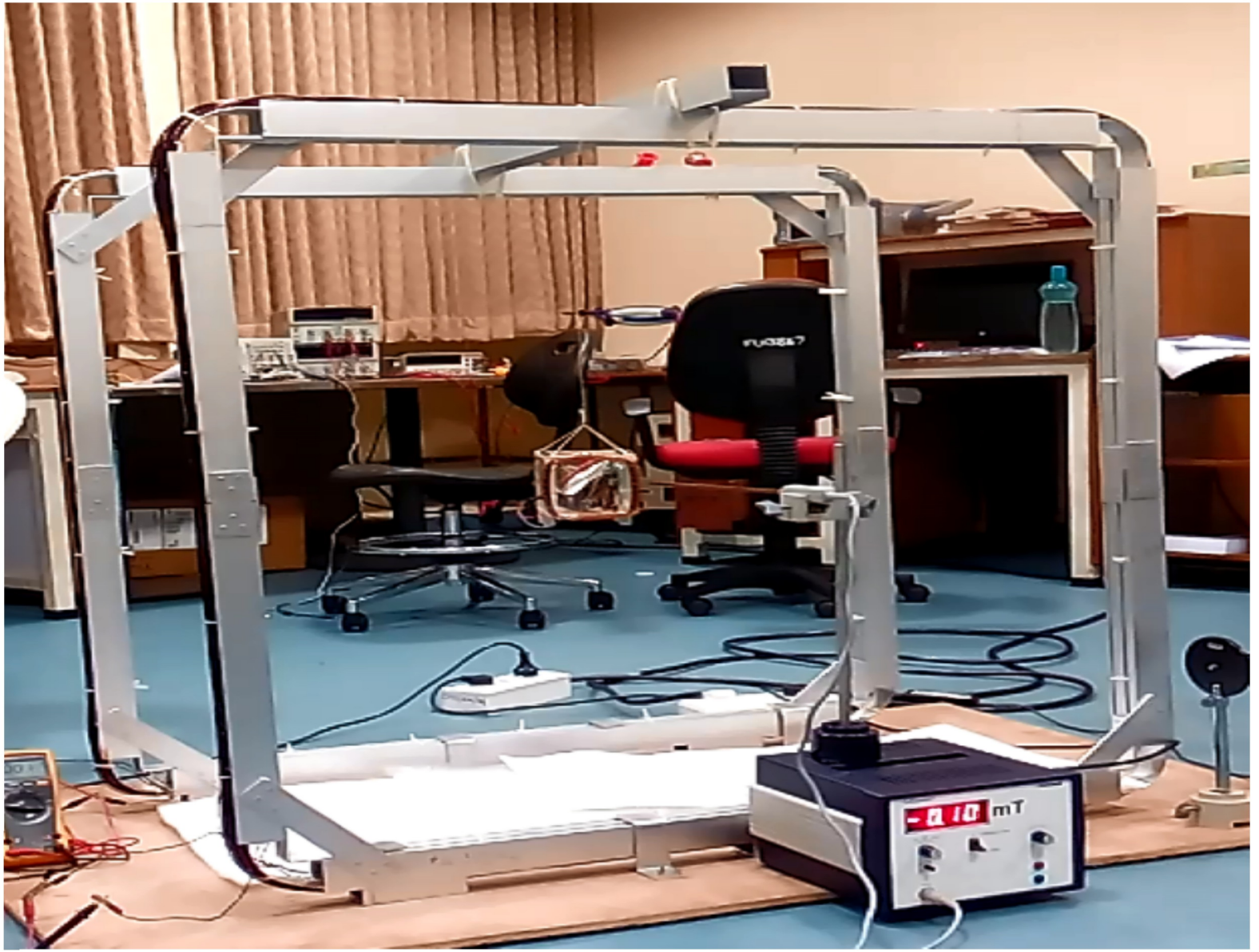
EPS ver 1

Prototype-1 of ADCS board





Test setups at IIST – Single Axis Helmholtz Coil



Test Setups at IIST – Airbearing for Reaction Wheels

Propelled by the students

Approximate number of students working on the satellite project over the years

Year	2016-2017	2015-16	2014-15	2013-14	2012-13	2011-12
B. Tech I	42 +5(Reg)	60 (Reg)	0			
B. Tech II	35 (25)	25 (15)	20			
B. Tech III	5	14	10			
B. Tech IV	6	1	2	6	3	3
M. Tech	2	1	1	1	0	0
PhD	1	0	0	0	0	0
Project Engineers	1	2	2	2	2	0

Challenges

- Retaining student is difficult
  - Most of the satellite work is done by undergraduates
  - Student work is voluntary
  - no credits for working on satellite project
- Schedules are impossible to meet
  - Students have short semester duration – 4 months
  - 3 exams per semester – no activity before and during the exams!
- Students are able to do concept products but not finished product which can fly

Challenges

- Faculty members are not experienced in understanding and designing space products
- ISRO engineers are willing to cooperate but difficult to get their time
- Poor manufacturing support from local Industries
- Funding was an issue until recently but expected to be better in future

New curriculum?

- Need a think of a curriculum which starts with space mission and ends with spacecraft hardware which can be launched
  - Should it be at undergraduate level or higher?
- What will the students do after graduating?
  - Not many space industries in India other than ISRO and a few small startups

INSPIREsat1 Experiences

- When students from different countries working on a project are put together in a same room (new place new faces)
  - the work progresses faster
  - helps in cross-cultural exchange of thoughts and ideas
- Student exchanges across university increases the enthusiasm to work

How to go ahead?

- Long term training for the professor
  - Creates a permanent resource in the institute
- Regular student exchange to boost their energy levels
- Setup credit courses for students to take up the challenges in space technology development

Suggestions for UNOOSA

- Continue to support the travel and hospitality for the candidates from “third world” for long term training of faculty member
- Discuss with all space faring nations and convince them to provide free launch facility for university satellites which are done in collaboration with local university
- Establish regional **university** centres for UNOOSA activities (IIST would like to be university UNOOSA centre in India)

Suggestions for UNOOSA

- Develop international small spacecraft standards
  - This will enable multiple universities across the countries to develop subsystems in parallel
  - Every subsystem need not be developed by each university
  - Each university can develop an expertise in a specific subsystem
  - Reduces cost

Thank You