Challenges under DISC 8

S. No	Composite Challenge S.No	Component Challenge S. No	Composite Challenge Title	Component Challenge Title
1		**1.4**		CC-SiC Throat and CFRP based Nozzle
2		**5.1**		L/P band Continuous Wave SAR payload for LEO Small satellites
3		**5.2**		Unfurlable, Electronically Steering Antenna for L/P band SAR Payload for Small Satl
4		**6.1**		Miniaturisation of Payloads (EO and SAR) for a small satellite upto 150 kgs
5		**6.2**		Miniaturisation of Payloads (IR & Hyperspectral) for a small satellite upto 150 kgs
6		**6.3**		Miniaturisation of On-board Antenna sys using Additive Manufacturing Techniques
7		**6.4**		High-speed Onboard Data Processing Technology for LEO Imaging Satellites
8		**6.5**		AI/ ML based Change Detection for Multi Payload fused Imagery Data
9		**6.6**		Motion Controller (Hardware and Software) for LEO Antenna Stations
10	**18**		**Secure Satellite Comn based Automated Info Broadcast system using Receive only User terminals**	
11		**19.1**		Development of Anti-Jamming circuits for SatPhone
12		**19.2**		Development of Anti-Spoofing Circuits for PNT services
13		**21.1**		Cloud based Geo-AI software for monitoring of Facilities/Assets using IoT data
14	**23**		**Programmable Handheld Adapter (L/S band) to convert Android Phone into a SatPhone**	
15	**25**		**Low Latency Multicast Data links for Accelerated File tfr and Video Streaming over existing SATCOM links and Remote Platforms/Sites**	
16	**26**		**Below the Noise Floor Modems in S / C / Ku band (1 Kbps to 20 Mbps) to operate within existing out/in routes on S, C and Ku band.**	
17	**27**		**Portable (Handheld/Manpack) Ku band Terminal for IN SATCOM Network**	
18	**28**		**Development of On board Processing and Beam Switching payload for ‘Ku’ and ‘Ka’ band GEO Satl for High Throughput Maritime Requirements**	
19	**29**		**Beam Steering Ku band SATCOM Antenna over IN SATCOM Network for MR Aircraft**	
20	**30**		**Compact, Light Wt, Multiband SATCOM (UHF/ S/ C/ Ku/ Ka) SDR for Ships,Submarines and Aircraft.**	
21	**31**		**Customised Remote Modem with Ruggedised FPGA based Platform with inbuilt Post Quantum Encryption for VSAT baseband for Naval Platforms.**	
22		**35.2**		Micro propulsion system for Cubesats
23		**35.3**		Hall Effect Plasma Thrusters for Spacecraft orbit corrections

Challenges under iDEX PRIME (SPACE)

S. No	Composite Challenge S.No	Component Challenge S. No	Composite Challenge Title	Component Challenge Title
1		**2.3**		Autonomous Onboard system for small LEO satellites capable of scheduling Inter-Satellite data comms with GEO data relay satellite
2		**2.5**		Beam steering Antennae for high speed Inter Satellite data links for LEO satls
3		**3.1**		Intelligent Onboard System for satellite mission planning
4		**3.2**		Ground controlled Satellite Antenna Frequency Switching Sys
5		**3.3**		Multiband RF Sensor Data Processing and Analysis solution
6	**6**		**Miniaturised Multi-Payload Satellite (EO, IR, SAR, HyperSpectral) upto 150 Kgs**	
7	**19**		**Secure, Compact, Handheld SatPhone capable of Multimedia (voice/data/image/video/PNT) Txn/Rxn**	
8	**20**		**Secure, Space based Troop/Convoy mgt platform using SATCOM at dedicated Control Centres**	
9	**21**		**GEO Satl supported IoT platform for real-time monitoring of Remote Facilities/Assets from dedicated Control Centres**	
10		**32.1**		Development of Nano and Micro Imaging Satellites for LoD
11	**35**		**Autonomous CubeSat Swarms in LEO**	
12		**35.1**		Attitude Determination and Control System (ADCS) for cubesats

The remaining 40 challenges are under various Make schemes.

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Defence Space Challenges with Description

1. Transportable/Mobile Launch System for Small Satellite (upto 650 Kgs) with integrated Launch Control Centre (*Defence Space Agency*)

Static launch sites are vulnerable to hostile actions and could be prime targets in case of hostilities. This necessitates development of transportable launchers which can be moved and deployed for launch as per convenience. It is proposed to develop Transportable/Mobile Launch Systems that can operate from ground/ aerial/ sea-based platforms to provide launch capabilities with flexibility of launch windows for different kind of payloads. The launch system should be all weather capable and be able to deploy satellites weighing upto 650 Kgs to altitudes upto 700 Kms. The system should be able to change from transportable position to 'Launch ready position" in not more than 60 minutes.

1.1 Mobile Multi Object Tracking Radar with detection range upto 250 Kms (*Defence Space Agency*)

As a component of the Challenge 1, it is proposed to develop a mobile Multi Object Tracking Radar which can be deployed on any existing suitable military prime mover or develop a suitable one, for mobile operations. This radar should have a detection range of min 250 km or more and should be able to track at least 15 objects (25 x 25 cms) simultaneously. All radar system accessories incl power system should also be integrated with the radar.

1.2 Development of modular small satellite bus for rapid integration into the launcher (*Defence Space Agency*)

As a component of the Challenge 1, it is proposed to develop a modular small satellite bus which is capable of integrating different payloads in short time for LoD purposes. The satellite bus design has to be modular for easy and quick integration with different payloads and finally with the mobile launcher with overall weight between 150-650 kgs. The design should consider the option of multiple small satellites, with in the specified overall weight and space, for integration into mobile launcher.

1.3 Small Satellite Launch Vehicle for launching Satellite weighing 150 -650kg to LEO (*Defence Space Agency*)

As a component of the Challenge 1, it is proposed to develop a Small Satellite Launch Vehicle, which can be integrated into a transportable/mobile launcher system, deployed on a suitable prime mover. The launch vehicle should be able to accommodate multiple satellite configurations with overall weight ranging between 150-650 kgs and deploy satellites upto 700 km altitudes. It should not take more than 72 hrs to prepare and launch.

1.4 CC-SiC Throat and CFRP based Nozzle (*Defence Space Agency*)

As a component of challenge 1, it is proposed to build Carbon Carbon-Silicon Carbide (CC-SiC) Throat and Carbon Fiber Reinforced Polymer (CFRP) based Nozzle divergent without metallic back-up which can withstand the thermo-structural loads for considerable performance enhancement compared to conventional ablative material based nozzle system, which demand metallic back-up to withstand the structural loads. These nozzles enable rockets for extended ranges or carry heavier payloads.

2. <u>Development of a GEO Data Relay Satellite having high speed optical Inter-Satellite Link capable of communicating with Satellites in LEO (*Defence Space Agency*)</u>

LEO imaging satellites are visible to any single GES (Ground Earth Station) for a short period of time. For rapidly increasing voluminous data download from sensors in space, necessitates more number of GES to enable complete data dump by the satellites before the next imaging session. However, the LEO satellites are visible to a GEO satellite for comparatively more amount of time and GEO satellite is constantly visible to GES.

It is proposed to develop a GEO satellite with modular TDRS (Tracking and Data Relay Satellite) payload for communicating with LEO satellites along with the pointing assembly and the power electronics. The GEO TDRS module to have a high speed Laser based Optical Inter-Satellite Link (ISL) facility. This module should be able to seamlessly integrate with a LEO ISR satellite and should be able to transmit data at rates greater than 1.5 Gbps. The TDRS to have a High Throughput System (HTS) for data downlink with GES preferably in Ku band.

2.1 <u>Highly Agile (Agility rate > 7°/sec) Small Satellite Constellation (2 Satellites) for LEO (*Defence Space Agency*)</u>

It is proposed to develop two highly agile satellites that will provide significant boost to the imaging capability compared to existing EO satellites. The challenge is to develop two highly agile platforms that can house an Optical and a SAR payload respectively. The agility to be 7°/sec or better and should be compatible with three axis stabilised satellites. The inter-spot imaging distance derived out of this agility rate should be 2 kms or less. The weight penalty of the Attitude and Orbit Control System (AOCS) should be approximately 40 to 60 kgs providing this agility rate.

2.2 <u>Development of V-band based Inter-satellite Link communication module for Small Satellites offering data rate upto 1.5 Gbps (*Defence Space Agency*)</u>

As a component of Challenge 2, it is proposed to develop a RF based (‘V’ band) Inter-Satellite Link module for small satellites in LEO to communicate with other LEO satellites and GEO satellite as part of the TDRS system. The module should be able to easily integrate into LEO satellites. A compatible receiving system has to be integrated into the GEO satellite. The data rate for this system is proposed to be upto 15.Gbps.

2.3 <u>Autonomous Onboard system for small LEO satellites capable of Scheduling Inter-Satellite Link comns with GEO Data Relay Ssatellite (*Defence Space Agency*)</u>

As a component of Challenge 2, it is proposed an autonomous on-board system for small satellites in the LEO. The on-board module would autonomously schedule Inter-Satellite Link with the nearest available GEO satellite considering the dynamic link traffic at the GEO satellite end. “Scheduling” includes all aspects of the data link, from antenna pointing to the most efficient uplink.

2.4 <u>Laser based communication system as modular payload for Small LEO satellites offering > 1.5 Gbps data transfer rate between LEO and GEO Data Relay Satellite (*Defence Space Agency*)</u>

As a component of Challenge 2, it is proposed to develop a Laser based Optical Inter-Satellite Link payload for small satellites in LEO to communicate with other LEO satellites and GEO satellite as part of the TDRS system. The system with all its power electronics should be able to easily integrate into LEO satellites. The desired data rate for this system is greater than 1.5Gbps.

2.5 <u>Beam Steering Antennae for high speed Inter Satellite data links for LEO Satellites (*Defence Space Agency*)</u>

As a component of Challenge 2, it is proposed to develop a Beam Steering Antenna with high gain and directivity, compatible for high speed Inter-Satellite data links between LEO satellites and GEO satellite in TDRS system.

3. <u>Development of Multiband Programmable RF Sensor Satellite (*Indian Air Force*)</u>

It is proposed to develop a Multiband Programmable RF Sensor Satellite which is capable of detecting RF sources (0.5-40 GHz) from LEO. Critical parameters that are to be measured from the space-based sensor include intercepted parameters comprising of emitter identification along with time of arrival, direction of arrival, frequency range for emitter (minimum and maximum with deviation), all frequency pattern (Fixed, Agile, Batch, Dwell and switch etc.), Pulse Repetition Interval and Pulse Group Repetition Interval (with all PRI pattern like Constant, Jitter, Stagger, Dwell & Switch etc.), PRI associated with each spot frequency Pulse Width, Effective radiated power of emitter along with type of Antenna Scan, Scan Rate, Polarization, Beam width (Elevation and Azimuth), Side Lobe Level (with Standard deviation), Time on Target Wave, Localisation Information (in user defined format) along with Intra Pulse data.

3.1 <u>Intelligent Onboard System for Satellite Mission Planning (*Indian Air Force*)</u>

As a component of challenge 3, it is proposed to develop an Intelligent On-board System for Mission Planning of Satellites with RF sensors. This intelligent on-board system should be able to execute missions autonomously based on inputs from ground control and collect critical RF data in an efficient manner for successful detection of various RF sources.

3.2 <u>Ground controlled Satellite Antenna Frequency Switching System (*Indian Air Force*)</u>

As a component of challenge 3, it is proposed to develop a Space based, Multi-band Antenna system for RF sensor satellites that can operate in different frequency bands, eliminating the need for separate antennae for different frequency bands. It should be configurable by a ground based control system for switching and tuning the on-board antenna for various frequency bands.

3.3 <u>Multiband RF Sensor Data Processing and Analysis System (*Indian Air Force*)</u>

As a component of challenge 3, it is proposed to develop a Data Processing and Analysis tool for multiband RF data collected by RF sensor satellites. This multiband RF data is to be processed by a ground-based processing platform and analysed using AI tools.

4. <u>Integration of Optical and Radar Sensors into a network with AI based Analytics</u> <u>(*Defence Space Agency*)</u>

Presently, the capability for detecting, tracking and monitoring satellites/ space debris is very limited. There is a need for development of an integrated optical and radar sensors network along with AI based analytical system. The developed system should be scalable in terms of addition of incremental number of sensors for credible and real time Space Situational Awareness (SSA). The system should be capable of real time monitoring and trajectory analysis of very large number of space objects, confluence analysis and collision prediction of any space object and provide timely warning and window for evasive manoeuvres.

4.1 <u>Imagery data fusion for Optical and Radar data sources (*Defence Space Agency*)</u>

As a component of challenge 4, it is proposed to develop a multi format imagery data fusion platform along with AI analytical tool which is capable of integrating the data received from multiple optical and radar sensors into a unified data set. The AI tool will analyse this unified data set to provide reliable space situational awareness.

4.2 <u>Geo-AI based Multi-Sensor Optical/Radar Equipment Siting Simulator (*Defence Space Agency*)</u>

As a component of challenge 4, a Sensor Equipment Siting Simulator is proposed to be developed which uses Geo-AI tool for easy and efficient siting of optical and radar equipment in our areas of operations. This would greatly assist in faster deployment of future sensors for optimal equipment performance.

5. <u>L/P band Synthetic Aperture Radar (SAR) Small Satellite (*Indian Air Force*)</u>

The existing SAR satellites mostly use X-band SAR, which are best suited for detection of man-made objects but performs badly with natural vegetation like foliage or forest cover. L/ P band SAR with sub-metric resolution has capabilities of foliage penetration and detection of sub-surface targets and hence, is desirable for detection of concealed targets. It is therefore proposed to develop an L/P band SAR small satellite for effective foliage penetration.

5.1 <u>L/P band Continuous Wave SAR payload for LEO Small satellites (*Indian Air Force*)</u>

As a component of challenge 5, it is proposed to build an L/P band Continuous Wave SAR payload for small satellites to be deployed in the LEO. The SAR payload would be integrated into the small satellite developed for this purpose.

5.2 <u>Unfurlable, Electronically Steered Antenna for L/P band SAR Payload for Small Satellite (*Indian Air Force*)</u>

Origami technology is a promising field to innovate various antenna designs. Origami techniques offer many interesting characteristics, including self-foldability, programmable curvature and programmable collapse. Origami technology offers very efficient and low-cost alternatives, enabling flexible and deployable antennas that were previously impossible with conventional antenna fabrication processes. Therefore, as a component of challenge 5, Origami based Unfurlable and Electronically Steered L/P band SAR antenna for a small satellite in LEO is proposed to be developed.

6. <u>Miniaturised Multi-Payload Satellite (EO, IR, SAR, Hyper Spectral) upto 150 Kgs (*Indian Air Force*)</u>

With the advancement in electronics, many payloads earlier deployed on dedicated large satellites are now being miniaturised. These payloads can be easily integrated into a small satellite with an overall weight of 150 kg. An advantage of such small sats is the ease of manufacture, low cost and ease of launch. It is proposed to design and develop a modular type small satellite, which should be able to integrate these miniaturised payloads (Electro-Optical, Infrared, Synthetic Aperture Radar and Hyper Spectral).

6.1 <u>Miniaturisation of Payloads (EO and SAR) for a small satellite upto 150 kgs (*Indian Air Force*)</u>

As a component of challenge 6, it is proposed to develop miniaturised Electro-Optical sensor (Sub metric resolution) and Synthetic Aperture Radar sensor (X band) to be integrated on a miniaturised small satellite as a single package. The developed sensors package should be able to integrate easily into a small satellite with overall weight less than 150 kgs and provide complete imagery data for on-board processing.

6.2 Miniaturisation of Payloads (IR & Hyper spectral) for a small satellite upto 150 kgs (*Indian Air Force*)

As a component of challenge 6, it is proposed to develop miniaturised Infra-Red sensor and Hyper Spectral sensor to be integrated on a miniaturised small satellite as a single package. The developed sensors package should be able to integrate easily into a small satellite with overall weight less than 150 kgs and provide complete imagery data for on-board processing.

6.3 Miniaturisation of On-board Antenna sys using Additive Manufacturing Techniques (*Indian Air Force*)

Additive Manufacturing (AM) uses data computer-aided-design (CAD) software or 3D object scanners to direct hardware to deposit material, layer upon layer, in precise geometric shapes. As a component of challenge 6, it is proposed to develop miniaturised on-board antennas for Payload data download and TM/TC communication which are to be deployed on small satellites. The AM technology is to be utilised to for fabricating the miniaturised antennas for smallsats.

6.4 High speed on-board Data Processing Technology for LEO Imaging Satellites (*Indian Air Force*)

As a component of challenge 6, the multi payload satellite in orbit will be generating a huge quantity of data. This necessitates the development of a high speed on-board processing system to analyse the generated data before sending it to the ground stations. The On-board Data Processing module should generate Level-1 products for EO and SAR payloads separately on board and directly transmit to ground.

6.5 AI/ ML based Change Detection for Multi Payload fused Imagery Data (*Indian Air Force*)

As a component of challenge 6, it is proposed to develop a AI/ML based analytics on board for EO imagery which can give change detection and also can take intelligent decisions based on the outcome of imagery analysis. The on-board AI system which analyses the data generated from different payloads to glean useful information.

6.6 Motion Controller (Hardware and Software) for LEO Antenna Stations (*Indian Air Force*)

The present satellite ground stations for LEO satellites require a motion controller module which tracks the movement of satellites during the visibility. These motion controllers have both software and hardware components. It is proposed to develop an antenna motion controller for LEO satellite antenna stations. The motion controller should be able to steer the antenna up-to velocities of 16 degree/sec or more. The building blocks like axis control cards, safety logic cards, Processor cards, high power relays (3 ph, 440 volts) of this motion controller to be indigenous. The software should be able to accept the '.tle' and related file formats with IRNSS timing signal to steer the antenna for given velocity. Remote operation of the antenna motion controller through an IP network should be possible.

6.7 Ultralight Weight, Sub-Meter Resolution Monolithic SiC Telescope as Optical Payload (*Indian Air Force*)

Silicon Carbide (SiC) is the preferred material to develop optical telescopes due to its high stiffness, low coefficient of thermal expansion and high thermal conductivity. As a component of challenge 6, it is proposed to develop a space grade optical telescope using SiC which will offer a sub metric resolution. The optical telescope should be able to integrate as a payload on a small satellite with overall weight of 150kgs.

7. <u>Quantum Encryption Modules for Secure Satellite Communication (*Indian Navy*)</u>

The present satellites use traditional cryptographic algorithms for ensuring confidentiality of data. The requirement of employing Quantum Encryption in satellite communication is the need of the hour. The quantum encryption module should be able to support standard data rates of DVB-S2 modems which are typically at 2 to 4 Mbps. The module should be in a plug and play form factor. The module should be able to interface with the existing antenna systems.

8. <u>Training Simulator for Space Activities (*Defence Space Agency*)</u>

There is a requirement to simulate space-based contingency scenarios periodically so as to train upon the requisite counter measures and also to test the efficacy of these counter measures once they are developed. It is proposed to develop a space simulator, which is a software-based training simulator specifically designed for simulating dynamic space situations. The simulator should be scalable to include many feasible scenarios and its counter measures.

9. <u>200-Watt Ka band Solid State Power Amplifier (SSPA) for Satellite Ground Station (*Defence Space Agency*)</u>

The SSPA plays a critical role in establishing the ground to satellite communication link. Currently, there are no indigenous brands available which offer Ka band SSPAs with a power rating of 200 Watt. With future satellites operating in high frequency bands like Ka which offer high data rates and most LEO imaging satellites using Ka band for satellite to ground links, it would be imperative to develop this capability as an indigenous product.

10. <u>Development of Orbital Transfer Vehicle for Space Debris removal in LEO (*Defence Space Agency*)</u>

With the number of satellites being launched by private industries worldwide, the risk of debris and its management will be a major challenge in future. There is a need to develop an OTV which can be operated in space for debris removal. This would require a space vehicle to undertake close proximity operations and development of associated guidance system for autonomous/ semi-autonomous operations. As per the debris detection, the OTV should be capable of shifting from one orbit to other in LEO. The challenge includes development of sensors such as LIDAR, EO etc and associated ground systems.

10.1 <u>Development of Space-grade Robotic Arm with Ground-Control (*Defence Space Agency*)</u>

As a component of challenge 10, a robotic arm is one of the prevalent ideas for orbital debris removal. It is proposed to develop a 3m long robotic arm, with at least 4 degrees of freedom. This arm must not derive too much power from the host satellite. It must be able to fold easily when not in use. The arm should be dexterous enough to capture even misshapen debris and release them in a designated orbit/towards Earth. Another desirable capability would be that the arm can aid in proximity operations and docking of satellites.

10.2 <u>Intelligent Object Identification System with LIDAR and EO sensors (*Defence Space Agency*)</u>

As a component of challenge 10, it is proposed to develop an AI-based system to recognise potential threats to the satellite from debris. The satellite will carry LIDAR and EO sensors as payloads, whose data will be analysed by the on-board AI tool to predict approaching debris for collision avoidance and for providing inputs to the proximity and docking operations.

11. <u>Innovative Space Applications of Fourth/ Final Stage of Launch Vehicles (*Indian Air Force*)</u>

The last stage of a rocket after separation of spacecraft will be loitering in the outer space for considerable time, before eventually becoming debris. This stage could be converted into a short-term satellite bus for experimental payloads. Integration of an ELINT or EO payload to the final stage of the launch vehicle is proposed as a challenge. The necessary on-board support elements for controlling and extracting the information from the payload would also need to be developed. The challenge should include the required protection mechanism for the payloads during the rocket operation and its deployment on demand.

12. <u>High Throughput Communication Satellite in LEO with User Terminals (*Indian Air Force*)</u>

At present communication satellite services availed through GEO has inherent disadvantages in terms of its known location and latency. It is proposed to develop a LEO constellation of two satellites for extending satellite communication services. The payload configuration could be 'Ku' or 'Ka or higher bands of microwave spectrum to accommodate high data rate applications. End-to-end solution is envisaged, with ground control systems and hub infrastructure. Multiple SDR based user terminals could be planned depending upon operational utility with data rates better than 100 Mbps. The user terminals could be static, airborne and mobile.

13. <u>Development of Network Management Port (NMP) for efficient SATCOM Bandwidth Management using multiple Satellites (*Indian Air Force*)</u>

Towards effective utilisation of SATCOM bandwidth, a centralized dynamic bandwidth allocation centre (i.e., Network Management Port) to be developed, wherein the bandwidths are assigned to needy user as per user segment capability. Initially 'C' & 'Ku' could be optimized for centralized allotment. Network Management Port should have the complete control over the bandwidth available from all the satellites, with a network of multi band antennas for different satellite. Demand prioritization could be done at space port. A certain amount of unused bandwidth could be kept as reserve to meet emerging requirements. A unified Network Management System has to be developed for converting various user segment protocols into a standard/common protocol for efficient resource allocation.

14. <u>On Orbit Maintenance and Refuelling (OOMR) technology in LEO (*Indian Air Force*)</u>

Existing satellites be it communication, ISR or PNT will become non-operational once its fuel is exhausted or in case of a malfunction to the component/ sub-system. The concept has significant advantages as the spacecraft or the payload of a satellite could be serviced by a service module for refuelling the spacecraft thereby enhancing its mission life, service/replace an unserviceable module and integrate/ replace an out-dated component with an advanced component. Therefore, it is proposed to develop this OOMR technology for future satellites in LEO.

14.1 <u>On Orbit Propellant Storage and Transfer system (*Indian Air Force*)</u>

As a component of challenge 14, it is proposed to develop a space based, on orbit refueller for LEO satellites. This would necessitate transferring fuel from tanker satellite to the receiving satellite. Given the micro-gravity conditions and the extremities of the environment, space grade fuel storage and fuel-transfer system have to be innovated.

14.2 <u>Autonomous Docking Operations for OOMR (*Indian Air Force*)</u>

Refuelling, maintenance and upgrading operations in orbit requires precise rendezvous, proximity and docking operations. As a component of challenge 14, it is proposed to develop an AI-based system for these critical operations. Using data from the various payloads, the AI should autonomously calculate and complete the proximity operations, as per the mission objectives.

14.3 <u>On Orbit Space Infra maintenance and upgrade operations (*Indian Air Force*)</u>

As a component of challenge 14, it is proposed to develop mechanism to perform in-orbit maintenance of space infra and upgrade operations of satellites/payloads. Sometimes, certain payloads may not work as desired, or may reach their end-of-life. As the satellite is still operational, it is cheaper to undertake maintenance activity to replace the payload via another satellite.

15. <u>Development of a Computer Defence System for Cyber Situational Awareness to Secure own Satellites from Cyber Attacks (*Indian Air Force*)</u>

The existing satellites have limited capabilities to withstand sustained EW or Cyber-attacks. With space being increasingly contested, it is matter of time that space assets become more prone to EW and Cyber-attacks by adversaries in a hostile climate. There is a need to identify vulnerabilities in the current satellites to develop EW and Cyber suites that overcome these vulnerabilities. Such suites will have to be incorporated in future satellites to make them EW and Cyber hardened. Therefore, it is proposed to develop EW and Cyber hardening suites for incorporation in LEO and GEO satellites.

15.1 <u>Cyber hardening Suite for Satellite Communication links/Hubs (*Indian Air Force*)</u>

As a component of challenge 15, it is proposed to develop a hardening suite that is capable of automatically detecting security weakness in communication links and Hub infra. This technology should have the potential to identify hackers interfering and controlling links or breaking into a ground station or tampering with user terminal and sending malicious inputs. All attack vectors of cyber domain including injection attacks, replay attacks, spoofing attacks etc should be prevented by the system.

16. <u>Modular, Multi payload Configurable VLEO Bus (*Indian Air Force*)</u>

VLEO is Very Low Earth orbit, which is usually populated by small satellites. These satellites are low cost but carry certain payloads from which useful information can be derived. It is proposed to build a VLEO satellite bus, which is modular, low cost and easily integratable with multiple payloads, should have efficient propulsion system to effectively perform housekeeping operations and also achieve the mission life. This satellite bus should be able to carry miniaturised payloads, depending on the mission requirements.

16. 1 <u>Ultra High-Resolution Optical payload with Edge Computing for VLEO Bus (*Indian Air Force*)</u>

Edge computing is a distributed information technology architecture in which client data is processed at the periphery of the network, as close to the originating source as possible. As a component of challenge 16, it is proposed to develop an ultra-high resolution optical payload to be deployed on a VLEO satellite along with Edge Computing based On-board processing system. This on-board edge computing tool should be able to process huge data received from UHR payload of VLEO satellite.

16.2 <u>CBRN Threat detection and Monitoring Sensors for VLEO Bus (*Indian Air Force*)</u>

Space based surveillance has the capability for early warning and detection of any CBRN activity on ground. Space based sensors will act as the primary triggering layer for early detection of these CBRN activities. As a component of challenge 16, it is proposed to develop specific sensors for detection and identification of CBRN (Chemical, Biological, Radiological, and Nuclear) activities and their sources. The sensors should be easily integrated into the VLEO satellite bus.

16.3 HySIS Payloads for VLEO Bus (*Indian Air Force*)

As a component of challenge 16, Hyper Spectral Imaging Spectrometer (HySIS) payload is proposed to be developed for satellites to be launched in the Very Low Earth orbit (VLEO). The challenge also includes real-time processing of data and storage of the data generated. This payload may be miniaturised for deployment on smallsats.

17. Advanced Extremely High Frequency (AEHF) GEO Satellite for Secure Communications (*Indian Air Force*)

AEHF satellites provide a network of encrypted, jam-proof communications for strategic for tactical secure communications. It is proposed to develop an AEHF GEO satellite which should capable of handling ten times more data than the existing rate and feature advanced encryption technology.

18. Secure Satellite Communication based Automated Info Broadcast system using Receive only User terminals (*Indian Army*)

Right info at right time to field forces is a vital element in operations. Hence, a secure Information Broadcast System using Receive only Terminal to combat teams in field is proposed. This broadcast system should have high data rate (greater than 1Mbps) with small form factor, ruggedized Receive only Terminals, operating in S band and powered by a battery offering backup time of 2 hrs. The broadcast system should be able to transmit images, text messages and small video to dedicated terminals.

19. Secure, Compact, Handheld SatPhone capable of Multimedia (voice/data/image/video/PNT) transmission/reception (*Indian Army*)

Communication-on-the-Go (COTG) is an inescapable requirement for agile troop deployments. Hence there is a requirement of user terminal which is capable of supporting voice/video/images/text and PNT info being transmitted on a single form factor. Hence, it is proposed to develop a secure, compact, handheld SatPhone terminal to support secure communication protocols. The SatPhone has to be complaint with MSS standard of satellite communication. The handset should be capable of:

- SATCOM – Enable voice and msg comn
- PNT – Be able to receive and transmit Satl NavIC Data.
- ISR – Capability to receive satl imagery and terrain/ weather updates.

19.1 Development of Anti-Jamming circuits for SatPhone (*Indian Army*)

As a component of challenge 19, the developed SatPhone may be susceptible to jamming from various ground-based and space-based systems. In this regard, it is proposed to develop anti-jamming circuits to be incorporated in the SatPhone under development.

19.2 Development of Anti-Spoofing Circuits for PNT services (*Indian Army*)

As a component of challenge 19, the PNT data being received may be spoofed to deceive the user. In this regard, it is proposed to develop anti-spoofing circuits, particularly for PNT services, which would be integrated with the SatPhone under development.

20. Secure, Space based Troop/Convoy management platform using SATCOM at dedicated Control Centres (*Indian Army*)

Asset and Convoy/troop movement is essential for both operational and logistics management. The Armed forces operate in a rugged and inhospitable terrain where in the tracking of deployed troops or assets becomes challenging due to the topological conditions. In view, a pervasive network footprint offered by SatCom could prove beneficial for such geo-tracking applications. Hence, it is proposed to develop a SatCom based tracking solution. The solution should have two elements namely, user element and logging element.

User element:

- small form factor terminal that can be carried by mobile teams/ vehicles
- able to transmit its positional information (like PNT) to a centralised server using the GEO SatCom link

Logging element:

- Server along with requisite storage for archiving and displaying the positional information transmitted by various user terminals
- host a display GUI which can plot the received PNT information on a digital map at a central location

21. GEO Satellite supported IoT platform for real-time monitoring of Remote Facilities/Assets from dedicated Control Centres (*Indian Army*)

Facility monitoring assumes critical importance in both civil and military parlance. Many installations store a variety of equipment/stores, each requiring specialised storage and environmental conditions. Any deviation of these environmental specifications could be detrimental /hazardous. This becomes challenging when the storage facilities are located at remote locations. Hence a remote monitoring and control solution, based on Internet of Things (IoT) would be ideally fulfilling the requirement.

An IoT based Sensor-Control loop working on SatCom backhaul is proposed to be developed. The solution should be able to offer the Machine-to-Machine (M2M) communication with SatCom backhaul links working on GEO satellite. The solution should be able to relay the sensor data to a central location for archiving and analytics. The central solution should be able to achieve automatic control action without human intervention in a near real-time manner. The solution should be capable of accommodating a large number of sensors. The sampling data rate of sensors should be customisable by users.

21.1 Cloud based Geo-AI software for monitoring of Facilities/Assets using IoT data (*Indian Army*)

As a component of challenge 21, it is proposed to develop cloud based Geo-AI software to monitor the facilities using the IoT data. IoT data which is stored in a secure cloud has to be utilised by this AI software for effective monitoring and quick decision making during contingencies.

22. Development of V/UHF Handheld Satellite Software Defined Radio (SDR) (*Indian Army*)

There is a requirement of indigenous handheld V/UHF Satellite SDRs to be utilised in remote areas in Indian Subcontinents. Desirable features are as follows: -

- Total weight incl battery – below 500 gm.
- Programmable V/UHF Freq band.
- SCA 4.1 or above compliant.
- Data Rate – Min 8 Kbps at all times over entire band.
- MANET Compatibility.
- Fall back mode for connecting to terrestrial TETRA/ UHF station.
- Support communication on the move the speed up to 60 Kmph.

23. <u>Programmable Handheld Adapter (L/S band) to convert Android Phone into a SatPhone (*Indian Army*)</u>

It is proposed to develop a programmable handheld adapter, which can convert an android phone into a SatPhone using micro USB Type C or Bluetooth. The indigenous hand held adapter device should have following features:-

- Total weight incl battery – below 500 gm.
- Programmable L / S Band.
- Interface – Micro USB / Type C and Bluetooth.
- Data Rate – Min 2.4 Kbps at all times
- Talk time – 2hrs (min) (Assuming phone is completely charged and is capable of supporting this talk time parameter)
- Standby time – 10 hrs (min)

24. <u>Lightweight, Compact Ka band User Terminals for mobile Ground & Airborne platforms (*Indian Army*)</u>

Data rates from SatCom are dependent on the frequency band of operation. Higher bands offer higher data rates with a trade-off of attenuation and processing complexity. However, with a greater user demand for higher bandwidths in coming future, the move towards higher frequency bands like ‘Ka’ is inevitable. But the challenge lies in using Ka band SatCom for platform with high mobility. This is because at high speeds and frequently changing orientation of platform, the doppler shifts induced are great and need to be compensated with signal processing techniques.

Low mobility Ka band terminal:

- Data rates up to 16 Mbps for speeds ranging up to 60 Kmph (min).
- net antenna weight should be no more than 50 kg
- less than 75 cms in length and the overall volume (excluding the volume of battery bank) should be less than $0.1875m^3$
- BUC power range of 40W to 50W.

High Mobility Airborne Ka band Terminal:

- Support data rates up to 2Mbps at a speed of 400 Kmph with random acceleration of (+/-) 4g.
- net weight including antenna should be no more than 10 kg
- overall volume (excluding the volume of battery bank) should be less than $0.1m^3$
- BUC power range of 12W to 20W.

25. <u>Low Latency Multicast Data links for Accelerated File transfer and Video Streaming over existing SATCOM links and Remote Platforms/Sites (*Indian Navy*)</u>

The present SatCom infrastructure is designed for TCP / IP traffic acceleration and does not specifically address the mail / FTP and video streaming. This results in congestion / latencies in the network. Hence, it is proposed to develop a low latency multicast data link with the following requirements:

- low latency multicast accelerated mail / FTP and video streaming for the IN SatCom network
- multicast over the DVBS 2 / 2x network (for one to many transmission)
- transfer of large files over FTP / mail attachments
- For video streaming it should be able to multicast HD over the network with gradual graceful degradation as per network bandwidth
- enhance the performance of existing video calls
- based on server client model

- operate in the dense EMI / EMC environment of naval platforms and should comply with relevant standards
- stand the marine environment

26. <u>Below the Noise Floor Modems in S / C / Ku band (1 Kbps to 20 Mbps) to operate within existing out/in routes on S, C and Ku band (*Indian Navy*)</u>

The existing baseband are based on DVB S2 standard. The in routes / out routes are prone to interception. Further, for sub one meter terminals there is a requirement for spread spectrum to comply with extant ITU regulations for transmitting antennas. Therefore, it is proposed to develop a baseband system which has spread spectrum technology implemented so that the transmissions from the remote modem are below the noise floor of the spectrum of operations. The system should have following requirements:

- work in server client mode with the Hub having server mounted system and the remote terminals having individual modem
- work in various data rates from 2.4 Kbps to 256 Kbps (allow for voice / data and video)
- work over the existing SatCom network i.e. the remote terminals and the indigenous satellite

27. <u>Portable (Handheld/Manpack) Ku band Terminal for IN SATCOM Network (*Indian Navy*)</u>

Presently, there are limited hand held / man pack / portable Ku band SatCom terminal. Therefore, it is proposed to develop a portable Ku band terminal with following requirements:

- Handheld/ Manpack
- Provide voice and messaging services
- Light weight and deployable by single person
- Self-powered as well as able to take external source
- Self-contained and should not require any external reference
- Inbuilt encryption which should be quantum proof
- Operate over the existing IN SatCom network

28. <u>Development of On-board Processing and Beam Switching payload for 'Ku' and 'Ka' band GEO Satellite for High Throughput Maritime Requirements (*Indian Navy*)</u>

There is a need to have a Ku/Ka band High Throughput Satellite for maritime requirements. This will require multiple spot beams with terminals operating in different beams, being switched over using on-board processing and beam switching. It is proposed to develop on-board processing and beam switching payload with the following requirements:

- Programmable, able to be configured / updated / upgraded from ground
- Requisite security protocols including encryption
- Compatible with ISRO satellite bus / standards and should be space qualified
- Protocols for ground terminals including modules to be incorporated in the ground terminals

29. <u>Beam Steering Ku band SATCOM Antenna over IN SATCOM Network for MR Aircraft (*Indian Navy*)</u>

The present terminals are mechanical with gimballed antenna units. This makes the equipment heavy and not flush with the hull of the aircraft. It is proposed to develop light weight equipment with beam steering technology requiring no mechanical steering. It should be air qualified. The terminals should operate over existing IN SatCom network

30. <u>Compact, Lightweight, Multiband SATCOM (UHF/ S/ C/ Ku/ Ka) SDR for Ships, Submarines and Aircraft (*Indian Navy*)</u>

Presently, separate terminals exist for operations over different bands. Each equipment requires space for locating its own antenna and has its own RF / IF / Baseband hardware to integrate with the SatCom network. This takes up space and causes blind arcs / loss of services in certain orientations. It is proposed to develop an equipment which should be light weight and able to operate over all frequency ranges of UHF / S / C / Ku / Ka band and should be able to use SDR concept for integrating with the SatCom network.

31. <u>Customised Remote Modem with Ruggedized FPGA based Platform with inbuilt Post Quantum Encryption for VSAT baseband for Naval Platforms (*Indian Navy*)</u>

The present VSAT baseband is based on COTS DVB S2 standard and equipment is of foreign make. It is proposed to develop indigenous equipment which can be realized by having a ruggedized FPGA based platform for baseband. This ruggedized FPGA will go into the remote modems as well as the baseband servers in the Hubs. It would be feasible to configure the FPGA as per user requirements as well as enable encryption on the baseband.

32. <u>Modular SSTO Launch Vehicle System (Land/Sea launch) with Configurable Satellite Integration Mechanism for Launch on Demand of Small Satellites (*Defence Space Agency*)</u>

Single Stage to Orbit (SSTO) launch vehicles employ non-conventional propulsion and have modular architecture. These launch vehicles have single stage which employs only a specific fuel and hence are restricted by their payload capacity. However, they have an all-weather launch capability and can be readied in record times. Hence, the challenge involves developing a Single stage to Orbit Rocket that employ's only green propulsion and can carry payloads upto 150 kgs to 400 Kms altitude. The launch vehicle should have modular design and should be assembled in 48 hours.

32.1 <u>Development of Nano and Micro Imaging Satellites for LoD</u> <u>(*Defence Space Agency*)</u>

Nano and Micro satellites give the flexibility of multiple satellites deployment in a single launch meeting the specific mission goal. COTS components make the fabrication, integration and storage of these satellites much easier. Hence, it is proposed to build a Nano and a Micro imaging satellite with EO / SAR payloads with a swath of around 10 kms and resolution of around 0.8 mtr for EO and 1.0 mtr for SAR.

33. <u>Modular TSTO Launch Vehicle System (Land/Sea launch) with Configurable Satellites Integration Mechanism for Launch on Demand of Small Satellites</u> <u>(*Defence Space Agency*)</u>

Two Stage to Orbit (TSTO) launch vehicles have the ability to propel to LEO heights and can be assembled in short times. Moreover, these launch vehicles have reduced launch costs and have high mobility factor. The challenge involves developing a Two Stage to Orbit Rocket that can employ either green propulsion or conventional propulsion and can carry payloads upto 500 kgs to 400 Kms altitude. The launch vehicle should have modular design and should be assembled in 72 hours.

33.1 <u>Development of a Mini Imaging/Communication Satellites for Launch on Demand (LoD) (*Defence Space Agency*)</u>

Mini satellites are the game changers for future missions due to their quick developmental times and modular designs. The LoD option would require compatible mini satellites for quick integration into the launch vehicle. Hence development of one mini communication and one mini imaging (EO/IR) satellite for integrating into the LoD launch vehicle is proposed as a challenge.

34. <u>Develop a High-Resolution Ground based Optical Telescope with Aperture size of 1-3m (*Defence Space Agency*)</u>

Ground based optical telescopes are essential for sourcing the inputs for Space Situational Awareness (SSA). Optical telescopes have shorter developmental time lines and can be developed in a cost effective way, thereby helping for building sovereign Space Sensor Network capability in shortened time lines. It is proposed to develop a HR optical telescope which should be able to detect and track space objects (minimum size 10cm x 10cm) accurately

35. <u>Autonomous CubeSat Swarms in LEO (*Defence Space Agency*)</u>

A 1U Cubesat is about 10 cm X 10 cm X 10cm and satellite weighing 1.33kg. An advantage of a Cubesat is the ease of manufacturing, low cost and easy scalability. Therefore, an autonomous Cubesat swarm (20 satellites) with swarming capability is proposed to be launched in LEO for remote sensing mission.

35.1 <u>Attitude Determination and Control System (ADCS) for Cubesats (*Defence Space Agency*)</u>

The Attitude Determination and Control System (ADCS) is crucial to any space mission that requires pointing to achieve the mission goals. The purpose of this subsystem is to estimate the actual orientation of the Nano satellite in space, i.e. its attitude, and to change it, if necessary. In order to perform these functions, the Nano satellite needs a hardware which has sensors and actuators. As a component of challenge 35, it is proposed to develop ADCS for the CubeSats.

35.2 <u>Micro propulsion system for Cubesats (*Defence Space Agency*)</u>

CubeSats require micro propulsion devices to deliver precise low thrust “impulse bits”. As a component of challenge 35, it is proposed to design and develop tiny nozzles that release minuscule bursts of water vapor / noble gas based on capillary action to manoeuvre the spacecraft very precisely.

35.3 <u>Hall Effect Plasma Thrusters for Spacecraft orbit corrections (*Defence Space Agency*)</u>

Hall-Effect Thruster (HET) is a type of ion thruster in which the propellant is accelerated by an electric field. The applications of Hall-effect thrusters include control of the orientation and position of orbiting satellites and used as a main propulsion engine for medium-size robotic space vehicles. It is proposed to develop this system for cubesat applications.