Work Report: From 15th December 2016 to 15th October 2018

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**HIGHLIGHTS OF THE CONTRIBUTIONS DURING THIS TENURE**

1. Satellite constellation design for ISRO-CNES maritime surveillance and ship detection
2. Novel approach to manage solar glint for OCEANSAT-2 & 3
3. HRSAT constellation design and analysis for systematic coverage and daily revisit
4. Sun synchronous satellite constellation design at 500 km altitude
5. Orbit decay analysis for various satellites
6. Active participation and support during T &E, pre-launch and post launch operations of IRS satellites
7. Participation and presentation of papers in various seminars and conferences (6 papers submitted out of which one paper received best research paper presentation award)

**CONTRIBUTIONS DURING THIS TENURE IN DETAIL**

**Satellite Constellation Design and Analysis**

***ISRO-CNES Maritime Analysis***

* Design of Satellite constellation was carried out to monitor and track ships in the Indian latitudes (-40o to +40o latitude).
* Independent analysis was carried out to obtain the number of satellites required for 6-hour coverage. The results were verified and validated with respect to the constellation proposed by CNES.
* Alternatively, a new satellite constellation is designed to obtain 6-hour revisit with minimum number of satellites.
* Satellite constellation has been designed for various payload swaths that includes 100 km, 200 km, 400 km and 800 km.
* Microwave payload as well as optical payloads were considered for the analysis.
* The designed satellite constellation consists of two layers for payload swath lesser than 400 km. The first layer gives daily coverage and second layer targets any location within 6-hours (revisit)
* For payload swath equal to or greater than 400 km, a single layer constellation is proposed to obtain 6-hour coverage, thereby achieving the revisit.

***HRSAT (High Resolution Satellite)***

* Orbit constellation studies have been carried out extensively for 3 satellite and 6 satellite constellation (with optical payload), to meet daily revisit and systematic global coverage requirement.
* Initial analysis was carried out near 660 km altitude, from the analysis, a 650 km altitude sun-synchronous - hopping type orbit is proposed to obtain coverage and daily revisit with minimum roll tilt.
* Further, a detailed analysis was carried out to identify orbits around 450 km and 560 km altitude to get better resolution images.
* The analysis revealed a 484 km and 562 km altitude sun synchronous orbits. Both the orbits meet the systematic coverage and daily revisit requirements with 42o and 38o roll bias respectively.

***Satellite Constellation Design at 500 km altitude***

* The present CARTOSAT-2 series satellites are placed in a 505 km altitude sun-synchronous orbit. With all four satellites the CARTOSAT-2 constellation can give systematic global coverage for every 93 days.
* A preliminary analysis revealed that the number of days required for global coverage is higher for 4 satellite constellation.
* Therefore, a detailed design analysis was carried out to identify feasible orbits near 505 km altitude.
* From the analysis, a 502 km and 517 km sun synchronous orbit has been identified to achieve systematic coverage within 73 and 75 days respectively.

***FSBS-3***

* The primary requirement of this constellation is to monitor any given location (in the region of interest) within 3-hours.
* A preliminary design study has been completed and the results were filtered for finer analysis to reduce the number of satellites and to improve the revisit time.
* An optimization algorithm is being developed in MATLAB specifically for this constellation design, keeping number of satellites and revisit time as objective functions.

**OTHER ANALYSIS**

**Solar Glint Management Strategy – OCEANSAT-2 & 3**

* It is observed that the OCEANSAT-2 images are affected by solar glint thereby global and local coverage requirements are not met.
* Therefore, a software was designed and developed to compute glinted region and the computed results are validated with the real data.
* A novel approach has been proposed to manage the solar glint with payload roll tilt mechanism.
* Though the number of roll tilts are restricted, the proposed method uses only 200 tilts per year obtain glint free images.
* In addition to that, the new approach ensures global area coverage in 4 days and local area coverage in 2 days.
* A detailed report has been generated and presented in the Ground Segment meeting.

***Orbit Decay Analysis***

* Orbit decay analysis for TRISHNA (ISRO-CNES joint venture) satellite series, was carried out for 666 km and 761 km altitude sun synchronous orbits.
* A generic study to bring out the local time variation (RAAN) effects on orbit decay for a 630 km altitude orbit has been carried out.
* Orbit decay analysis for HRSAT constellation was carried out for different orbit altitudes varying from 450 km to 660 km.
* Orbit decay analysis for MICROSAT-2 at an altitude of 350 km was carried out for different launch years (from 2019 to 2024) and for various drag areas (from 1 m2 to 4 m2).

***GSAT-18 Signal Loss Analysis***

* Signal loss is observed during May and August 2017 in different user locations, therefore, an analysis has been carried out to study the effect of orbit parameters on sensor trace.
* The analysis was carried out using a commercial software STK and an in house developed visualization tool kit (SOAVT).
* From the analysis, it is observed that the satellite sensor trace is slightly oscillating away from certain user places. This oscillation was maximum during May and August of 2017, therefore the users could have experienced signal reduction/loss.

***MOTR (Multi-Object Tracking Radar) Analysis***

* Analysis was carried out to find optimum locations all around Indian region.
* A preliminary analysis using STK software was carried out to identify the ideal locations to establish/implement MOTR to track spacecraft and debris in the low earth orbits.

**Algorithm Development And Support Activities**

***CARTOSAT/P5***

* An algorithm has been developed for payload calibration.
* The algorithm was structured to give the orientation of a reflecting surface such that the solar emission from the reflecting surface will re-direct the sun rays towards the satellite payload.
* It is useful for payload calibration. The data obtained from the software was tested successfully in NRSC, Hyderabad.

***CARTOSAT-2D, 2E, 2F and MICROSAT***

* Actively supported during Level-0 Internal and Ground Segment External T&E 1 and 2, initial phase and payload operations at NRSC, Shadnagar.
* Actively supported during the implementation and ATP activities at User station - DEAL, Dehradun.

***INS-1B***

* For EELAA payload a software has been developed to provide time, latitude, longitude and sun elevation/zenith angle of the satellite for the given epoch.
* Developed Frame kernel and Instrument kernel for EELAA payload.
* Provided support during launch activities at ISTRAC.

**General**

***SOAVT (Satellite Orbit Attitude Visualization Toolkit) Software***

* Graphical depiction of satellite constellation, orbit traces, ground trace and satellite swath
* Actively participated and supported during TDP review, internal T & E and installation at MCF, Hassan
* Demonstration for GSAT-9, GSAT-17, GSAT-19, IRNSS-1H and IRNSS-1I at MCF, Hassan

***ISRO INDUCTION TRAINING PROGRAM – BATCH 29 (IITP-29)***

* IITP-29 participation from October 24th, 2017 to January 25th, 2018.
* IITP-29 project on “Satellite Constellation Design through Exhaustive search” presented at Satish Dhawan Auditorium on 30th January 2018

**Publications/Papers**

1. *“Multi-objective Optimization of Hybrid Airship”* in SIG-MDO (Special Interest Group of Multi-Disciplinary Design Optimization) at VSSC, Trivandrum, Jan 21st and 22nd, 2017 – Oral Presentation.
2. “*LEO Satellite Constellation Design for Earth Observations*”, 3rd, ISSE National Conference – INAC03, SS0030 – Oral presentation at SCL, Chandigarh, on October 12th and 13th, 2017.
3. “*Orbit Selection Analysis for CARTOSAT Constellation*” in Satellite Technology Day – 2018, ISAC - submitted
4. “*New Conceptual Design for Flight Dynamics Level - ‘0’ System*” in Satellite Technology Day – 2018, ISAC – submitted
5. “*Airships for Satellite Data Acquisition and Disaster Management*”, SPARK-2018, ISAC – abstract submitted
6. “*Satellite Constellation Design Through Exhaustive Search*”, 4th International Conference on Recent Challenges in Engineering and Technology (ICRCET-18) 2nd & 3rd April, 2018, Pune, India – presented - **This paper has been awarded as “The Best Research Paper Presentation” of the conference.**

**Technical Notes and Documents Released:**

1. Technical note: *“Survey on various Landers and Rovers using SPICE kernels”*, January 2016
2. Technical Report: *“Oceansat-3 OCM Payload Solar Glint Computation and Avoidance”*, *ISRO-ISAC-OCEANSAT-3-PR-2827* – Technical Report/Document, March, 2017
3. Technical note: *“Note on Glint Management for OceanSat-2”,* April, 2017
4. Technical note: *“Study on Daily Repeat Orbit and Maneuver Strategy for IRS-P6”*, May, 2017
5. Technical note: *“SOAVT software installation guide”*, May, 2017
6. Technical note: *“HRSAT Orbit Constellation Design*”, July & December, 2017
7. Project Report: “*Satellite Constellation Design*”, IITP -29, Project report, January-2018
8. Technical note:“*OCEANSAT Glint Management Strategy Using +/- 20 Deg Pitch Tilt*”, February, 2018
9. Technical note:“*HRSAT New Hoping Orbit Proposal*”, March, 2018
10. Technical note:“*HRSAT Orbit Constellation Design - Consolidated - Note*”, May, 2018
11. Technical note:“*ISRO-CNES Satellite Constellation Design*”, June, 2018
12. Technical note:“*Solar Flux Prediction Analysis in Comparison with Observed Data*”, Doc No: 25/D/29/FDG/2018/01, Dated: 31/08/2018

Things I forgot to add

1. Microsat-2 revisit analysis and the technical note (Doc. No: 25/D/29/FDG/2018/02)