A DISCUSSION ON DATA COLLECTING SATELLITES REPLACEMENT IN BRAZIL

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***Abstract**: This paper addresses a discussion on data collecting satellites replacement in Brazil to improve the performance at system level and guarantee the space segment continuity. The National Environmental Data Collecting System (SINDA) is composed of two dedicated small data collecting satellites (SCD-1 and SCD-2), two data receiving stations, more than 800 Data Collecting Platforms installed over Brazil, and a data collection mission center for message processing, archiving and distribution, which was created and have been operated by the National Institute for Space Research – INPE. The space segment being proposed and studied is intended to be a candidate to replace the Brazilian Data Collecting Satellites SCD-1 and SCD-2, respectively launched in 1993 and 1998, which are still operational in orbit and whose data are being used by 100 organizations . The discussion comprises the system use as well as the main applications and previous results about the determination of the best low earth orbit (between 700 km and 800 km) orbital constellation configuration to provide one hour or less satellite visibility for any ground platform located in the Brazilian territory.*

***Key-words**: satellites, data colleting system, space segment, orbital constellation,replacement.*

1 Introduction

Brazil effectively starts its satellite developments almost 30 years ago with the establishment of the Brazilian Complete Space Mission - MECB. The objectives were the development of a satellite launcher vehicle, and four small satellites, two of them dedicated to environmental data collecting and the other two for Earth´s remote sensing. The first MECB satellite, named Data Collecting Satellite – SCD-1, having 115 kg mass, was launched on Feb 9th, 1993. The second MECB satellite, the SCD-2, was launched on Oct 22nd 1998. Both SCD-1 and SCD-2 satellites overcome their designed lifetime and are still operational in orbit. The SCD-1 and SCD-2 satellites are part of the Data Collecting Environmental System.

The Data Collecting Environmental System has nowadays more than 800 ground Data Collecting Platforms (DCPs), spread over the Brazilian territory, continuously transmitting environmental data to the SCD-1 and SCD-2 satellites. These data are relayed back by the mentioned satellites to two Ground Reception Stations (Cuiabá and Alcântara), from where the data is sent to the Data Collection Mission Center (CMCD) (Cachoeira Paulista) and distributed to the final users.

This paper addresses a discussion on data collecting satellites replacement in order to provide improvement and maintenance of the Data Collecting Environmental System.

2 Data Collecting Environmental System

The Data Collecting Environmental System is composed of two small data collecting satellites SCD-1 and SCD-2; two data receiving stations located at Cuiabá and Alcântara; more than 800 DCPs installed over Brazil; and a data collection mission center (CMCD) located at Cachoeira Paulista for message processing, archiving and distribution.

Each DCP transmits to the satellite in UHF-band and the satellite retransmits the data back to ground receiving stations in S-band (SCD-1, SCD-2). The DCPs messages are stored in receiving stations. After a satellite pass, the stored messages are transferred to the CMCD, where they are processed and distributed to the users via Internet [4].

As the SCD-1 and SCD-2 satellites have an orbit period of 100 min., each satellite passes over the Station 8 times a day, and with the two satellites, an average of 15 passes over the Station per day. The SCD-2 Right Ascension of ascending node is 180 degrees with relation to SCD-1, this permits a satellite pass over the Station at least each 100 min [3].

3 Data Collecting Environmental System Applications

The Data Collecting Environmental System was developed to feasible the utilization of space technologies in support of a large community of environmental data users in Brazil, in areas as identified by [2]:

- Hydrology;
- Meteorology;
- Oceanography;
- Atmospheric Chemistry;
- Water quality;
- Civil Defense;
- reservoirs level Monitoring of power plants;
- Environmental Monitoring.

The Data Collecting Environmental System is structured as the following segments:

The Space Segment consists of satellites with a data collecting payload.

The Ground Segment has the responsibilities of monitoring and controlling the satellites, and receiving, processing and distributing the payload data. To realize these objectives the Ground Segment comprises: the DCP Networks; the Satellite Control Center (CCS); the Ground Segment Data Communications Network (RECDAS); the Data Collection Mission Center located in Cachoeira Paulista-SP; and the Cuiabá and Alcântara Stations.

4 Current Space Segment Main Characteristics

The current Space Segment is constituted by the SCD-1 and SCD-2 satellites. The Table 1 presents general characteristics of the SCD-1 satellite and the Table 2 presents the SCD-2 satellite characteristics.

Table 1 – SCD-1 Satellite Characteristics

MASS	115 kg
DIMENSIONS	100 cm base diameter 80 cm height
STABILIZATION	Spin 120 rpm (initial)
ORBIT	Circular at 750 km 25° inclination 14 orbits/day minimum
TT&C	S Band, ESA Standard Lifetime 1 year
PAYLOAD	DCP Transponder RX: 401.65 MHz 401.62 MHz TX: 2.26752 GHz , PM
LAUNCH DATE	February, 9th 1993 (operational)

Table 2 – SCD-2 Satellite Characteristics

MASS	117 kg
DIMENSIONS	100 cm base diameter 80 cm height
STABILIZATION	Spin AT 34 rpm
ORBIT	Circular at 750 km 25° inclination 14 orbits/day minimum
TT&C	S Band, ESA Standard Lifetime 2 years
PAYLOAD	DCP transponder RX: 401.65 MHz 401.62 MHz TX: 2.26752 GHz , PM
LAUNCH DATE	October, 22nd 1998 (operational)

5 Space Segment Preliminary Proposal

The microsatellites constellation configuration (SCDs N) is intended to replace the current space segment, which the main objective is to provide continuity and improvement of the services being provided by the Data Collecting Environmental System to its users, through the replacement of the SCD-1 and SCD-2 satellites, which have their lifetime expired since more than 10 years ago.

In this sense, also to improve the Data Collecting Environmental System performance at system level. Thus, there are some important aspects to take into consideration:

The mass and size reductions can contribute directly to reduce the launch costs, making feasible to build a Walker constellation having two orbit planes and two microsatellites per orbit plane as reported below.

Associated with the significant mass and dimensional reductions, there are important onboard functionalities that can be incorporated in the microsatellites constellation, which were not provided by the SCD-1 and SCD-2 satellites, like onboard data storage and capacity for onboard demodulation and decodification of the signals received from the ground Data Collecting Platforms (PCDs).

6 Preliminary Coverage Analysis Results

A comparative analysis was performed in order to determine the orbital configuration that would provide the best coverage of the Brazilian territory. The analysis objective was to minimize the access time between ground platforms and microsatellite. It was considered in this analysis parameters like the number of orbital planes; number of satellites per orbital plane; right ascension longitude; and orbit inclination. It was also considered that the microsatellite shall be spin stabilized, therefore, the following orientations of its spin axis were considered: spin axis nadir oriented at equator crossing; and spin axis north oriented.

In the following is summarized the orbital analysis results to define the number of orbital planes and number of microsatellites per plane. In the results shown, the satellite antennas are parallel to the spin axis and located in the north and south sides of the microsatellite, with the spin axis north oriented. The following parameters were considered as input for the analysis:

- Constellation type: Walker;
- Walker Parameter: 1;
- Orbit Altitude: 750 km;
- Orbit Inclination: 20o to 30o;
- Number of Orbital Planes: 2 and 3;

- Orbit Eccentricity: 0o;
- Right Ascension of Ascending Node: 50o;
- Transmitter Antenna Half Cone: 80o;
- Satellite Spin Axis Orientation: North;
- Minimum Elevation Access Angle: 5o.
- Analysis duration: 1 day.

Table 1 summarizes the simulation results. The simulations were performed using STK/AGI™ software. The highest possible coverage of the Brazilian territory, minimizing the number of orbit planes and number of microsatellites, and meeting the requirement of having access time between microsatellite and any PCD less than one hour, is given by "Case 1", shown in Table 4.

Table 4: Coverage analysis results for two and three orbit planes and two or three microsatellites per orbit plane

Case	Orbit Inc. (deg)	Number of Orbit Planes	Number of Satellites per Plane	Brazilian Territory Coverage (%)
1	**20**	**2**	**2**	**77**
2	25	2	2	66.10
3	30	2	2	51.91
4	20	3	2	86.51
5	25	3	2	93.15
6	30	3	2	95.90
7	20	2	3	78.38
8	25	2	3	64.68
9	30	2	3	54.72
10	20	3	3	86.51
11	25	3	3	91.15
12	30	3	3	95.90

No significant change in the above results was verified for long duration analysis (60 days) and orbit inclination variations from 20° to 34°.

7 Conclusions

This paper addressed the preliminary results of a microsatellites constellation configuration carried out to demonstrate the possibility of replacing the Brazilian Data Collecting Satellites (SCD-1 and SCD-2).

The preliminary orbital configuration analysis results show that it is possible to cover 77% of the Brazilian territory, with an access time lower than one hour for any PCD. The proposed microsatellite configuration also opens the doors for future applications where the PCD identification would be necessary, as for example, animal's route and position tracking.
The improved constellation would assure, not only the future continuity of the Brazilian Data Collection System, but also enable an increased quality on the provided services

8 References

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