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Satellite Operations Management, Nigeriasat-2 Experiences and Challenges

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Abstract: **Launching satellites and maintaining a mission while in orbit is a procedural and expensive activity. It is therefore imperative; satellite operations are designed to suit mission requirements so that operational activities are planned and managed properly. The earth station design and mission control planning are con-currently conducted with satellite payload and platform design and development. This strategy will ensure adequate testing of both satellite and ground facilities prior launching into the desired orbit. In this paper, Nigeriasat-2 ground segment management experiences and other contemporary satellite ground operations principles are reviewed. The challenges and variations among different satellite category are discussed. The paper provide a comprehensive requirements needs for successful ground station management operations including human requirements and satisfactory layout structure based on practical experiences for an effective mission operation.**

Keywords: **Satellite, Operations, Management, Challenges, Nigeriasat-2.**

1. INTRODUCTION

Satellite mission project involves several number of activities from mission requirement specifications up to the end of the vehicle life time in orbit. Space system engineering project will require the system modules specification, design and manufacture, modules integration and testing and finally launching the spacecraft into the designed orbit. The satellite design and mission operation design are two activities that move con-currently up to a final stage when the manufactured and integrated satellite is functionally tested and launched into space.

However, achieving a satellite in orbit could not meet a mission objective without successful designed mission operation centre for the life time of the vehicle in orbit. In space mission operations centre design, tasking challenges are involved in driving the required hardware and software modules that are conforming with the designed payload and platform. Basic operations involve payload mission control, attitude control and stabilisation, frequent and scheduled spacecraft updates and daily monitoring of spacecraft health and functionality. Space mission operation remains an on-going activity to the end of mission lifetime and passivation of the space vehicle.

There are four standard operational plans required for a spacecraft mission. *Launch* and *Early Orbit Operation (LEOP)*, *Commissioning Operations*, *Mission Operations* and the *End of Life* operational activities. *LEOP* is the initial phase of operation which includes launch operations, signal acquisition, initial attitude acquisition to place the spacecraft into safe mode. *LEOP* operations usually last within a week. Experience from N2, N1 and NX satellite missions shows that at least two ground stations are required to effectively achieve this operational phase of any satellite mission. This is so because at the initial stage of the spacecraft in orbit, there is no stability and communication time and contact with an earth station is un-predictable. *Commissioning Operations* activities include functional platform testing, payload testing and performance measurements, and validation of customer requirements. This operational phase can last up to thirteen weeks and can be less when a pair of control stations are used. *Mission Operations* activity include routine operations, periodic payload characterisation and orbit maintenance. *Mission operation* activity continuous up to the end of the mission designed life time. *End of Life* activity involve passivisation of spacecraft and or expelling the unused fuel to reduce debris risk. This activity usually last for a week.

Satellite ground segment(GS) can either be for communication or earth observation (Remote sensing) satellite. Satellite earth stations (ES) are designed and built to achieve a specific mission objective. However modern ES function and operate for a number of satellite missions. This technology will require several number of software and hardware configurations that allow implementation of operations for a mission at an instance. Software programs are automatically set and configured to prepare for a particular spacecraft operation such as tracking at its specific or prioritised time. This process is usually applied by sending pre-configured commands to the spacecraft to allow its resources to be utilised at a specified time [1]. Satellite missions are basically classified based on mission objectives and the type of hosting orbit in space. Two basic ESs types are described in section 1.1 and 1.2. This paper is organised into four sections, apart from section 1 which is introduction, the remaining sections include section 2 satellite operation management, section 3 and section 4 are conclusion and references respectively.

1.1. Satellite communication Earth's station.

The ground segment of a communication satellite employ a several and different design nodes and network configurations in order to provide and manage services delivered to end users. The design nodes in the networks ranges from large earth stations used as gateways in a telephone network via VSATS (Very Small Aperture Terminals) that deliver data communication application to remote business locations. These VSATS can be in the range of 60cm to 2.8m. Also, included are low-cost end user communication devices such as desktop, mobile handheld telephones and direct broadcast satellite home receivers. The broad range of ground components and systems employ many of the same hardware/software technologies found in modern telecommunication and broadcasting networks that are the core of terrestrial wireless and internet services.

Figure 1 illustrates a typical satellite communication ground segment. The space segment consisting of orbiting communication satellite and the control system.

Operators of geostationary (GEO) space ground segment includes INTELSAT, Society of European Satellite (SES), GEAmerican communications, Panitmsat , EUTELSAT, companies such as GlobalStarLLLC, ICO Teledesic and Japan satellite Telecommunication (JSAT) [2].

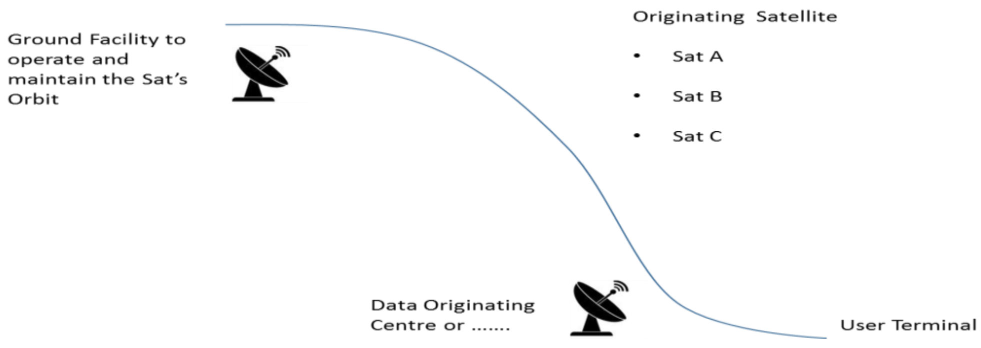

Figure 1: Typical satellite communication ES

1.2. Remote sensing satellite (RS) Earth's station.

The Remote Sensing operational ground segment refers to satellite for earth observation missions. Majority of these satellites are sun-synchronous orbiting satellite at low earth orbit. The space segment of earth monitoring satellite can be controlled using one or more ground segment. It's ground segment basically perform payload or mission activities which allows earth images to be captured by the satellite. The Segment also monitor the health status of the space segment using telemetry, telecommand and control operations. Major components of a complete Remote Sensing Earth's Station include antenna systems and the control electronics, spacecraft control and monitoring software and hardware systems, payload and

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mission control systems and data processing and archiving systems. The number of these components and configurations usually changes depending on the mission objectives and number of satellites that are hosted by the Earth Station. Modern ground segment now are configured with automatic operation with reduced amount of human intervention. The automation of the system functionalities has increase safety in the operational functions with reduced cost.

Ground segment can be linked with other ground segment or data repository systems for data collection to efficiently maximize the satellite capacity of mission activities. Figure 2 shows that maximum utilization of Sat-A with on-board memory capacity of 4GB is obtained by employing a second GSN-A2 for data downloading activity at target TA1. Figure 2 can be improved by employing spacecraft with real-time download capability. In this situation, the spacecraft power, it's configurations capacity including human personnel, station location are the limitations in the ground station performance. Power requirements are calculated and specified for the entire space craft lifetime. The antenna facility may be an X–band or S–band or other different frequency bands which determines the bandwidth requirement for download.

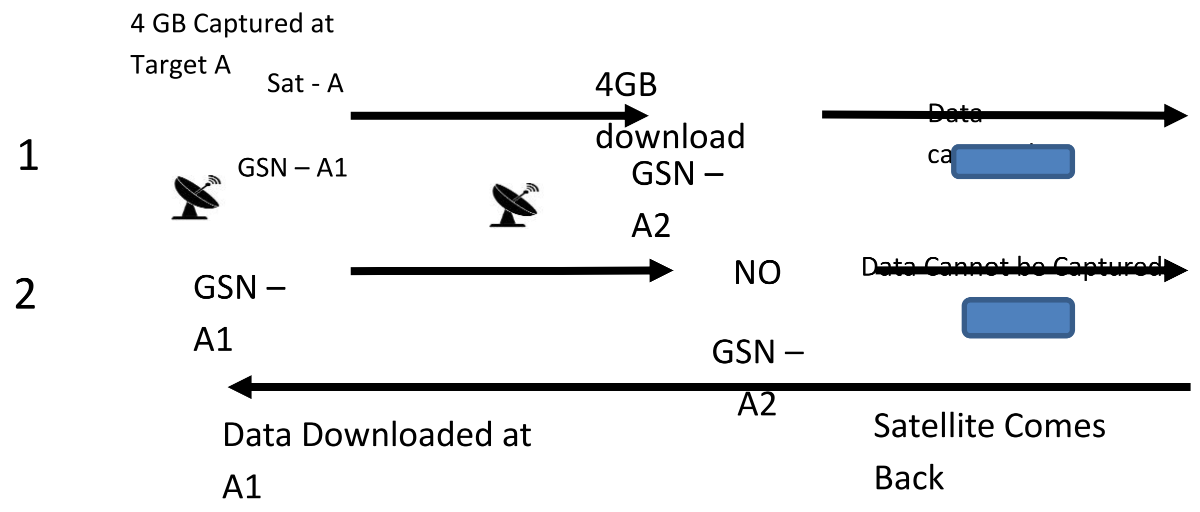

Figure 2 -1. Two Earth Station (GSN-A1 and GSN-A2) for download 2. One ES (GSN-A1) only for download

The facility location is useful in determining how many times in a day spacecraft can be at a latitude with high elevation angle that can allow data download.

Another aspect that can influence the performance of spacecraft data download is an optional compression from payload planning application; for instance, on-board compression can be chosen for A1, A2 and A3 group of application but not group A4, A5 and A6. This will actually depend on the final user request. Users for geological investigation, environmental monitoring, mapping and agricultural activities may differ in data format requirement [1]. However power budget of the mission and requirement resources will determine the suitability for this concept implementation.

2. SATELLITE OPERATIONS MANAGEMENT

Satellite operations management involve, the overall mission management from LEOP operations to the passivation of spacecraft or expelling the unused fuel. The overall management is usually assigned to an experienced personnel with a sound knowledge of ES from requirements, development and operations. Other personnel for routine operations and orbit maintenance are assigned duties based on their experiences. It is usually necessary for all personnel managing an ES to undergo a special training detailing the basic functionalities of the ES systems and how they are operated and maintained. section 2.1 and 2.2 describe standard activities and the required human resources.

2.1 Standard Operational Activities

The main activities that are involved in operations include spacecraft control and monitoring which comprises of organising spacecraft schedules for upload. The scheduling usually includes daily request for telemetry data for monitoring the health of the spacecraft, spacecraft attitude and orbit maintenance, spacecraft tracking schedules which include transmitters/receivers and payload daily in-orbit operation. The mission operation can differ in remote sensing and

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geostationary satellites. In geostationary mission, the main operations are the spacecraft control and monitoring and maintenance of terrestrial mission activities while in remote sensing satellites, additional operational activities are carried out which mainly include mission operations and payload characterisation and calibration. The payload periodically captures data of earth's target of interest and is downloaded at the station. Further activities in remote sensing satellite are, data capturing and archiving, image data processing to remove errors and restore data to its natural state. The data is further processed to a standard format for distribution to application users. Figure 3 summarised the required standard activities in both the ground station for a communication satellite and remote sensing satellites.

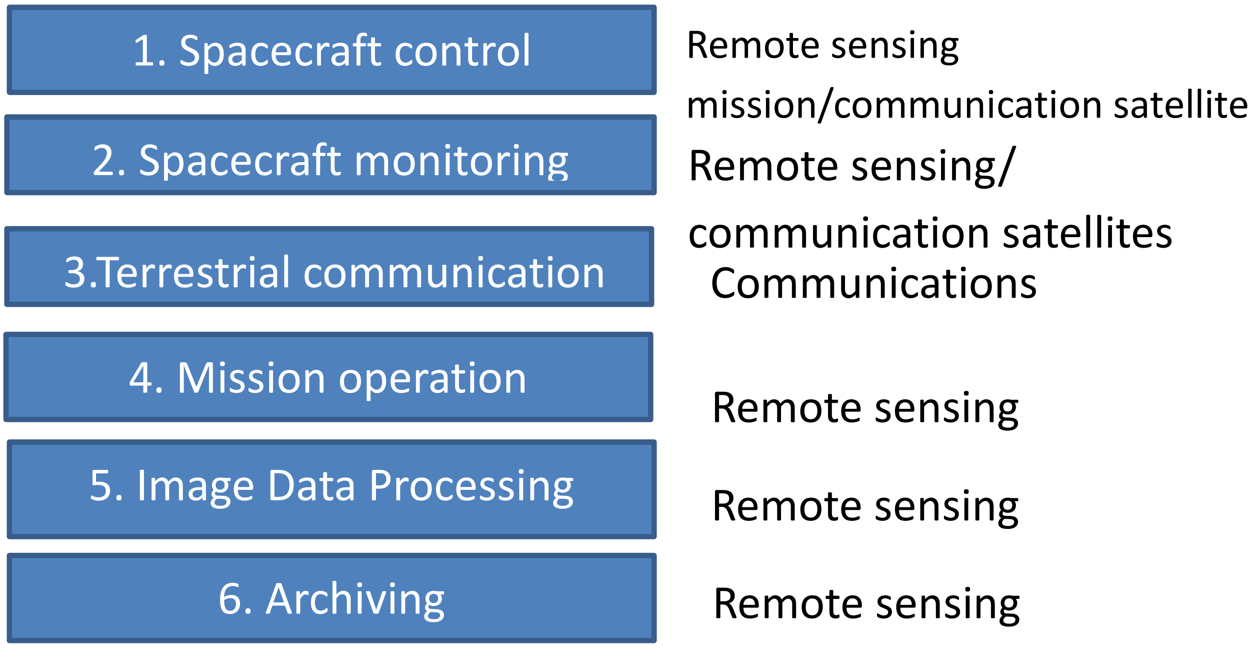

Figure 3: Standard operational activities in Satellite Earth Stations

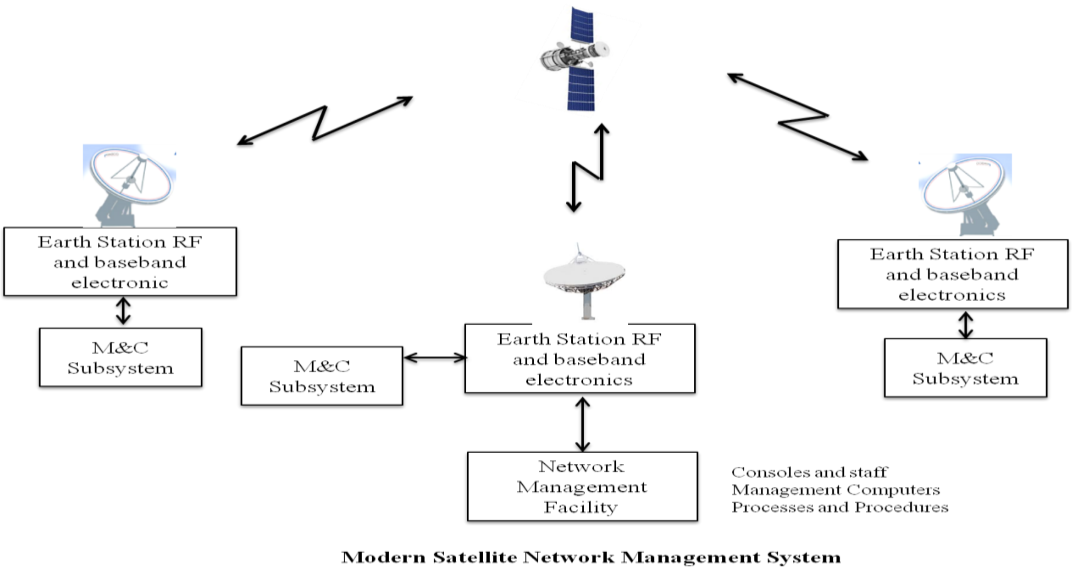

Fig 4

2.2 Mission Operation Team Size and Responsibilities

The number and size of operation team depend on the mission design and complexity. Satellite missions where automation techniques are used, the number of employed personnel will be reduced. Automation techniques now allow operators to receive any abnormality on the spacecraft via mobile phones text messages and email. The automation techniques reduce the number of personnel at a time and allow staff to only interact with the system when necessary.

In geostationary satellite for communication mission operation a minimum of twelve people are required per spacecraft to operate and supervise the whole mission. Department of Defence (DOD) operation team is a size of about twenty-seven people per spacecraft and ESA operation team size is about twenty people [3]. The team in each of the agency and the department perform the same task for a one mission spacecraft. However, the size varies due to the mission demand and philosophy of the organisation. The Nigeriasat-2 mission operation team made up of about fifteen engineers and scientist. These number of staff include power maintenance staff, mission operation, Antenna maintenance, spacecraft and orbit control.

The personnel consist of Ground segment manager (GSM), spacecraft control operation team, mission planning operation team and antenna system team. The GSM is the supervisor of all the team including power and maintenance team. The GSM assigns responsibility to the team. His responsibility is to ensure that operations for each spacecraft pan are assigned, the team responsible for antenna equipment are specified, and the team responsible for payload task operation and processing the data at the end of data download are designated [4].

3. VARIATIONS AMONG SATELLITE OPERATIONS

The frequency of operations varies and is based on the mission type, orbit and the objectives of the program. In satellite communication mission the major and most frequent orbit operation is to ensure satellite station and orbit stability. This type of manoeuvring can happen within several weeks of time depending on telemetry received, the orbit, satellite position and direction as well as solar panels direction and performance determine the natural drift and the required station manoeuvre for the platform. The performance and behaviour varies from mission to mission since every mission is configured with a specific and required size and weight of solar panels as well as other mechanical structure.

Another important factor is the visibility issue of a satellite at a particular ground station. When a satellite is in the ground station’s antenna line of sight, it has the opportunity of establishing communication. The signals are communicated during this period of time. The start of the visibility is called acquisition of signal (AOS), and the end is called the end of signal (EOS). During this time interval, the pointing of the antenna must be suitable to obtain a good data. During its visibility window, each satellite has the opportunity to establish a data transmission link, called DDO (Data Downlink Opportunity). When one the presence of more than one satellite is taken into account, or a constellation of satellites, the contacts can be free of conflicts, and sometimes cannot. This complication requires appropriate action to circumvent them. In this case some orbit adjustment is done to avoid conflicts where necessary a downlinking priority is assigned for one of the satellites. Each satellite has a visibility cone-shaped area, which depends on the altitude and antenna specifications. The projection of this cone in the ground is called footprint. To optimize this problem of conflict, a number of ground stations can be used.

4. CONCLUSION

In this research work, a significant industrial experiences on satellite mission management and operation are discussed. It serves as an essential reference and documentation for new and experienced satellite operators and Earth Stations management personnel. Challenges involving Multi-Ground station functionalities and how the limitations of station affect data throughput and system capability. The paper also discussed and highlighted the major components specifying the principles and requirements of an effective operation of an Earth Station in both communication and remote sensing satellites.

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