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THE OPTIC SYSTEM REQUIREMENTS OF NAVIGATION SATELLITE TO COMMUNICATE WITH THE HUMAN ASSETS ON THE MOON

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Abstract

The lunar missions need a permanent system design in which the functions shall be linked with the requirements of the information and communications system in deep Space. This system integrates the assets from the Moon and the one from the different orbits on Earth. The capabilities to use the electromagnetic techniques to exchange data is known thanks to the computation of line budget and the initial conditions to emit and to receive the signals. To go further to the system and the human presence on the Moon, the functionalities available on Earth should be used to the Moon for exploration with robots, for facilities to built the first human outpost. It exists the observation, telecommunication functions and the navigation functions integrated in the satellites. The combinaison of these functions improve the process on the ground for many purposes. The GPS and others navigation system like Galileo, Beidu or Glonass shall be available to send signals to the orbit and the lunar surface. The electromagnetic signal is not enough to support the requirement to the Moon. Indeed, the quantity of data shall be higher to ensure the availability of the system. The use of the laser through the optic system embedded provide the means to send data to the Moon to support the assets planned with the Artemis missions and the robots on the surface. At last, its utility shall be more suitable in Space for the filter of Earth atmosphere should create the interferences. It involves to transform the nature of the signal by the components inside the navigation system.

Keywords: optic, Moon, navigation

1-Introduction

The objectives of this work is to underline the optic communication able to be used in a Moon transmission through the GNSS constellation integrated with the Earth ground segment.

2-Methods

2.1- The optic system architecture to the Moon

The humanity assets on the Moon are represented by Spacecraft with humans and robots in a restricted area and by the exploration of its far side. It exists several projects to put human on the Moon through the facilities : energy provider, village based on regolith, robotnauts, astronauts with exosqueleton to carry heavy burden. All this projects are connected without understanding the specificity to create a colony in another planets in a context where the gravity and the climat environment is far way of what our brains are prepared. That's why, the technology road map to the Moon shall integrate the unusual process to put humans on this context [1]. If the transportation have been solved, the time to stay in Space Moon environment should be written by test bed engineering by installation bricks.
Each one shall provide both a scientic and economic interest in regard of the budget need to go to the Moon. The test bed engineering infrastructure should be installed antennas. Indeed, the antennas functions are various aand its depends on the forms : transmission and communication improvement, test the permanent facilities, look at the quantum link budget in Space, the use of signal to study the Moon structure through the Deep Space networks or support the manoeuver assets going to the Moon.
The Deep Space networks shall be linked with others means to ensure the data transmission for the robots and the crew orbiting out of the trajectory known close on Earth. The GNSS constellations are the nodes useful in the futur Lunanet to the Moon [2]. Moreover, the number and the variety of assets in Space contributes to think the operations management to monitor the data. And the electromagnetic spectrum offers the optic capacity to extent the signal information electromagnetic management and the flow of data.

Most space missions use radio frequency communications to send data to mission control. Radio waves have been used in space communications since the beginning of space exploration. Launched on 7 December 2021, the Laser Communication Relay Demonstration payload is aboard the US Department of Defense Space Test Program Satellite 6 (STPSat-6) begin transmitting data via infrared lasers.
The solution proposed is to exploit the infrared fraction of the electromagnetic spectrum by means of photons. The information is transmitted in the form of hundreds of millions of short light pulses every second. Space laser communication uses infrared rays in the range of 3THz to 3000THz. Morevover, NASA's Deep Space Optical Communications (DSOC) is experimented as th first demonstration of optical communications beyond the Earth-Moon system. It consists of a flight laser transceiver, a ground laser transmitter, and a ground laser receiver. New advanced technologies have been implemented in each of these elements.
The main advantage of using laser communication is to being able to transfer data at a speed between 10 and 100 times faster than that of current communication systems, is its greater bandwidth compared to radio frequency waves. The data transfert shall provide the management of the robots on the Moon easier. This means that while the transmission area of a radio frequency transmitter can be up to 160 km, a laser can transmit data through narrower and tighter beams.
The optical wavelengths offer the technical features for the figur of merit. The diffraction is low and the beam spreads less giving the possibility to re-create the signal. For a Gaussian beam, the beam diverges as a cone of total angle $2\lambda/ \pi w0$ with w0 the original width. The point is the way to organize the optic architecture between the assets in Space and the ground taken account the signal information electromagnitc management including different carriers and physical environment.
The gateway between the Earth, Space and the Moon is composed of the particules and the molecule actiong as filter or biological firewall. In the computation of the budget line, the data processing include the spectrum analysis with the quantum requirement in the behaviour of the signal including cybersecurity. The quantum cybersecurity describes the methodology and the tools to manage the polarization of binaries to initiate, by the light, the communication and the transmission of data. The main purpose is the capacity to support the exchange of huge data with better speed for future Space mission and to ensure the integrity of data.
The quantum cybersecurity means the capacity to secure with new technologies introduced in the Spacecraft through the concept of computer in Space with or not the quantum network. The networks use the electricity to send and to receive a signal including data.This transmission works at speed of light using the properties of physics through its celerity. Moreover, the electromagnetic wave provide the energy of the transmission for an information encoded. Before the transmission by the light, the information is encoded by binaries.
The Space networks integrate the light of vacuum and the one uses within the Spacecraft on orbit. It means the encoded information is sensible to the radiation to the allocation of binaries. In a context of the satellites begins to use quantum technology on board, the cybersecurity should understand the behaviour of particle physics at the moment where the information encoded is carried by the properties of light, the electric and magnetic field and the photon. In this context of system architecture in Space where the connectivity needs new generation of communication and information system, the biomimetic as the XNAV processing algorithm demonstrates the use of X-ray pulsar sources from Space to initiate the signal processing. As the sources are based on the photon particles from detectors, the information and communication system should be improved by using the matter information theory through the vacuum energy. The architecture of XNAV telecom system can be deployed on Earth orbits and in Deep Space by limiting the means to get the energy required for the systems and the sub-systems. The protection of these networks is reliable with the quantum cybersecurity principles.

3-Discussion

3.1- Communication in Space

Space exploration uses the specific requirement to manage signal for the probes, the spacecrafts, the suits of people in Space. The handbook of these requirements is described through the Deep Space Network. The station data owns several parameters to ensure the signal in Space and as data source for the dissemination to the mission control and the infrastructures. The role of the receivers determine the capacity to forward the quality of data to manage the probes in Space. These receivers holds on band X, band S, and earlier band Ka. Between these frequencies, the variation of the distances are able to move from few million kilometers to several dozen million kilometers. Considering the telecommunication equation, the key parameters shall be taken account into the line in budget in Space are the frequency, the modulation, the correction based on the algorithm, the energy conditions. The international organizations as telecommunication International Union and the Consultative Committee for Space Data Systems provide the frameworks to apply the line of budget. The common modulations are BPSK, QPSK and

OQPSK. The specific communication in Deep Space uses the Gaussian Minimum Shift Keying. The size of the antenna and the capacity to gather them in a networks give the transmission on uplink and downlink between the probes and the ground segment [3]. It results the figur of merit to evaluate the performance of the system[4].
The science of data in Space combines the monitoring of spacecrafts, the radiation data on its instruments and mainly the ones coming from the electromagnetic spectrum. To prepare the Space mission analysis, data is a requirement to provide the operational steps until the Space design. Unlike the Big data on the ground segment, the data incoming from Space is to be considered as huge. The huge data consists of the data far away from the big data known in the ground. Thanks to the first Black Hole image in 2017, Space mission analysis and design from the ground provide a way to understand how to manage the huge level of data. If new Spacecrafts like CubeSat, NanoSat are able to observe the ground as the classical satellites, the geospace observation in the Deep Space gives data for Space mission analysis and design through the specificity of Space geography.
The huge data techniques for Space operations can be understood as several ways. Those from the Spacecraft in Space like GAIA telescope, Rosetta probe, and those on the ground to design Space. The Space data means the need to describe the characteristics of Space geography links with the data lifecycle, the data dimensions, the New Space requirements, the Space territory and the ground segment relationship to manage and design the mission. Then, the conditions of Space geography imply the data volume, the algorithm to deal with data in Space combined with data in the ground segment. Moreover, the Space geographic representation introduces data in the matters information theory with other dimensions. Otherwise, through this representation, the Space geographic territory can be analyzed to detect, to observe an geographic object in deep Space. That's the way where this huge data process considers geospace as a territory itself in which the data sets techniques provide the key factors to analyze and design a Space mission.
The historic cycle of economic innovation moves on to Space with the opening of new commercial routes. The support of new cycle is the networking of the orbits through the new generation of satellites and the smaller carrier rockets. The networking in Space is based on the information and communication system connected with the ground stations on Earth. And above all, Internet by Space provides the framework to improve the exchange and to stimulate the activities of territory on Earth. The new actors make innovation to complete easily the accessibility of the Internet service by Space. The trend is also combined with the need to secure the networking in Space to the ground with the existing domains to maintain the functionalities of the services. These conditions associated with the exploration dynamic give the parameters to open and consolidate the new commercial through Space.

3.2- The assets of on the Moon
The Artemis and Chang'e missions introduce the operational concepts close to Apollo mission. The necessary gap to be considered is the lunar ecosystem which should be deployed on the Moon. The security and the safety should require the methodologies completed to the Moon missions[5]. The scenarios to send materials can be described by several use cases taking account the lunar orbit and the gravity. The purpose being to ensure the security and the safety of preliminary logistic deployment.
The significance of the results from the work demonstrates by the gravity equation the proof of concept for the Moon deployment. The impact should liberate the materials or put them on the surface with a structure which could protect the sensors, small robots and others. The example of flight data recorder matches with the gravity equations. Considering a flight recorder around 7 and 8 kilos composed by titanium and silicon stainless steel which is able to resist at 1400°C during 30 minutes and the 1300 data parameters which can stored, this material represents the proof of the requirement able to demonstrate that a crash simulated on the Moon is possible. Moreover, the flight data recorder can resist at an acceleration of 3400 g during 6,5 milliseconds. On Earth, the crash of planes happened in the context of gravity more important than the Moon.
The ratio is to 9,81/1,622 = 6,04. It means the mass of an object doesn't change between Earth and the Moon. And the acceleration shall be less strong on the lunar surface. Taking account the gravity, the result of the maximum acceleration can be deduced from the ratio 3400 * 6,04 = 20 536 g. This order of magnitude underlines that the rocket crashing on the Moon shall resist theorically at 20 536 g. For the flight data recorder, 8kg on Earth represents 8kg on the Moon. The point is that the gravity on the Moon will make this mass 6,04 times lighter. The requirements to sent any optic materials on the Moon retain the principle of the mass is no the matter [6].
The advantage of this space operational solution give two interests. First, the materials can be tested on real time on the Moon for a long period with no connection with a mission from Earth. Once more with Iot solution, the materials could be monitored and identified by the crews on the surface or on orbit. For the robots, the test can be done directly

from the orbit with the capacity to use them for simple or complex purpose. The scenario of the mission can be described into several typologies :
- the first should be the scientific missions in which the necessary materials include sensors on the Moon surface to collect the features of the day at the location point chosen for the base. It concerns the temperature variation, the unexpected events like space weather able to destroy life by any kind of waves or by meteor. The sensors can be simple card as the hardening Rasberry Pi and robots in order to study how manage them from the Earth to build the primary installation.
- the second should be the telecommunication missions in which the permanent network between the Earth and the Moon ecosystem shall be linked to ensure the connectivity with the sensors and the robots.
- the third should provided the medium capacity of the base to ensure its protection and its autonomy for two weeks. The common point is the crash site must be fixed with a rate of faillure around 100 meter close to the Moon installation.

4-Conclusion:

The density of the information and communication assets to sustain the missions back to the Moon shall combine the different means. The optic solution with others technologies shloud improve the capacity to get more materials on the Moon and to manage at distance the assets on the Moon to implant the facilities.

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