SpaceOps-2023, ID # 109

THE DESIGN PROCESSING FOR THE OPERATIONS ON THE MOON : THE RAMS FRAMEWORK APPLICABLE ON THE MOON

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Abstract

The missions back to the Moon need to think the lunar operations away from the requirement on Earth. The Apollo missions introduce the way to send humans on the Spacecraft out of Earth with a touchdown on the surface to another planet. Now, the processing design operations shall push the requirements to response at the permanent human occupation on orbit and on the lunar surface. The baseline should taken account of the lessons of Apollo mission completed by the one linked with the technical requirements to get infrastructures on the Moon. To sustain life on it, the operational management shall have in more the facilities on Earth a lunar segment. This segment should fill the requirements of ”RAMS” to support the life processing in a long term context. The information and communication system should include a specific design processing differently from the Earth. Indeed, the vacuum put on the line equipments and configurations where the matter acknowledge shall take into account. The design processing could adopt the operational lunar methodology as a baseline for futur installation to planets in our solar system. The lunacyber methodology includes speficic functions in the ”RAMS” framework between Earth and the Moon which are initiated by Lunanet. Considering the Moon itself, the functions shall also get the robotic requirements in addition to those from humans presence on the lunar surface.

Keywords : Design, Moon, RAMs

1-introduction

The objectives of this work is to propose from the lunar ecosystem incoming the framework applicable to ensure the safety od Moon operation.

2-Method

According to the Moon's environment and the features of installation, the applicability of RAMs methodology for people and materials shall take account the requirement of the distances. The feed back of the operational mission will be useful for the RAMs model to the Moon[1]. And the infrastructure already existing could be completed by first with the information and communication system able to make data transfer with high speed to be near to the real-time and to manage the anomalies at the distance. The term anomaly refers to unintended or off-nominal function of vehicle systems with consequences that can range from benign to life-threatening. Anomalies that require urgent response are those that affect critical subsystems, deplete essential resources, and/or involve uncertainty, meaning there is no set procedure in place for response, causal analysis is required, and short-times-to-effect for unwanted consequences are possible

The NASA Mission Control Center (MCC) manages the combined state of the mission, vehicle, and crew. MCC staff monitor and analyze mission data, identify trends of concern, diagnose and respond to vehicle anomalies, and oversee effective execution of actions. The ISS over the past few years, showing an average of 1.7 vehicle anomalies per year requiring urgent attention and diagnosis. Even with the best engineering processes in place, vehicle anomalies will continue to occur throughout the duration of a mission.

In the Moon context, the hardware software interaction analysis should be managed through the long-duration missions taken account several assets in Space [2]. To consider the Earth-independent, the Moon's mission shall integrate in the RAMs framework the artificial intelligence to support the crew in data visualization for the systems and the equipments. As they must act with a safety model, it considers to anticipate the behaviour expected in terms of data. The equipments can be advanced sensors, sensor fusion for diagnosis and repair robots at the distance for the software components. And the advanced maintainability standards concepts which could be applied for routine operations and conditions requiring critical repairs. The predictibility of the operations become the key parameters for the RAMs life on the Moon missions. In each component of the system and the sub-system, the simulation provide the level of functionalities with the data expected for the operations planned. The same approach is applicable for the crew.

3-Discussion

3.1- Lunar Ecosystem

The Lunar ecosystem should be considered as the factors in Space and on the Moon surface [3]. The project of the Deep Space station, the Artemis mission requires the modules in orbit and the infrastructure on the ground. The process flow that shall be performed is the capability to provide module service close to IIS Station with Spacecraft additionnal for the Lunar surface.

Moreover, it shall considers several countries invest the Moon through the different technical means : the missions Chang'e, the robotic campaign from India, Japan, The United Emirates. The lunar ecosystem completes itself by the competition of equipment on the Moon. The goals should be the exploration of the ground for the ressources like water, Helium 3, the new technologies development for the industries on the Earth.

The success of the Artemis I gives the tempo of major human logistic deployment through the Orion module and the Space station on Moon orbit.The engineer rules for the design Deep Space Station concerns the building of service module for exploration E-M1 and E-M2. The work of the astronauts on board in the Station with the Deep Space Station habitat. The digital netwok used to communicate with bandwitch close to the Internet services on the Earth. The main steps of the permanent station would be to build the Deep Space Gateway on the Low Orbit in the same IIS process management including the Deep space requirements, puts the Deep Space Gateway, by the docking of service module, on the Lunar Orbit or towards at the Lagrange points, back the docking spacecraft on the Earth, test the Deep Space Gateway on the Deep Space Orbit without crew inside, except the sensors or robots, sends a mission to check the outside structure of Deep Space Gateway.

The requirements of Deep Space for a Station orbiting around the Moon include the new events of lunar environnement : gravitation, radiation storm, dust from solar system, safety and security management far away from Earth. It seems to be the intent location for the DsD will be near rectilinear Halo Orbit (NRHO) in cislunar space. This choice would combine low cost and effective inside the station, out the station, and the crew. The Lunar requirements concerns as much the moon landing as full back to the Gateway Station. Above all, the lunar gravity and the radiation must be supported by human with a long period on the ground.

The Mission operations can be supported by the current infrastructure with some control center as a relay in Space and forward control center in low orbit around the Earth. This center has the capabilities to communicatte with the Gateway Station to coordonate its operation without the constraints of the atmosphere through the networks between the Earth and the Moon, the low orbit dand the Gateway, the Earth and the low orbit.

The Gateway station in the Deep Space owns the IIS properties station, in more, there are specific modules linked with the distance with Earth and the contact with the Lunar surface. The magnetic field is the point for the Deep Space Station for the Earth magnetic field protects the Spacecraft against the radiation from the Sun and from the deep space. Unlike the Earth orbit, the Lunar orbit is strongely exposed to these radiations. For example, the astronauts in the IIS Station already sustained the radiations from Space 60 % in more than usually. It means that the astronauts living a long time inside the Deep Space Station should have a local protection. The module magnetic will be proced by multiple couchs : create a local magnetic field thanks to the structure from the Spacecraft, get a new suit using the local electricity from the human body, transmit an artificial field by signal from the Earth orbit. The micro-meteor impact against the station would be avoided if an electromagnetic force surrounds the Spacecraft.

The one is used to connect at the plateform in the moon in the same process than the docking in Space. The module connects to the other except the one on the ground is already on the lunar surface, and permantly no move . The primary site of this module is crucial because it will determine the lunar base. And with the dust and the lunar meteorology, it can be damaged. So, the lunar docking module should be simple like the a LEM from Apollon 11 mission without electronic, just an habitat to go inside for the astronauts who will go on the Lunar surface. The lift off could be the same as the Apollo mission to join the Gateway station around the Moon. The list of laboratory testing in Deep Space Station shall take account the elements following : High quality fiber optics experience, Electric power propulsion, 3D printers testing on Space, 4G netwok testing between the Moon, Gateway Station and the Earth, Cyber-cognitive testing with the Earth distance, Radioprotection human body, Solar power testing to the Earth via the laser, Solar power testing to the Moon via the laser, Lense testing to the moon for energy, Vegetables culture in the laboratory, Probe detector for the asteroid, Observation to the deep space, Magnetism Earth testing. These elements are forwarded to the life in the Moon infrastructure. The main buiding should owned the first elements with the capacity to use the resources on the Moon.

3.2- Lunar Building requirement

The lunar requirement [4] holds on the human capacity to stay during a long period and that to use at distance the robots in the complex tasks for the buiding and the digging for the habitats. Following the RAMs framework, the lunar deployment shall follow the exchange of machine-to-machine and the human to machine supporting by the information and communication system based on the anti-radiation hardening.

The return to the Moon is an international effort and Moonlight is designed to integrate into the global lunar infrastructure, in harmony with programmes such as NASA LunaNet. With a store and forward architecture through the Lunar Pathfinder, a proximity link allowing for two simultaneous links with lunar missions in S-band and UHF, and backhaul link to Earth in X-band, a data-relay satellite will be able to solve both direct line of sight and performance limitation due to distance between the Earth and the Moon. In addition, an ESA GNSS receiver capable of detecting weak signals coming from the Earth GNSS infrastructure (GPS and Galileo) will be hosted onboard Lunar Pathfinder, demonstrating GNSS's role in Lunar navigation as a future services. Building on the foundations of Lunar Pathfinder [5], and as part of the ESA-Moonlight Phase A/B1 study, SSTL is also looking at the next steps. With a team of established commercial space organizations, the aim is to characterize the end-to-end service infrastructure, as well as the commercialization model, that would enable the provision of Moonlight lunar communication and navigation services.

The information and communication system shall provide the support to manage the art of statement of Moon's environment [6]. The lunar axial tilt with respect to the ecliptic is only 1.54°, determining the absence of seasons on the surface. The cycle period highly differs according to the location on the surface: considering the equator, it is possible to subdivide and cycle period in lunar day and night, both characterized by an equal duration of 29.4 terrestrial days imaging instead to settle the mission at the poles, the irradiation of the site will be constant, with the exception of geographical elements and the phases in which the satellite crosses the Earth shadow cone.

These scenarios acquire particular importance in the thermoenergetical design of living environment solutions. Partial gravity is a challenging factor in the definition of the structural behaviour of human equipment and facilities to be utilized on the Moon: the gravitational force on the surface is equal to 1,62 m/s2 , about 1/6 of the terrestrial gravity we are used to. With this acceleration, the vertical loads are not the governing one, and the entire system remain in tension, with resultants pointing the exterior of the habitat Federation.

On the contrary, in launch phase, the same components must be designed to resist to more than 1 g, facing the Gravity Loss, determined according to the escape velocity, and not to collapse for the vertical weight. The aforementioned pressurization is a necessary measure to face the lack of atmosphere on the lunar surface: this imposes the necessity of an oxygen production locally performed, through the extraction from local soil, and several concepts have been developed in the last decades.

Furthermore, a delta in the pressure between the external and internal environment requires the adoption of methodologies for gas retention to be considered in envelope and joints design. External elements also affect the life on the surface, and considerations regarding orbital radiation must be taken into account: the atmospherical shield that usually protects Earth and others celestial bodies with a gas layer protection is absent on the Moon, and all the radiowaves impacting the surface are not filtered.

Two different categories are in particular identified: Galactic Cosmic Rays (GCRs), almost constant and generated in the outer space and Solar Energetic Particles (SPEs) also called Solar Flares, and produced by the thermonuclear reaction on the surface and in the deeps of the Sun. Here also, several strategies have been considered, to limit the impact on astronauts in order to maintain the level of absorption, identified as equivalent dose, within acceptable limits not dangerous for human life. Another external element is represented by Micrometeoroids (MMOD) that periodically bomb the surface and usually unstopped on Earth. Even if the impact of large-scale object is highly unprobeable, it is necessary to estimate the statistical probability of an event and according with this value correctly estimate the mechanical resistance of the external layers of the envelope. Together with constraints, several resources will be exploited in the design and operation of human equipment on the Moon. The lunar surface is composed by regolith, a mixture of elements, mainly oxygen, silicon and iron with good properties of workability and easily accessible. Several techniques of 3D printing are experimented to utilize the raw soil as construction material. Together with regolith, the presence of water have been proofed after the observation of the SOFIA (Stratospheric Observatory for Infrared Astronomy) airborne observatory, that pointed the lunar poles for years and revealed the presence of H2O in form of ice in the permanently shadowed area of the surface, mainly at the bottom of the craters formed by ancient meteoroids impact. Moreover, the presence of water in form of permafrost and volatile have been

assumed after the survey of soils samples brought back in the Apollo mission and the through the last observations of the satellite's surface.
Due to these constraints, the design thinking of the solutions for Moon exploration should not follow the same way as that known on Earth for building. Another methods consists to use the combinaison of these means to send easily sensors or materials to be used on the Moon without huge capacity rocket. The material and the method is to use a rocket with a flight recorder principle to resist to the crash in order to be use as sensors or materials for Moon installation.
The rocket did already the proof of concept linked with the methods of the sensors crash. Indeed, At 7:25 a.m. on March 4, 2022, a rocket portion impacted the moon. It doesn't matter the origin of this rocket. The point is to use these events to explore the materials and above all the methodology to accelerate human presence on the Moon. The material is a rocket with or without booster composed by a hardening structure able to resist to the crash or to explose at the contact of the surface. Inside the boosters and the rocket, the quantity of logistic materials could be stored : sensors, robots, solar panel, gonfable structure, automatically deployable antenna, 3D printers for regolith use. These equipments could also be protected by air bag mechanisms. The theory approach requires a rocket with the transport capacity. The Electron rocket can carry 300 kg of payload. The case studied is connected with the Falcon 9 rocket and the Starship. This rocket owns the functionalities to carry and to deliver the payload on the Moon surface with the 22,8 tons. And with the Starship capacity, the payload can reach 100 tons. The calculation shall take account the types of materials, the trajectory, the rocket, the location of the crash, the point of gravity contact with the surface to ensure the liberation of the materials. This point is the major issue of the proof of concept for the exploration. Indeed, the gravity equation on the Moon is the parameter to be consider for the speed of the impact. This to avoid the destruction of the materials inside the rocket.

4-Conclusion:

The model expected shows the bricks to aid the crews to understand the context, the errors, the failures, the anomalies. The point is to maintain the network link in Space with the different ground to provide data for the management of the system. The RAMs approach should also considered to be completed by the C-SOC to operate the security and the safety of these data.

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