ESA STUDY CONTRACT REPORT

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4000134882/21/NL/GLC/mkn	Executive summary of Activity "Satellite Communications via Space-Based Internet Service Providers"	University of Luxembourg

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ABSTRACT:

University of Luxembourg studied and evaluated a new concept of connecting space missions via space internet providers. The system requirements, necessary adaptations, and possible limitations are provided and discussed. Three types of space internet provider are studied and evaluated (i.e. Starlink, Oneweb and O3b mpower). The study revealed that higher constellations have better coverage towards the space missions. The study also provided some options for terminals that can be plugged into the space mission satellites for connection. However, although the concept is very promising and can be implemented, there are still some regulations aspects to be solved for future deployment.

EUROPEAN SPACE AGENCY CONTRACT REPORT

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Satellite communications via space-based Internet service providers

Executive summary

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1 Background

A space-based internet system, despite possessing the capability to provide internet services to on-ground users on a global scale, can dramatically change the way the satellites are operated in the foreseeable future. Nowadays, the number of satellites launched in a low earth orbit (LEO), usually for data gathering missions such as Earth Observation (EO) and remote sensing, is constantly increasing. Assuming a scenario where LEO satellites (space missions in general) can access the internet via a space-based internet provider, the satellite can be connected to the network permanently. This is certainly a game changer which will cause a paradigm shift from relying on ground stations to downlink data from the LEO satellite (or send data to the satellite) once per orbit, to accessing the data whenever needed (24x7). The ability to communicate with the satellite (either downlink or uplink) on-demand through the internet can improve several important aspects, such as: i) throughput; ii) real-time tasking; iii) timeliness of data; iv) selective downlink, v) operation cost, etc.

In this context, the SATSPIN project tries to study this new concept/use case and evaluate its viability by performing system level analysis.

2 Objectives of the Activity

The objective of SATSPIN project is to perform a feasibility study on using space-based internet systems to connect space missions. In particular, the project focuses on identifying and analyzing relevant characteristics of the current and near future space-based internet providers and the most important space missions that can take advantage of this concept. It also provides coverage as well as system level analysis to quantify the time of access and the achievable data rate for space missions when connecting to space internet providers. Moreover, the project focuses on the potential legal aspects stemming from the RF spectrum usage and the principles of international space law, covering the next steps for the development and exploitation of any identified potential solution.

3 Study Logic

Figure 1 presents the SATSPIN summarized study logic, where the three main tasks of the project are provided in blocks. In particular, SATSPIN is organized into: (1) Space based internet system providers system review, (2) feasibility analysis including space mission specification and communication system characteristics, and (3) Activity summary and future directions. In Figure 1, each main block is linked to the main outputs of the project.

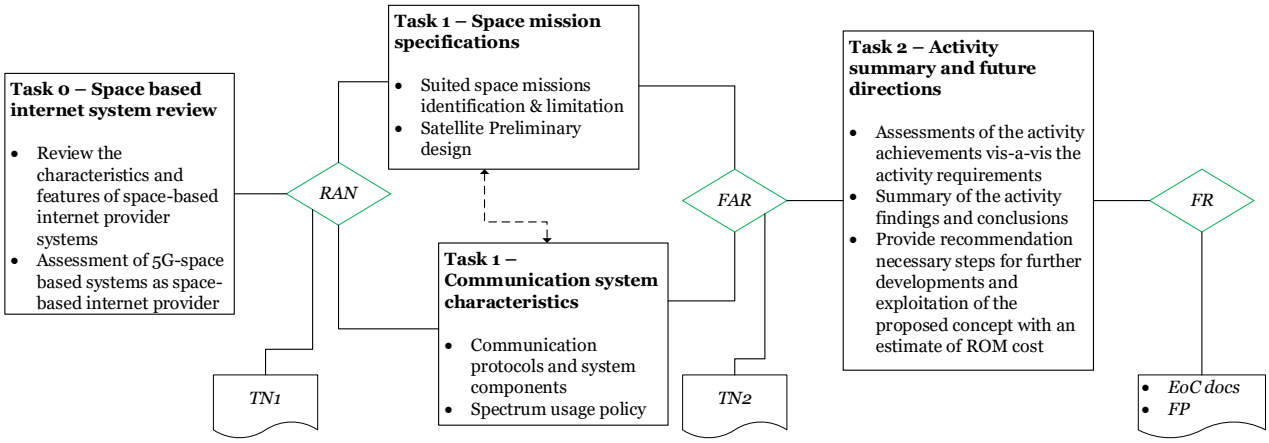

Figure 1. FlexPreDem summarized study logic

4 Results

The project evidences that the connection of space missions via space internet providers is beneficial and most importantly is practically possible in the near future.

In SATSPIN, we reviewed all current and near-future space internet providers, with their characteristics, that might be of interest for the SATSPIN concept. These include Starlink, OneWeb, Kuiper, Telesat, O3b mPower, ViaSat-3 and future 5G NTN system. Their orbital configurations are included, together with the minimum elevation angle of communication, which enabled later to obtain the connectivity outages as well as link budget for the whole system.

Additionally, the project provided a list of the decayed, ongoing, and future space missions that can take advantage of a communication link via space-based internet providers and found that the most probable candidate that can take advantage from the proposed concept is Earth observation missions because of (1) their overwhelming need to transfer large amounts of data, (2) their need to transfer data quickly, (3) their orbital compatibility with mega-constellations (i.e. their low orbits) and (4) their abundance results in a critical mass of users. The project selected NASA's past mission Aqua and ESA's future mission BIOMASS as a reference for the remainder of the study.

After the identification of the potential space internet providers and space mission, the project performed a coverage and system level analysis and identified, via results, the space internet providers that can be used to connect the space mission with their limitations. It appeared that O3b is the best system for the SATSPIN concept followed by Oneweb, thanks to their relatively high altitude.

In terms of performance, the project considered the best system, i.e. O3b mPower, and evaluated the link budget to both selected Aqua and BIOMASS space missions. The evaluation showed that the link budget is good to perform communication between O3b mPower and the two space missions. About 8 dB and 6.5 dB are obtained for the downlink (DL) and uplink (UL), respectively, considering a bandwidth of 100 MHz and 4 MHz, respectively. Assuming a DVB-S2X communication protocol, this led to 228 Mbps and 8.4 Mbps bit rate for DL and UL, respectively.

As per the legal aspects, the study focused on the current legal regime at the ITU for the establishment of the satellite-to-satellite link, necessary condition for the compliance with the regulatory framework. It was found that at the state of the art the systems under investigation could only rely on a flexible use of the spectrum allowed on a non-interference and non-protection basis, the so-called Article 4.4 assignments. The lack of international protection jeopardizes the operations at issue. This commercial and operational disadvantage could be bridged by the possible changes to Table of Frequency Allocations during the 2023 World Radiocommunication Conference. Moreover, the research analyzed the governing principles of outer space law in relation to the responsibility profile.