SnT 2023

CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

HOFBURG PALACE - Vienna and Online

19 TO 23 JUNE

Next Generations of the Global Communications Infrastructure (GCI): The Role of Low Earth Orbit Satellites (LEOs)

IEEE Advancing Technology for Humanity

Fernando Araujo

IEEE

INTRODUCTION

Recent advancements in satellite technology have led to the increased deployment of broadband and low-latency services in areas where terrestrial connectivity infrastructure is not easily available.

The IMS station operator's experience and field activities could be improved by leveraging new connectivity options for improving data transmission.

METHODS/DATA

- A concise analysis of Low Earth Orbit (LEO) services for the GCI III and IV timeframes was conducted using standard research methods.
- The poster examines the status of LEOs and their potential applicability to IMS and OSI.

START

RESULTS

- LEO connectivity can be deployed to provide service in geographical regions with no standard geostationary satellite coverage or mobile data connections.
- LEO connectivity could be provisioned in upcoming OSI field exercises and in future deployments of new monitoring stations and upgrade on existing ones.

CONCLUSION

- GCI IV could benefit from the services made possible by availability of LEO mega-constellations.
- A SD-WAN solution offering LEO as primary link and GEO (or other) as backup could be deployed for selected sites to maximize SLA performance

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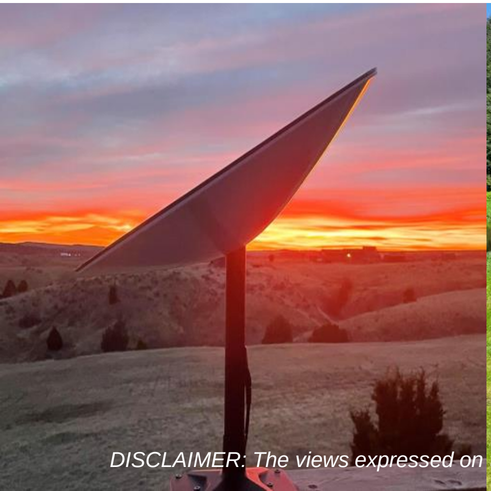
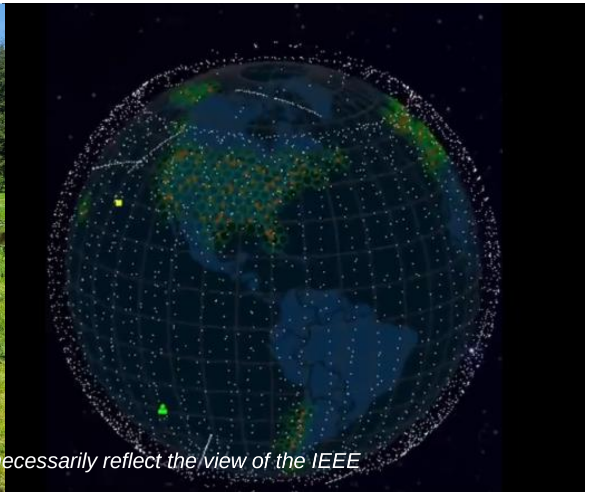
Introduction

- Broadband access and low latency connectivity are available globally thanks to the increasing ongoing deployment of low earth orbit satellite (LEOs) mega-constellations . Three platforms are in operations or test stages and one more is planned to start operations during 2024.

- Several commercial entities, such as SpaceX, Amazon, OneWeb, Telesat, and others, are competing to deploy large-scale constellations of Low Earth Orbit satellites (LEOs) for the purpose of providing Internet access.

- Maximizing data availability and simplifying complex infrastructure -normally associated with the deployment of VSATs- as well as providing innovative services and applications would enhance not only the transmission of data but also the customer experience available to station operators in remote regions.





ARTICLE IV VERIFICATION
"(a) Make arrangements to receive and distribute data and reporting products relevant to the verification of this Treaty in accordance with its provisions, and to maintain a global communications infrastructure appropriate to this task"

- Currently, GCI III is moving through its mid-life cycle and technology refreshment;

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Objectives

- Can LEO connectivity **seamlessly integrate** into the GCI, particularly in difficult locations?
- **What integration challenges would be present? Installation, Training, Maintenance?**
- Could International Monitoring System stations and OSI IFEs benefit from this type of service? Is it **resilient** and can be **deployed quickly**? Is it **secure**?
- What **improvements in data transmission and end user applications** can be achieved?

- Meet the costs of transmitting IMS data to the IDC by the most direct and cost-effective means available, including, if necessary, via appropriate communications nodes...
- Make available all data and reporting products to all States Parties
- Provide to all States Parties open, equal, timely, convenient access to all IMS data and products

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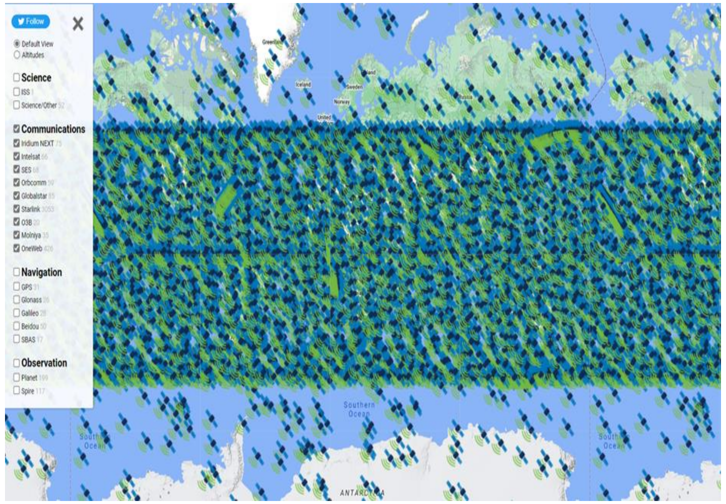
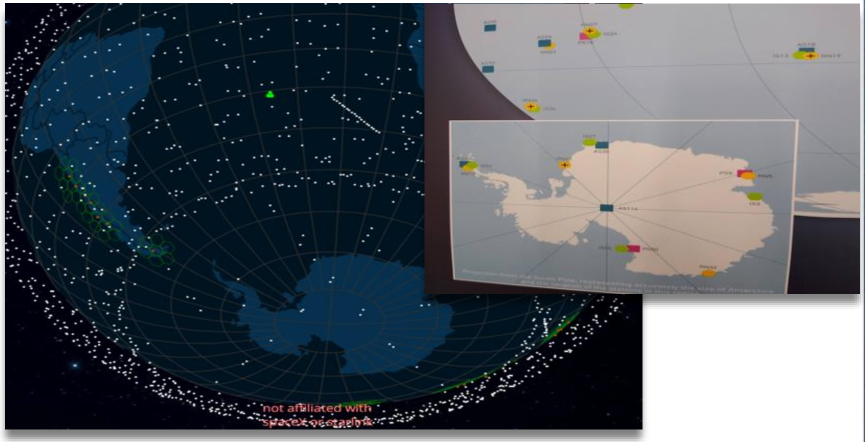
The LEOs relevance for the CTBTO's verification regime GCI component

The IMS Stations Map



Satellites in Orbit

LEO Satellite Coverage



Framework: " The aim is to ***increase the available data rate****, achieving higher Quality of Service (QoS), thus helping to lower the cost per bit for serving the* ***hardest-to-reach areas****." [1]*

5G access for monitoring stations: " ***Integrating the 5G networks with satellite communications*** *as a unified system is a paradigm with technical challenges." [2]*

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Scenario 1: Potential applications on future OSI IFEs (1/2)

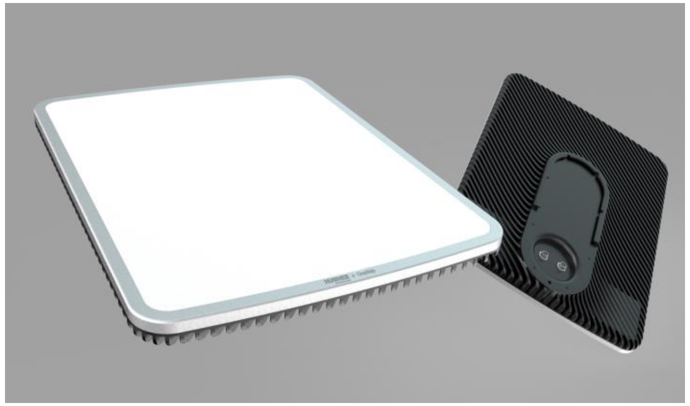
Inflatable VSAT antenna deployed in previous OSI field exercise

Mobile LEO equipment and networking equipment

LEO Terminal sample

VSAT on vehicles

Mobile LEO Flat Panel antenna



LEO terminal sample

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Scenario 1: Potential applications on future OSI IFEs (2/2)

- Permission of Operation. (Country telecommunications regulation)
- Decision on deployment on Base of Operations and/or to include "in motion" connectivity.
- DC Power, networking considerations and type of antennas.
- Clear definition on strategy of use:
  Communications with headquarters, intra site communications.
- Integration with remote and on-site systems.
- Use of third-party applications for communications.

Mobile LEO terminal kit size (antenna and router)

LEO antenna installed on vehicle

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Scenario 2: Deploying new data connectivity schemes in remote geographical locations


LEO terminal at McMurdo Station


NSF Starlink Experiment


Broadband Wi-fi test


Cats discovering heated LEO antennas (CONUS)

- International Monitoring Systems in Antarctica: Connectivity speed and potential for modified router firmware for sensors.
- Deployment of terminals for polar services: Weather considerations for extreme temperatures.
- Easy maintenance and High-performance broadband and connectivity.
- Antennas need de-icing capabilities. (it is integrated on LEO antennas)

The density factor: " Laser intersatellite links (LISLs) are envisioned between satellites in upcoming satellite constellations, such as the one in phase I of SpaceX's Starlink. Within a constellation, satellites can establish LISLs with other satellites in the same orbital plane (OP) …" [3]

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Conclusion

- **The past:** Limited data rates, **high latency** (extended catch-up after data outages, no voice capabilities, issues with deployment), size, complexity, cost.

- **The present:** A significant **increase in bandwidth** compared to the previous GCI generations, reduced equipment size, persistent **latency issues** and a deployment of mixed backup solutions including BGAN and 3G/4G modems as well as VPNs.

- **The future:** Smaller and lighter equipment, **enhanced bandwidth**, **low latency**, smart sensors (IoT), deployment of interactive **user applications** and seamless access to the CTBTO web portal as well as **emergency support**. Potential use as primary link or backup for terrestrial connections (MPLS, SD-WAN). Use of portable terminals on site surveys and station visits by IMS Engineering and Maintenance teams.

❖ LEOs could constitute a component of the next generation of GCI (and potentially be integrated into GCI III) and various use cases could be examined. The adoption of the technology requires a thorough analysis of each existing or new link, as well as the service plan type and future price reductions.

❖ There are innovative opportunities for new communications paradigms in the GCI IV. A future reference framework can increase the level of operability and support of IMS stations and facilitate communication with national data centers, strengthening their national relevance.

❖ These novel services could be evaluated by the Commission for their potential to contribute to a GCI that is adaptable to future needs and challenges.

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References

-[1] O. B. Osoro and E. J. Oughton, "A Techno-Economic Framework for Satellite Networks Applied to Low Earth Orbit Constellations: Assessing Starlink, OneWeb and Kuiper," in IEEE Access, vol. 9, pp. 141611-141625, 2021, doi:10.1109/ACCESS.2021.3119634.

-[2] A. Sattarzadeh et al., "Satellite-Based Non-Terrestrial Networks in 5G: Insights and Challenges," in IEEE Access, vol. 10, pp. 11274-11283, 2022, doi:10.1109/ACCESS.2021.3137560.

-[3] U. Chaudhry and H. Yanikomeroglu, "Laser Intersatellite Links in a Starlink Constellation: A Classification and Analysis," in *IEEE Vehicular Technology Magazine*, vol. 16, no. 2, pp. 48-56, June 2021, doi: 10.1109/MVT.2021.3063706.

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