Access Analysis of GEO, MEO, & LEO Satellite Systems

Gukyoung An, Neha Pasnoori, Razan Abdulhammed
Poster Advisors: Abdelshakour Abuzneid, Miad Faezipour
Department of Computer Science and Engineering
University of Bridgeport, Bridgeport, CT

Abstract

The goal of this study is to calculate access duration and intervals for three different kinds of satellite schemes to support a WSN (wireless sensor network). The first scenario involves only LEO-level satellites. The second scenario involves LEO, MEO, and GEO level satellites. The third scenario involves only MEO level satellites. These scenarios are simulated using STK (Systems Tool Kit).

Introduction

Satellite based environment monitoring is when multiple wireless sensor network across multiple areas around the world are able to communicate with each other through a network consisting of satellite connections.

GEO, LEO, and MEO are three categories of satellites based on altitude.

GEO stands for Geostationary Earth Orbit, which means the satellite's orbit is synchronized with Earth's orbit. They typically maintain 35,786 km (22,236 mi) altitude.

LEO stands for Low Earth Orbit and is usually under altitude of 2,000 km (1,243 mi).

MEO stands for Medium Earth Orbit and is between GEO and LEO, though most common altitude is at 20,200 kilometers (12,552 mi)). [1]

The following constellations applies for this study's scenario:

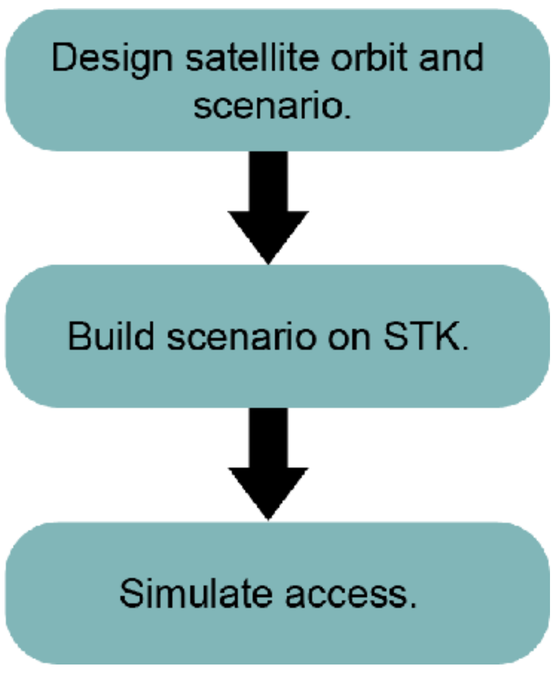
LEO is in Walker constellation of type Delta, has 2 planes, and 6 satellites per plane. Highlighted in Blue on the 2D map.

MEO is in Walker constellation of type Star, has 2 planes, and 2 satellites per plane. Highlighted in Green on the 2D map. [2] [3]

GEO plane is of zero inclination, and has three satellite equally spaced apart, one hovering latitude near Americas, Africa, and Australia respectively. Highlighted in Purple on the 2D map.

The locations chosen as end nodes for these scenarios are the University of Hawaii in Honolulu, Hawaii, and the Telkom Earth Station in Johannesburg, South Africa.

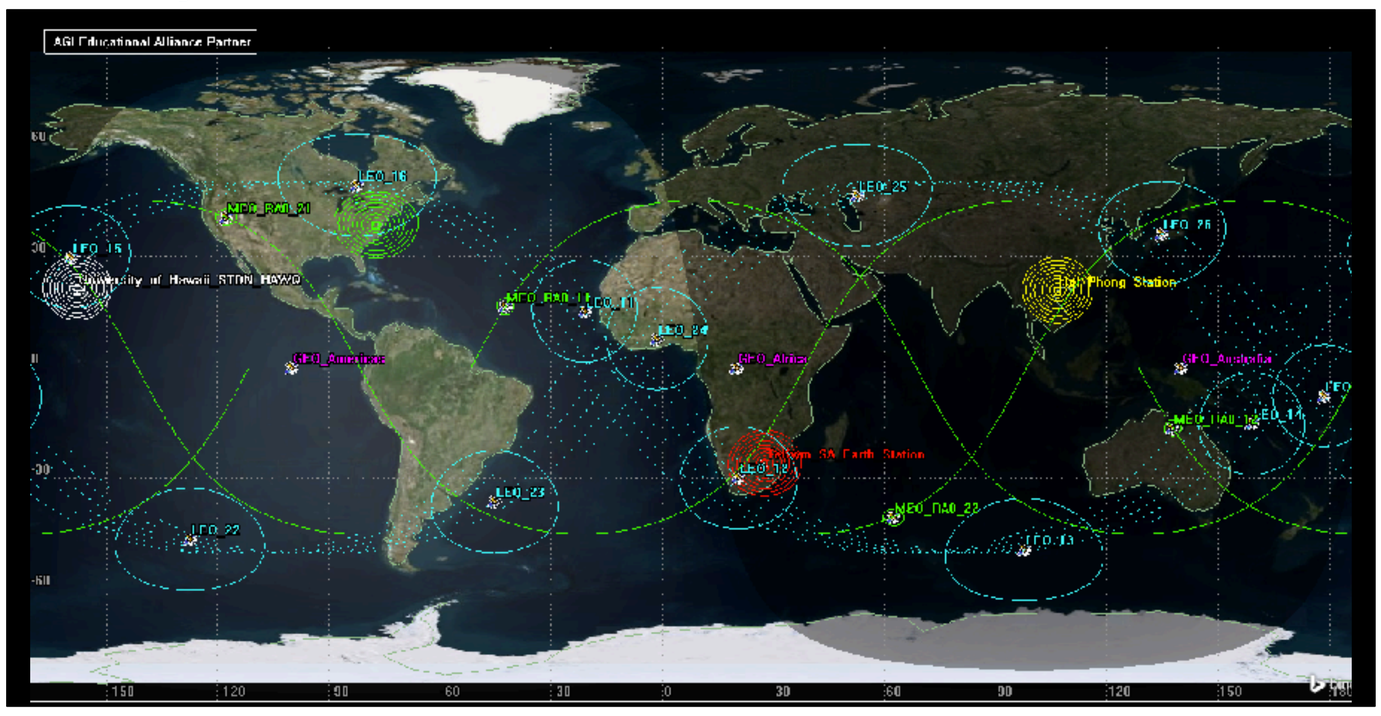
Process



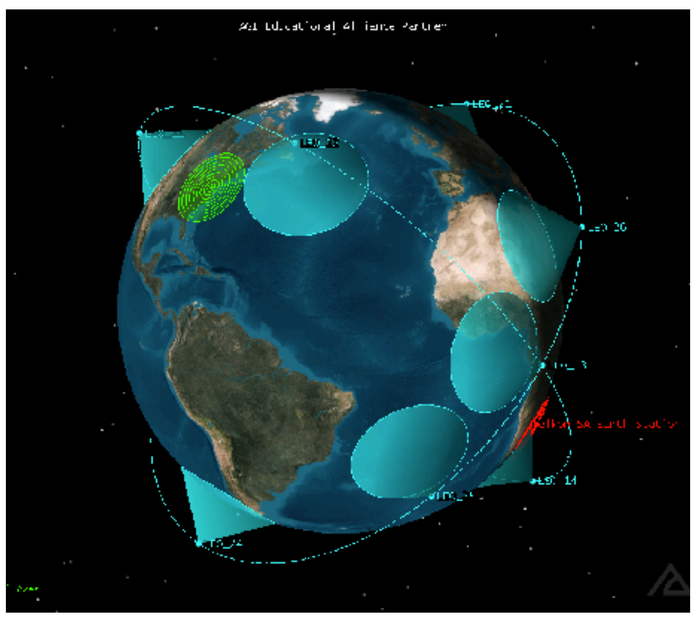
Conclusion

The similarity between LEO and LEO + MEO + GEO in terms of their complete access interval and cumulative access graph indicates that the latter satellite access depends on LEO access. The MEO only satellite scheme achieves 98.115% access total, meaning it would practically make GEO level satellite scheme unnecessary for reliable access without a significant addition of satellites.

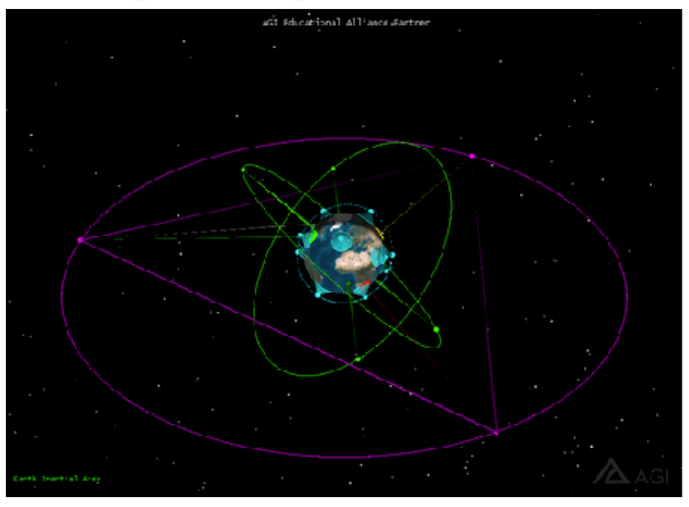
2D Map of All Satellites



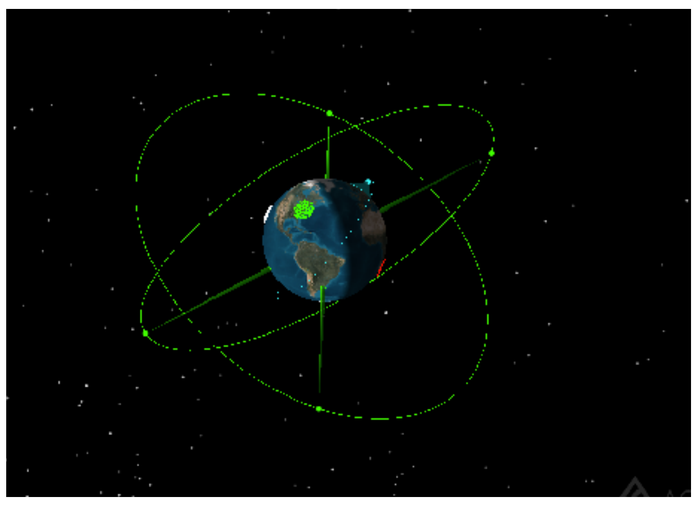
LEO



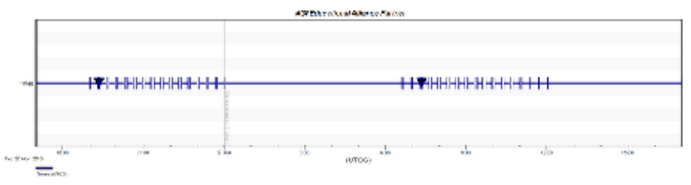
LEO, GEO, & MEO



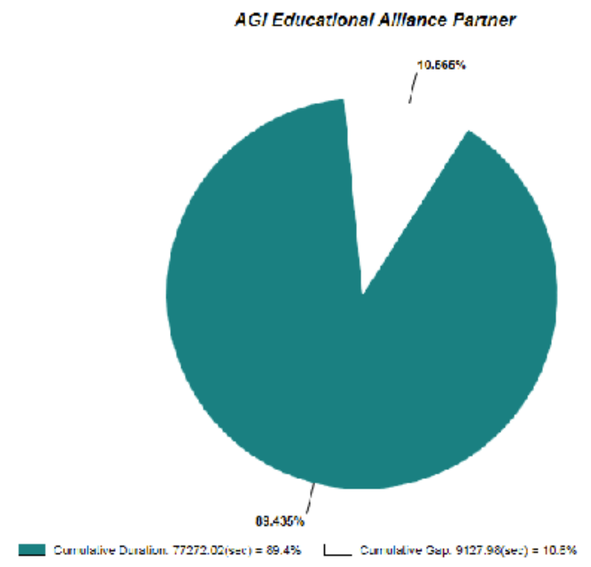
MEO



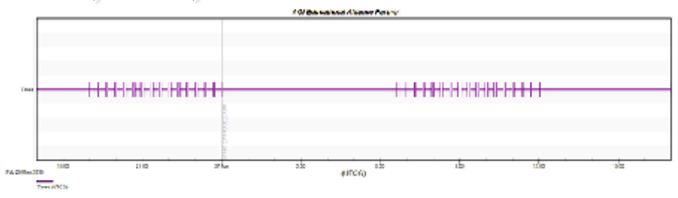
LEO Access Interval



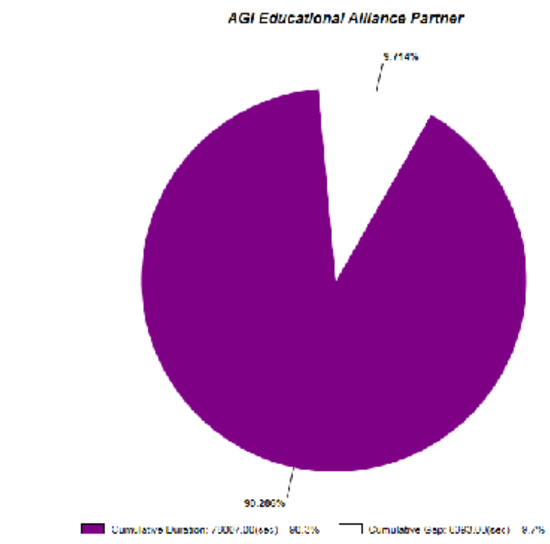
LEO Cumulative Interval



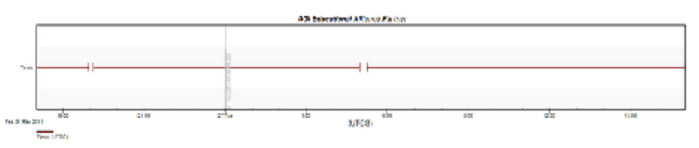
LEO, GEO, & MEO Access Interval



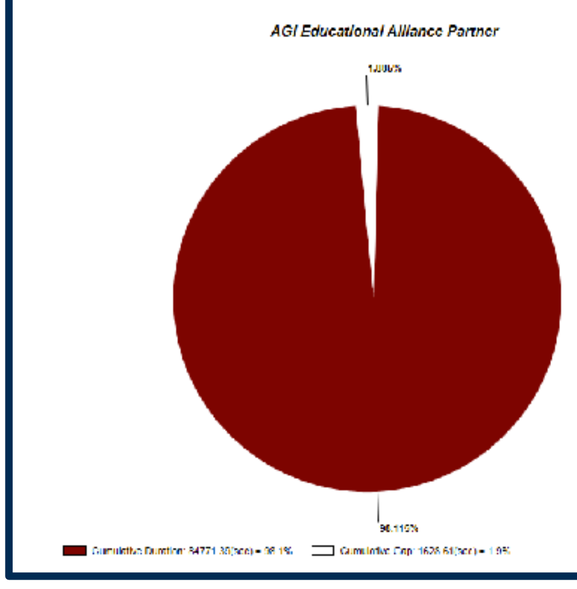
LEO, GEO, & MEO Cumulative Interval



MEO Access Interval



MEO Cumulative Interval



References

[1] MEDIUM EARTH ORBITS: IS THERE A NEED FOR A THIRD PROTECTED REGION? Nicholas L. Johnson Chief Scientist for Orbital Debris, NASA, Houston, Texas, USANicholas.L.Johnson@nasa.gov

[2] Y. Mo, D. Yan, P. You and S. Yong, "Comparative Study of Basic Constellation Models for Regional Satellite Constellation Design," 2016 Sixth International Conference on Instrumentation & Measurement, Computer, Communication and Control (IMCCC), Harbin, 2016, pp. 171-176.
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[3] P. Muri, J. McNair, J. Antoon, A. Gordon-Ross, K. Cason and N. Fitz-Coy, "Topology design and performance analysis for networked earth observing small satellites," 2011 - MILCOM 2011 Military Communications Conference, Baltimore, MD, 2011, pp. 1940-1945.
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