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A TECHNICAL COMPARISON OF THREE LOW EARTH ORBIT SATELLITE CONSTELLATIONS SYSTEMS TO PROVIDE GLOBAL BROADBAND

Abstract

The idea of providing Internet access from space has made a strong come-back in recent years. After a calm period that followed the setbacks suffered by the projects proposed in the decade of the 90's, a new wave of proposals for large low Earth orbit (LEO) constellations of satellites to provide global broadband emerged in 2014 - 2016. The main differences of these systems compared to their predecessors from the 90's are the increased performance that results from the use of digital communication payloads, advanced modulation schemes, multi-beam antennas, and higher frequency reuse schemes, as well as the overall cost reductions that result from advanced manufacturing processes and reduced launch costs.

This paper compares three large LEO satellite constellations to provide global broadband, namely SpaceX's 4,425 satellites Ka-band system, OneWeb's 720 satellites Ka-band system and Telesat's 117 satellites Ka-band system. First, we present the system architecture of each of the constellations as described in their respective FCC filings. Our review highlights the similarities and differences amongst the systems analyzed in this paper. Second, we develop a statistical method to estimate the total system throughput considering both the orbital dynamics of the space-segment and the variability in performance induced by atmospheric conditions both for the user and feeder links.

The location and number of ground stations play a major role in determining the total system throughput; since the characteristics of the ground segment are not described in the FCC applications, we run an optimization procedure to minimize the total number of stations (out of a pool of candidate ground stations locations) required to support the system throughput. This optimization is conducted considering the International Telecommunication Union (ITU) Recommendations to characterize the atmospheric attenuation, and a Monte Carlo simulation method to estimate the statistics of the throughput achieved when multiple ground stations are within the line-of-sight of a given satellite.

We conclude the paper by identifying the major technical challenges that the three systems will have to overcome before becoming operative.