Application of Earth-Space Path Loss as a Constraint in the Design of LEO Satellite Constellations

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Low Earth Orbit (LEO) satellite constellations were first deployed over half a century ago for use in navigation, Earth-space communications and Earth observation missions. Most satellite constellation design methodologies focus on methods for deploying multiple satellites in a manner that guarantees minimum position uncertainty (for navigation), continuous Earth-space or inter-satellite coverage (for communications) or minimum re-visit time (for Earth observation) over a given region. Systems that involve an uplink channel between an Earth station and the satellite are generally based upon the notion that the available uplink power is sufficient to permit communication as soon as the satellite is just several degrees above the horizon and still at extreme range.

Many emerging satellite-based IoT (Internet of Things) and M2M (machine to machine) applications do not require continuous coverage and are instead ultimately constrained by the transmit power available at the Earth station. Here, based upon a multiplicity of simulations conducted using AGI's System Toolkit, we show how satellite constellation design and performance are affected by constraining the maximum allowable path loss on a viable Earth-space link. In particular, we show the precise manner in which decreasing the maximum allowable path loss increases the number of satellites required to maintain continuous coverage or, alternatively, introduces gaps in coverage and increases revisit delays if the number of satellites remains fixed. While a few authors have mentioned the possibility of accounting for path loss constraints in the past, we believe that ours is the first study to consider the problem systematically.