

## Evaluation of Regional On-Demand Service Capability and Key Influencing Factors for Low Earth Orbit Mega-Constellations

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**Abstract :** Low Earth Orbit (LEO) mega-constellations are poised to become crucial future infrastructure, providing dynamically configurable communication, navigation, remote sensing, and other services. The rapid deployment of these constellations has spurred an increasing focus on their regional service applications. This paper addresses this need by introducing a Payload Unit Service Capability Indicator (PUSCI), which quantifies the average service capacity that a single payload unit provides to a fixed-size ground area within the minimum service time, considering time, space, and performance dimensions. Using PUSCI, a framework is developed for evaluating the on-demand service capability of mega-constellations within specific regions. This framework divides the target region into Geographic Service Units (GSUs), defined by the size and shape of individual payload unit coverage. The method of employing time snapshots is used to determine satellite-ground coverage. PUSCI serves as the smallest unit of service acquisition for a GSU. By incorporating payload service rules, multi-satellite collaboration rules, and multi-satellite payload resource allocation rules, the framework assesses service demand satisfaction for each GSU, thereby evaluating overall regional service levels and fairness. This framework is applied to evaluate the on-demand service capability of regional communication services in mega-constellations, utilizing simulations to analyze key influencing factors. The results demonstrate that multi-satellite collaboration rules significantly impact regional service capability, with load-balancing strategies yielding superior performance. The multi-satellite payload resource allocation rules primarily affect service fairness, while GSU service demand is the main determinant of resource acquisition. Furthermore, the demands of neighboring GSUs influence service availability, highlighting the significant impact of ground demand distribution on overall mega-constellation performance. This PUSCI-based framework provides a quantitative tool for understanding and optimizing regional service capabilities in mega-constellations, offering substantial practical value.

**Keywords :** LEO mega-constellations, regional service, payload unit service capability indicator, capability evaluating, key influencing factors, simulations

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