Flexibility in space: challenges and evolution in satellite antennas specification, design and test

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Multibeam antennas play a fundamental role today in the satellite communications world due to the increase in demand for capacity together with the limited available bandwidth. Multibeam antennas offer increased spectral efficiency and capacity via the multiple re-use of the allocated frequency spectrum, and can offer in-orbit flexibility with the agility to adapt to traffic variations. The mobile satellite sector has always been at the forefront of this trend due to the very nature of the mobile services provided: mobile users require higher system flexibility and better link performance than standard fixed satcom users. The need to add flexibility in the system is becoming even more evident as the satellite operators seek to drive down the cost per bit, which can be achieved by allowing the satellite capacity to move across the coverage as the demand vary. Also, spatial flexibility means the capability to freely relocate a satellite on a different orbital location while keeping compliance with capacity and coverage needs, largely reducing the financial risk.

When a high degree of flexibility is added into a satellite system, the pillars of the usual satellite antenna design start to tremble as specification and test issues start to arise. If we take the example of an on-board antenna able to relocate its coverage across the visible Earth, should the antenna directivity be specified for the worst case position over the visible Earth or should it be specified for an average operational case? In the first case an overdesign is pushed into the system to guarantee the performance in a marginal case that will probably happen rarely in the life of the satellite, but if the average value is specified, the operator will have to deal with the risk attached to not having a minimum guaranteed performance. Same issue applies to the antenna testing. The traditional approach to antenna on-ground testing relies on making sure all the operational configurations are tested and validated as antenna performance is key to guarantee service commitments. This approach cannot be pursued with flexible coverage antennas as it is extremely expensive and time-consuming to test them in every possible configuration. A different approach has to be used in this case to reduce the amount of analysis and test, by relying on modeling and simple targeted tests. With the introduction on the market for space of Ka multibeam antennas with beamforming network, able to produce thousands of movable beams of different shape and size, these issues and many more become remarkably actual.

The objective of this study is to investigate how different ways of defining the requirements of flexible antennas can impact the dimensioning of the system, its design and analysis, and its test. Through the example of flexible antennas on board of Inmarsat present and future satellites, we will show how the flexibility is impacting in the definition and realization of the antenna tests and what can be done to move toward a reliable new approach to flexibility specification.