URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Low orbit satellite constellations and the SKA radio telescope

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1- Extended Abstract

The Square Kilometre Array Observatory is the first intergovernmental organisation dedicated to radio astronomy. With plans to start its operations in 2028, it is considered one of the largest science facilities on the planet. The observatory has its headquarters in the United Kingdom and will consist of the SKA-Low telescope in the Murchison shire in Western Australia with 132'000 log periodic antennas and the SKA-Mid telescope in the Karoo area in South Africa with 197 dish antennas (including the precursor telescope MeerKAT). The science products of the observatory will be distributed through 5 regional centres to observers all around the world.

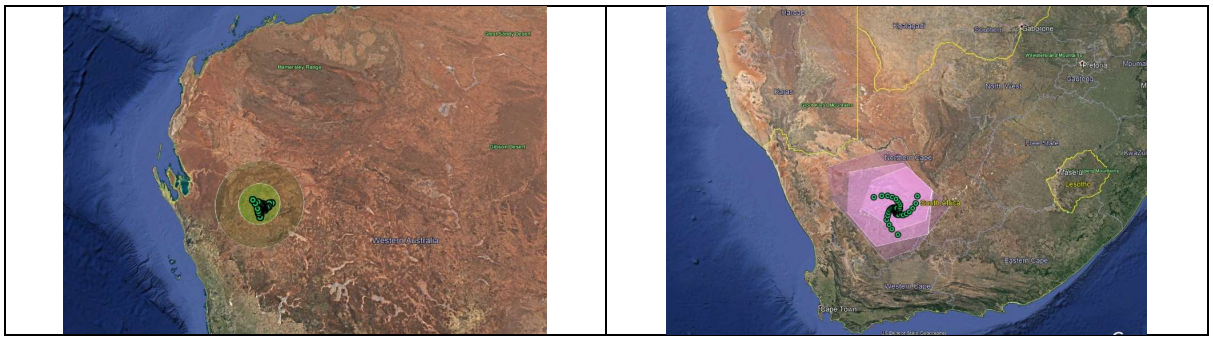

Figure 1 – SKA-LOW (left) and SKA-MID (right) configurations with their respective Radio Quiet Zones.

The SKAO will address fundamental science topics about the universe such as the "Cosmic Dawn", the "Cradle of Life", "Gravitational Waves" and "Radio Transients" among others. To be able to do this, both telescopes are designed to be highly sensitive and very wideband, with sensitivities greater than 1000 m^2 /K and bandwidth ratios of up to 7:1. This great sensitivity and bandwidth not only provides the power to do science, but also opens a window for radio frequency interference (RFI) into observations. RFI can have a range of effects in radio astronomy observations, from loss of a percentage of the useful bandwidth for a fraction of the observation time, to receiver damage due to LNA overload. Managing RFI and minimizing its impact on science has been a priority for the SKAO from the early design phase of the telescopes. This is done by applying EMC techniques for internal interference, Spectrum Management for external interference and RFI detection and mitigation mechanisms within the signal chain of the telescopes.

The site selection for the two telescopes considered the radio quietness as one of the main requirements. The Australian and South African administrations have declared the telescope sites as Radio Quiet Zones (RQZ), an area in which the use of the radio frequency spectrum is regulated to give priority of use to radio astronomy. RQZ regulations are enforceable on terrestrial emitters, which can protect the site from, for example, TV stations, Wi-Fi and Bluetooth transmitters, cell phones base stations, etc. Unfortunately, airborne transmitters (airplanes, balloons, satellites, etc) are not subjected to these regulations, making the RFI "from above" much more difficult to manage.

The recent developments on low earth orbit constellations, with plans for several thousand of satellites using X, Ku, K and Ka bands (8 GHz-40 GHz), has changed the forecast on how radio astronomical observations will be conducted on these frequency ranges. For these frequency ranges, the situation will change from satellites being bounded to the geo-stationary belt in numbers lower than 1500, to a global coverage in low orbits where more than 400 satellites will be above the horizon at any time and geographic location.

This paper presents a quantitative study of the impact that these constellations could have on the SKA, from a technical and operational point of view. The international regulation applicable to protect radio astronomy bands is also discussed along with possible mitigation strategies.