ANTENNA DEFORMATION EFFECTS IN THE DESIGN OF A NANOSAT SAR SENSOR

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Synthetic Aperture Radar (SAR) space-borne sensors are revolutionizing the area of earth remote sensing, providing images with extremely large resolution over wide swathes (compared to their optical counterparts) and with the additional advantage of nighttime and thru clouds observation capabilities. The demand for short revisit time, scalability and diversified image tasking capabilities has pushed the research and development of smaller sensors that can be quickly built and inexpensively deployed. The research presented in this paper is part of an effort to push the miniaturization of SAR sensors toward the CubeSat/NanoSat form factor to enable new application-specific Low Earth Orbit sensing solutions. Two applications (of specific interest to NZ) are considered in the design of the radar, namely (i) a wide-swath maritime mode for ship detection (e.g., to monitor illegal fishing activities); and (ii) a ground imaging mode. The ship detection mode has previously shown to be feasible using a low-power radar [1] and an azimuth-ambiguous acquisition mode compatible with a *small* antenna [2]. A system capable of both ambiguous and non-ambiguous imaging for future low-power detection/monitoring applications (e.g., repeat-pass interferometry) was also shown to be theoretically feasible using a 0.3 m x 2 m aperture antenna [3].

Given the limitations of a NanoSat-based system, special attention must be placed on the choice of the characteristics of the antenna. Due to the size requirement for the effective aperture (comparable to the dimensions of a NanoSat) mechanically deployable antennas are the only realistic option. In this paper a deployable structure is investigated. A thin rollable high strain dielectric membrane [4] is used as a substrate for a reflectarray. The radiation characteristics of the antenna under deformation are estimated and used to derive the SAR imaging performance metrics for the aforementioned applications. This kind of analysis is a critical step toward the definition of a more comprehensive co-design process for the thermal/mechanical and electrical parameters of the SAR sensor.

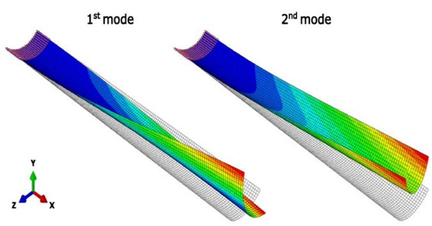

Fig. 1: First two structural torsional and bending modes, at 2.78 Hz and 7.64 Hz respectively, for a 2 m x 0.3 m shell. The colors represents the (exagerated) peak displacements from the reference shape. (Courtesy of A. Tresoldi [4])

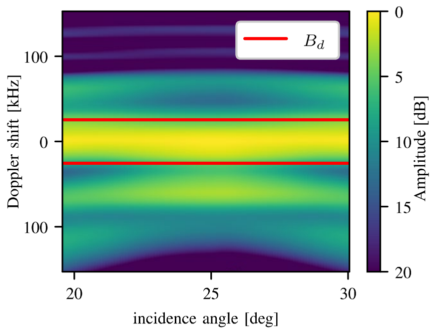

Fig. 2: Antenna pattern scene illumination in the range-Doppler space. The processed Doppler bandwidth is marked in red.

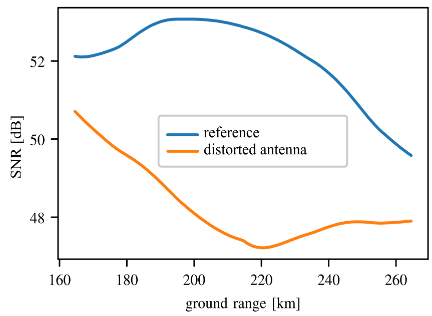

Fig. 3: Predicted scene SNR over ground range for the reference antenna and the deformed antenna, both pointed to a 25° broadside ground incidence angle.

The degradation of image *Signal to Noise Ratio* (SNR) to the antenna deformation is shown in Fig. 3 assuming an antenna deformation given by the first torsional mode of the structure, shown in Fig. 1, which shows the largest difference in the antenna pattern at broadside when compared to the reference shape.

The SNR is calculated from the Range-Doppler gain pattern projections of the nominal (Fig. 2) and distorted antenna patterns within the nominal processed Doppler bandwidth. The image Azimuth Impulse Response can also be computed in a similar fashion, although in this case it was not found to differ significantly from the reference configuration.

In conclusion the main performance degradation is predicted to be in the image SNR, with a peak degradation of 6 dB. Inclusion of the effect of range and azimuth ambiguities will be the object of further studies.

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