Basic Requirements for Synthetic Aperture Radar Satellite Mission

COSTA, M.M.S.[1], BOGOSSIAN, O.L.[2], PASSARO, A.[3]

[1]Technological Institute of Aeronautics, ITA, São José dos Campos, SP, Brasil
Doctoral Student in Sciences and Space Technologies - CTE

[2]National Institute for Space Research, São José dos Campos, SP, Brasil

[3]Technological Institute of Aeronautics, São José dos Campos, SP, Brasil

marcio.costa.br@ieee.org

Abstract. *This paper introduce the main requirements that must be observed for Synthetic Aperture Radar (SAR) satellite mission. A brief analysis of the main parameters is performed considering the success results of previous missions and the future trend of the space-based radar technologies. Taking Brazil area as a reference, examples of some parameters are presented.*

Keywords: Synthetic Aperture Radar; Satellite System Design

1. Introduction

The use of the Synthetic Aperture Radar (SAR) satellite has been increasing in the last years. Several missions are being conducted and there are at least 10 new missions that will be launched in the next 5 years. The ability of monitoring large areas with high resolution images, independent of daylight, vegetal and cloud coverage, smoke, and weather conditions, gives to SAR sensors advantages over optical sensors (MOREIRA et al., 2013). These resources are very important for areas like Amazon forest, for example, in order for monitoring deforestation, fires and biomass changes. This paper makes a brief analysis of the critical requirements that must be observe considering a SAR satellite mission.

2. Analysis of parameters

The orbit definition criteria for a SAR satellite system depends on several factors. However, the first step is to analyze de the radar equation:

$$P_{Dr} = P_t G^2 \lambda^2 \sigma \big/ (4\pi)^3 R^4, \text{ for } G = 4\pi A_e / \lambda^2 \quad (1)$$

where P_{Dr} denote the total power delivered to the radar signal processor by the antenna G; P_t is the peak transmitted power; λ is the wavelength; σ is the target-specific parameter called Radar Cross Section (RCS); R is the distance from the satellite to the imaged area; and A_e the antenna effective aperture. According to equation (1) in order to double R, P_t must increase sixteen times to keep the equivalent echo signal at the receiver, or alternatively, A_e must increase four times. This relation affects the choice of the altitude of the orbit (MAHAFZA, 2009). In summary, higher altitudes imply in a

more expensive satellite with bigger solar array and a larger antenna That's why all current SAR missions operate in low earth orbit, between 500 and 1,000 km (OFFICE, 2007).

All existing SAR satellites are in Sun Synchronous orbit, at between 90 and 100 degrees inclination. This design allows provides a global coverage and also provides more time facing their solar panels to the Sun (OFFICE, 2007).

In terms of wave polarization, the employment of polarimetric response is also important. The best configuration lies in a system referred as "fully polarimetric" or quadrature-polarized, that provides different kinds of image responses.

The choice of frequency band depends on the information needed. For example, to estimate the vegetal coverage using the canopy data, the X-Band frequency could be better, but with this frequency range it is more difficult to detect targets in ocean. L-Band, with λ from 15 to 30 cm, provide good results in general.

The actual technology of most SAR systems employs planar antennas facing to image area. However, the heritage of reflector antennas used with success in communications systems have boosted the employment of a respective antennas in association with digital beamforming. The results are lower power needs, a larger swath width and more data collected after satellite pass (KRIEGER et al., 2009).

3. Example of basic requirements

Table 1 presents just suggestions of the parameters discussed above. It'll depend on mission.

Table 1. Examples of Requirements for SAR Satellite Mission

Parameter	Value	Parameter	Value
Orbit Height	750 Km	Polarization	Quad. Pol.
Orbit inclination	Sun synchronous	Frequency Band	L-Band
Incident Angle	26º - 46º	Spatial resolution	10 m
Look Angle	23º - 40º	Swath Width	300 Km
Antenna	Reflector	Look	Asc. / desc.
PRF	2,400 Hz	Revisit time	Weekly

4. Conclusion

The parameters presented in this work don't exhaust all requirements that must be observed in a SAR satellite mission. However, they are considering the basic for any radar orbital system. The parameters could be appropriate for covering large areas, which is of particular interest for countries of continental dimensions like Brazil.

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