Sentinel-1 C-SAR Calibration

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***Abstract*— The ESA Sentinels constitute the first series of operational satellites responding to the Earth Observation needs of the EU-ESA Global Monitoring for Environment and Security (GMES) programme. The GMES space component relies on existing and planned space assets as well as on new complementary developments by ESA. This paper describes the in-orbit calibration aspects for the Sentinel-1 mission. It provides an overview of the calibration requirements, and a potential technical concept for the implementation.**

I. Introduction

ESA is developing the Sentinel-1 European Radar Observatory (Fig. 1), a constellation of two polar orbiting satellites for operational SAR applications. The two C-band radar satellites will provide continuous all-weather day/night imagery for user services, especially those identified in ESA's GMES service elements programme and on projects funded by the European Union (EU) Framework Programmes. Three priorities ('fast-track services') have been identified by EU user working groups: marine core services, land monitoring services and emergency services.

Fig. 1 Artist impression of Sentinel-1 in orbit

Radiometric calibration must be performed as part of the normal operation of the SAR. The calibration process is divided into two components: internal and external calibration.

Internal calibration provides an assessment of radar performance using internally generated calibrated signal sources, especially in the context of pre-flight testing.

External calibration makes use of ground targets of known RCS to render an end-to-end calibration of the SAR system, thereby assessing the impact of those elements that are difficult, if not impossible, to assess using internal methods. External calibration methods can involve the use of: passive and precisely constructed targets, such as corner reflectors and spheres; natural terrain with known backscattering properties, such as the Amazon rainforest; or active transponders.

II. Internal Calibration

The Sentinel-1 SAR instrument has demanding requirements for measurement stability. Considering in orbit conditions and ageing effects, the hardware alone can not provide sufficient stability to fulfil these requirements. Therefore an internal calibration system is implemented to measure the actual instrument gain and phase changes in order to apply them later, in the ground processing, for correction of the image data. The parameter to be derived by internal calibration is the so called PG product, a quantity proportional to the product of transmit power and receiver gain. It is to be noted that the PG product is complex and allows correcting both amplitudes and phases of the image data.

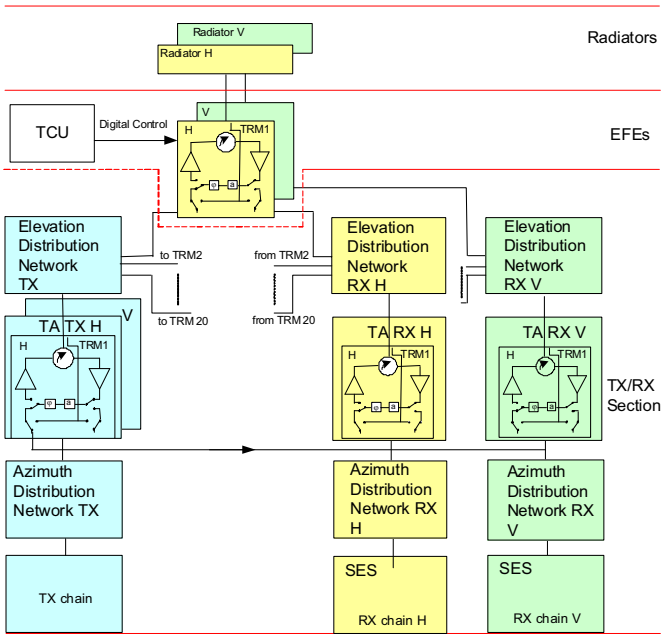

Fig. 2 Overview of the internal calibration paths

A basic principle of the internal calibration method is that the calibration signals shall experience the same changes as the measurement signals. This implies that calibration signals follow the nominal image signal paths as far as possible and cover at least all active elements (Fig. 2). Radio Frequency paths (RF) not covered by calibration signals or dedicated paths used exclusively by calibration signals need a high stability. A further aspect is that the calibration signals have