



Recommendation ITU-R RS.2043-0
(02/2014)

**Characteristics of synthetic aperture radars
operating in the Earth exploration-satellite
service (active) around 9 600 MHz**

RS Series
Remote sensing systems



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Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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Series	Title
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RA	Radio astronomy
RS	Remote sensing systems
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SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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RECOMMENDATION ITU-R RS.2043-0

Characteristics of synthetic aperture radars operating in the Earth exploration-satellite service (active) around 9 600 MHz

(2014)

Scope

This Recommendation provides characteristics for synthetic aperture radars operating in the Earth exploration-satellite service (active) allocated around 9 600 MHz. This information should enable sharing and compatibility studies with other radio services coexisting in the same frequency range or nearby frequency ranges. The use of this frequency range comprises remote sensing satellite systems that are implemented with different radar transmission bandwidths ranging from 100 MHz up to 1 200 MHz.

The ITU Radiocommunication Assembly,

considering

- a) that spaceborne active microwave remote sensing requires specific frequency ranges depending on the physical phenomena to be observed;
- b) that certain frequency bands have been allocated for spaceborne active microwave remote sensing;
- c) that the transmission bandwidth of a radar sensor is directly related to the achievable measurement resolution;
- d) that a growing demand for high-resolution radar information exists as shown in Report ITU-R RS.2274;
- e) that observations in the 9 GHz frequency range provide data critical to the study of the characteristics of the Earth and its natural phenomena, including data relating to the state of the environment;
- f) that only the 9 600 MHz frequency range offers the most advantageous situation of highest possible bandwidth in a frequency band which offers good propagation conditions,

recognizing

that Recommendation ITU-R RS.1166 provides performance and interference criteria for Earth exploration-satellite service (active) sensors including synthetic aperture radars operating around 9 600 MHz,

recommends

that the characteristics of typical space-borne synthetic aperture radar systems operating in the 9 GHz range, as described in the Annex, should be used for sharing and compatibility studies involving the Earth exploration-satellite service (active) around 9 600 MHz.

Annex

Characteristics of synthetic aperture radars operating in the Earth exploration-satellite service (active) around 9 600 MHz

1 Principles of synthetic aperture radars (SAR)

A synthetic aperture radar (SAR) is a coherent spaceborne side-looking radar system which utilizes a satellite's flight path to emulate an extremely large antenna or aperture electronically, and that generates high-resolution remote sensing imagery.

In principle, a SAR is an active phased array antenna. But instead of using a large number of parallel antenna elements, SAR uses one antenna element in time-multiplex. The different geometric positions of the antenna elements are the results of the moving platform.

The satellite travels forward in the flight direction with a nadir pointing towards the centre of the Earth. The microwave beam is transmitted obliquely at right angles to the flight direction illuminating a swath. Range refers to the across-track dimension perpendicular to the flight direction, while azimuth refers to the along-track dimension parallel to the flight direction. Swath width refers to the strip of the Earth's surface from which data is collected as a side-looking radar. It is the width of the imaged scene in the range dimension. The longitudinal extent of the swath is defined by the motion of the aircraft with respect to the surface, whereas the swath width is measured perpendicularly to the longitudinal extent of the swath.

Over time, individual transmit/receive cycles (pulse repetition time, (PRT)) are completed and the gathered data from each cycle is stored in on-board memory. The signal processing uses the magnitude and phase of the received signals over successive pulses from elements of a synthetic aperture. After a given number of cycles, the stored data is recombined to create a high resolution image of the terrain being overflown.

2 Modes of operation of synthetic aperture radars (SAR)

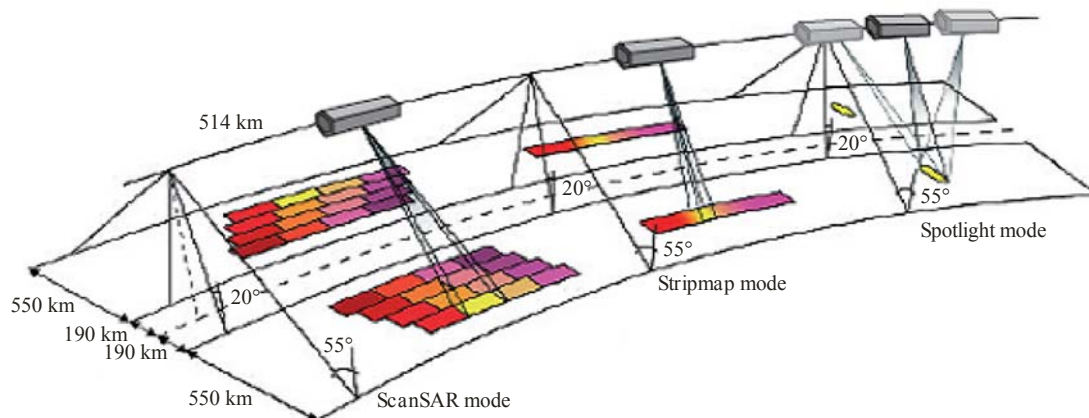
2.1 Geometry

The SARs operating near 9.6 GHz are controlled via a ground command to turn on and off as required to view only specific areas on the Earth. From all SAR modes shown in Fig. 1, the full 1 200 MHz chirp bandwidth is only intended for use when operating in spotlight mode.

Other modes may use the frequency band 9 300-9 900 MHz, in accordance with provisions given by RR footnotes Nos. **5.475A**, **5.476A**, **5.478A** and **5.478B**.

The conventional SAR strip map mode assumes a fixed pointing direction of the radar antenna broadside to the platform track. A strip map is an image formed in width by the swath of the SAR and follows the length contour of the flight line of the platform itself. In the scanSAR mode, the SAR can illuminate several sub-swaths by scanning its antenna into different positions.

FIGURE 1
Modes of operations for SAR system in the 9 GHz Earth
exploration-satellite service (EESS) allocation



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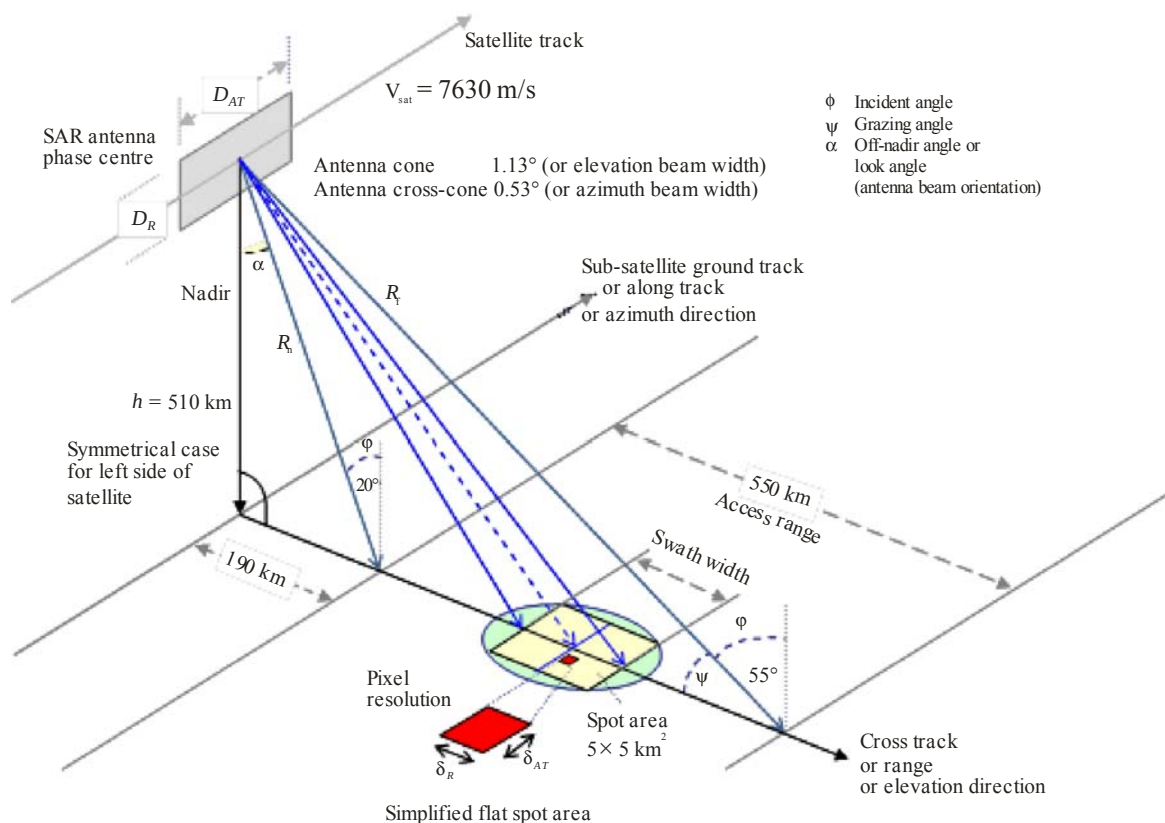
Spotlight is the SAR mode for obtaining highest resolution by electronic steering of the radar beam pointing at a target in the beam thus forming a longer synthetic aperture. The spotlight mode is capable of improving the resolution of SAR imaging capability to less than 30 cm. As more pulses are used, the azimuth resolution also improves.

Spotlight mode of operation is usually at the expense of spatial coverage, as other areas within a given accessibility swath of the SAR cannot be illuminated while the radar beam is spotlighting over a particular target area. Details on the imaging geometries of this mode are shown in Fig. 2.

Data will typically be collected by taking between 49 and 65 sub-swaths of 20 km in range by 0.35 km in azimuth. This data can then be used to create a mosaic of sub-swaths in azimuth to process a 5 km by 5 km image.

All SARs are controlled via ground command to turn on and off as required to view specific areas on the Earth. The “on”-command triggers a transmission of radio-frequency pulses (chirps) for a short period of around five seconds or less depending on the intended observation.

EESS SAR imaging geometry for high resolution spotlight mode (wideband with 1 200 MHz chirp bandwidth)



2.2 Timing characteristics for SAR-4 in high resolution mode

In this mode, SAR-4 transmits for a short period (typically 5 seconds) per event of SAR exposure (“snapshot”). During the five seconds of transmission, the satellite travels actually more than 38 km along the orbit track, thus permanently changing the effective incident angle into the exposed spot area as shown in Fig. 2. In spotlight mode, there can be up to 20 snapshot events per satellite orbit (95 minutes), with a minimum time of 1 second between consecutive events, corresponding to a distance of 45 km on the ground. A graphical representation of the situation is given in Fig. 3.

Adjacent areas are considered to be areas affected by antenna sidelobe illumination. Peak level areas and adjacent areas are illuminated not more than once per orbit period.

A SAR-4 system transmits pulses at a fixed duty cycle of 50 μs followed by 120 μs of silence. The pulse timing is adapted to a fixed pulse repetition rate. During the 50 μs of each transmission pulse the unmodulated (CW) transmit carrier sweeps over the entire bandwidth of 1 200 MHz (“chirp”). The resulting transmission duty cycle, as shown in Table 1, remains fixed under all conditions of pulse width and pulse repetition rate.