

REPORT ITU-R RS.2068

**Current and future use of the band near 13.5 GHz
by spaceborne active sensors**

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1 Introduction and background

1.1 Introduction

The purpose of this Report is to address the continued need of the EESS (active) to access frequencies near 13.5 GHz, the bandwidth requirements, and the scientific feasibility of performing the same measurements in bands other than the band near 13.5 GHz. These requirements will be addressed from the viewpoint of the three major instruments that make use of the band: scatterometers; altimeters; and precipitation radars.

1.2 Background

The World Radiocommunication Conference 2003 (WRC-03) made many changes to the allocations in the 13.75-14 GHz band. Prior to WRC-97, several bands were allocated on a secondary basis to the EESS and the space research service for use by radiolocation stations (i.e. spaceborne active sensors) installed on spacecraft. One of these bands was the 13.4-14 GHz band. WRC-97 decided to allocate the 13.25-13.75 GHz band to the EESS (active) and space research (active) service on a primary basis as a result of the various allocation decisions taken at the Conference with regard to active sensors. However, WRC-97 also saw the need to maintain the 13.75-14 GHz portion of the previous secondary allocation for use by several active sensor instruments that were currently in orbit or were planned and built as their characteristics could not be changed. These provisions were set forth in the Radio Regulations with termination dates of 1 January 2000 and 1 January 2001 for various sensor instruments.

2 Scatterometers

2.1 Use of the band near 13.5 GHz for scatterometers

Scatterometers are radar type devices that measure the near surface vector winds over the oceans. Wind data are critical to determination of regional weather patterns and global climate. No other instrument can provide all weather measurements of the global vector winds.

At the present time, good capability for acquisition of weather data exists over land, but not over the oceans where our only knowledge of surface winds comes from infrequent, and sometimes inaccurate, reports from ships. Since approximately two-thirds of the Earth's surface is covered by oceans, data from scatterometers will play a key role in understanding and predicting complex global weather patterns, ocean circulation, and climate systems.

Two scatterometers that were developed in the United States of America are the NSCAT (NASA scatterometer) that was launched in 1996 on Japan's Advanced Earth Observing Satellite (ADEOS) and the SeaWinds scatterometer which was launched in 1999 on NASA's QuikScat satellite and in 2002 on Japan's ADEOS-II satellite as part of the Earth Observing System (EOS). NSCAT was designed to operate at a center frequency of 13.995 GHz. SeaWinds is a derivative of NSCAT and uses many of the same components, however the center frequency was changed to 13.4 GHz.

2.2 Bandwidth requirements

Existing scatterometer designs near 13.5 GHz use a fixed-frequency, continuous wave pulse to probe the sea surface. The transmitted frequency spectrum is narrow due to the low pulse repetition rate (62 Hz) and large pulse width (5 ms). When the frequency stability of the transmitter and Doppler shifts of frequency are included, the required radio-frequency bandwidth for present-day scatterometers is 1 MHz.

Future scatterometers may use spread spectrum modulation in order to obtain more precise definition of the surface cell where wind measurements are being taken. The bandwidth requirement for these future instruments could be higher than 1 MHz.

2.3 Feasibility of using other bands

Scatterometer measurements, and the derived knowledge about wind vectors, are based on microwave scattering effects over water-surface capillary waves. Measurements at wavelengths comparable to that of the capillary waves caused by water-surface wind interaction is necessary in order to achieve the sensitivity required to measure wind speeds and directions for winds having velocities as low as 3 m/s. Measurements of winds with such velocity are needed to satisfy the requirements for determination of variation in weather and climate. The wavelength in the band near 13.5 GHz is commensurate with the dimensions of the capillary waves produced by low speed winds with the result that the scatterometer is highly sensitive to local winds, especially low wind speeds. At the same time, a scatterometer operating in the band near 13.5 GHz exhibits low sensitivity to non-wind effects such as swells and surface film/surface tension.

Possible alternative bands to the band near 13.5 GHz have been considered. The two bands closest to 13.5 GHz that are currently available to the Earth exploration-satellite service (active) are the 9.5-9.8 GHz and 17.2-17.3 GHz bands. Neither the 9.5-9.8 GHz band nor the 17.2-17.3 GHz band is as desirable for use by scatterometers as the band near 13.5 GHz. This is a consequence of there not being a large body of data on radar scattering from the ocean surface at frequencies other than 13.5 GHz where the Seasat scatterometer operated and 5.3 GHz where the ERS-1 scatterometer operated. Moving to a new band would require redeveloping the algorithm that relates the radar return to the wind speed and direction. The algorithm developed for the 5.3 GHz band required a number of aircraft and tower experiments before launch and more than six months of refinements after the launch of ERS-1. An effort to develop a new algorithm would result in an interruption of the data flow to the science community for the period that is required to gain confidence in the new algorithm. A frequency change will result in some loss of the continuity of the long-term data set for the same reason. Scatterometers operating near 13.5 GHz have higher sensitivity to low wind speeds than scatterometers operating near 5.3 GHz. The low speed wind vectors are important to the studies of the variability of ocean currents. At frequencies above 13.5 GHz, atmospheric attenuation due to water content (e.g. cloud cover and rain) becomes more variable. At 17.2 GHz, it is probably possible to operate a wind scatterometer, however, operating at a frequency of 17.2 GHz or greater would result in degraded performance since the scatterometer would be more sensitive to atmospheric water content and surface film/surface tension effects. At frequencies above 20 GHz, the variability of the atmospheric attenuation would render the instrument useless without other means of measuring the atmospheric variability.

Another factor that makes continued use of the band near 13.5 GHz for scatterometry important is the large amount of data that has been acquired at this frequency over the past 15-20 years. The Seasat scatterometer and the NASA aircraft scatterometer both operated at this frequency, as well as the NSCAT. Continued use of this band for future scatterometers will allow more meaningful cross-comparison of data sets acquired in the future with those from the past. A broader database acquired by instruments operating with similar parameters can be expected to produce a more accurate scientific model.

2.4 Long-term need for operation around 13.5 GHz for scatterometers

There is a long-term requirement to operate spaceborne scatterometers in the band near 13.5 GHz. Scatterometer measurements will be used in operational systems to derive wind speed and wind direction data. These data will be used to measure and predict weather, ocean circulation, and climate, all key factors in management of the environment. As discussed above, only in the band