

Review of Frequency Usage for Oceanographic Radar in the 3-50 MHz Band

Joo-hwan Lee*, Jong-ho Kim*, Young-jun Chong*

*Department of Radio Technology, ETRI (Electronics & Telecommunications Research Institute), Korea

joohlee@etri.re.kr, yjchong@etri.re.kr, jonghkim@etri.re.kr

Abstract— WRC-12 on February under the Agenda Item 1.15 reviewed the possibility of frequency allocations for oceanographic radars in portions of the 3-50 MHz frequency range, and resolved to allocate several portions of the frequency bands in accordance with the Resolution 612 (Rev. WRC-12). Thus it is possible to use for oceanographic radars as much as 2 425 kHz width in the frequency range of 3-50 MHz in the Republic Korea. However, those allocated bands are not freely usable in the Korean oceanographic radars because of the radio environments and/or the radio interference to existing fixed and mobile services. In order to investigate the number of radio signals which are being introduced at coastal area of Korea, the mobile measuring system was used for the observation test of the radio environment in the frequency of 3-50 MHz band. This paper illustrates the results of the observation test.

Keywords— WRC-12, Frequency Allocations, Oceanographic Radar, Radio Environment, Interference

I. INTRODUCTION

Oceanographic radars have been operating in the 3 to 50 MHz range since 1970s on an experimental, non-interference basis. There is an increasing interest in the ability to accurately measure the currents and waves in coastal waters and to maintain maritime domain awareness. Oceanographic radar systems operating at frequencies higher than 50 MHz are limited in their ability to provide data meeting the combined range, accuracy and resolution requirements. The global oceanography community is planning for the implementation of coastal oceanographic radar networks. The potential benefits to society for improved measurement of coastal currents and sea state include a better understanding of issues like coastal pollution, fisheries management, search and rescue, beach erosion, maritime navigation and sediment transport. Oceanographic radar measurements of the sea surface provide support to meteorological operations through the collection of sea state and dominant ocean wave data. In addition, HF oceanographic radar technology has applications in maritime domain awareness by allowing the long range sensing of surface vessels. This could benefit the safety and security of shipping and ports [1].

In oceanographic radars using Bragg scattering, the frequency range of 3 to 50 MHz (wavelength of 100 to 6 m) is very useful in measuring ocean waves driven by wind (see Fig. 4). Spatial resolution of the radar is limited by the bandwidth

of the signal e.g. the bandwidths of 100 and 300 kHz give resolutions of 1.5 km and 500 m, respectively .

The objectives of these systems are to: obtain continuous, real-time information for environmental operation (e.g. pollution collection and control), provide disaster-mitigation services (e.g. tsunami wave detection), provide maritime-safety services (e.g. oceanic-current monitoring sea state observation) by oceanographic radars.

The physical parameters that are measured by oceanographic radars and associated performance requirements dictate the frequency ranges that will support data collection. Oceanographic radars for ocean observing utilize the rough surface of the ocean to measure ocean currents and sea state. When the wave spacing on the ocean surface is equal to the half wavelength of the frequency used by the oceanographic radar, a strong signal is reflected back in the direction of the radar. This is the phenomenon known as Bragg scattering. The frequency range 3 to 50 MHz is very useful for oceanographic observing radar operations since ocean waves are always present where the wave spacing matches the radar's operational frequency. The higher temporal resolution is to be pursued for disaster-mitigation purposes while the higher spatial resolution is to be pursued for environmental operation. In addition, measurement of Doppler shift of the signal returns allows operators to measure other properties of sea state and currents [2].

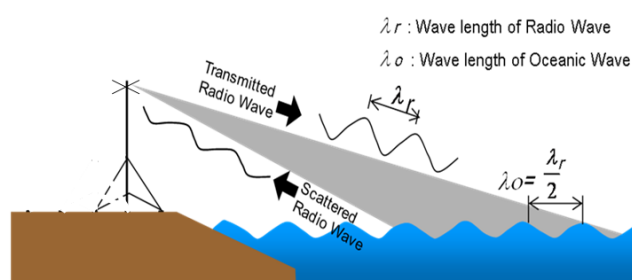


Figure 1. Radio Principle of Oceanographic Radar

Increased reliance on the data from these systems for maritime safety, oceanographic, climatological, meteorological and disaster response operations have driven the need to improve the regulatory status of oceanographic radars while taking into account the protection of existing allocated services. WRC-12 on this February reviewed the possibility to

allocate some portions of 3-50 MHz frequency range to radiolocation service for the oceanographic radars on a shared basis with existing fixed and mobile services under the Agenda Item 1.15.

WRC-12 on February under the Agenda Item 1.15 has conducted to review the allocation of sub-bands in 3-50 MHz frequency range to radiolocation service for operation of oceanographic radars, and finally agreed to allocation of the following frequency bands in accordance with the Resolution 612 (Rev. WRC-12) of the Radio Regulations.

Based on the results, it is possible to use for oceanographic radars as much as 2 425 kHz width in the frequency range of 3-50 MHz in the Republic Korea, as shown in Table 1 [3].

TABLE 1. ALLOCATED FREQUENCY BANDS AT WRC-12

Band (MHz)	Width (kHz)	Priority			Related Provisions
		R1	R2	R3	
4.438-4.488	50	S	P	S	No. 5.132A; No. 5.132B
5.250-5.275	25	S	P	S	No. 5.132A; No. 5.132C
9.305-9.355	50	S	N	S	No. 5.132A; No. 5.132B
13.45-13.55	100	S	S	S	No. 5.132A; No. 5.149A
16.10-16.20	100	S	P	S	No. 5.145A; No. 5.145B
24.45-24.60	150	S	P	S	No. 5.132A; No. 5.158
26.20-26.35	150	S	P	S	No. 5.132A; No. 5.133A
39.00-39.50	500	S	N	N	No. 5.132A; No. 5.159
39.50-40.00	500	N	N	P	No. 5.132A
41.02-41.67	650	N	P*	P*	No. 5.161A
42.00-42.50	500	S	N	N	No. 5.132A; No. 5.161B
43.35-44.00	650	N	P*	P*	No. 5.161A

R1 : Region 1 (Europe, Africa)
R2 : Region 2 (South & North America)
R3 : Region 3 (Asia-Pacific Region)
N : Not Allocated
P : Primary Allocation
P* : Limited to US and KOR
S : Secondary Allocation

However, those allocated bands are not freely usable in the Korean oceanographic radars because of the radio environments and/or the radio interference to existing fixed and mobile services.

In order to investigate the number of radio signals which are being introduced at coastal area of Korea, the mobile measuring system was used for the observation test of the radio environment in the frequency of 3-50 MHz band.

II. OBSERVATION TEST

In order to review the potential impact between oceanographic radars and existing fixed and mobile systems in

the allocated band for oceanographic radars at WRC-12, the observation of radio environments in the whole range of the band was carried out using a mobile observation system.

A. Observation System

The mobile measuring system was used for the observation of radio environment in the allocated sub-band in 3-50 MHz frequency range.

Figure 1 shows an overview of the observation system used for this test. The system consists of two HF antennas for reception of radio signal at the range of 3-50 MHz band, antenna selector for switching the frequency, vector analyser for data processing, personal computer for saving data and monitor. Two types of HF antenna were used to fully cover the 3-50 MHz band. One is HE010 antenna covering the lower frequency of 3-20 MHz, and the other is HE309 antenna for 20-50 MHz [4][5].

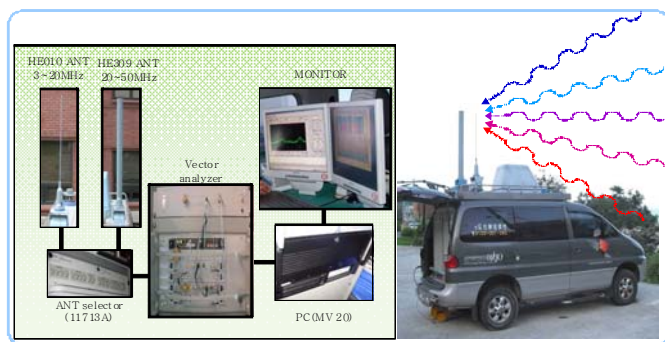


Figure 2. Observation system mounted on board vehicle

B. Observation Sites

Currently, about 25 radars are operating in Korean Peninsula, based on experimental radio stations under the Radio Regulations (RR) No. 4.4. They use slightly off-set frequencies because of absent allocation in the RR.

Two sites in Jeju do were selected in this observation. One site is located in Western part of Jeju, and the other is in Eastern part, existing oceanographic radars are operating near the sites (see Figure 2).



Figure 3. Observation sites

III. OBSERVATION RESULTS

The tests were carried out 3-days measurements from 25 to 27 July, and each test for scanning radio environment on 3-50

MHz band was made for 3 times a day during 2 hours in each test. The measurements for observing radio signals introduced to the receiver of measurement system were applied to RBW 1 kHz in each sub-band.

A. 5 MHz Band

There exists two allocated sub-bands in this frequency band, which are 4.438-4.488 MHz and 5.250-5.275 MHz. Based on the observation test in the Jeju area, the spectrum status would be good for the operation of oceanographic radar with more than 25 kHz bandwidth. Samples of observed radio spectrum in these sub-bands are shown in the Figs. 4 and 5, respectively.

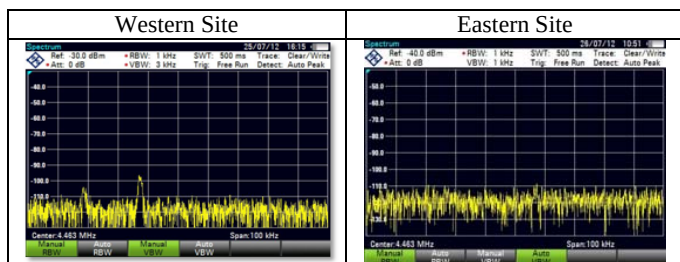


Figure 4. Observation Results in 4.438-4.488 MHz Band

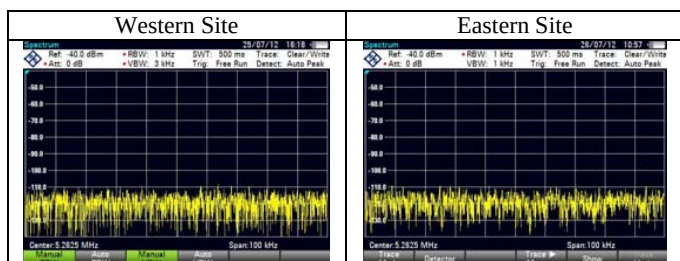


Figure 5. Observation Results in 5.250-5.275 MHz Band

B. 13 MHz Band

One sub-band is allocated for oceanographic radar operation in this band. Moreover, experimental radars are currently operating near the allocated band. Samples of observed radio spectrum in the allocated sub-band are shown in the Figure 6.

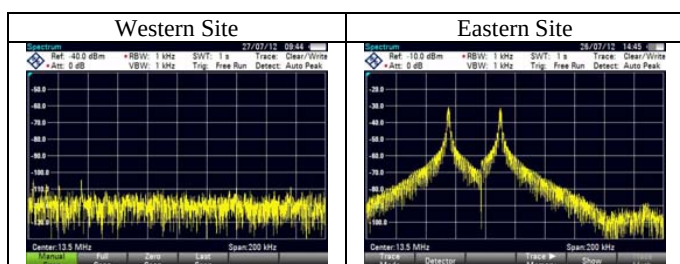


Figure 6. Observation Results in 13.45-13.55 MHz Band

In case of Eastern Site, a sweeping radar signal was captured, which radar is operating in 13.455-13.485 MHz. The radar waveform with Max-hold measurement is shown in Figure 7.



Figure 7. Radar Waveform with Max-hold Measurement

C. 24 MHz Band

Two sub-bands were allocated for the radar in this frequency band, which are 24.45-24.60 MHz and 26.20-26.35 MHz. Based on the observation test in the Jeju area, the spectrum status would be good for the operation of oceanographic radar with more than 100 kHz bandwidth. Samples of observed radio spectrum in these sub-bands are shown in the Figs. 8 and 9, respectively.

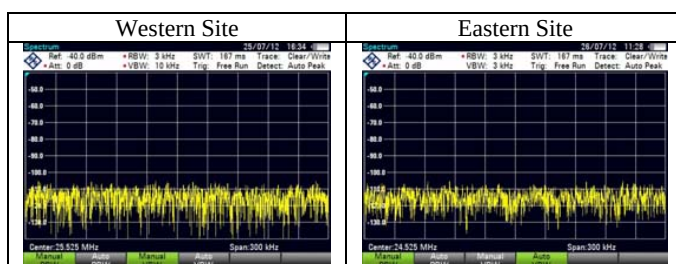


Figure 8. Observation Results in 24.45-24.60 MHz Band

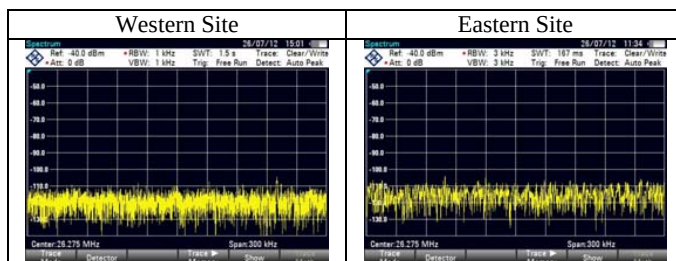


Figure 9. Observation Results in 26.20-26.35 MHz Band

D. 44 MHz Band

In this frequency band, two sub-bands are allocated for the radar related to the Rep. of Korea, which are 41.02-41.67 MHz (exactly 41.015-41.665 MHz) and 43.35-44.0 MHz. The spectrum status would be good for the western area, Aewol area, however, the other site (Kimnyung area) be affected by radio signals radiated from adjacent radio stations.

Samples of observed radio spectrum in these sub-bands are shown in the Figs. 10 and 11, respectively.

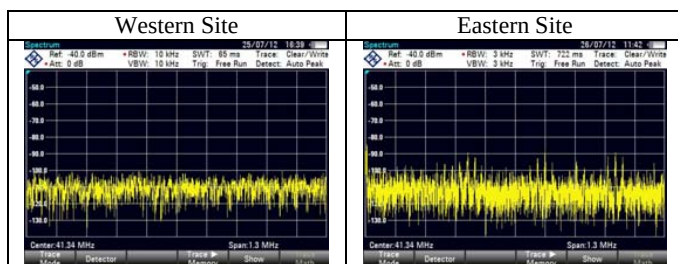


Figure 10. Observation Results in 41.015-41.665 MHz Band

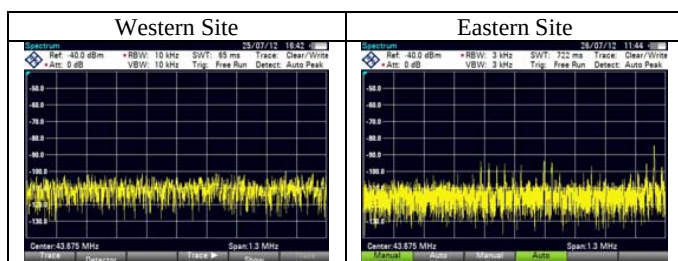


Figure 11. Observation Results in 43.35-44.0 MHz Band

A captured signal at the Eastern site was come out emission of adjacent oceanographic radar, probably used in Japan. The centre frequency of the adjacent radar was found 40.04 MHz with sweeping bandwidth of 200 MHz. The adjacent radar waveform with Max-hold measurement is shown in Figure 12. Even though 43.35-44.0 sub-band is offset from the adjacent radar, it is known that residual signals are widely spread.

Thus this sub-band in Eastern area of Jeju is not good for operation of oceanographic radar with 44 MHz band.



Figure 12. Adjacent Radar Waveform

IV. CONCLUSIONS

According to the results of the WRC-12 related to Agenda item 1.15, multiple sub-bands in the frequency range of 3-50 MHz were allocated to radiolocation service for oceanographic radars. However, there is no evident study on the stability of radar operations under the geographical radio environment in those sub-bands. Thus, it has been recognized that more information of radio environment with respect to the allocated sub-bands is required to deploy a lot of radars in the Korean Peninsula.

By informative and practical reasons, some results of observation test through the whole allocated sub-bands, limited to Jeju area, are shown in this paper.

The results showed that there appeared to be sufficient available spectrums in most part of the sub-bands, to support allocation of radiolocation service for oceanographic radars. However, in case of eastern site of Jeju, 44 MHz band is not available for oceanographic radar due to the emission of adjacent radio stations.

Hence, careful considerations to use radiolocation service have to be required because the existing radio stations are able to affect newly deployment of oceanographic radars in Korean Peninsula.

ACKNOWLEDGMENT

The authors wish to acknowledge the assistance and support of the Spectrum Policy Division of KCC (Korea Communications Commission), RRA (National Radio Research Agency), and CRMO (Central Radio Management Office) of KCC (Korea Communications Agency).

REFERENCES

- [1] ITU-R, "The feasibility of sharing sub-bands between oceanographic radars operating in the radiolocation service and fixed and mobile services within the frequency band 3-50 MHz", *Report ITU-R M.2234*, Oct. 2011.
- [2] ITU-R, "Technical and operational characteristics of oceanographic radars operating in sub bands within the frequency range 3-50 MHz", *Recommendation ITU-R M.1874*, Apr. 2010.
- [3] ITU-R, *Final Acts WRC-12*, Article 5, ITU, 2012
- [4] ROHDE & SCHWARZ GmbH & Co. KG, "R&S HE010", Technical Information, July 2009.
- [5] ROHDE & SCHWARZ GmbH & Co. KG, "Active Vercicle Dipole R&S HE039", Technical Specification