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Development of Active Phased Array Weather Radar

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1 Introduction.

In recent years, it is increasing weather disasters by severe storm and gust in the regional Japanese cities. Localized severe storm and gust are mostly caused by a cumulonimbus developing to more than 10 km attitude. Weather radar can observe the developing situation and the internal structure. In addition, observational data can be utilized in the prediction of precipitation. Weather radar is essential system for observing the severe storm and gust. The importance of weather radar is increasing.

However, conventional weather radar with parabolic antenna is unable to secure sufficient time resolution a cumulonimbus, because the life cycle of cumulonimbus is shortly about 30 minutes but conventional weather radar needs about 5-10 minutes of time to observe three-dimensional structure of cumulonimbus. [1] Moreover, the number of elevation angle is short. It is difficult to observe exactly inside the cumulonimbus.

In order to achieve both shorter time-resolution and to satisfy the observed elevation angle, we have developed a technology for active phased array weather radar (APAWR) of X band with Digital Beam Forming (DBF). In this paper we describe the characteristics of this new-generation weather radar and its active phased array antenna. And we show the measured results of the active phased array antenna.

2. System Overview

Figure 1 shows the image of system operation in this APAWR. To capture in real time and in detail the internal structure of clouds, this radar with 2 x 2 meter antenna is on the roof of the tower buildings in urban areas. Figure 2 shows a distinctive of the concept difference between this APAWR and conventional weather radar. This APAWR adopted a one-dimensional phased array to supply this APAWR at same price range as compared to conventional weather radar. This is a mechanical drive for the azimuth angle and an electronic scan for the elevation angle. For the elevation angle, the transmitted beam is formed as a fan beam, and the received beams are by

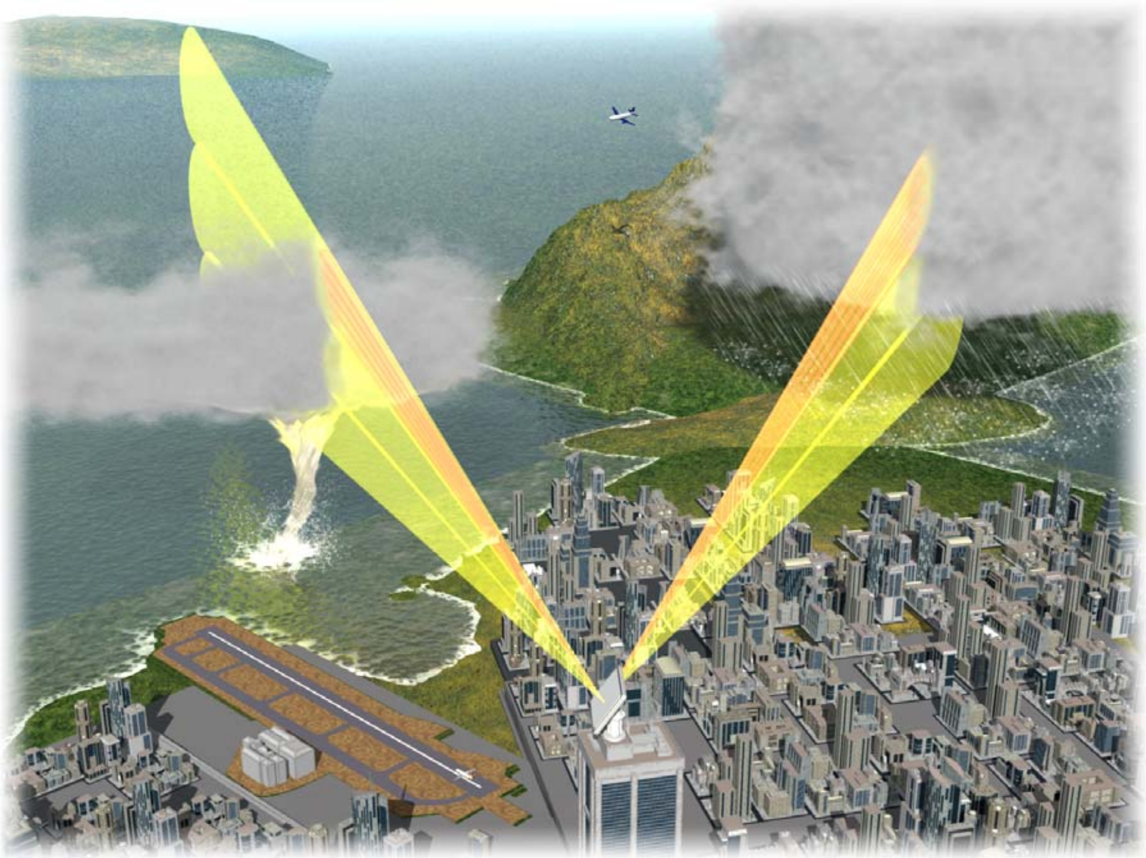
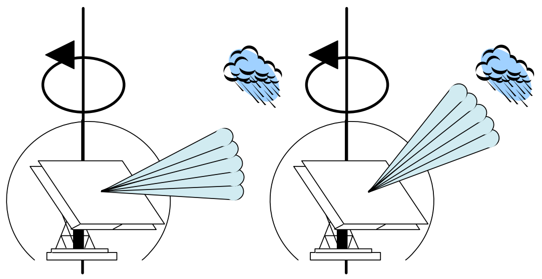
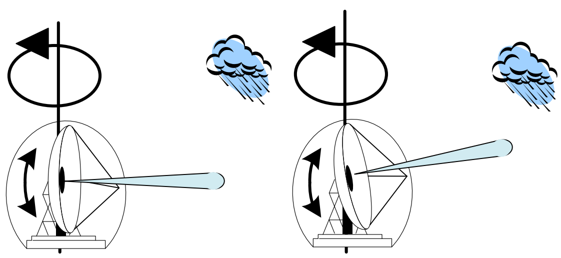


Figure 1 - The Observational Image of Active Phased Array Weather Radar



(a) Active Phased Array Weather Radar.



(b) Conventional weather radar.

Figure 2 – Concept of the new-weather radar.

formed as multi-beam using DBF technology. The width of transmitted wave can be extended reducing the number of antenna elements, so the number of received multi-beam can be increased. Thus, APAWR can be characterized by observing the three-dimensional space without gaps fast and closely.

This system has two observational mode as shown in Table 1. One is fast observation mode with a minimum of 10 second interval to have about 20 km observation range. Another is wide observation mode with a minimum of 30 second period to capture about 60 km observation range.

Table 1 – Main Observational mode and specification.

	Spec	
Maximum Power	Upper to 430W	
Frequency	9320 to 9445MHz, 5MHz step	
Beam Width (after DBF)	About 1 degree	
Mode	Fast Observation	Wide Observation
Coverage	20km	60km
Scan Interval	10 seconds	30 seconds
Number of Hit	About 10	About 20
Number of Elevation	About 100	About 100

3. Development and Evaluation of Active Phased Array Antenna

We have already developed the active phased array antenna. Figure 3 shows the picture of APAA. In addition, we have already performed for the antenna pattern evaluation. A developed antenna has 128 of waveguide slotted antennas arranged at 16.5mm pitch. The aperture length of this antenna is 2.2 x 2.1 m.

This antenna has transmitting and receiving units (TxRx Unit), receiving units (Rx Unit), and DBF unit [2]. This radar can transmit maximum 24ch and receive 128ch, with 3 TxRx Units and 13 Rx Units.

DBF Unit is possible to get 128ch synchronized A/D conversion and I/Q detection. It has 60dB of dynamic range at least. The receiving multi beams at 1 degree from 128ch I/Q signals are formed by DBF technology. DBF Unit is capable of handling up to 16 beams simultaneously.

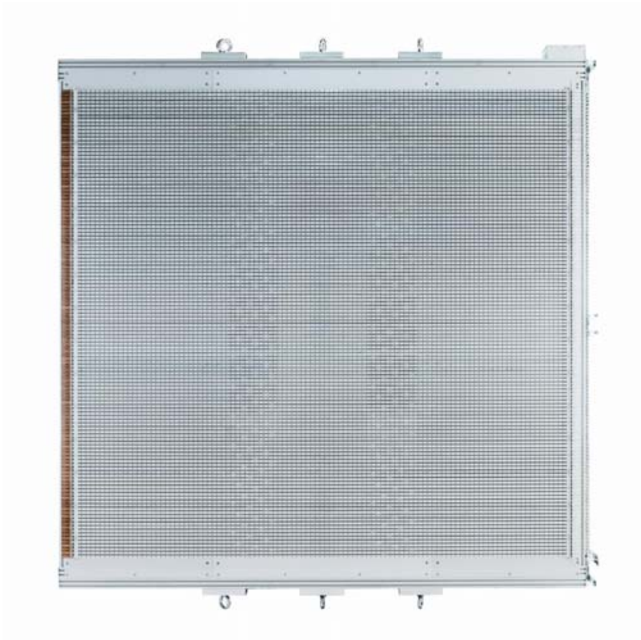
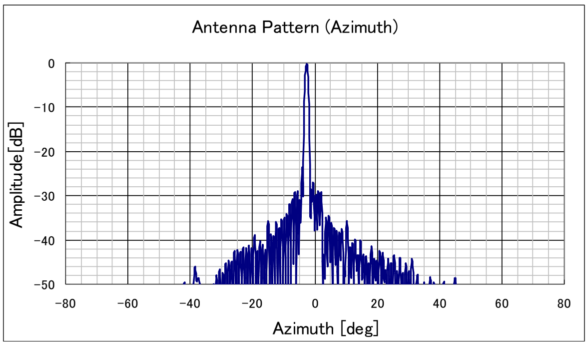
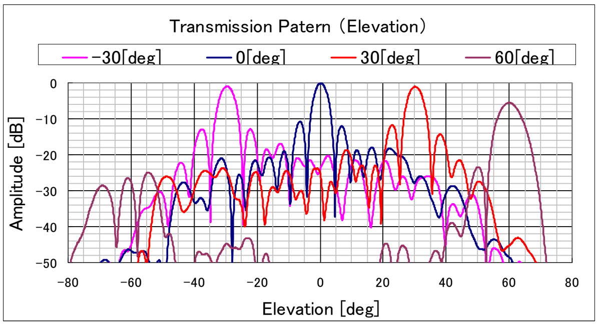


Figure 3 – Developed the active phased array antenna.

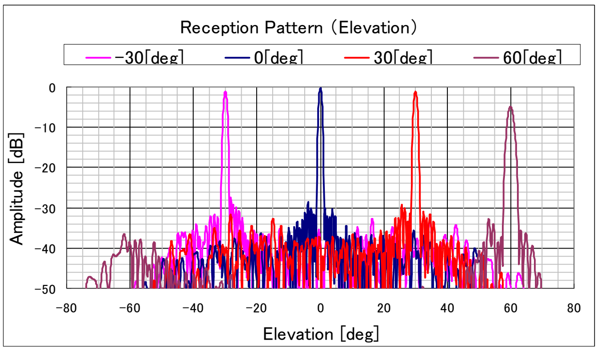
Figure 4 shows antenna pattern of the APPA. The transmitting antenna gain is 36dBi or more, and the receiving antenna gain is 42dBi or more. The side lobe level of azimuth angle is -23dB or less. The transmitting side lobe level of elevation angle is -10dB or less, and the receiving one is -23dB or less. The receiving beam width both azimuth and elevation angle is 1.2 degree or less at elevation 0 degree.



(a) Transmission and Reception Pattern (Azimuth).



(b) Transmission Pattern (Elevation.)



(c) Reception Pattern (Elevation)

Figure 4 – Far-field Antenna Patterns.

4. Future Work

We are developing active phased array weather radar. We performed an evaluation of the antenna array. This radar was found to be able to achieve three-dimensional observation period of 10 seconds minimum. Going forward, we will develop the signal processing system. The APAWR system will be evaluated at Osaka urban area in 2012.

5. REFERENCES

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[2] Y. Shiraishi, R. Suzuki, M. Tanabe, T. Kumamoto, and Y. Masuda, "An X-Band Transmitting and Receiving Power Amplifier Unit using GaN HEMTs for Active Phased Array Antennas," IEICE Technical Report, SANE2010-157, Jan., 2011.

8. ACKNOWLEDGMENTS

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