# Development of Phased-Array Weather Radar System for 3D Observation of Cumulonimbus Clouds

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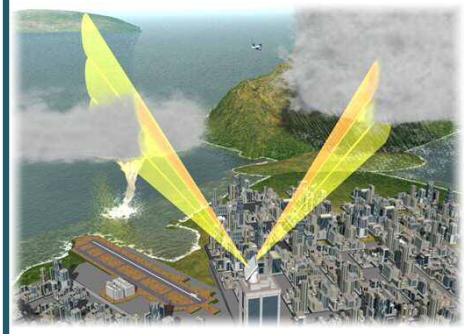
## Abstract

**Field test of the first Phased-Array Weather Radar (PAWR) has begun in Japan. In order to achieve precise three dimensional observations of cumulonimbus clouds for predicting severe weather, PAWR is expected to observe the full volume of meteorological phenomena within 1 minute. The performance and observation result of PAWR are introduced in this poster.**

## Introduction

In Japan especially in urban areas, natural disasters caused by extreme weather are recently increasing and the lives of citizen are at risk. Severe weather phenomena such as localized heavy rainfalls, gusts and tornadoes are mainly caused by the rapid growth of cumulonimbus clouds which grows to more than 10 km altitude. Generally, the lifecycle of a cumulonimbus cloud is as short as 10 to 30 minutes. However, conventional weather radar systems with parabolic antenna requires approximate 5 to 10 minutes for full volume scanning to observe the three dimensional structure of a cumulonimbus cloud, which has an inadequate capability in temporal and spatial resolution for observing the behavior of cumulonimbus clouds. [1]

## Conceptual Image of PAWR



## System Appearance Configuration

**X-band PAWR installed at Osaka University**

**Phased-Array Antenna System of X-band PAWR**

**Radar Processor and Controller of X-band PAWR**

Radar Processor Radar Controller

## System Overview

Toshiba's newly developed X-band Phased-Array Weather Radar (PAWR) has the capability to observe cumulonimbus clouds within 1 minute. PAWR is already installed at Osaka University (Japan) under a grant of NICT, has a 128-slotted array antenna and applied Digital Beam Forming (DBF) technique to simultaneously generate the multiple vertical beams for covering the elevation angle from 0 to 90 degrees. PAWR antenna is mounted with a mechanical drive for azimuth angle and electronic scanning for elevation angle. For the elevation angle, the transmitted beam is formed as a fan beam, and the received beams are formed as multi-beam using DBF technology. Tilt angle of the antenna is set to 30 degrees in elevation, transmitted and receiving by time-division radio wave from -30 degrees to +60 degrees, to observe without a gap from 0 degrees to 90 degrees in elevation. The main feature of PAWR is to perform dense 3-D volume scanning within 10 to 30 seconds without gaps between each beam.

Table 1 describes the major specifications of PAWR. This system has two observation modes. One is "Rapid Mode" which able to update the full volume scanning in 10 seconds with the 20 km radius range. Another is "Wide Range Mode" which observes a 60 km radius range in 30 seconds. Compared with conventional parabolic antenna weather radar, PAWR in "Wide Range Mode" has 100 elevation angles which is 10 times more numerous than conventional radar, and scanning time has been reduced to 30 seconds compared to 5 minutes for conventional radar. In total, performance is 100 times improved by PAWR. Typical observation range for rapid mode is shown in Figure 1. Comparison of PAWR and conventional radar are shown in Figure 2.

**Table 1 : Major Specifications of PAWR**

| Major Specification | | |
|---|---|---|
| Tx Power | 430 W or higher | |
| Tx Frequency | 9,320 to 9,445 MHz (5MHz step) | |
| Beam Width (after DBF) | About 1 degree | |
| Range Resolution | 100 m | |
| Doppler Velocity Measurement | 60m/s (max); Dual PRF | |
| Doppler Velocity Accuracy | 0.1 m/s | |
| Observation Mode | Rapid Mode | Wide Range Mode |
| Coverage Area (Radius) | 20 km | 60 km |
| Full Volume Update Time | 10 sec | 30 sec |
| Number of Hits | 10 hits | 20 hits |
| Simultaneous Elevations Scanned | 100 angles | 100 angles |

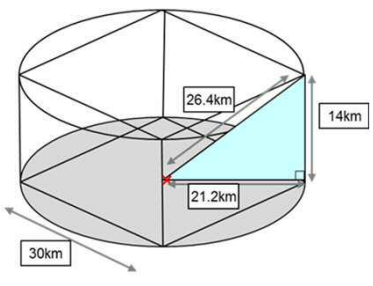



**Figure 1 : Typical observation range for rapid mode**

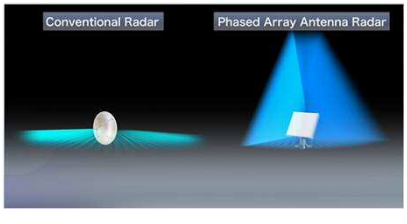



**Figure 2 : Comparison of conventional parabolic antenna radar and phased-array antenna radar**