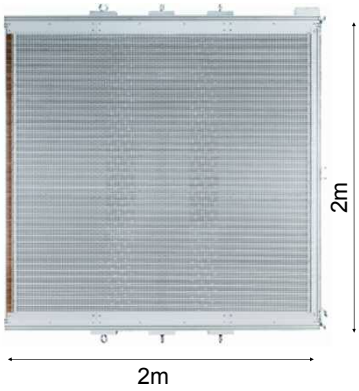
Development and Evaluation of Active Phased-Array Antenna

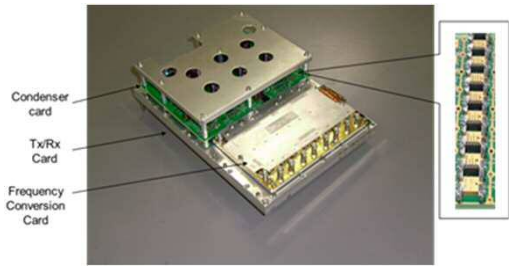
PAWR Antenna

PAWR consists of 128 slot antennas and its aperture length is 2 m by 2 m. This antenna has receiving and transmitting units, DBF units, and those units are located in the rear side of antenna.



Transmitting and receiving unit (TxRx unit)

Each TxRx unit or Rx Unit has the capability of transmitting or receiving up to 8ch. This radar is able to transmit up to 24ch with 3 TxRx Units, and receive up to 128ch with 13 Rx Units.



DBF Unit

The DBF Unit has the capability of processing 128ch synchronized A/D conversion and I/Q detection, and it has at least 60dB of dynamic range.

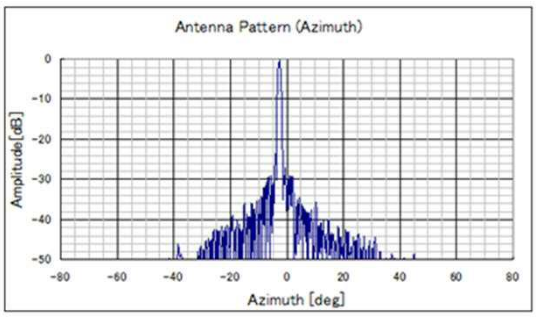
The receiving multi beams at 1 degree from 128ch I/Q signals are formed by DBF technology.

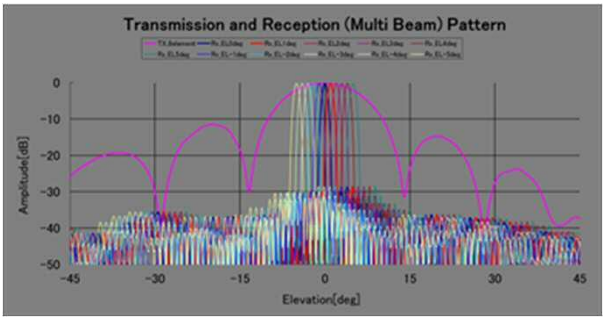
DBF Unit is capable of simultaneously handling 16 beams at same time.

Actual measured Antenna pattern

Azimuth beam width is about 1 degree and side lobe is less than -23 dB. Elevation beam width is about 4 degrees for transmitting by using 24 elements (24 slots), and about 1 to 1.2 degrees for receiving by DBF technique.[2]

For the reception pattern of elevation direction, we have achieved the reduction of the beam width to less than 1.2 degree at 0 degree elevation. Thus, the spatial resolution is about 500 m at 20 km, 1.3 km at 60 km; also able to observe all of the observation space and output 3D data such as radar reflectivity factor (Z) and Doppler velocity (V) within minimum of 10-second intervals.

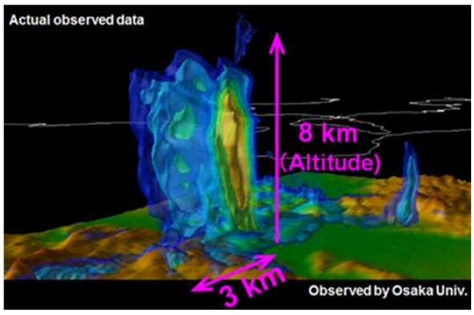




Observstion Result

The three dimensional image of actual observation results is shown as follows observed in July 26, 2012.

One cumulonimbus echo was about 3 km vertically and 8 km horizontally. Observation data showed a small indication of heavy rainfall (we call it an "a heavy rainfall in the making") of 4 to 6 km in attitude has exponentially grown and then became localized heavy rainfall within few minutes. By using PAWR, any changes in localized meteorological phenomena can be observed every 30 seconds or less. Our system is expected to use for preventing disasters by forecasting localized heavy rainfalls, gust and tornadoes.



Localized heavy rainfall at East Osaka, view from Kyoto (North-East) direction (July 26, 2012,17:00:16)

Future Work

Continuing collaboration with Toshiba Corporation, NICT and Osaka University., we will work on the development of new signal processing techniques which adaptively forms antenna patterns, data archiving and the analysis of so-called "big data" and three-dimensional visualization.

Acknowledgments

The authors wish to thank of Toshiba radar antenna engineers for their contribution to the measurement process of Active Phased-Array Antenna: M. Tanabe and Y. Masuda.
This research is supported by the National Institute of Information and Communications Technology (NICT), Japan.

References

[1] F. Mizutani, M. Wada, R. Muto, and J. Horikomi, "Development of 9GHz band Solid-State Multi-Parameter Weather Radar," IEICE Technical Report , SANE2008-85, Nov., 2008.
[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.
[3] F.Mizutani, M.Wada, H.Marui1, H.Handa, T.Ushio, S.Satoh, and T.Iguchi, "Development of Active Phased Array Weather Radar", WMO TECO-CIMO2012, Oct., 2012