

P2.14 OPTIMIZATION AND TESTING OF A TERMINAL DOPPLER WEATHER RADAR FOR THE NEW HONG KONG INTERNATIONAL AIRPORT AT CHEK LAP KOK

David B. Johnson*, R. Jeffrey Keeler, Cathy Kessinger
National Center for Atmospheric Research†, Boulder, Colorado

C.M. Shun
Hong Kong Observatory
Hong Kong

Peter Wilson
Ambidji Group
Melbourne, Australia

James G. Wieler
Raytheon Company
Sudbury, Massachusetts

1. INTRODUCTION

A new international airport is being built at Chek Lap Kok (CLK) in Hong Kong. As part of a comprehensive set of weather systems designed to support the new airport, Hong Kong has acquired a Raytheon Terminal Doppler Weather Radar (TDWR) for detecting hazardous weather, including windshear and microburst events associated with convective storms. A complimentary system, the Operational Windshear Warning System (OWWS) is being developed to detect, forecast and provide warnings for significant terrain-induced windshear and turbulence in the vicinity of CLK (see Poon and Wagoner, 1995; Neilley and Keller, 1995; Mahoney and Donaldson, 1996).

Initial studies in support of the TDWR project included a detailed user requirements study, technology reviews, and detailed site engineering studies leading to the selection of a preferred TDWR site at the Tai Lam Chung Marine Police Base, roughly 12 km northeast of CLK (see Figure 1).

Based on the results of the site selection and user requirements studies, technical specifications for the Hong Kong TDWR system were prepared and tenders for the commercial supply of the system were invited in March, 1994. In late 1994 a contract was signed with Raytheon Company for the radar system, installation, and training. Access roads, buildings, and the tower to support the radar antenna and radome were provided by the Architectural Services Department (ASD) of the Government of Hong Kong. Site preparation and construction activities began in mid-1995. The radar was installed during summer, 1996.

Following the installation and initial run up of the radar, a series of on-site optimization studies were performed by Raytheon, Ambidji, and NCAR/WITI. Additional data reviews were performed at NCAR throughout autumn, 1996, leading to a second round of testing and optimization in January 1997. Following this second optimization period, the Hong Kong TDWR entered an extended period of trial operations that

will continue until the new airport opens. During this period the TDWR will provide data for training of meteorological and air traffic personnel, as well as providing data for use by the OWWS system.

2. HONG KONG TDWR DESCRIPTION

The Hong Kong TDWR is a sensitive, 250 kW peak power system operating in the C-Band with a high performance antenna with a 0.55° pencil beam. The system was designed to work in the high clutter airport environment and uses a klystron-based transmitter and low sidelobe antenna giving at least 50 dB of clutter suppression for stationary targets, augmented by clutter residual maps using indexed beams and point target removal algorithms. The system is designed for fully automatic, unattended operation with weather products and warnings automatically communicated to air traffic personnel.

Although based on the U.S. TDWR (Michelson, et al., 1990), the Hong Kong TDWR includes a number of local enhancements, including upgraded computers, a dedicated microwave radio link with backup via land line for communication between the radar site and the airport at CLK, ethernet output of base data, and additional displays – including both product and base data displays at the Airport Meteorological Office. Ultimately the most distinctive feature of the Hong Kong system will be the integration of the standard display and warning products into a unified display incorporating both TDWR and OWWS products.

To prevent possible beam blockage by nearby ship traffic, the Hong Kong TDWR is installed with an antenna height of 60 m. The 7.6 meter diameter antenna is protected by a 11.3 meter diameter, rigid, compensated seam, A-sandwich radome mounted atop a 30 meter tower with enclosed stairway.

3. TERRAIN BLOCKAGE

Figure 1 is a topographic map of the area surrounding the new airport. Lantau Island, immediately south of the airport, is quite mountainous, with peaks reaching 934 m. Figure 2 shows the observed radar horizon from the TDWR site. While the view of the airport is unimpeded, the radar beam is seriously blocked in most other directions. While the

* Corresponding author address: Dr. David B. Johnson, National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80303 e-mail: djohnson@ucar.edu

† The National Center for Atmospheric is sponsored by the National Science Foundation.

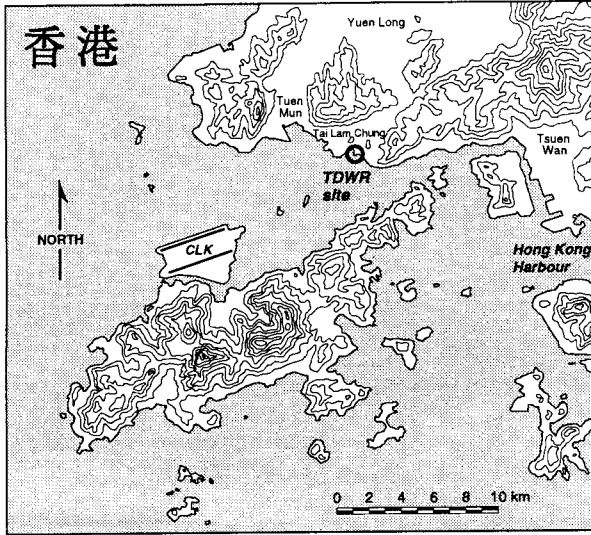


Figure 1. Topographic map of the area surrounding the new airport at CLK. Elevation contours have been drawn at 100 m intervals. The main commercial and residential areas of Hong Kong and Kowloon are located immediately off the map to the right, with the western tip of Hong Kong Island visible just below Hong Kong Harbour.

low level blockages limits the effective range of the radar, it also minimizes problems associated with second-trip echoes.

During the optimization studies, we discovered that the combination of main beam blockage and strong sidelobe returns echoes could result in false microburst alarms. These problems were eliminated by the addition of manually applied polygon maps to the standard clutter residue editing maps, adjusting sector scan limits, and through the application of sector blanking.

4. SEA CLUTTER AND SHIP TRAFFIC

The waters immediately surrounding CLK have an unusually high density of ship traffic. Informal estimates of ship traffic suggest that one hundred ships per hour may transit the waters north of the new airport in addition to fifty ships or more that might be moored within the field of view of the radar. Since both sea clutter and ship targets are moving, normal frequency domain clutter filtering techniques are not effective in this environment.

Sea clutter intensity levels were found to be quite variable, with a strong seasonal dependence that is ultimately related to the wind speed and direction. The highest returns were observed in August and September, during the southwest monsoon. On one occasion the sea clutter returns were observed to reach +10 to +18 dBZ. In November and January sea clutter levels had generally dropped to much lower levels in the vicinity of -10 to -18 dBZ. Although sea

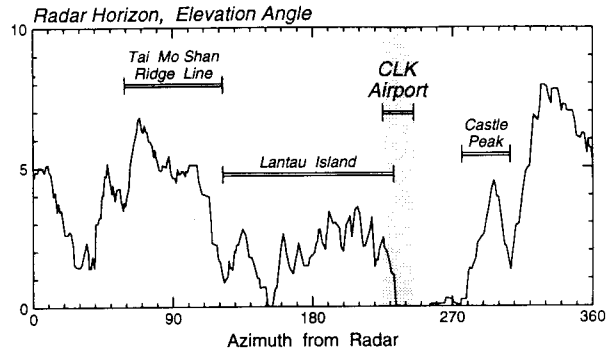


Figure 2. Measured radar horizon for the Hong Kong TDWR installed at Tai Lam Chung.

clutter is not found to affect the windshear and microburst detection algorithms, at its most intense it may occasionally generate erroneous precipitation returns.

In general, the standard Raytheon point target removal algorithms handle the high density of ship traffic quite well, including returns from large bulk carriers. The point target algorithms, however, were not successful at producing a totally clean data set and small residual returns from the moving ships (most easily visible in the velocity data) are quite common.

5. SUMMARY

The new Hong Kong International Airport is currently scheduled for completion in April 1998. When the airport opens it will be served by a modern Terminal Doppler Weather Radar and a state-of-the-art warning system for terrain induced windshear and turbulence.

Acknowledgments: The Hong Kong TDWR project was conducted under the immediate direction and sponsorship of the Hong Kong Observatory. This paper represents an unofficial progress report on the TDWR effort and is only intended to be used for scientific, academic, and research purposes.

6. REFERENCES

- Mahoney, W.P., and B. Donaldson, 1996: The operational windshear warning system for Hong Kong's new airport. *Journal of Air Traffic Control*, **38** (Number 4), 8-14.
- Michelson, M., W.W. Shrader, and J.G. Wieler, 1990: Terminal Doppler weather radar. *Microwave Journal* (February Issue), 139-148.
- Neilley, P.P., and T.L. Keller, 1995: Meteorological conditions associated with significant terrain-induced wind shear and turbulence at the new Hong Kong airport. *Preprints, Sixth Conf. on Aviation Weather Systems (Dallas, Texas)*, American Meteorological Society, Boston, 535-540.
- Poon, H.T., and R. Wagoner, 1995: Development of an operational windshear warning system for the new Hong Kong International Airport at Chek Lap Kok. *Preprints, Sixth Conf. on Aviation Weather Systems (Dallas, Texas)*, American Meteorological Society, Boston, 48-50.