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IMPLEMENTATION OF A
TERMINAL DOPPLER WEATHER RADAR
FOR THE NEW HONG KONG
INTERNATIONAL AIRPORT
AT CHEK LAP KOK

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1. INTRODUCTION

A new international airport is being built at Chek Lap Kok (CLK) in Hong Kong. As part of the New Airport Master Plan, a study was conducted in 1990-1991 to identify the basic requirements and recommend strategies for detecting potentially hazardous windshear and turbulence conditions in the vicinity of CLK, and for communicating the appropriate warnings to pilots and air traffic control personnel. The study concluded that installation of a Terminal Doppler Weather Radar (TDWR) was the best viable option for detecting windshear and microburst associated with convective storms. In addition, the study also recommended that a real-time Operational Windshear Warning System (OWWS) be 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).

The Royal Observatory has been given the responsibility for setting up meteorological facilities in support of the new airport. Consultants have been engaged by the Royal Observatory to provide expert assistance for the siting, acquisition and setting up of the TDWR, and for the development and implementation of the OWWS. Scientists and engineers of the National Center for Atmospheric Research (NCAR), in collaboration with Weather Information Technologies Incorporated (WITI), are directly involved in both the TDWR and OWWS efforts.

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2. TDWR SITE SELECTION

The new airport at CLK is being built on reclaimed land adjacent to Lantau Island. Figure 1 is an artist's depiction of the new airport, showing the completed airport with Lantau Island in the background. The illustration corresponds to the view that would be obtained from an aircraft flying at about 5,000 ft immediately north-northeast of the airport. Each of the two parallel runways will be 3,800 m in length, with a separation of 1,525 m.

Figure 2 is a topographic map of the area surrounding the new airport. Lantau Island, immediately south of the airport, is quite mountainous, with peaks ranging up to 934 m in height. Castle Peak, less than 10 km north-northeast of the airport, has a height of 583 m, while Tai Mo Shan (the highest peak in Hong Kong at 957 m) is visible near the northeast corner of the map. The main commercial and residential areas of Hong Kong are located immediately off the map to the right, with the western tip of Hong Kong Island visible just below the labeled position of Victoria Harbour.

The waters immediately surrounding CLK have an unusually high density of marine traffic. Informal estimates of the ship traffic suggest that as many as one hundred ships per hour may transit the waters north of the new airport, the location of the main shipping channel between Victoria Harbour (Hong Kong) and Guangzhou (off the map to the northwest). In addition to barges involved in the airport reclamation effort, as many as 50 ships are routinely moored in the waterways north of Lantau Island.

Following a detailed site engineering analysis study performed during autumn, 1993, a preferred site for the TDWR installation was identified at the Tai Lam Chung Marine Police Base, roughly 12 km north-east of CLK. From this site, the radar will have a clear

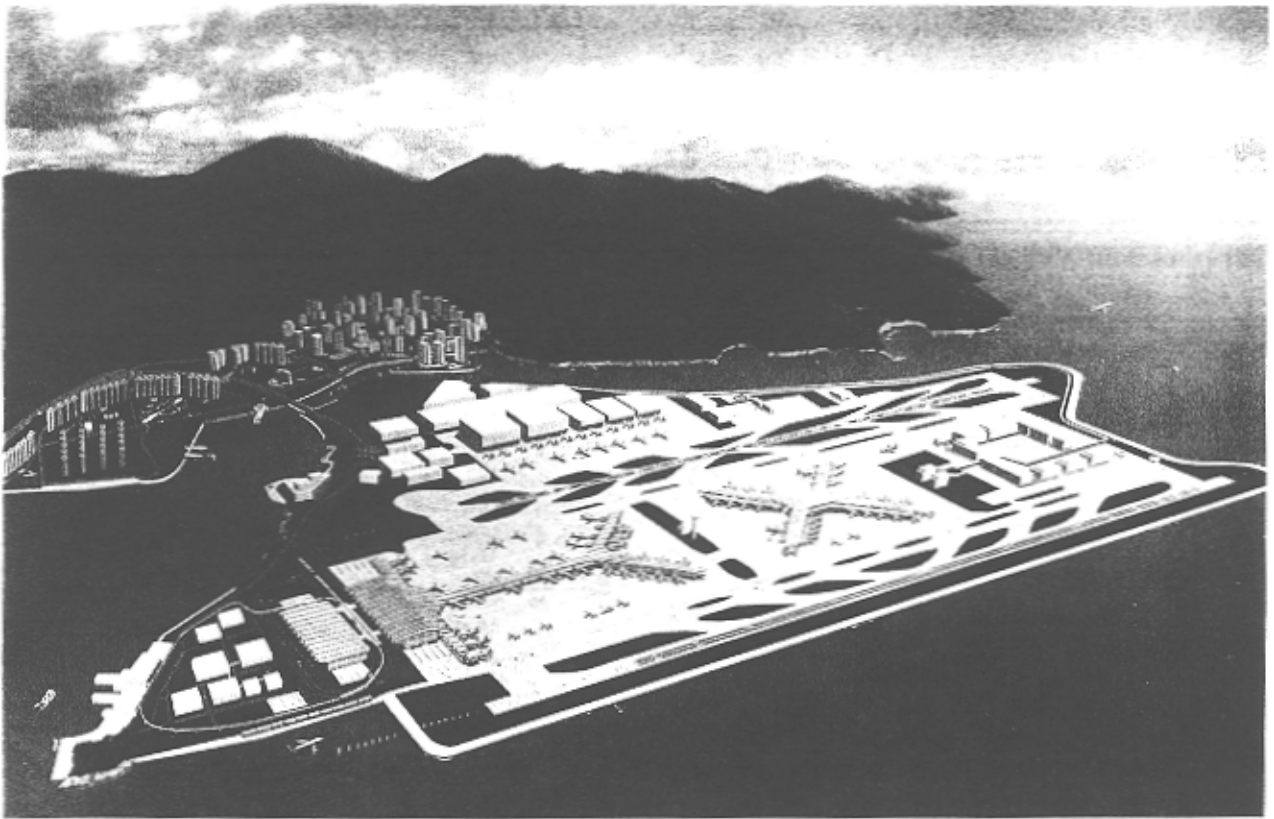


Figure 1. Artist's depiction of the new Hong Kong International Airport at Chek Lap Kok.

Figure 2. Topographic map of the area surrounding the new airport at CLK. Elevation contours have been drawn at 100 m intervals. The position and orientation of the airport runways are shown, as is the anticipated location of the TDWR at the Tai Lam Chung Marine Police Base, northeast of the airport (identified by a bold circle).



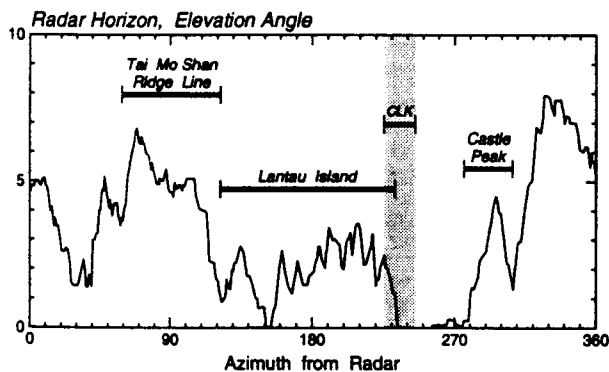


Figure 3. Anticipated radar horizon for a radar installed at the Tai Lam Chung Marine Police Base.

view of the airport approach and departure zones, but will have to scan directly over the main shipping channel which is immediately offshore from the radar site. To avoid beam blockage by nearby ships, the base of the antenna will be installed approximately 55 m above mean sea level (30 m above the local terrain). The relatively tall tower will also position the antenna safely above three nearby apartment blocks. To further minimize any hazards to nearby residents, the transmitter will be sector blanked in the direction of the apartments.

Figure 3 shows a plot of the anticipated radar horizon from the TDWR site. While the view of the airport will be unimpeded, the radar beam will be blocked to an elevation of roughly 3 degrees by Lantau Island, immediately behind the airport. Castle Peak and the mountains to the north of the radar site will give local blockages that extend as high as 6 to 8 degrees. Only a small sector to the west is completely unblocked by the local terrain. While the low level blockages will limit the effective range of the radar, it will also minimize possible problems associated with second-trip echoes.

To operate at short ranges in a high clutter environment, such as expected at CLK, it is essential that the TDWR has high performance clutter suppression capabilities. The system envisioned for Hong Kong will make use of a klystron-based transmitter giving at least 50 dB of suppression for stationary targets, augmented by clutter residual maps using indexed beams, and point target removal algorithms.

To minimize clutter, including return from the sea surface, and to give as much inter-clutter visibility as possible, the C-band radar system will have a beam

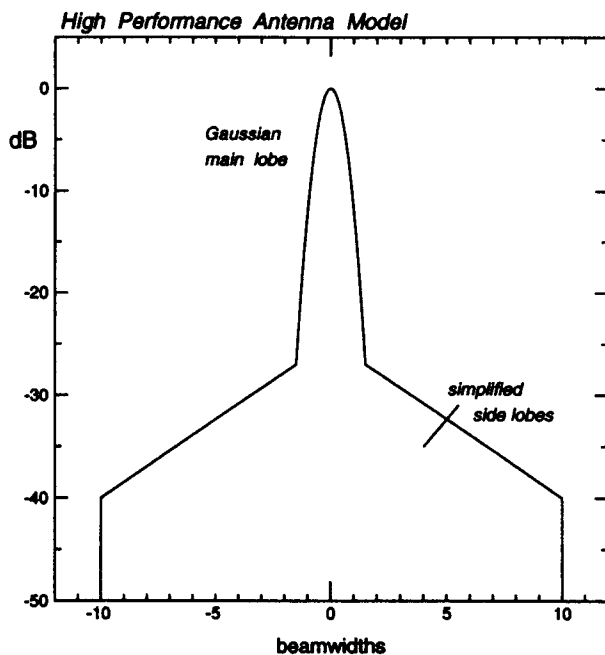


Figure 4. Schematic illustration of the antenna illumination pattern.

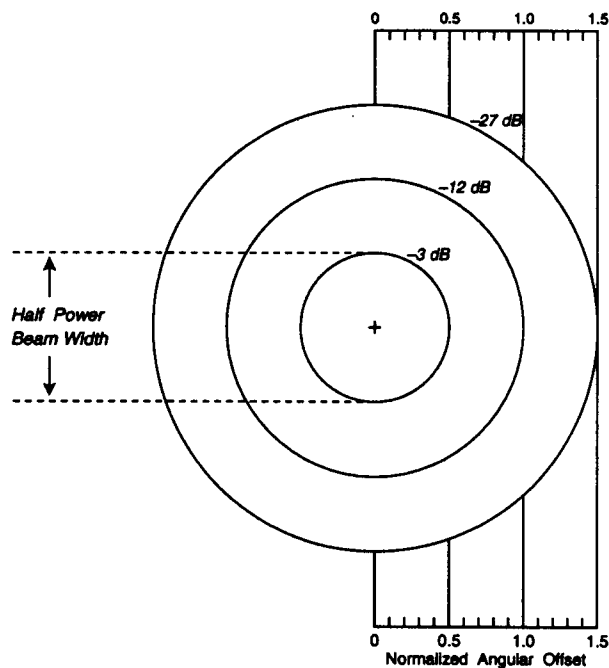


Figure 5. Main lobe beam geometry.

width of approximately 0.5 degrees, with excellent side lobe performance. Figure 4 shows a schematic illustration of the required antenna performance. With the relatively short range to the airport, the half degree beam will permit scanning the critical volume for

microburst detection from 100 to 300 m above the surface over the airport (and the arrival and departure corridors out to three nautical miles) without the main lobe striking the surface. To minimize surface return, of course, it is necessary to consider more than just the 3 dB half power beam width. As illustrated in Figure 4, and even more clearly in Figure 5, the "shoulders" of the main lobe can extend out as far as one and a half times the nominal beam width. Thus for a half degree beam (half power, full beam width), no part of the beam out to 0.75 degrees away from the beam center should intersect the surface over the arrival and departure zones. This is a much more rigorous requirement than just considering the half power beam width, but if the surface clutter is illuminated by any part of the main lobe, then the clutter return from the main lobe is likely to dominate, irrespective of the magnitude of the side lobes.

3. USER REQUIREMENTS STUDY

As part of the background for the acquisition of a TDWR system for the CLK, an extensive study was undertaken between August and November 1993 to identify the local user requirements for a Hong Kong TDWR. A series of eight meetings were held with local air traffic controllers, aviation forecasters, and local representatives of airlines and pilots with the results of the study incorporated into the technical specifications for the TDWR system. Specific organizations represented at these meetings included the Royal Observatory's Airport Meteorological Office, the Civil Aviation Department (CAD), Cathay Pacific Airways, Dragon Air, the International Federation of Airline Pilots Associations (IFALPA), the International Federation of Air Traffic Control Associations (IFATCA), and the Hong Kong Air Traffic Control Association (HKATCA). Briefing materials presented at the meetings included summaries of TDWR operations, products and displays, including five separate demonstrations of the workstation-based TDWR prototype display developed by the Research Applications Program at NCAR.

In general, the Hong Kong TDWR system will be quite similar to the TDWR system currently being installed in the United States by the Federal Aviation Administration (FAA), with limited local customization of displays and data presentation formats. As in the FAA system, the weather information and warning products will be routinely archived for use in accident investigations and for meteorological research.

Among the unique aspects of the Hong Kong system will be the development of integrated displays and warnings for both thunderstorm and terrain-induced windshear and turbulence conditions around the new airport incorporating data from both the TDWR and the OWWS. In another departure from the FAA system, TDWR data displays will also be installed in the Airport Meteorological Office, with a full capability to display the real-time radar base data in addition to the standard weather and warning products. An ethernet capability will be provided to allow transfer of the base data stream to additional remote sites as required. While the primary function of the TDWR system is to support air traffic control, it is anticipated that the meteorological information will also prove to be very valuable to local meteorologists.

4. FUTURE PLANS AND SCHEDULE

The new airport at CLK is scheduled to open in mid-1997. Based on the results of the site selection and user requirements studies, technical specifications of the TDWR system were prepared and tenders for the commercial supply of the system were invited in March, 1994. It is anticipated that a contract for the provision of a suitable system will be awarded by late-1994. Following recommendations by the consultants, the detailed design of the TDWR station (including access roads, buildings, and a tower to support the radar antenna and radome) is being carried out by the Architectural Services Department (ASD) of the Hong Kong Government. Site preparation and construction activities are scheduled to begin in mid-1995 under the direction of ASD.

Hardware fabrication, software customization, and site preparation works are expected to be completed by early-1996, with the system being delivered to the site and installed in mid-1996. Following the installation and initial tests, an extended operational test and system optimization will be carried out jointly by the manufacturer, the consultants, and staff from the Royal Observatory to optimize the performance of the system before commissioning.

On-site training of air traffic controllers, aviation forecasters and radar maintenance personnel will also be conducted after installation of the system. Following an extensive set of site acceptance tests, it is planned that the system will be integrated with the OWWS and put into operational use in early-1997 so that the users can have ample time to familiarize themselves with system operation prior to airport opening.

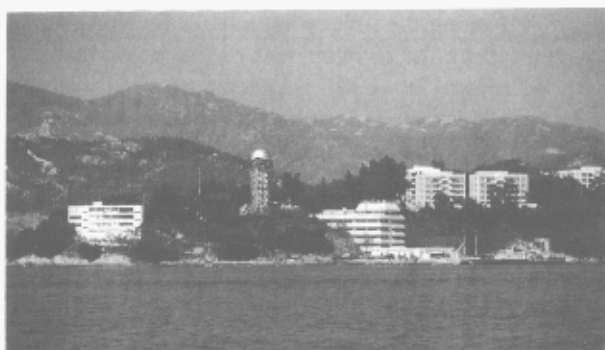


Figure 6. Photo montage showing the proposed TDWR radar site at the Tai Lam Chung Marine Police Base.

Figure 6 is a photo montage showing the planned TDWR station at the Tai Lam Chung Marine Police Base. The original picture was taken from a motor launch immediately off shore from the Marine Police Base, looking toward the radar site from the southwest, with an artist's illustration superimposed on the photograph.

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