International Civil Aviation Organization

THE SIXTH MEETING OF THE ASIA/PACIFIC GBAS/SBAS IMPLEMENTATION TASK FORCE (GBAS/SBAS ITF/6)

(Bangkok, 7- 9 May 2024)

Agenda Item 3: Updates from States/Administrations about GBAS/SBAS Implementation

GBAS Siting Considerations at Changi Airport

(Presented by Civil Aviation Authority of Singapore (CAAS))

SUMMARY

This paper presents some considerations for future GBAS implementation at Changi Airport.

Key objectives of this paper are to describe:
1. Introduction
2. GBAS siting considerations
   - RRS
   - VDB
3. Way forward

1. INTRODUCTION

1.1 CAAS is planning to install a GBAS with minimally GAST-C capability to support CAT I GLS operations at Changi Airport.

1.2 A single GBAS ground system has the ability to cover multiple runways ends and provides suitably-equipped aircraft with an alternative precision approach and smooth landing experience. It also increases the approach and landing flexibility with the use of advanced flight procedures such as curved approaches, as well as landing on displaced thresholds and at multiple glide path angles, etc.

1.3 One of the great challenges associated with implementation of GBAS in low-latitude and equatorial regions is the uncertainty of ionospheric impact to Global Navigation Satellite System (GNSS) signals in these regions. CAAS has started to assess the impacts on performance and availability of the GBAS with consideration of current buildings and future developments in the vicinity of Changi Airport.

2. GBAS SITING CONSIDERATIONS

2.1 General Criteria

2.1.1 Ideally, GBAS should be located at an open and flat area within the airport perimeter. This reduces the impact to airport operations.

2.1.2 A candidate site of a VDB transmit antenna shall meet all Signal-In-Space (SIS) requirements for CAT I GLS at a single runway. As for multiple runway operations, additional VDB antennas (multiple VDBs) should be considered to ensure coverage for all runways operations at a complex airport environment. The area near to the master VDB transmit antenna may also be considered for GNSS reference antenna locations.

2.2 Siting of Reference Receiver Stations (RRS)

2.2.1 A GBAS ground facility typically consists of four GNSS reference receiver stations (RRS).

2.2.2 The four GBAS receiver antennas as a group, will have a mathematical virtual center point that is referred to as the centroid. This centroid should be within 3.2 NM (or 6 km) of any desired Decision Height (DH) points for all the runways of interest.

2.2.3 The separation between the RRS has a typical value of 105 m, and they are arranged in a rectangular layout.

2.2.4 RRS sites should be chosen based on a clear horizon of above 3° elevation at all azimuths. A protection area of 155 m in radius around the reference antennas in order to keep free from obstacles that could produce multi-path effect.

2.3 Siting of VDB

2.3.1 In general, the siting of the VDB antenna should comply with the necessary obstacle restriction criteria defined in ICAO Annex 14.

2.3.2 The VDB antenna should be sited within 3 NM of circles centered at each runway threshold.

2.3.3 The VDB antenna should not be located any closer than 80 m slant distance from GBAS VDB receivers, VHF NAV or COM equipment.

2.3.4 A terrain model by Global Mapper and WRAP software were used to simulate the VDB coverage areas.

2.3.5 The terrain model uses level-20 satellite photo, 15-meter horizontal-accuracy GDEM of Changi aerodrome. The GDEM data was partially flattened at the ground altitude, to model the present and future architectures defined in the airport masterplan, as shown in Figure 1.

Figure 1 - The Layout of The Runway and Architectures (The pink areas are under development)

2.3.6 The VHF module in WRAP software was used to do the coverage analysis on VDB, assuming the VDB antenna is horizontal polarised, and VDB antenna height was set to 7 m and 14 m respectively.

2.3.7 The VDB emission power was set to 17dBw, and airborne antenna threshold was 47.76dBμV/m (-99dBW/m2).

2.3.8 There are 2 VDBs for Proposal A, the master VDB lies in the South-East, and the second VDB lies in the North-West of the airport respectively.

2.3.8.1 For the master VDB, the coverage over DH is shown in Figure 2.

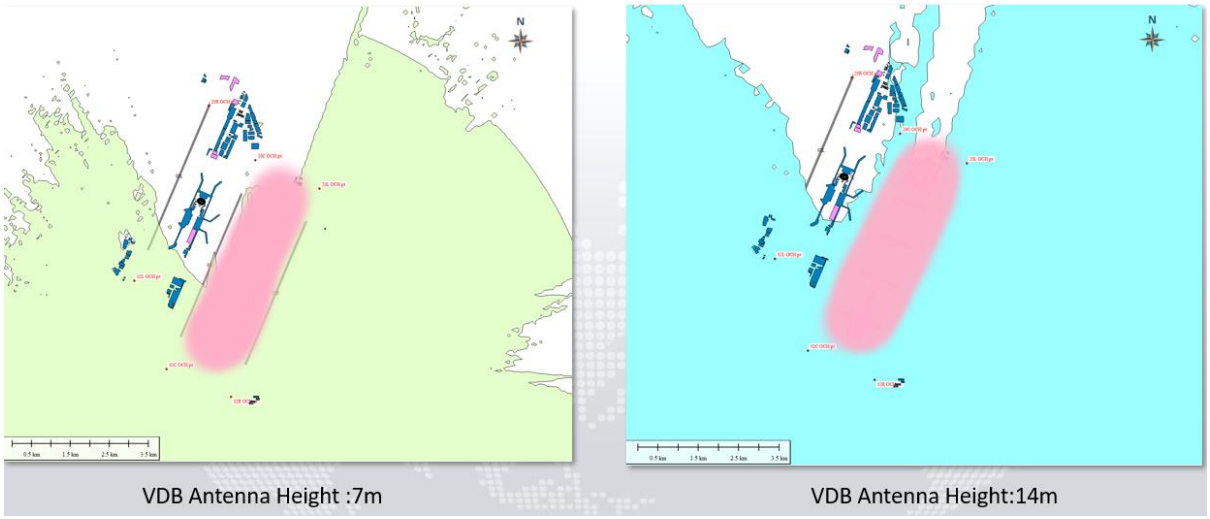

Figure 2 - The Contrast Coverage of the Master VDB for Proposal A

2.3.8.2 For the second VDB, the coverage over DH is shown in Figure 3.

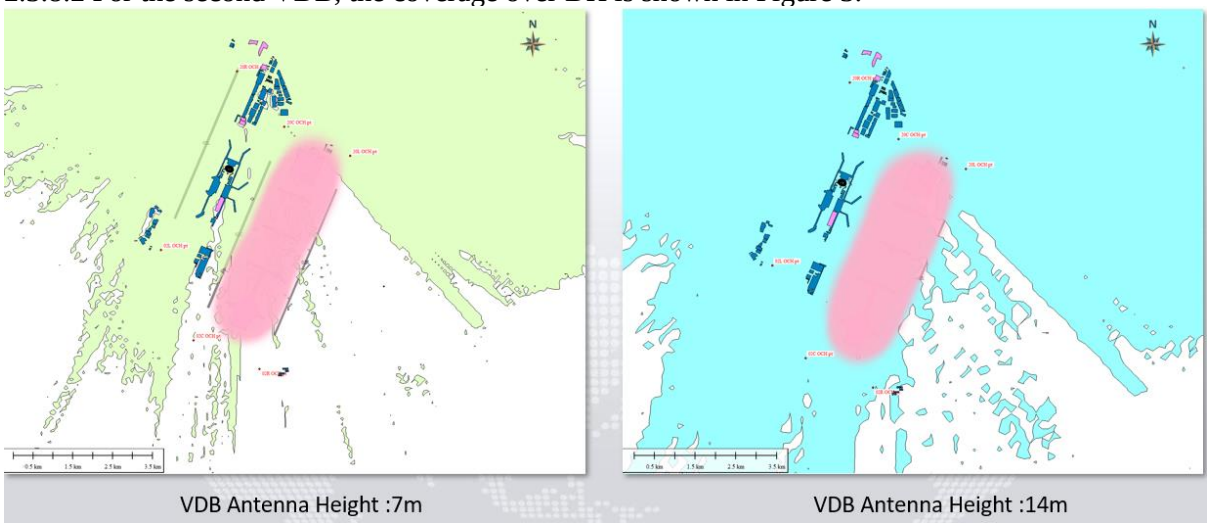

Figure 3 - The Contrast Coverage of the Second VDB for Proposal A

2.3.8.3 Based on the VDB antenna height of 7 m, the result of coverage is shown as in Table 1.

Table 1 - Coverage Simulation Results Based on 7 m - VDB For Proposal A

Site	*02L*	*02C*	*02R*	*20R*	*20C*	*20L*
VDB1 (SE)	*serviceable*	*serviceable*	*serviceable*	*failed*	*failed*	*serviceable*
VDB2 (NW)	*serviceable*	*failed*	*failed*	*serviceable*	*serviceable*	*serviceable*

2.3.8.4 Based on the VDB antenna height of 14 m, the result of coverage is shown as in Table 2.

Table 2 - Coverage Simulation Results Based on 14 m - VDB For Proposal A

Site	*02L*	*02C*	*02R*	*20R*	*20C*	*20L*
VDB1 (SE)	*serviceable*	*serviceable*	*serviceable*	*failed*	*critical state*	*serviceable*
VDB2 (NW)	*serviceable*	*serviceable*	*critical state*	*serviceable*	*serviceable*	*serviceable*

2.3.9 There are 3 VDBs for Proposal B, the master VDB lies in the West, second VDB lies in the South, and the third VDB in the North areas respectively.

2.3.9.1 For the master VDB, the coverage over DH is shown in Figure 4.

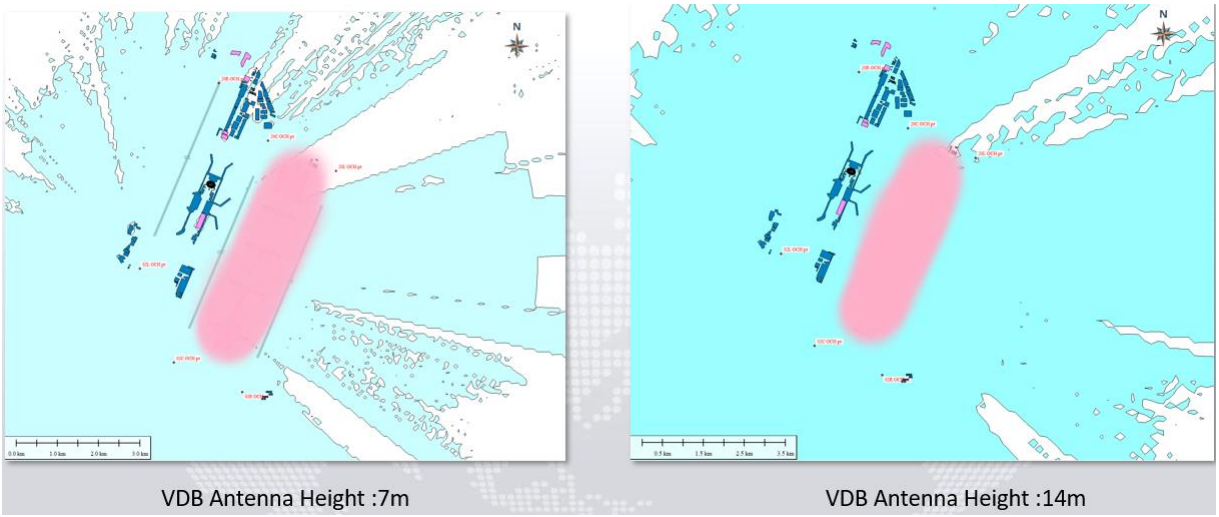

Figure 4 - The Contrast Coverage of the Master VDB for Proposal B

2.3.9.2 For the second VDB(South), the coverage over DH is shown in Figure 5.

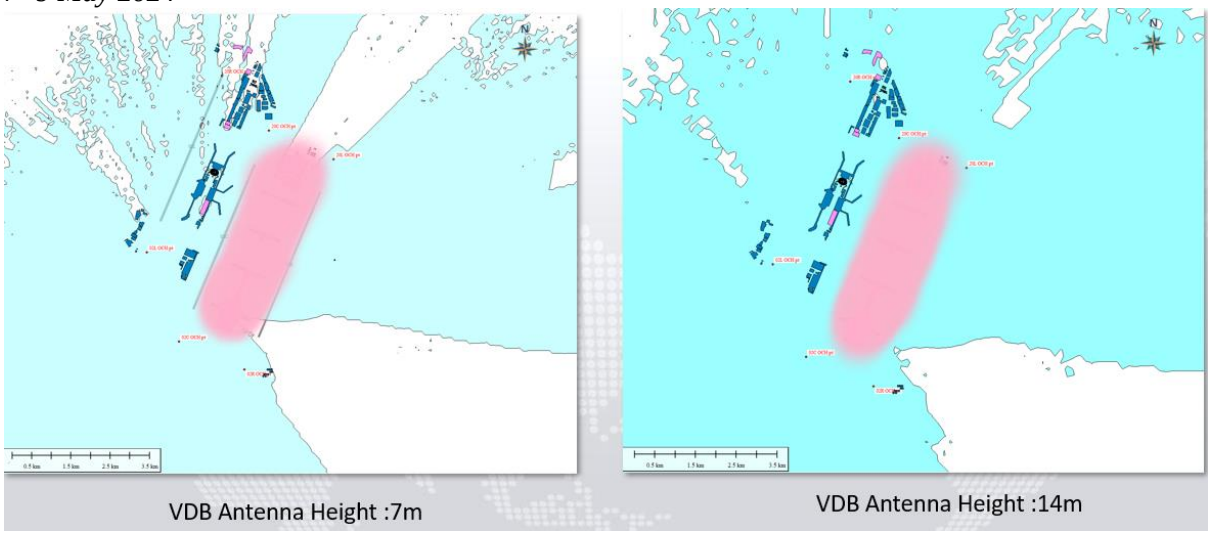

Figure 5 - The Contrast Coverage of the Additional VDB(South) for Proposal B

For the second VDB(North), the coverage over DH is shown in Figure 6.

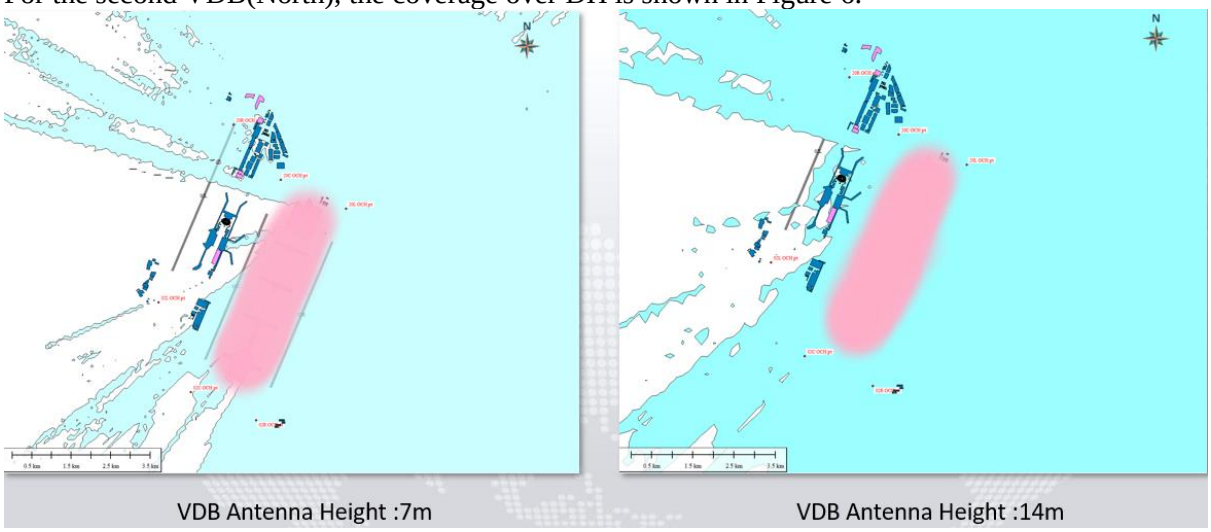

Figure 6 - The Contrast Coverage of the Second VDB (North) for Proposal B

2.3.9.3 Based on VDB antenna height of 7 m, the result of coverage is shown as in Table 3.

Table 3 - The Coverage Simulation Results Based on 7 m - VDB for Proposal B

Site	*02L*	*02C*	*02R*	*20R*	*20C*	*20L*
VDB1 (W)	*serviceable*	*serviceable*	*serviceable*	*serviceable*	*serviceable*	*failed*
VDB2 (S)	*serviceable*	*serviceable*	*serviceable*	*serviceable*	*serviceable*	*serviceable*
VDB3	*failed*	*failed*	*serviceable*	*serviceable*	*serviceable*	*serviceable*

(N)						

2.3.9.4 Based on VDB antenna height of 14 m, the result of coverage is shown as in Table 4.

Table 4 - The Simulation Coverage Results Based on 14 m - VDB for Proposal B

Site	*02L*	*02C*	*02R*	*20R*	*20C*	*20L*
VDB1 (W)	*serviceable*	*serviceable*	*serviceable*	*serviceable*	*serviceable*	*critical state*
VDB2 (S)	*serviceable*	*serviceable*	*serviceable*	*serviceable*	*serviceable*	*serviceable*
VDB3 (N)	*failed*	*serviceable*	*serviceable*	*serviceable*	*serviceable*	*serviceable*

2.3.10 **Conclusion for VDB coverage**

2.3.10.1 When VDB antenna height adjusted to 14m, its coverage shows improvement for CAT I GLS operations.

2.3.10.2 There is only one VDB coverage for some runway ends for Proposal A, and dual VDB coverage for all 6 runway ends for Proposal B.

2.3.10.3 However, a 14 m - VDB antenna height may penetrate the Obstacle Limitation Surfaces (OLS), and may require seeking exemption from the regulator according to Clause 9.9 in Annex 14 Vol 1.

3. WAY FORWARD

3.1 CAAS will continue working on GBAS integrity, performance and availability analysis. Singapore had observed up to a maximum 505 mm/km ionospheric gradient which may lead to disruption of GBAS service if the resulting vertical position errors are unacceptable. Therefore, the next focus area will be ionospheric monitoring (IM) with a GAST-C system setup, as the Ground Subsystem is responsible for mitigating the potential impact of ionospheric anomalies.

4. ACTION REQUIRED BY THE MEETING

4.1 The meeting is invited to:

a) take note of the advantages afforded by GBAS and specific challenges to be recognised in the low-latitude region and at a complex airport environment;

b) advise on the possibility of allowing VDB antenna to penetration the OLS for air navigation purpose, and exempted as an obstacle for OAS assessment;

c) note that Singapore will continue to study and share pertinent information, and welcome information sharing from other States / Administrations; and

d) discuss any relevant matters as appropriate.

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