Qatar GBAS Project

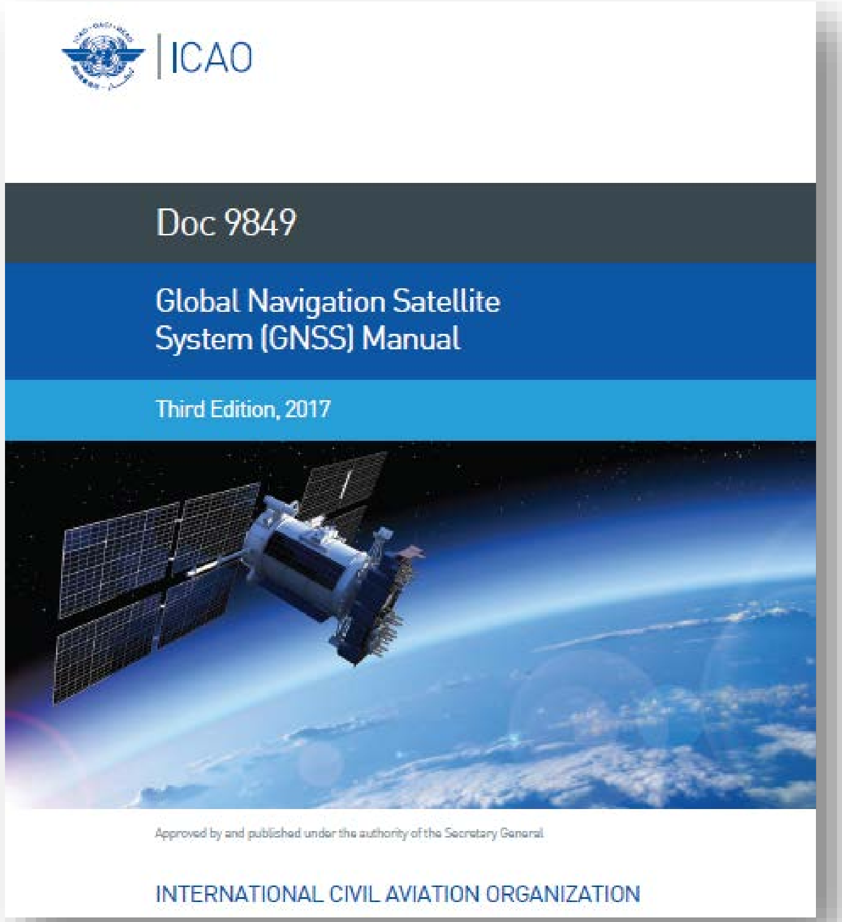
Antalya, Turkiye
06-08 February 2024
NAV-AIDS Unit, Electronics Engineering Section
Air Navigation Department, QCAA

الهيئة العامة للطيران المدني
CIVIL AVIATION AUTHORITY
QATAR قطر

Scope of the Presentation

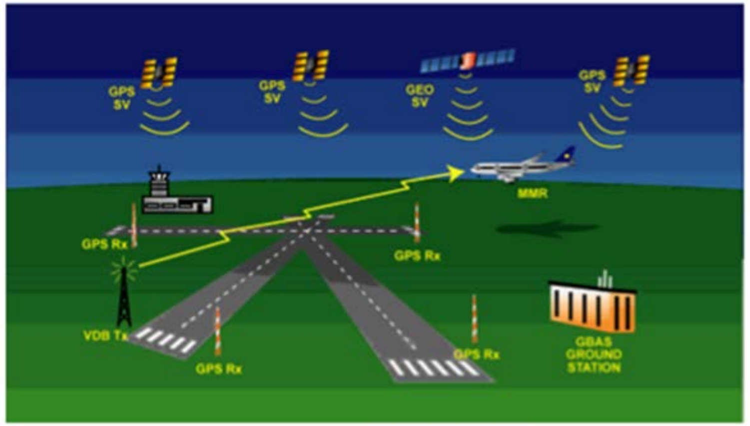
- A glimpse of GNSS and GBAS
- Working Principle of GBAS and its function
- Advantages of GBAS
- Qatar’s endeavour towards GBAS Implementation
- The road map ahead

A glimpse of GNSS and GBAS



- GBAS uses monitoring stations at airports to process signals from core constellations and broadcast corrections and approach path data to support precision approach operations.
- As of 2017, approximately 140 GBAS stations were certified and transmitting SARPs-compliant signals, about half of which have published procedures for CAT I operations;
- a number of prototype stations provide signals for test and evaluation, several of which are used for validation of GBAS approach service types to support Category II/III operations;
- over 100 airlines have GBAS equipage, totalling over 2 000 aircraft. GBAS is used in daily revenue service in several States.

A glimpse of GNSS and GBAS



- GBAS (**Ground Based Augmentation System**) is a satellite-based precision approach aid for aircraft landings.
- GBAS works with the **satellite-based GPS navigation system.**
- According to ICAO/Eurocontrol planning, GBAS will in the long term replace the current ILS (Instrument Landing System), due to increased accuracy and lower operational costs.

Working Principle of GBAS and its function

How Does GBAS Work? – Functions of the GBAS Ground Station

- **GBAS Function:** Ground-based **correction** of the **GPS data** sent from the satellite.

  The inaccuracy, which we know from car navigation systems, needs to be corrected.

  The GPS satellites send positioning data to the GBAS Ground Station, where the signals are corrected and sent to the aircraft.

  → This is why GBAS works more precisely than the GPS in cars.

- **GBAS Function: Transmission of approach path data**

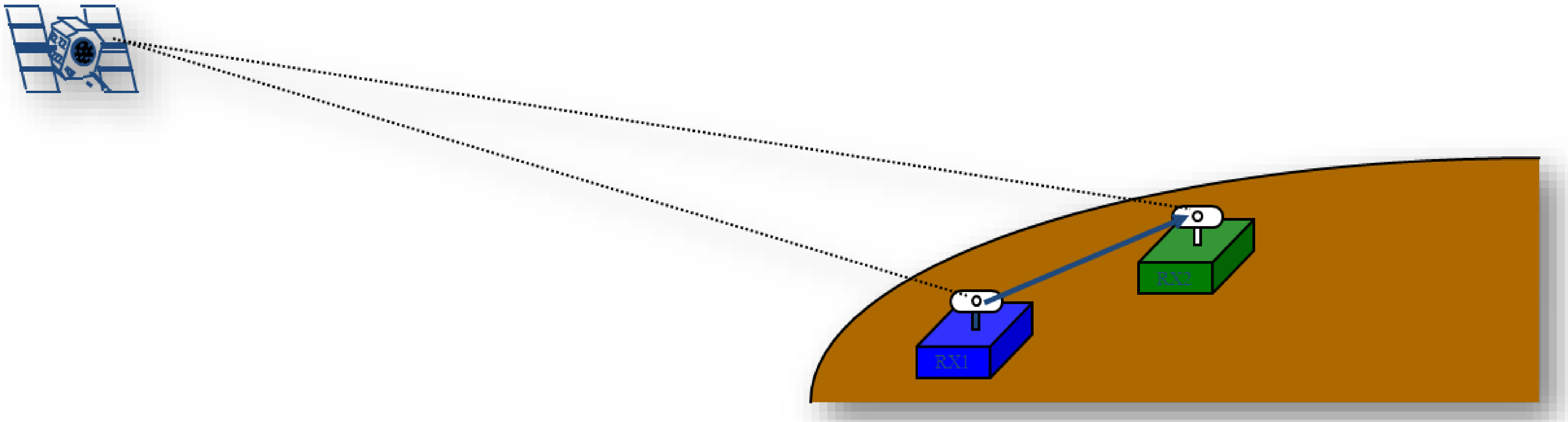
  The details of the approach path are sent to the aircraft on final approach.

Working Principle of GBAS and its function

LOCAL AREA DIFFERENTIAL PRINCIPLE

I - Basic Principle

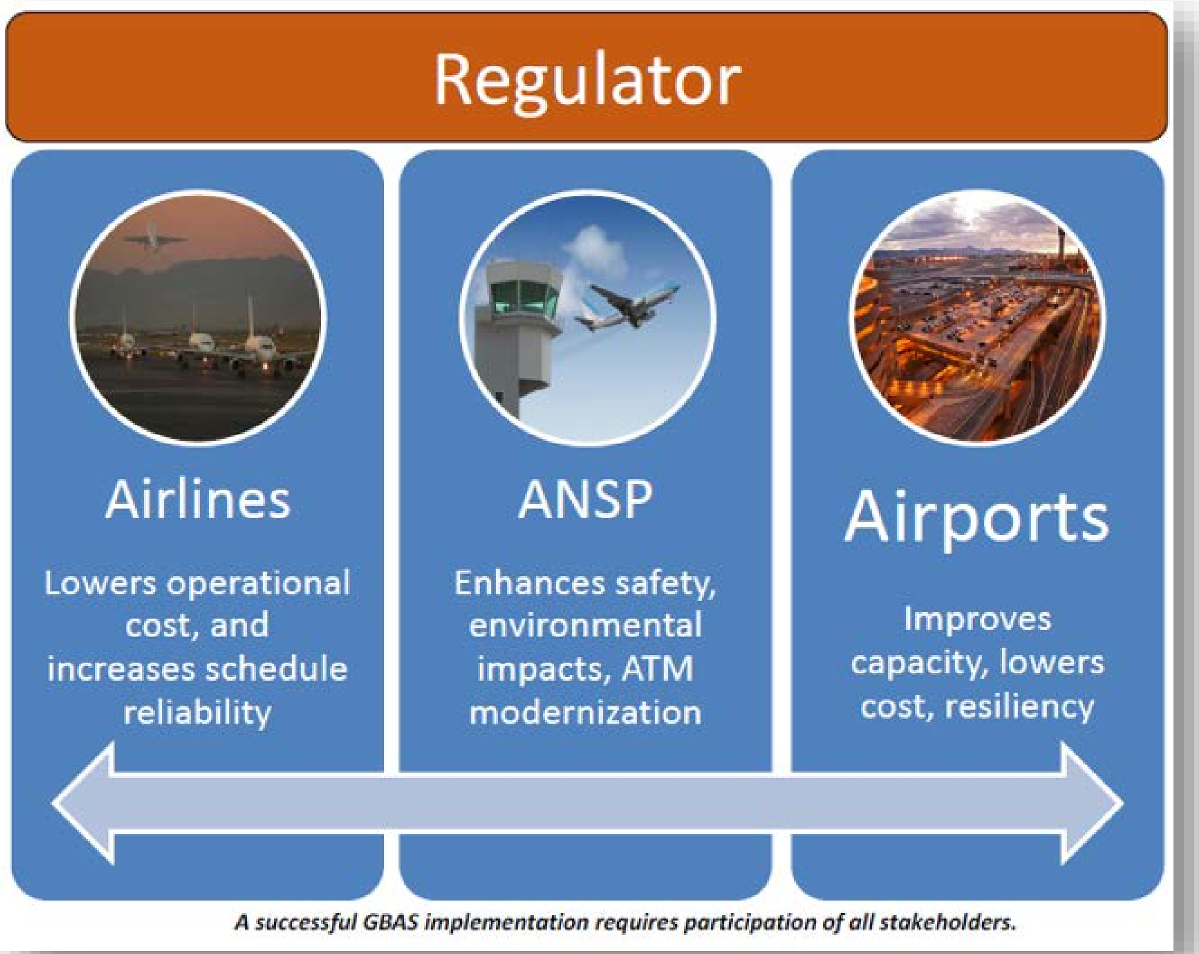
- Measurements made by two receivers are affected by the same errors as long as these two receivers are not too far from each other.



Working Principle of GBAS and its function

The GBAS Ground Station Consists of Four GPS-Receivers (RSMU), One Transmitter (VDB) and a Shelter

Advantages of GBAS



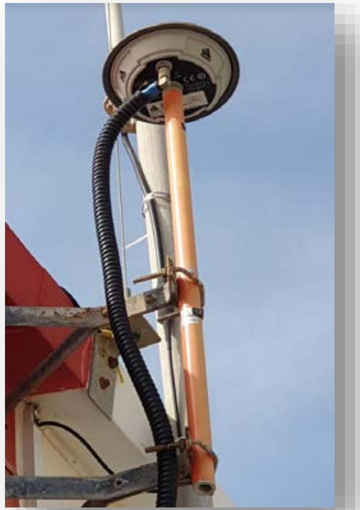
Qatar’s Endeavour towards GBAS implementation

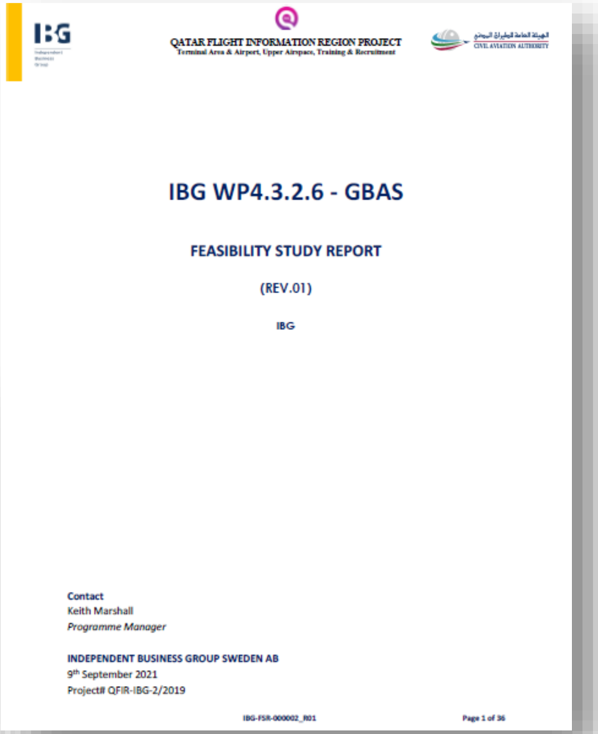
- In 2019, feasibility study was carried out for the Ionospheric effect on Navigational Satellite’s signals over Qatar.
- In 2022, the infrastructure was established to support the collection of iono data from October 2022 to October 2023 and its effect on GPS signals were analysed and recorded.

Qatar's Endeavour towards GBAS implementation

Qatar’s Endeavour towards GBAS implementation

- The ionospheric study was planned for one complete year commencing Oct 2022.
- Ionospheric analysis report were provided on quarterly basis.





QATAR FLIGHT INFORMATION REGION PROJECT
Terminal Area & Airport, Upper Airspace, Training & Recruitment

IBG WP4.3.2.6 - GBAS

FEASIBILITY STUDY REPORT

(REV.01)

IBG

Contact
Keith Marshall
Programme Manager

INDEPENDENT BUSINESS GROUP SWEDEN AB
9th September 2021
Project# QFIR-IBG-2/2019

Page 1 of 36

- Candidate days for 1st **Quarter**
  - October 23 , 2022; December 13 , 2022
- Candidate days for 2nd **Quarter**
  - March 24, 2023; April 15 , 2023; April 23 , 2023
- Candidate days for 3rd **Quarter**
  - June 27, 2023 ; July 31, 2023
- Candidate days for 4th **Quarter**
  - September 18, 2023 ; September 24, 2023

Ionospheric Study over Qatar's Hamad and Doha International Airport

Ionospheric Analysis First Quarter report, 16th Feb 2023

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Ref. No : HTS-GBAS-0116-LTR-006
Pages : 1 + attachments
Date : 16 February 2023

Project: Ionospheric Analysis Study & Survey Assessment for Ground Based Augmentation System (GBAS)

Subject: Ionospheric Analysis First Quarter report

Dear Sir,

Please find the attached first quarter report for the Ionospheric analysis.

Should you require more information, please contact the undersigned.

Yours faithfully,

Oguzhan Torunlar
Project Manager
Honeywell Building Solutions

Enclosures as above

Ionospheric Analysis Second Quarter report, 05th June 2023

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Ref. No : HTS-GBAS-0116-LTR-008
Pages : 1 + attachments
Date : 05 June 2023

Project: Ionospheric Analysis Study & Survey Assessment for Ground Based Augmentation System (GBAS)

Subject: Ionospheric Analysis Second Quarter report

Dear Sir,

Please find the attached Second quarter report for the Ionospheric analysis.

Should you require more information, please contact the undersigned.

Yours faithfully,

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Ionospheric Analysis Third Quarter report, 23rd November 2023

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Pages : 1 + attachments
Date : 23 November 2023

Project: Ionospheric Analysis Study & Survey Assessment for Ground Based Augmentation System (GBAS)

Subject: Ionospheric Analysis Third Quarter report

Dear Sir,

Please find the attached Third quarter report for the Ionospheric analysis.

Should you require more information, please contact the undersigned.

Yours faithfully,

Oguzhan Torunlar
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Honeywell Building Solutions

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Ionospheric Analysis Fourth Quarter report, 27th November 2023

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Ref. No : HTS-GBAS-0116-LTR-011
Pages : 1 + attachments
Date : 27 November 2023

Project: Ionospheric Analysis Study & Survey Assessment for Ground Based Augmentation System (GBAS)

Subject: Ionospheric Analysis Fourth Quarter report

Dear Sir,

Please find the attached Fourth quarter report for the Ionospheric analysis.

Should you require more information, please contact the undersigned.

Yours faithfully,

Oguzhan Torunlar
Project Manager
Honeywell Building Solutions

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The roadmap ahead

Roadmap Ahead

- The final report of one year study of Ionosphere over DOHA, Capital of Qatar has been submitted on 15th of January 2024.
- It has considered the analysis of 10 candidate days which are different from the days already covered in quarterly reports

Country	Qatar
Latitude	25.286106
Longitude	51.534817
DMS Lat	25° 17' 9.9816" N
DMS Long	51° 32' 5.3412" E

Ionospheric Analysis Final Report ,
15 January 2024

Honeywell

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Ref. No : HTS-GBAS-0116-LTR-012
Pages : 1 + attachments
Date : 15 January 2024

Project: Ionospheric Analysis Study & Survey Assessment for Ground Based Augmentation System (GBAS)

Subject: Ionospheric Analysis Final Report

Dear Sir,

Please find the attached Final Report for the Ionospheric analysis.

Should you require more information, please contact the undersigned.

Yours faithfully,

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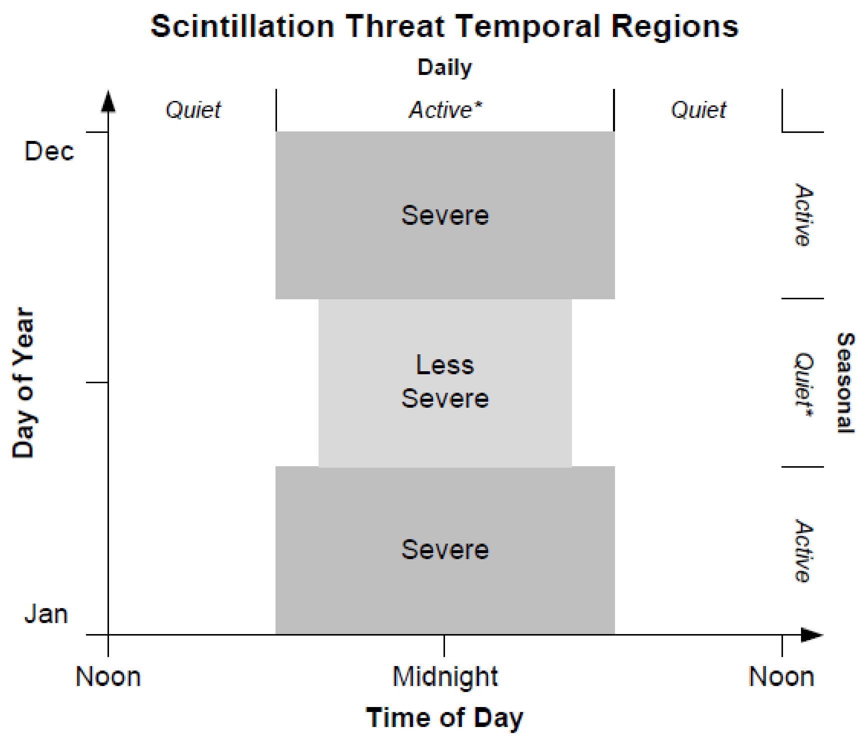
The roadmap ahead



The Seasonal Quiet period may possess a Daily Active period. However, this period may be less severe than the Daily Active period associated with the Seasonal Active period and may be shorter in duration.

Figure 4-1: Active and Quiet Seasonal and Daily Variation Example

Candidate Days

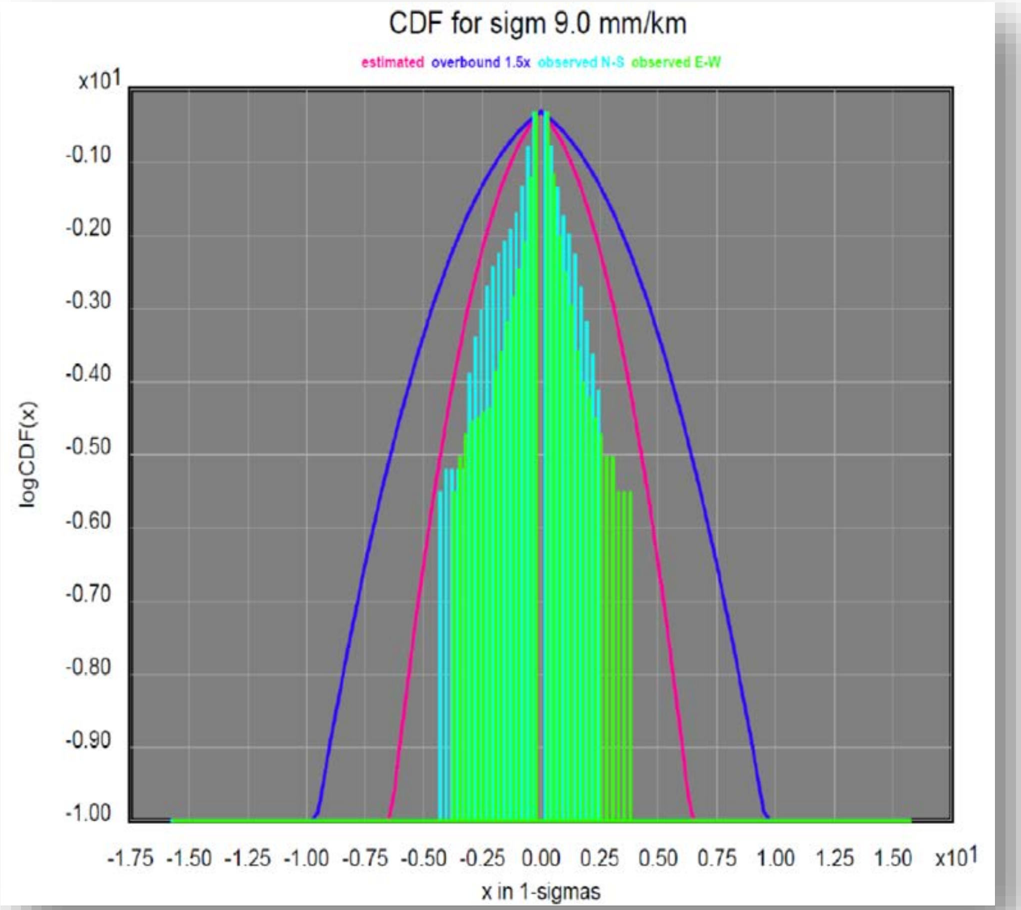
For Doha, between October 2022 and October 2023, LTIAM was used to collect and analyze 365 days of gradient data from receivers around Hamad and Doha International Airports. Ten (10) days of interest were selected for determination of Sigma VIG. These days are summarized in Table 7-2 below.

Table 7-2: Doha "Nominal Ionosphere" Candidate Days Analyzed

Date	(Iono) Activity Class	Kp	Dst	Peak (Slant) Gradient (mm/km)	Time (hours; UTC)	PRN
11/15/2022	Quiet	1	8	75	16.25	11
12/13/2022	Nominal	2	-10	28	11.5	19
1/18/2023	Nominal	4	-32	45	18	12
3/15/2023	Active	6-	-38	80	18.5	16
3/31/2023	Active	4+	-25	91	22.5	21
5/26/2023	Quiet	2-	-14	46	22	3
06/27/2023	Nominal	2+	-27	40	5	12
8/13/2023	Nominal	2	10	40	20	15
9/24/2023	Active	6-	-42	64	14.5	4
10/8/2023	Nominal	2+	-23	53	11.5	3

From Table 7-2, note that the majority of the peak gradient events occurred during the late afternoon and nighttime. Section 7.1.1 contains a plot of the daily maximum gradient observed on each day of the collected data. All peak gradients over 100 mm/km, which were all manually validated, occurred after 19:00 local time (UTC +3). The majority of the peak gradient events observed at Doha, due to their event times, are suspected to be caused by Equatorial Anomaly activity.

Doha Nominal Iono Gradient Overbound CDF



Note that the normalized gradients, with blue and green color, represent the gradient estimates between each GPS receiver pair combination that are then split into North-South and East-West components. For the Doha analysis, same-satellite gradients (simultaneously) from all pair combinations of two Novatel receivers are used to form gradient estimates. Given that the Doha nominal iono assessment is using mostly local-area gradient data, the inclusion of gradients from all receiver-pair baselines in the Sigma VIG parameter evaluation should yield a more conservative result.

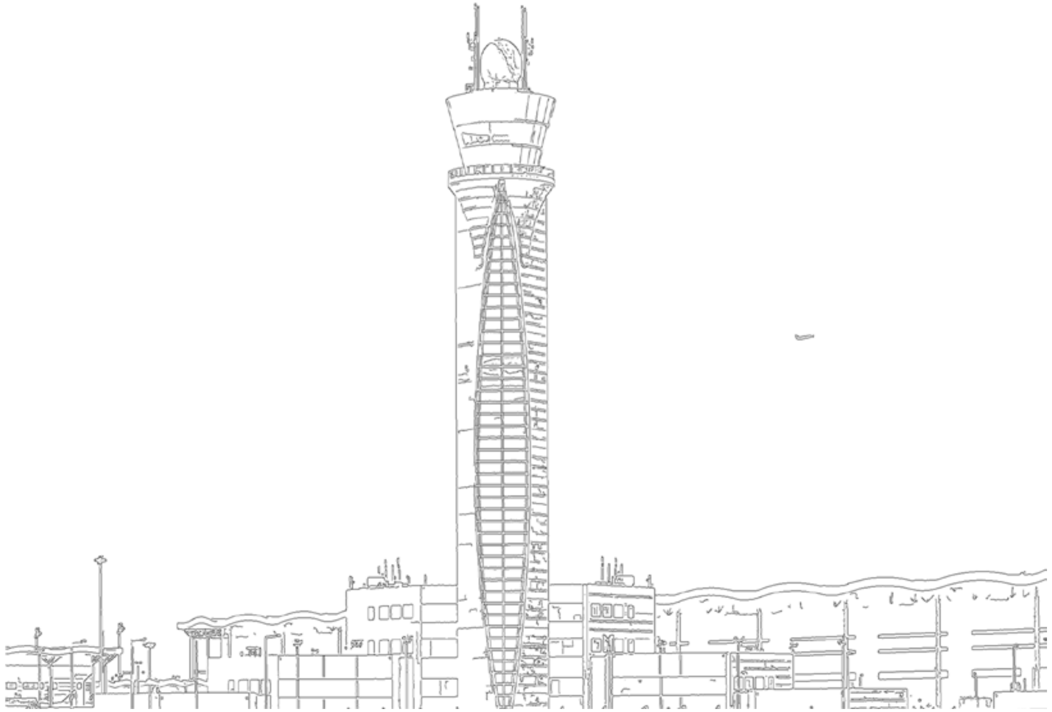
The red and blue lines represent Gaussian distributions with one-sigma values of 9.0 mm/km and (1.5x larger) 13.5 mm/km, respectively. This is well below 25.5 mm/km which represents the maximum possible Sigma VIG parameter value that can be encoded in a GBAS Type 2 message (refer to RTCA DO-246D, Table 2-24). From previous GBAS installation experience, service availability (typically) starts to be noticeably affected when Sigma VIG is larger than 16 mm/km.

Conclusion of Ionospheric Study

The data analysis results in this report show that **GBAS operations can support 24 hours per day in Doha**. The largest gradients identified at Doha are less severe than anomalous gradients observed in other low-latitude regions. The data for this report was collected close to the peak of the solar cycle during a time of elevated solar activity, so it is thought that these results are representative of gradients expected during a solar cycle peak. As described in Section 7.4, a Sigma VIG of 9.0 mm/km bounds the nominal vertical iono gradients measured in Doha during the period covered in this report. This is only slightly higher than the Sigma VIG used in the mid-latitude regions (4.0 mm/km). It is possible that future reference gradient sets collected at/near Doha may be significant enough to challenge the 9.0 mm/km result. This set of data was collected near a solar cycle peak, but larger gradients could be observed when there if a higher level of solar activity occurs. A Sigma VIG of 10 mm/km adds some margin for potentially larger future vertical iono gradients and is what Honeywell recommends for an SLS-4000 installation at Hamad International Airport. This analysis shows that ionospheric activity in Doha, Qatar does not significantly impact the availability or continuity of an SLS-4000.

Honeywell recommends on-going ionospheric analysis be performed to determine if the region experiences increased iono activities than what is captured in this analysis.

SINCERE THANKS TO ALL OF YOU



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