ISRO-IRNSS-PER-19-3

NavIC (IRNSS)

STANDARD POSITIONING SERVICE

PERFORMANCE REPORT

OCTOBER-DECEMBER 2019

SATELLITE NAVIGATION PROGRAM

U.R. RAO SATELLITE CENTRE

INDIAN SPACE RESEARCH ORGANIZATION

CONTENTS

1. INTRODUCTION..... 06

1.1 Introduction..... 06

1.2 Performance Indicators..... 06

2. SOUTHERN REGION..... 07-09

2.1 Signal in Space Accuracy..... 07

2.2 Satellite Availability..... 08

2.3 Dilution of Precision Statistics..... 08

2.4 Carrier to Noise Ratio..... 09

3. WESTERN REGION..... 10-12

3.1 Signal in Space Accuracy..... 10

3.2 Satellite Availability..... 11

3.3 Dilution of Precision Statistics..... 11

3.4 Carrier to Noise Ratio..... 12

4. CENTRAL REGION..... 13-15

4.1 Signal in Space Accuracy..... 13

4.2 Satellite Availability..... 14

4.3 Dilution of Precision Statistics..... 14

4.4 Carrier to Noise Ratio..... 15

5. NORTHERN REGION..... 16-18

5.1 Signal in Space Accuracy..... 16

5.2 Satellite Availability..... 17

5.3 Dilution of Precision Statistics..... 17

5.4 Carrier to Noise Ratio..... 18

6 EASTERN REGION..... 19-21

6.1 Signal in Space Accuracy..... 19

6.2 Satellite Availability..... 20

6.3 Dilution of Precision Statistics..... 20

6.4 Carrier to Noise Ratio..... 21

LIST OF FIGURES

Figure 1: Position accuracy across southern region 7

Figure 2: Percentage availability of number of SVs for SPS service in southern region 8

Figure 3: DOP statistics across southern region 8

Figure 4: Received C/N_0 across southern region 9

Figure 5: Position Accuracy across western region 10

Figure 6: Percentage availability of number of SVs for SPS service in western region 11

Figure 7: DOP statistics across western region 11

Figure 8: Received C/N_0 across western region 12

Figure 9: Position Accuracy across central region 13

Figure 10: Percentage availability of number of SVs for SPS service in central region 14

Figure 11: DOP statistics across central region 14

Figure 12: Received C/N_0 across central region 15

Figure 13: Position Accuracy across northern region 16

Figure 14: Percentage availability of number of SVs for SPS service in northern region 17

Figure 15: DOP statistics across northern region 17

Figure 16: Received C/N_0 across northern region 18

Figure 17: Position Accuracy across eastern region 19

Figure 18: Percentage availability of number of SVs for SPS service in eastern region 20

Figure 19: DOP statistics across eastern region 20

Figure 20: Received C/N_0 across eastern region 21

LIST OF TABLES

Table 1: Performance Indicators for NavIC (IRNSS) 6

ABBREVIATIONS

SPS	Standard Positioning Service
HPE	Horizontal Position Error
PE	Position Error
CEP	Circular Error Probability
drms	Distance root mean square
SV	Space Vehicle
NSAT	Number of Satellites
DOP	Dilution Of Precision

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The performance of the Signals in Space, broadcasted by NavIC (IRNSS) system, is continuously being evaluated for both single and dual frequency users across various locations within the service area. The NavIC (IRNSS) SPS service performance in dual frequency mode for the months of October, November and December 2019 has been provided in this document.

1.2 PERFORMANCE INDICATORS

Table 1 describes the various parameters considered as the indicators of performance.

Table 1: Performance Indicators for NavIC (IRNSS)

Position Accuracy	Horizontal Position Error (HPE) 3-D Position Error Circular Error Probability (CEP)	HPE is two dimensional in nature and can be quantified in terms of error in latitude and longitude. It is calculated as twice the distance-root-mean-square (2drms) with the probability of 95% in this report. 3-D Position Error describes the overall accuracy by combining the effects of horizontal as well as vertical accuracy. The values taken are 2-sigma with 95% probability. CEP is the radius of a circular region, defined in such a way that, the probability of computed estimates falling inside this region is 50%. CEP can be computed from the scatter plot of latitudinal and longitudinal errors.
Availability	Percentage availability of SVs	The availability of service is computed at any user location as the percentage of time an SV can be used for position computation. This metric has been calculated by examining the status of Alert flag and URE index of each SV at every 30 s interval.
Carrier-to-Noise ratio	Received C/N_0 in L5 band Received C/N_0 in S band	
Satellite Geometry	Dilution of Precision	

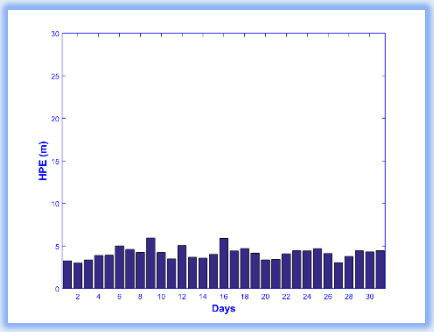
Note:
IRNSS 1G was not available for performance evaluation since October 05, 2019.

CHAPTER 2

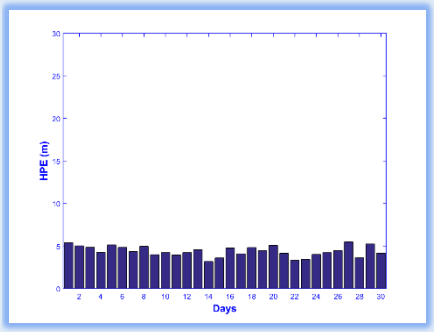
SOUTHERN REGION

2.1. SIGNAL IN SPACE ACCURACY

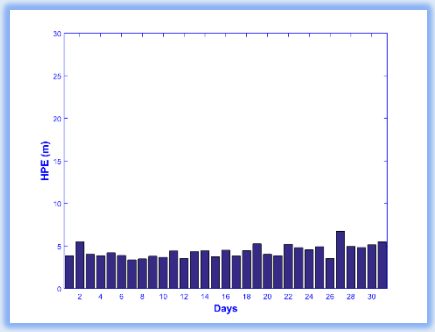
Horizontal Position Error



HPE in October

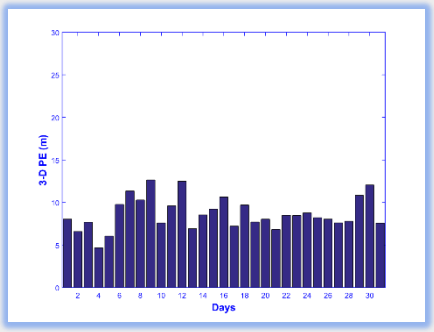


HPE in November

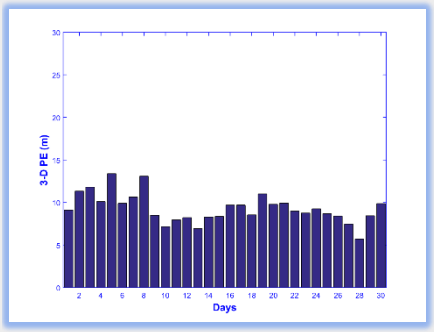


HPE in December

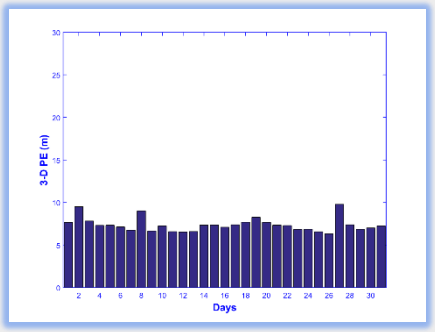
3-D Position Error



PE in October

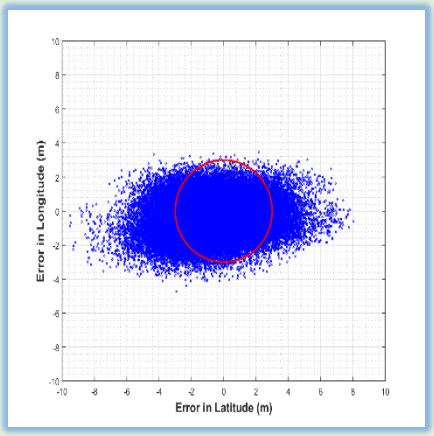


PE in November

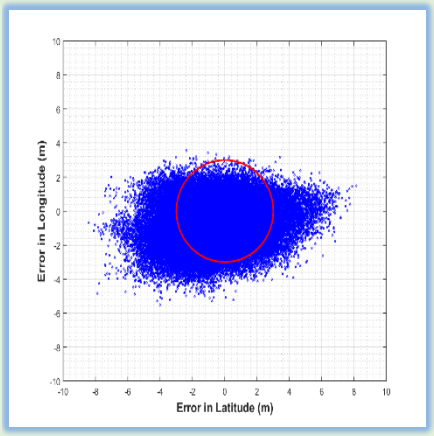


PE in December

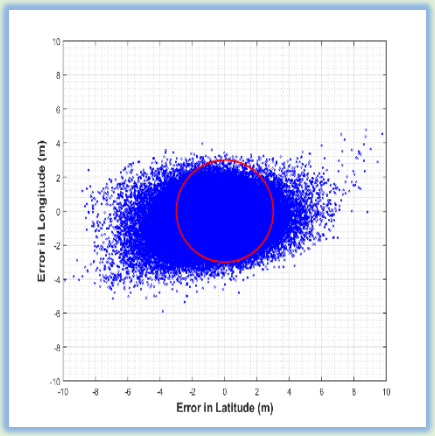
Circular Probability of Error



Scatter Plot for October
CEP: 1.8 m



Scatter Plot for November
CEP: 2.0 m

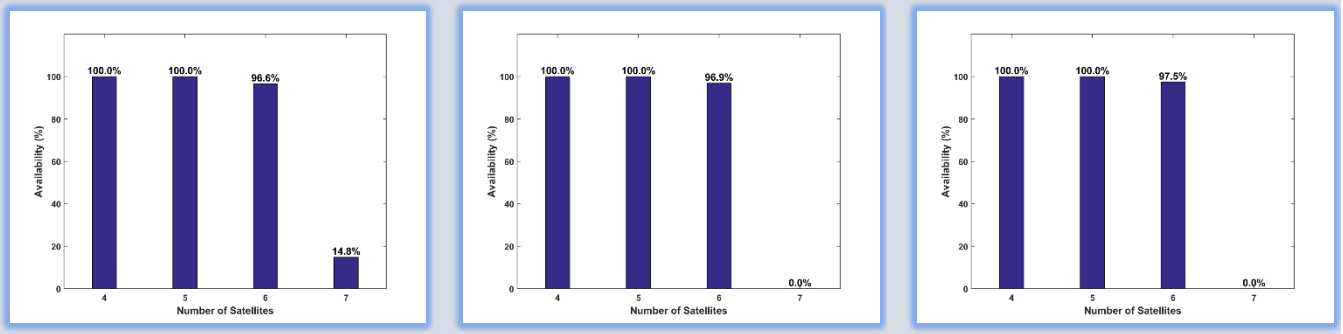


Scatter Plot for December
CEP: 1.9 m

Figure 1: Position accuracy across southern region

NOTE:

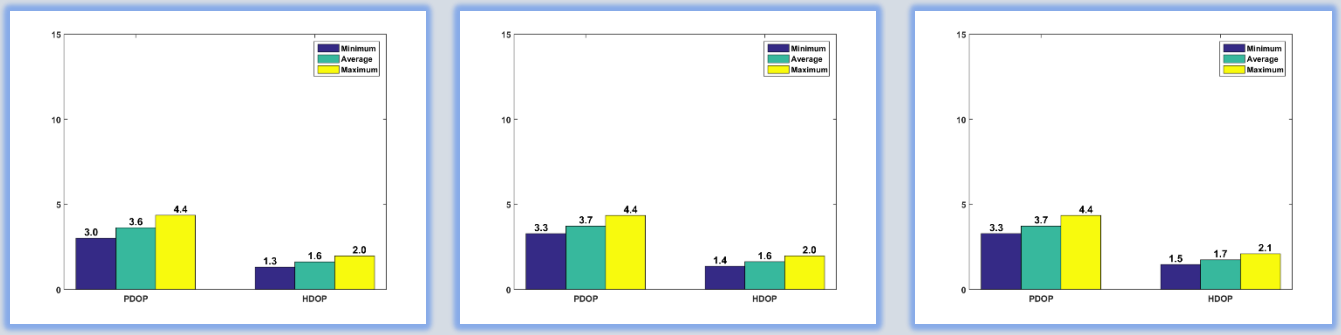
2.2. SATELLITE AVAILABILITY



Availability of NSAT in October **Availability of NSAT in November** **Availability of NSAT in December**

Figure 2: Percentage availability of number of SVs for SPS service in southern region

2.3. DILUTION OF PRECISION STATISTICS



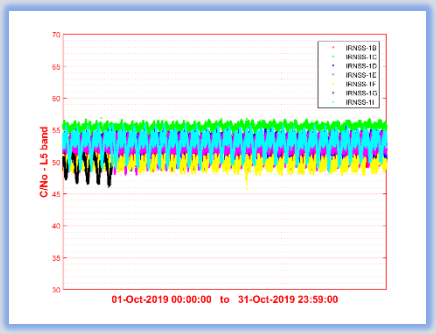
DOP in October **DOP in November** **DOP in December**

Figure 3: DOP statistics across southern region

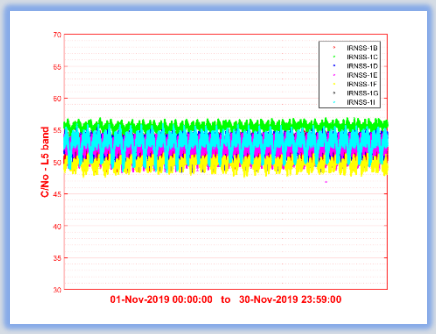
NOTE:

2.4. CARRIER TO NOISE RATIO

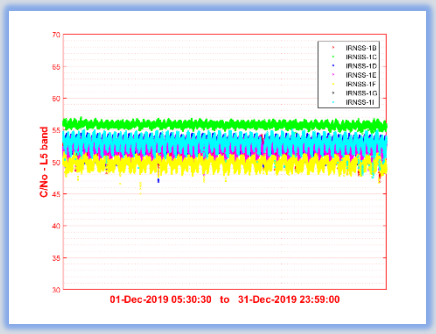
C/N_0 in L5 band



C/N_0 in October

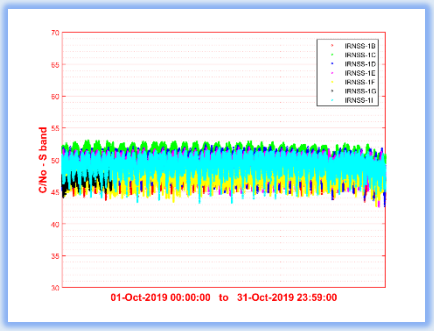


C/N_0 in November

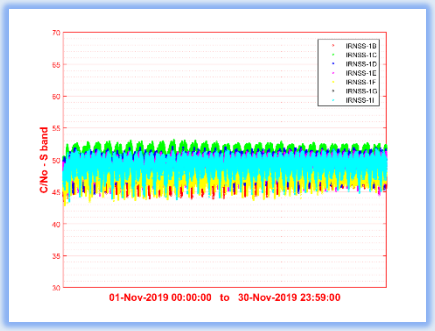


C/N_0 in December

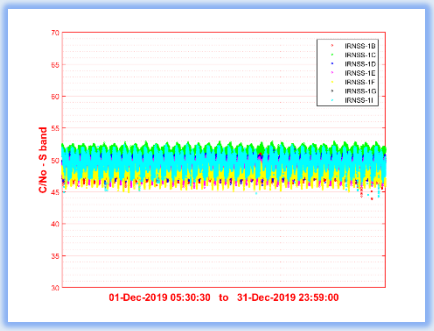
C/N_0 in S band



C/N_0 in October



C/N_0 in November



C/N_0 in December

Figure 4: Received C/N_0 across southern region

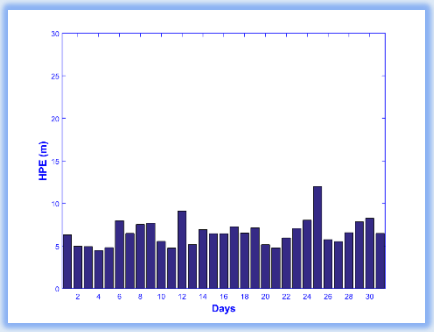
NOTE:

CHAPTER 3

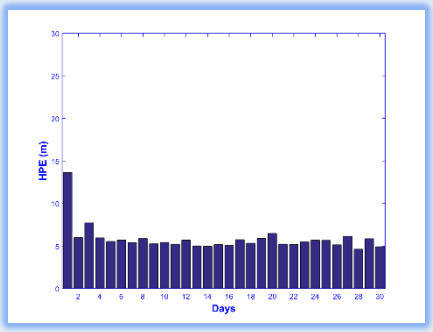
WESTERN REGION

3.1 SIGNAL IN SPACE ACCURACY

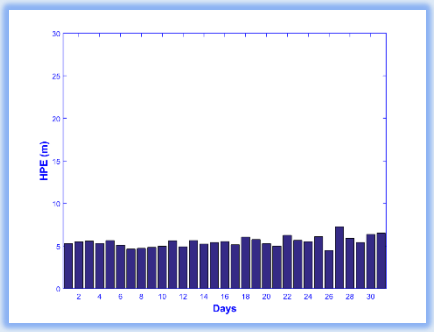
Horizontal Position Error



HPE in October

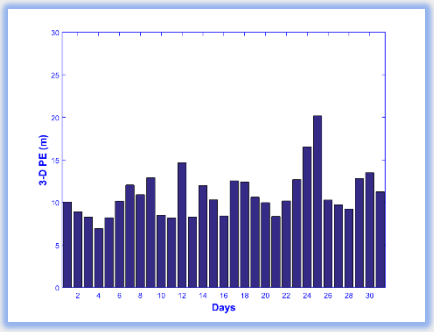


HPE in November

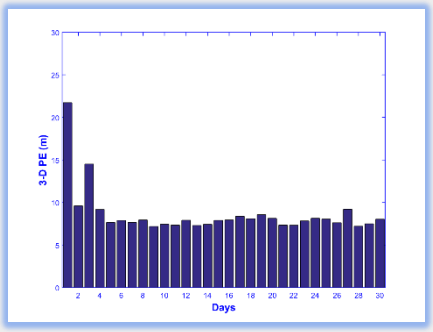


HPE in December

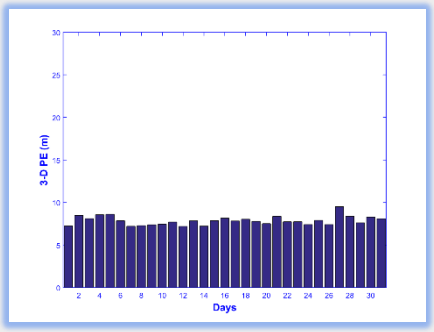
3-D Position Error



PE in October

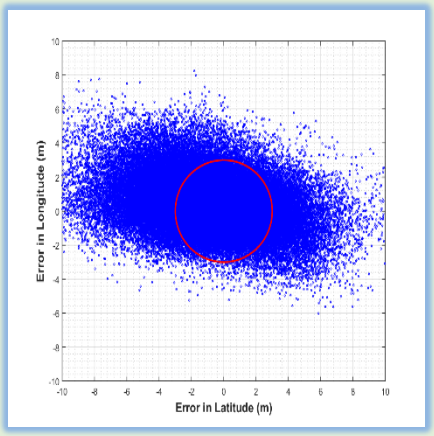


PE in November

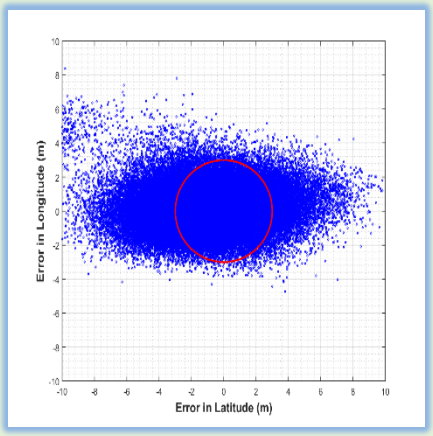


PE in December

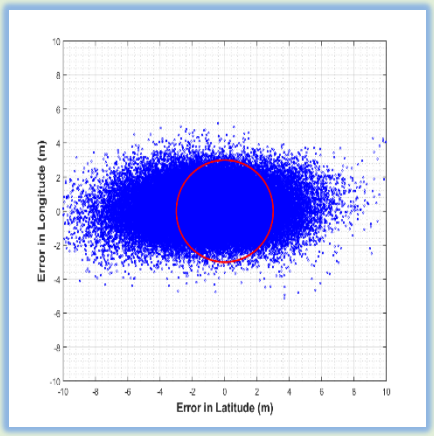
Circular Probability of Error



Scatter Plot for October
CEP: 2.5 m



Scatter Plot for November
CEP: 2.3 m



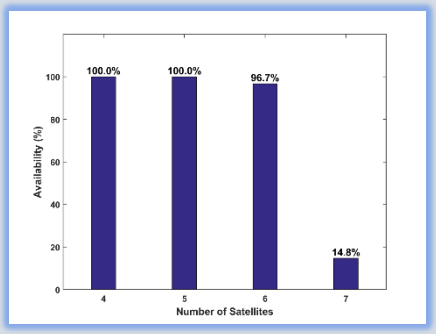
Scatter Plot for December
CEP: 2.1 m

Figure 5: Position Accuracy across western region

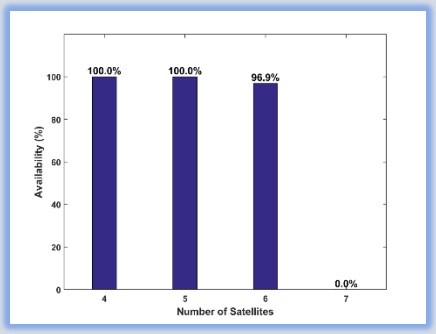
NOTE:

1. The three- dimensional position accuracy performance is better than 13m for 85% of time on October 24, 2019 and for 83% of time on October 25, 2019. The observation in 3D-PE plot is due to SV.
2. The three- dimensional position accuracy performance is better than 13m for 69% of time on November 01, 2019 and for 93% of time on November 03, 2019. The observation in 3D-PE plot is due to SV.

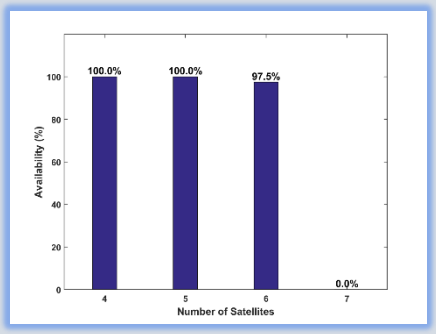
3.2 Satellite Availability



Availability of NSAT in October



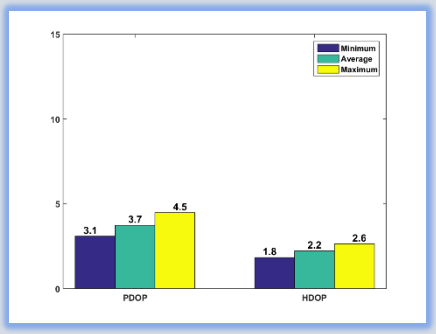
Availability of NSAT in November



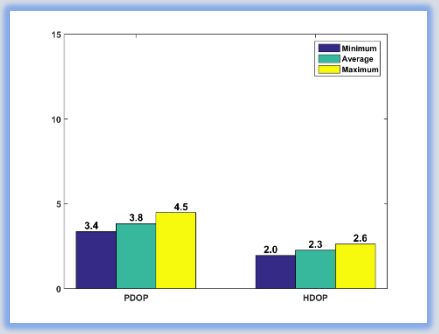
Availability of NSAT in December

Figure 6: Percentage availability of number of SVs for SPS service in western region

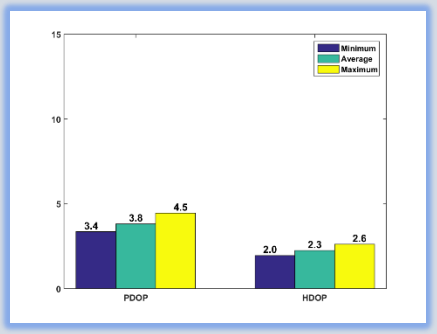
3.3 Dilution of Precision Statistics



DOP in October



DOP in November



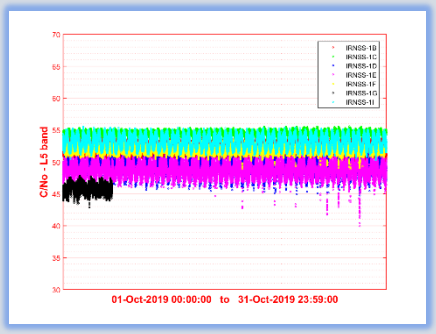
DOP in December

Figure 7: DOP statistics across western region

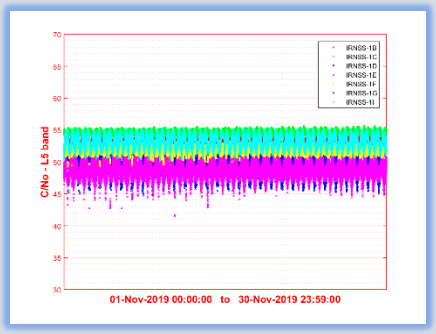
NOTE:

3.4 Carrier to Noise Ratio

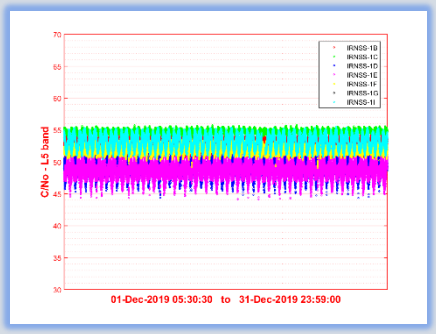
C/N_0 in L5 band



C/N_0 in October

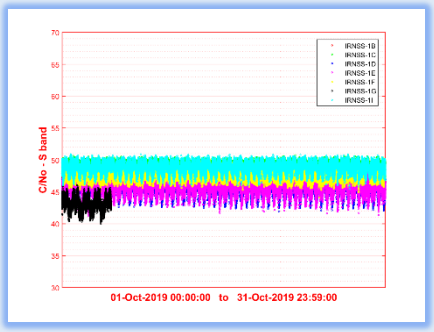


C/N_0 in November

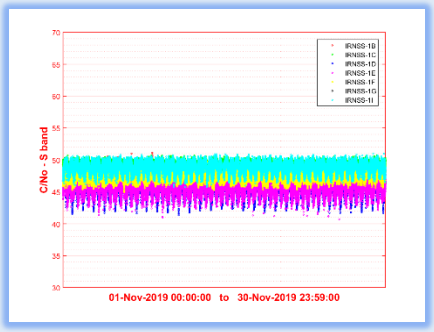


C/N_0 in December

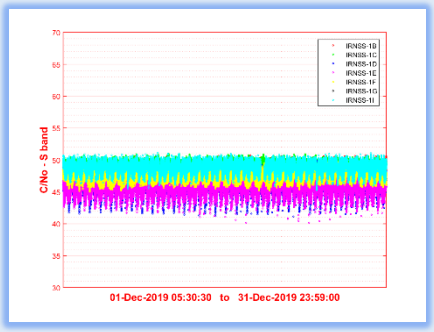
C/N_0 in S band



C/N_0 in October



C/N_0 in November



C/N_0 in December

Figure 8: Received C/N_0 across western region

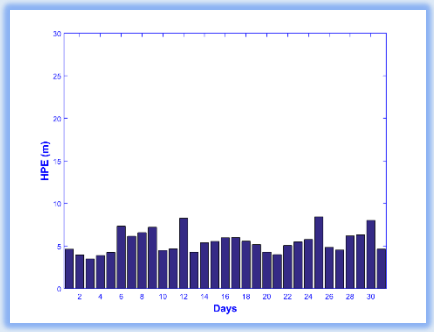
NOTE:

CHAPTER 4

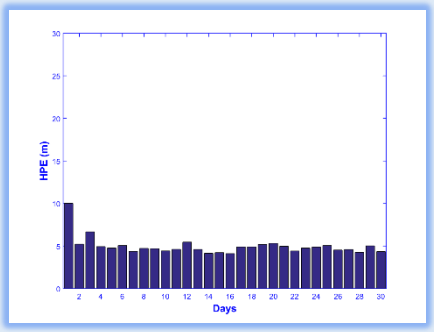
CENTRAL REGION

4.1 SIGNAL IN SPACE ACCURACY

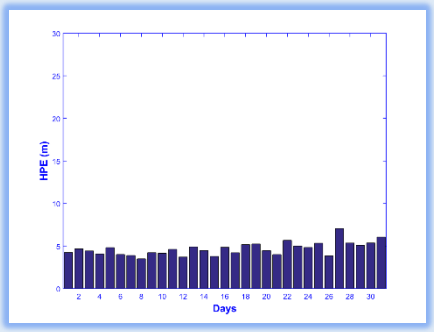
Horizontal Position Error



HPE in October

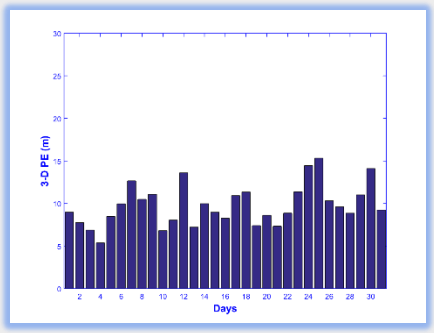


HPE in November

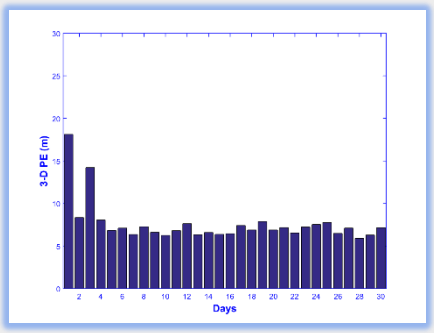


HPE in December

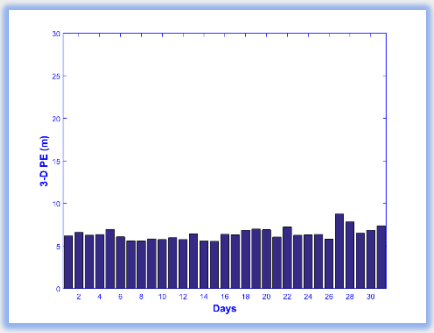
3-D Position Error



PE in October

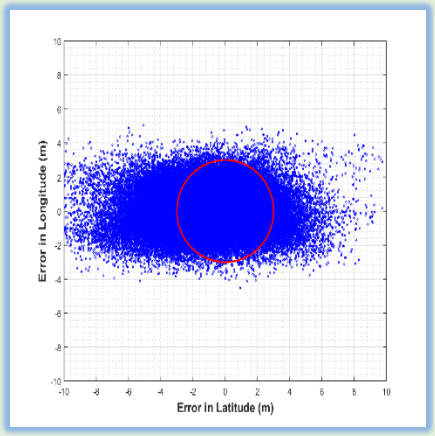


PE in November

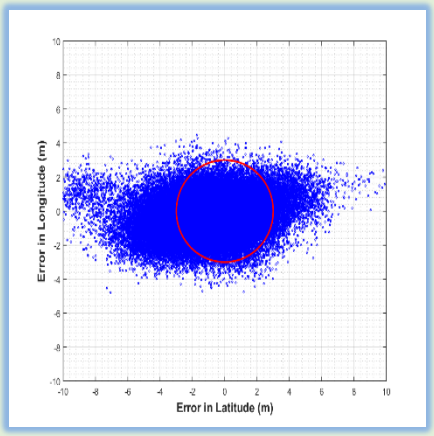


PE in December

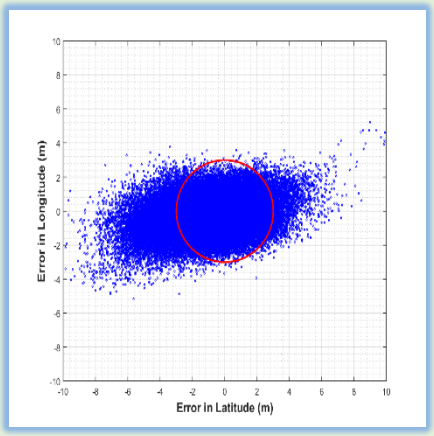
Circular Probability of Error



Scatter Plot for October
CEP: 2.1 m



Scatter Plot for November
CEP: 2.0 m



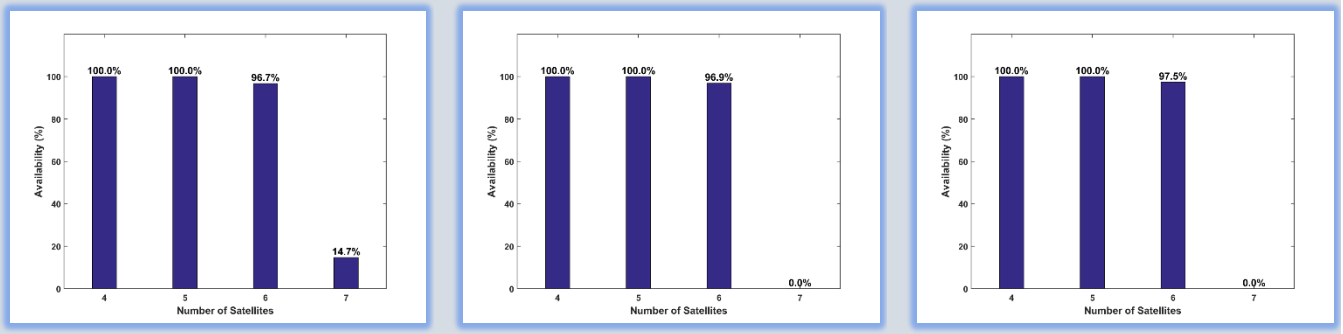
Scatter Plot for December
CEP: 1.8 m

Figure 9: Position Accuracy across central region

NOTE:

1. The three-dimensional position accuracy performance is better than 10m for 92%, 81% & 82% of time on October 23, October 24 & October 25, 2019, respectively. The observation in 3D-PE plot is due to SV.
2. The three-dimensional position accuracy performance is better than 10m for 70% & 87% of time on November 01 & November 03, 2019, respectively. The observation in 3D-PE plot is due to SV.

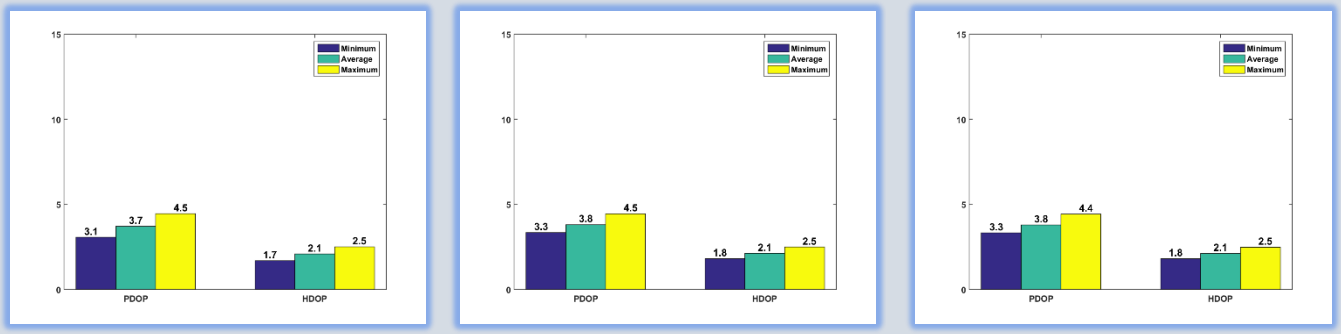
4.2 SATELLITE AVAILABILITY



Availability of NSAT in October **Availability of NSAT in November** **Availability of NSAT in December**

Figure 10: Percentage availability of number of SVs for SPS service in central region

4.3 DILUTION OF PRECISION STATISTICS



DOP in October **DOP in November** **DOP in December**

Figure 11: DOP statistics across central region

NOTE:

4.4 Carrier to Noise Ratio

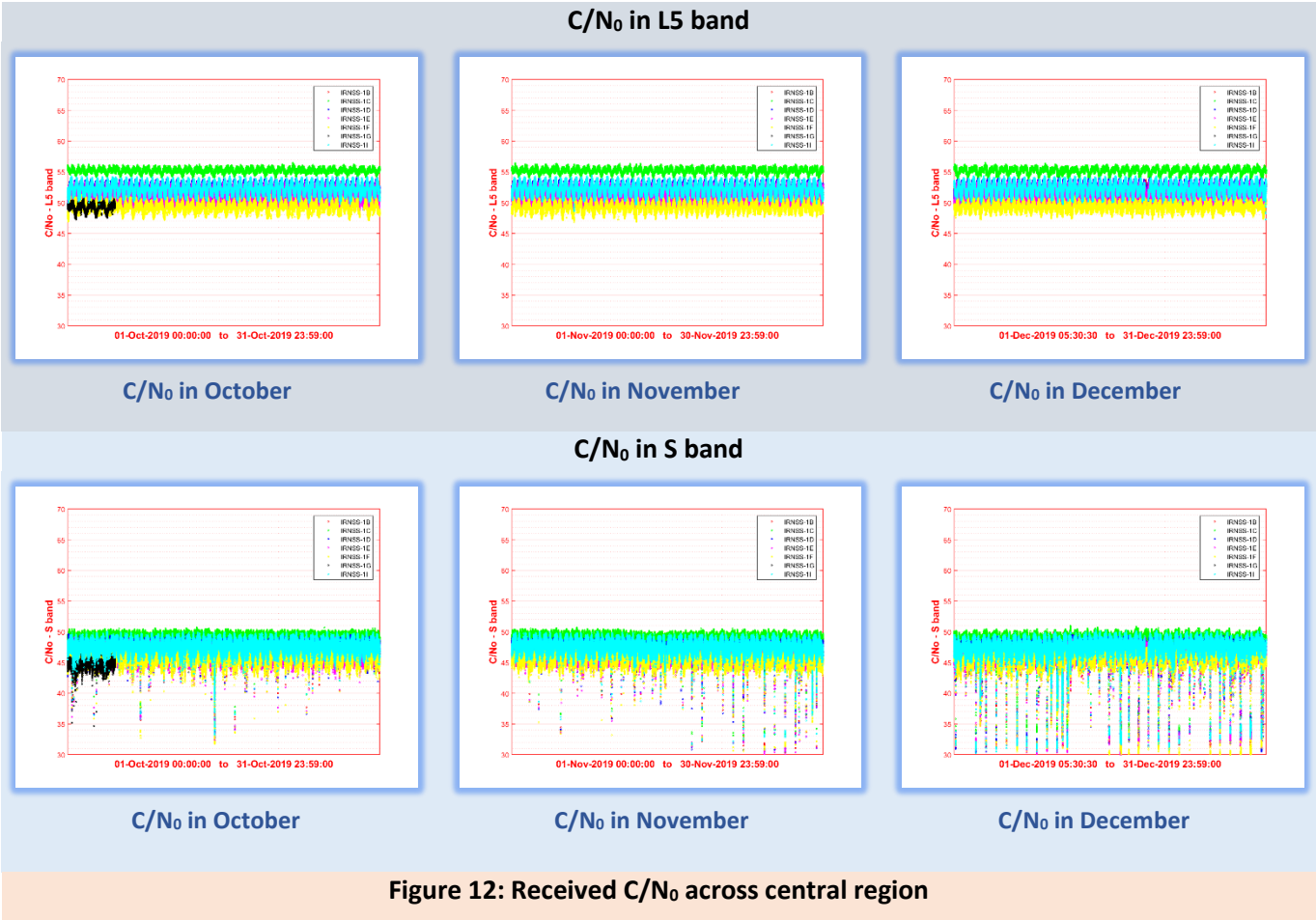


Figure 12: Received C/N_0 across central region

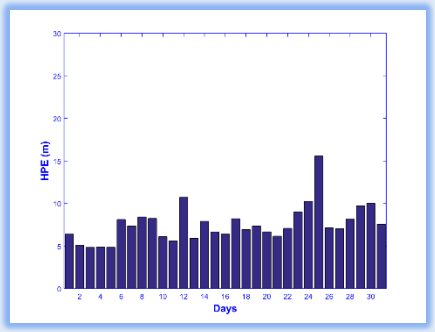
NOTE:

CHAPTER 5

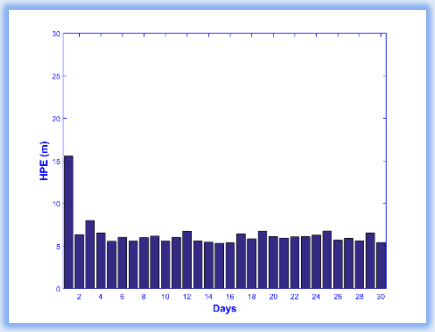
NORTHERN REGION

5.1 SIGNAL IN SPACE ACCURACY

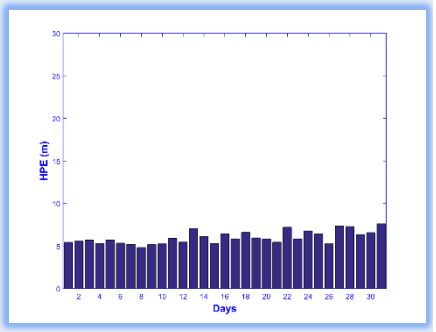
Horizontal Position Error



HPE in October

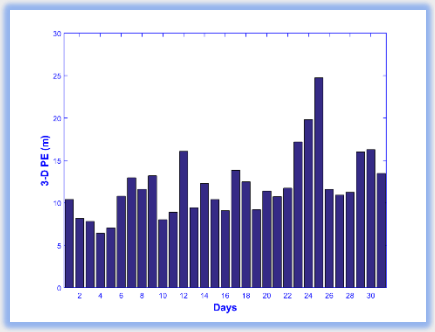


HPE in November

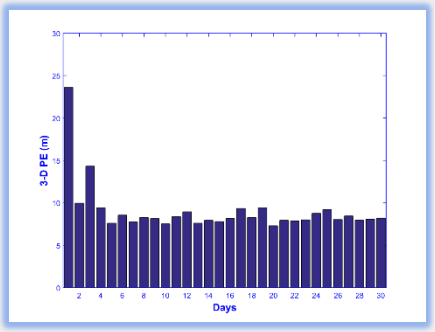


HPE in December

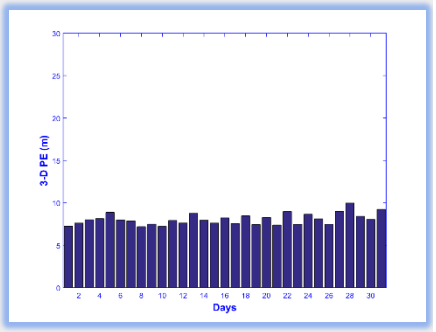
3-D Position Error



PE in October

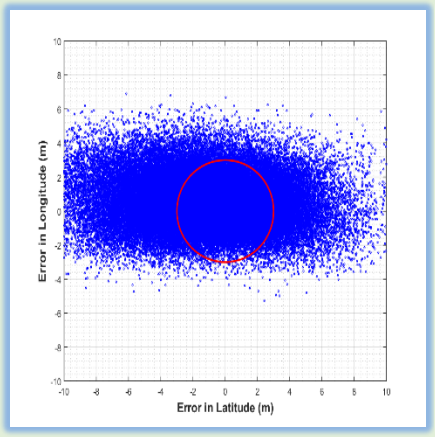


PE in November

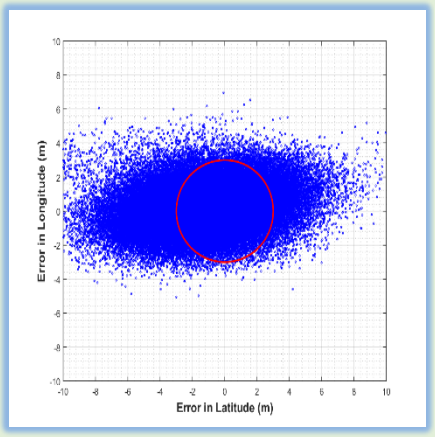


PE in December

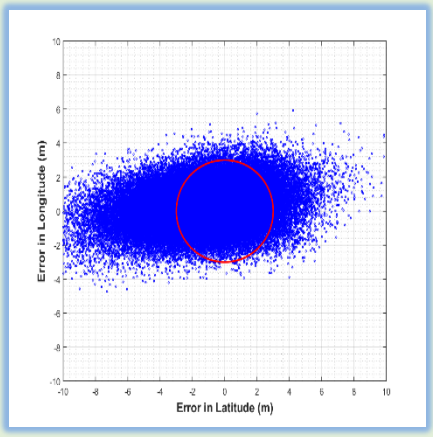
Circular Probability of Error



Scatter Plot for October
CEP: 2.8 m



Scatter Plot for November
CEP: 2.5 m



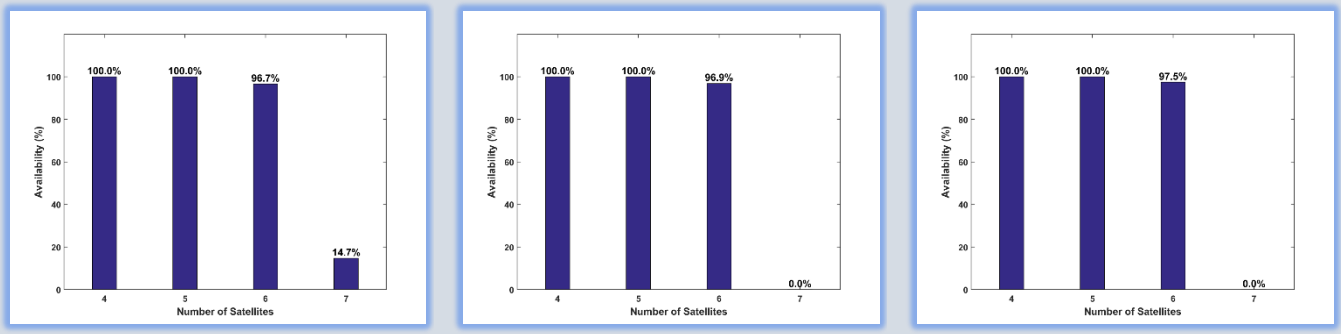
Scatter Plot for December
CEP: 2.3m

Figure 13: Position Accuracy across northern region

NOTE:

1. The three-dimensional position accuracy performance is better than 14m for 92%, 80% & 83% of time on October 23, October 24 & October 25, 2019, respectively. The observation in 3D-PE plot is due to SV.
2. The three-dimensional position accuracy performance is better than 14m for 70% & 94% of time on November 01 & November 03, 2019, respectively. The observation in 3D-PE plot is due to SV.

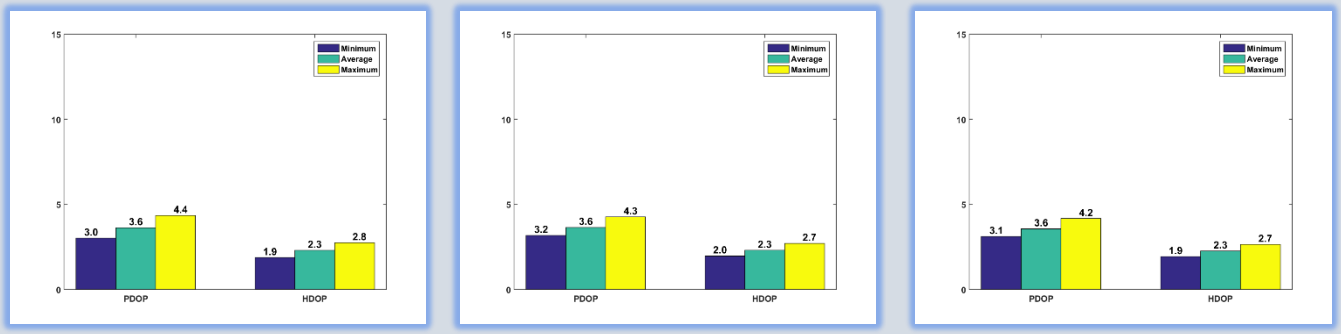
5.2 Satellite Availability



Availability of NSAT in October **Availability of NSAT in November** **Availability of NSAT in December**

Figure 14: Percentage availability of number of SVs for SPS service in northern region

5.3 Dilution of Precision Statistics



DOP in October **DOP in November** **DOP in December**

Figure 15: DOP statistics across northern region

NOTE:

5.4 Carrier to Noise Ratio

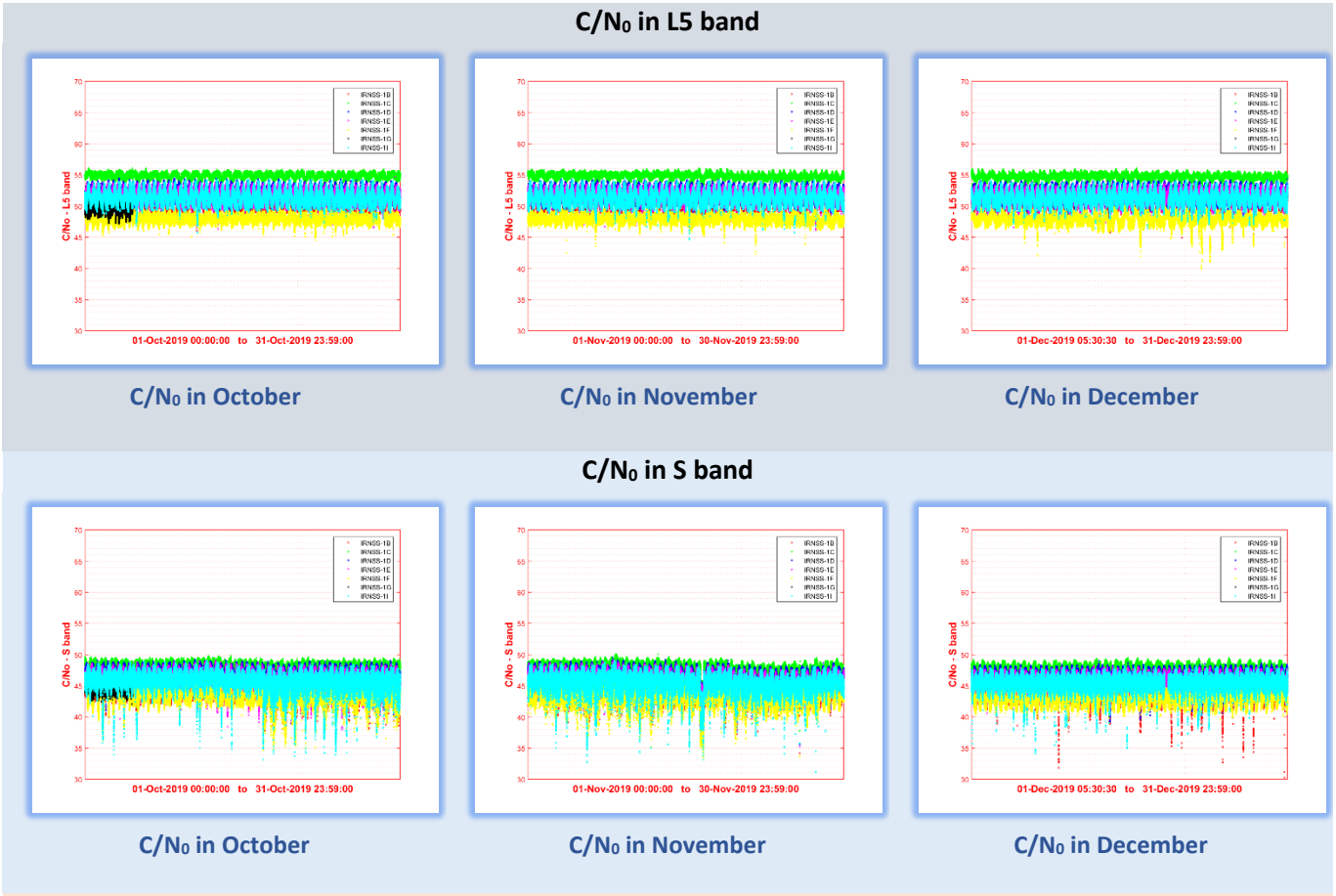


Figure 16: Received C/N_0 across northern region

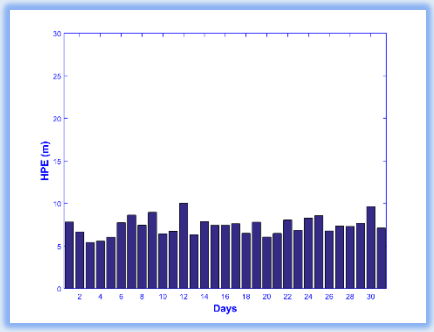
NOTE:

CHAPTER 6

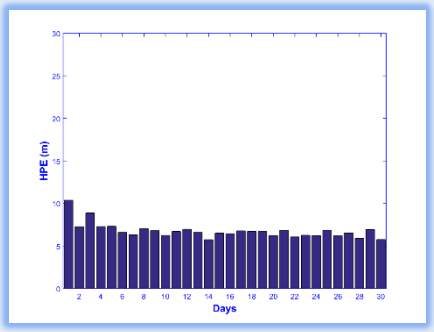
EASTERN REGION

6.1 Signal In Space Accuracy

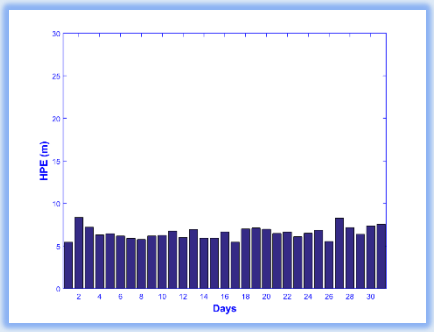
Horizontal Position Error



HPE in October

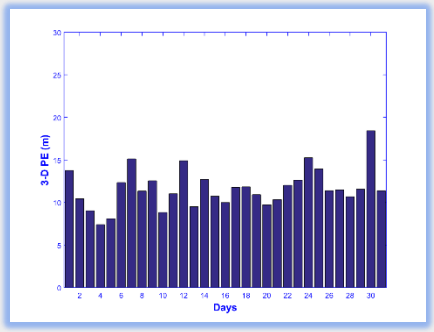


HPE in November

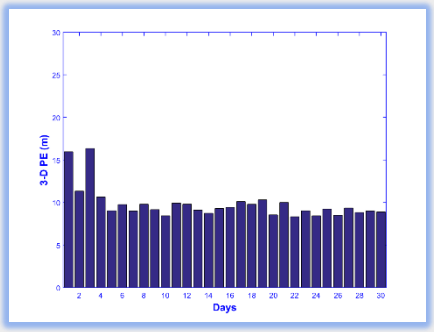


HPE in December

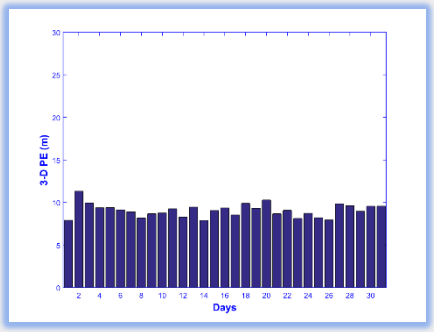
3-D Position Error



PE in October

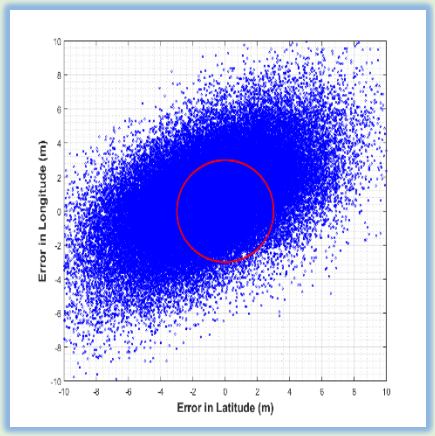


PE in November

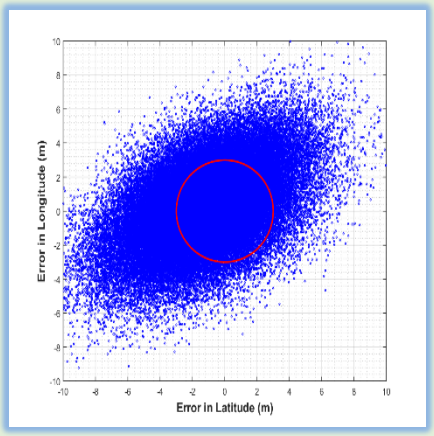


PE in December

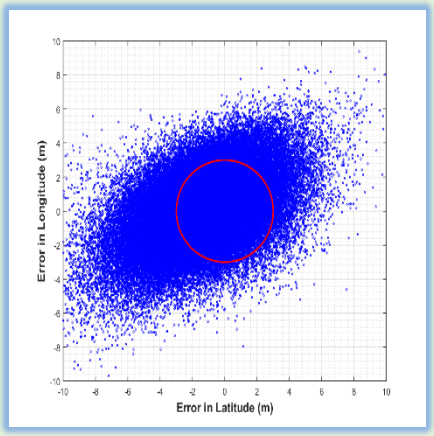
Circular Probability of Error



Scatter Plot for October
CEP: 3.2 m



Scatter Plot for November
CEP: 2.9 m



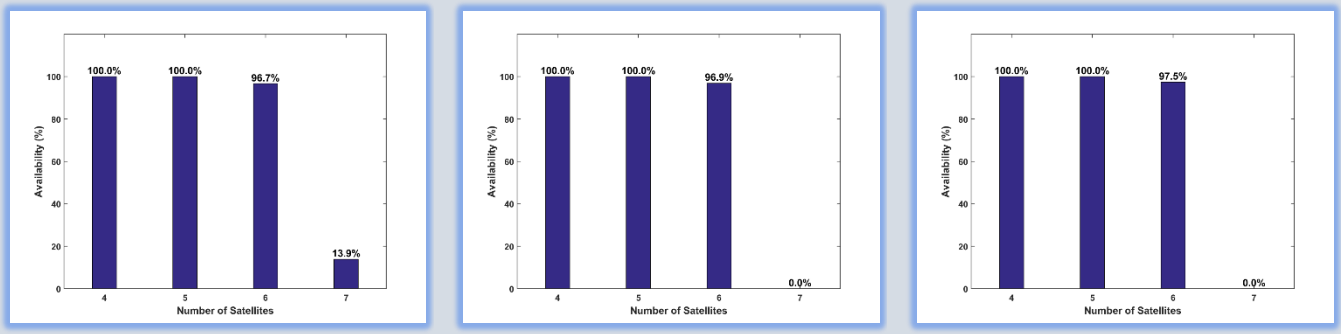
Scatter Plot for December
CEP: 2.8 m

Figure 17: Position Accuracy across eastern region

NOTE:

1. The three-dimensional position accuracy performance is better than 14m for 92% of time on October 24, 2019. The observation in 3D-PE plot is due to SV.
2. The three-dimensional position accuracy performance is better than 14m for 90% & 91% of time on November 01 & November 03, 2019, respectively. The observation in 3D-PE plot is due to SV.

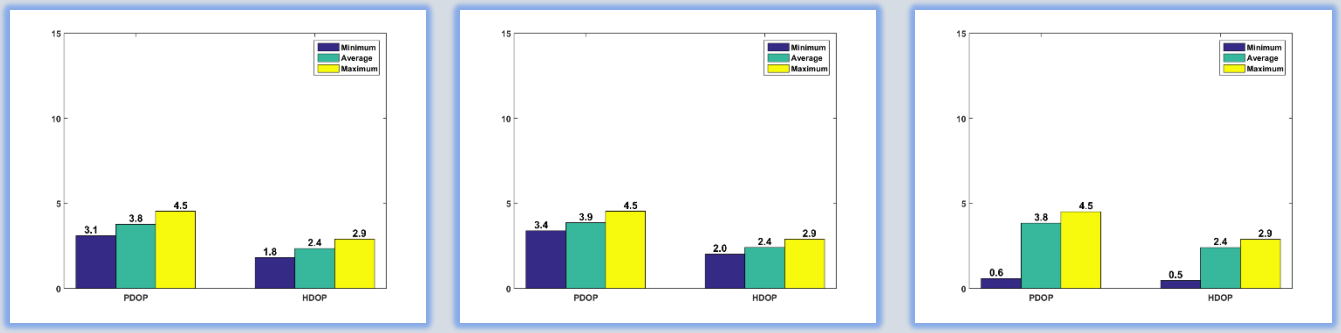
6.2 Satellite Availability



Availability of NSAT in October **Availability of NSAT in November** **Availability of NSAT in December**

Figure 18: Percentage availability of number of SVs for SPS service in eastern region

6.3 Dilution of Precision Statistics



DOP in October **DOP in November** **DOP in December**

Figure 19: DOP statistics across eastern region

NOTE:

6.4 Carrier to Noise Ratio

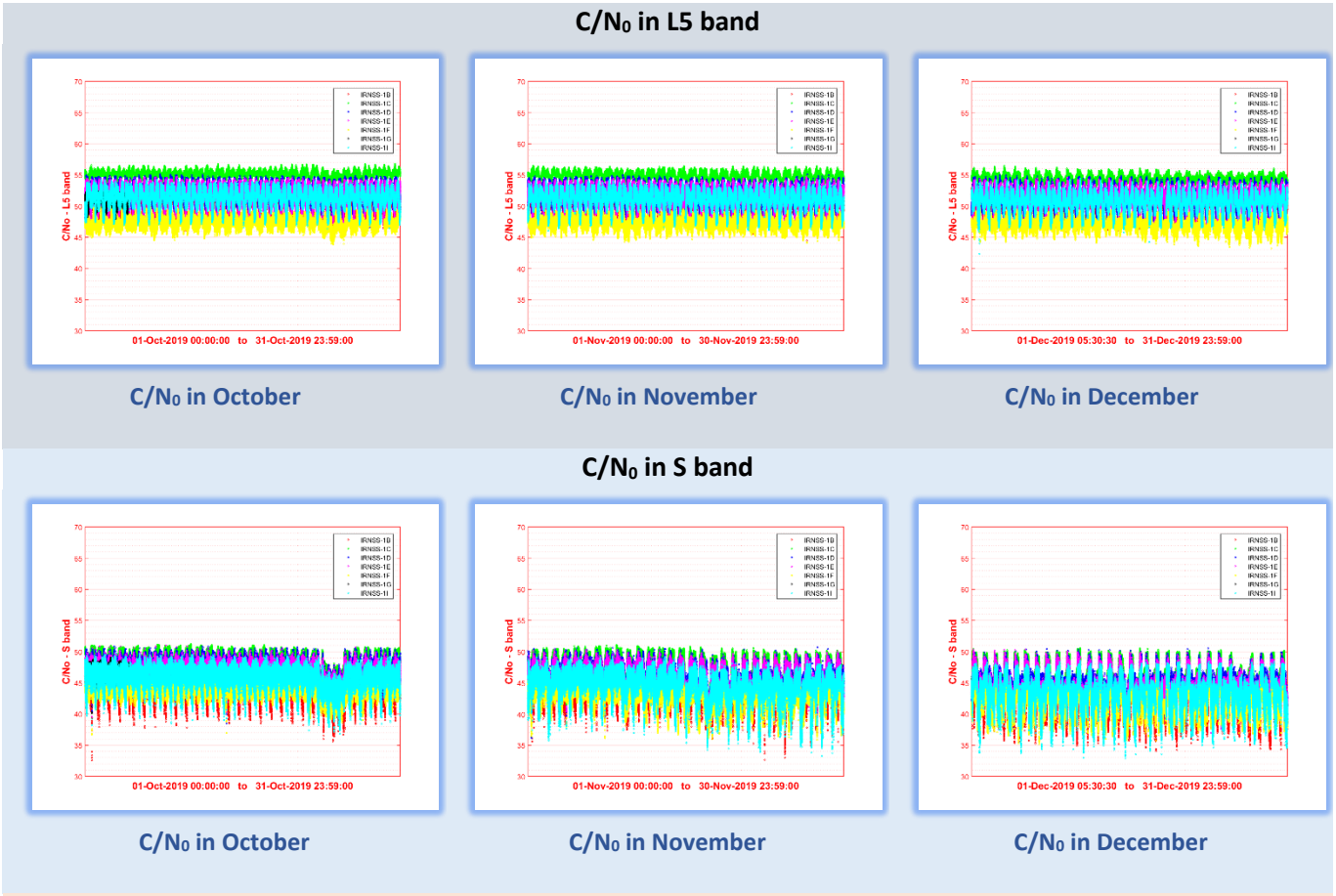


Figure 20: Received C/N_0 across eastern region

NOTE: