सत्यमेव जयते

नागर विमानन मंत्रालय, भारत सरकार

MINISTRY OF CIVIL AVIATION, GOVERNMENT OF INDIA

भारतीय विमानपत्तन प्राधिकरण

AIRPORTS AUTHORITY OF INDIA

ICAO APAC SBAS-GBAS IMPLEMENTATION WORKSHOP FOR AIRSPACE USERS

"Enhancing airport accessibility and safety on final approach with SBAS and GBAS"

14th to 16th October 2025

Bengaluru, India

Introduction to KASS, Challenges and Solutions

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(MOLIT)

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Contents

1

Introduction to KASS system

KASS R&D Organization, KASS service and Deployment, KASS Message

1 To receive GPS location information	2 Error value correction and integrity data for satellites		3 Correction of signal satellite service
			
Reference Station	Central Processing Station	Satellite Communication Station	geostationary satellites
Reference Station (7 Locations)	**Central Processing/Integration Station (2 Locations)**	**Satellite Communication Station (2 Locations)**	**SBAS Satellite (Leased)**
GPS signal reception SBAS signal reception	GPS error calculation, SBAS data generation and control	SBAS signal transmission to satellites	Delivery of SBAS signals throughout the country

KASS Development Timeline

October 2014
Project Initiation

December 2022
KARI was designated as the official agency responsible for managing and operating KASS, classified as a radio navigation safety facility

March 2023
Service agreement signed with the Office of Air Traffic, with operational centers established in Cheongju and Incheon

February 2024
After 9 years and 4 months of development and deployment, the KASS system was officially transferred to the government.

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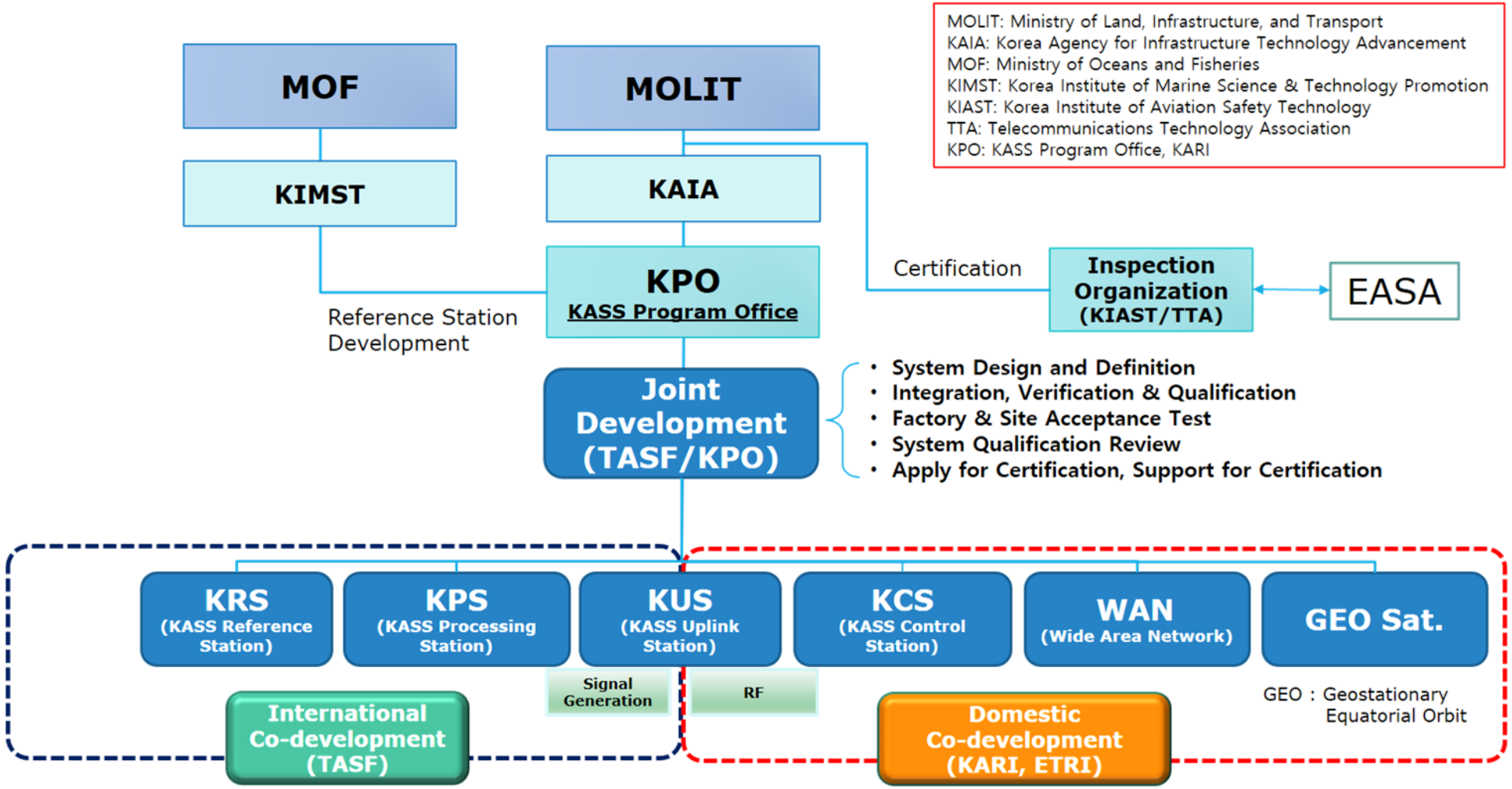
1. Introduction to KASS (1/5)

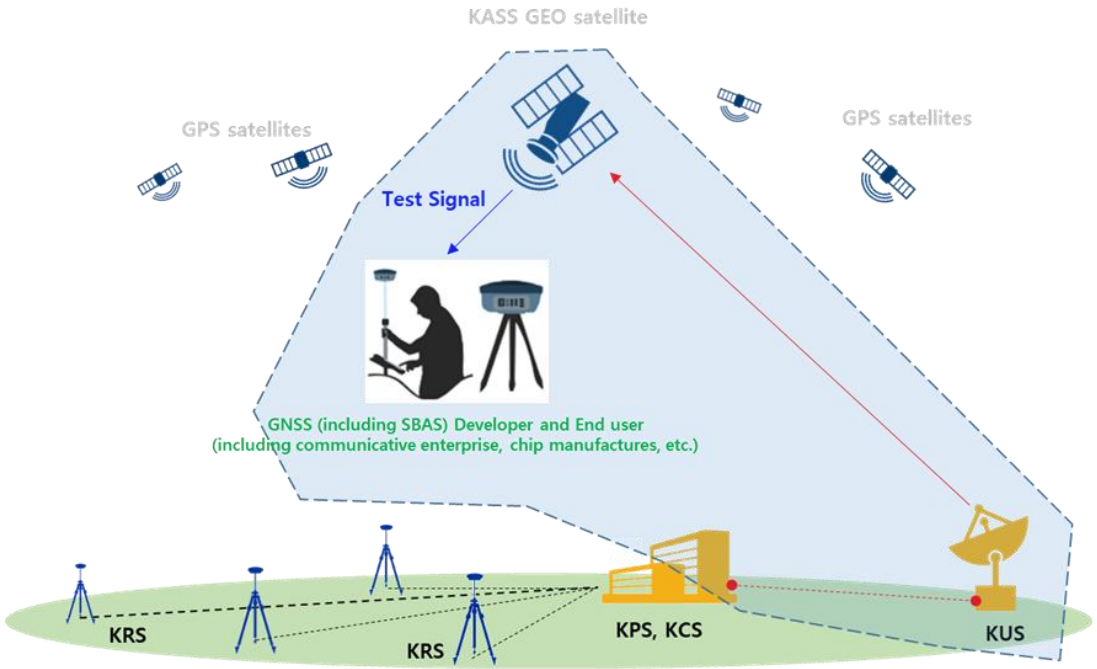
❖ **Organization of KASS system Development and Implementation**



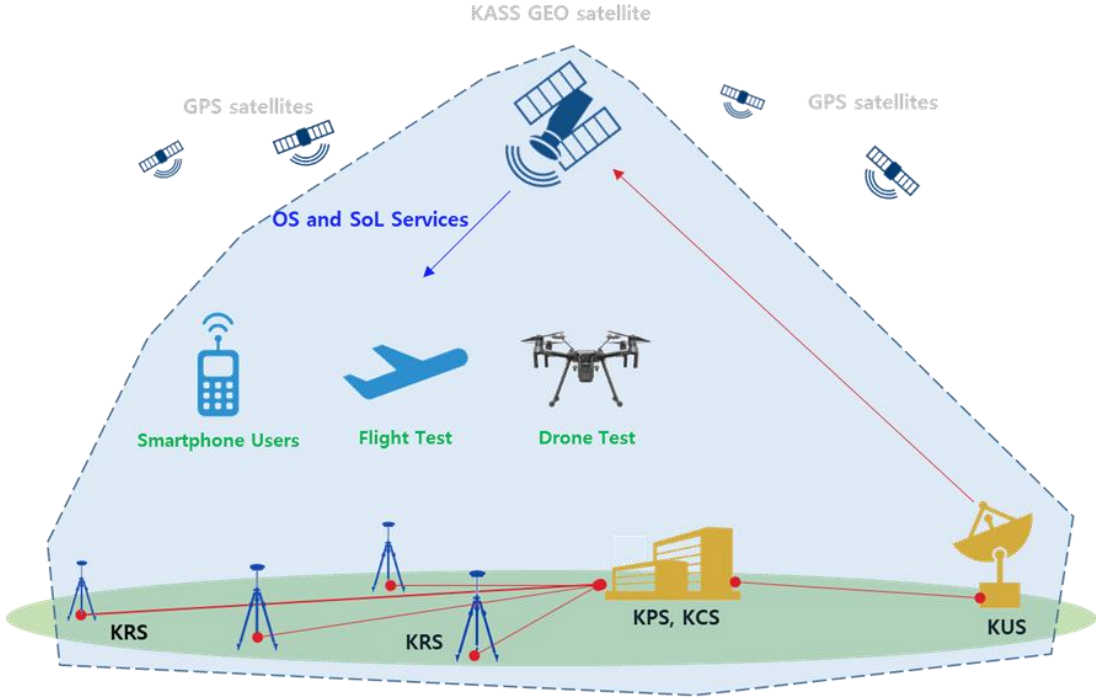
1. Introduction to KASS (2/5)

❖ KASS Service

- (15th December, 2022) Test Mode(including MT0/0) signal broadcasting Commencement, Intermittent Service (Pilot Service)
- (26th July, 2023) Test Mode(including MT0/2) signal broadcasting Commencement, more Stable Service (Open Service)
- (28th December, 2023) Aviation Mode(MT2) signal broadcasting Commencement (SoL Service : APV-I class)



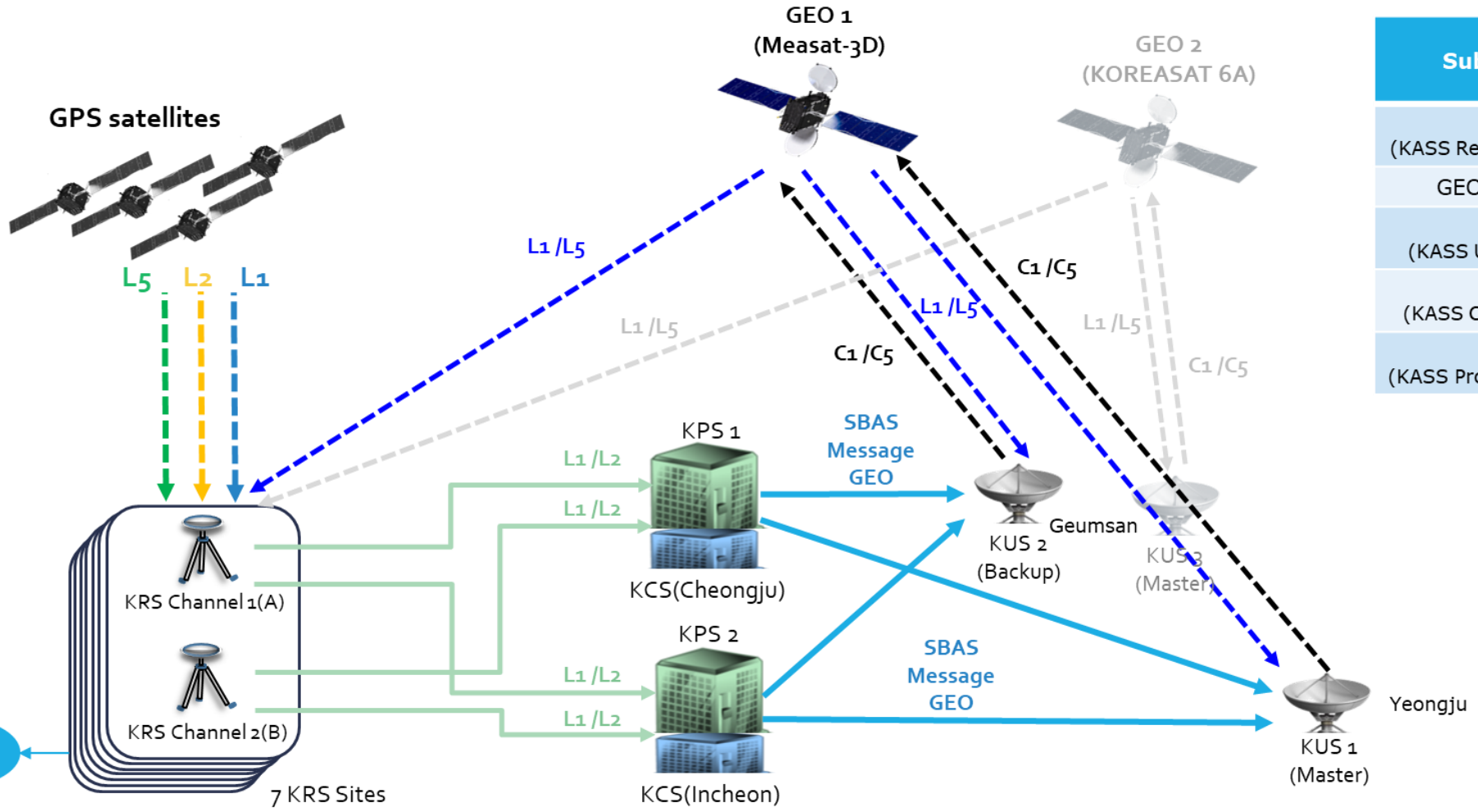
[KASS 1st signal service]



[KASS 2nd and 3rd(SoL Service) signal service]

1. Introduction to KASS (3/5)

❖ KASS Architecture



Sub System	Qty. (site) (Baseline)
KRS (KASS Reference Station)	7
GEO Satellites	2
KUS (KASS Uplink Station)	2
KCS (KASS Control Station)	2
KPS (KASS Processing Station)	2

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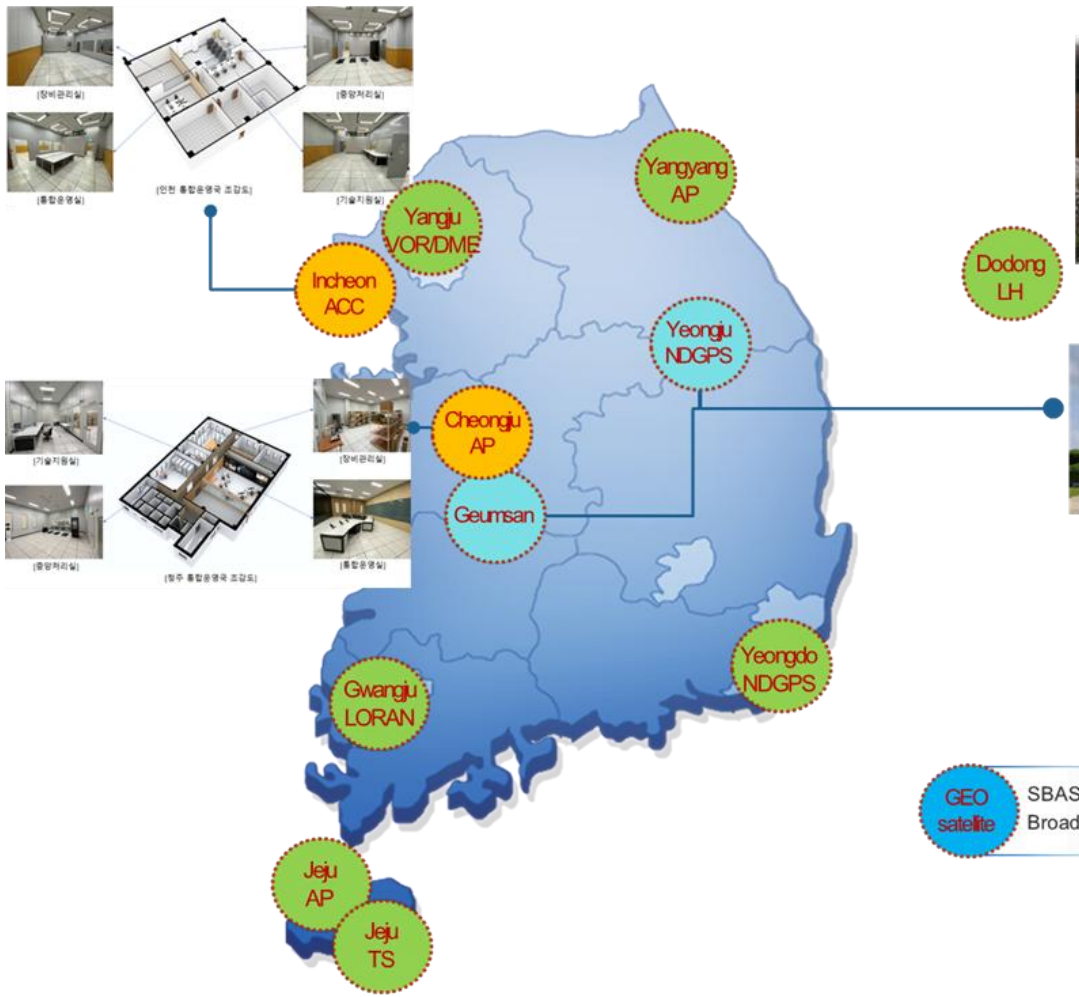
1. Introduction to KASS (4/5)

❖ KASS Subsystem Development Status



Dodong LH

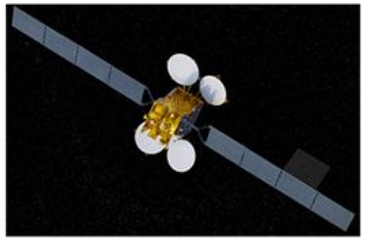
KRS : KASS Reference Station

Legend
- : KRS
- : KPS, KCS
- : KUS
- : GEO satellite

KPS : KASS Processing Station
KCS : KASS Control Station

KUS : KASS Uplink Station

GEO satellite — SBAS Message Broadcasting (2)



MEASAT-3d (91.5° East)

KOREASAT6A (116° East)

※ The KASS 2nd GEO satellite (KOREASAT 6A) was launched on 12th November, 2024. And, the satellite is currently broadcasting the test signal (MT0/0).

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1. Introduction to KASS (5/5)

❖ KASS Message

- Main Applicable Documents
  - ICAO SARPs Annex 10, Amendment 89 (Nov., 2014)
  - RTCA DO-229D with Change 1 (Feb., 2013)
- PRN number : **134** (for Measat-3D), **142** (for KOREASAT 6A temporary)
- Available KASS Message Types : 0, 1, 2, 3, 4, 6, 7, 9, 10, 17, 18, 25, 26, 27, 63

April 2023 Edition

L1 C/A PRN CODE ASSIGNMENTS

PRN Code Number	G2 Delay (Chips)	Initial G2 Setting (Octal)[i]	First 10 Chips (Octal)[i]	PRN Allocations System (Satellite)	Orbital Slot	Effective Through (Month Year)
1 – 63	See IS-GPS-200[ii]	See IS-GPS-200[ii]	See IS-GPS-200[ii]	Reserved for GPS	See NAVCEN[iii]	See NAVCEN[iii]
64 – 119	See IS-GPS-200[ii]	See IS-GPS-200[ii]	See IS-GPS-200[ii]	Reserved for GBAS & other augmentation systems	N/A	N/A
120 – 158	See Below	See Below	See Below	Reserved for SBAS	See Below	See Below
159 – 210	See Below	See Below	See Below	Reserved for other GNSS & other applications	See Below	See Below
Reserved for Satellite-Based Augmentation System (SBAS) (PRNs 120-158)						
129	762	1250	0527	MSAS (QZS-3)[iv]	127 E	Sep 2029
130	355	0341	1436	BDSBAS (G1)	140 E	Aug 2030
131	1012	0551	1226	WAAS (Eutelsat 117 West B)	117 W	Mar 2028
132	176	0520	1257	GAGAN (GSAT-15)	93.5 E	Nov 2025
133	603	1731	0046	WAAS (SES-15)	129 W	Oct 2029
134	130	0706	1071	KASS (MEASAT-3D)	91.5 E	Jan 2024
135	359	1216	0561	WAAS (Intelsat Galaxy 30)	125 W	Jul 2029
136	595	0740	1037	EGNOS (HOTBIRD 13G)	5 E	May 2031
137	68	1007	0770	MSAS (QZS-3)[iv]	127 E	Sep 2029

[KASS 1st GEO satellite PRN assignment, https://www.gps.gov]

Table A-3: Message Types

Type	Contents	Section No.
0	Don't use for safety applications (for SBAS testing)	A.4.4.1
1	PRN Mask assignments, set up to 51 of 210 bits	A.4.4.2
2 to 5	Fast corrections	A.4.4.3
6	Integrity information	A.4.4.4
7	Fast correction degradation factor	A.4.4.5
8	Reserved for future messages	—
9	GEO navigation message (*X*, *Y*, *Z*, time, etc.)	A.4.4.11
10	Degradation Parameters	A.4.4.6
11	Reserved for future messages	—
12	SBAS Network Time/UTC offset parameters	A.4.4.15
13 to 16	Reserved for future messages	—
17	GEO satellite almanacs	A.4.4.12
18	Ionospheric grid point masks	A.4.4.9
19 to 23	Reserved for future messages	—
24	Mixed fast corrections/long term satellite error corrections	A.4.4.8
25	Long term satellite error corrections	A.4.4.7
26	Ionospheric delay corrections	A.4.4.10
27	SBAS Service Message	A.4.4.13
28	Clock-Ephemeris Covariance Matrix Message	A.4.4.16
29 to 61	Reserved for future messages	—
62	Internal Test Message	—
63	Null Message	A.4.4.14

[KASS message type, RTCA/DO-229D]

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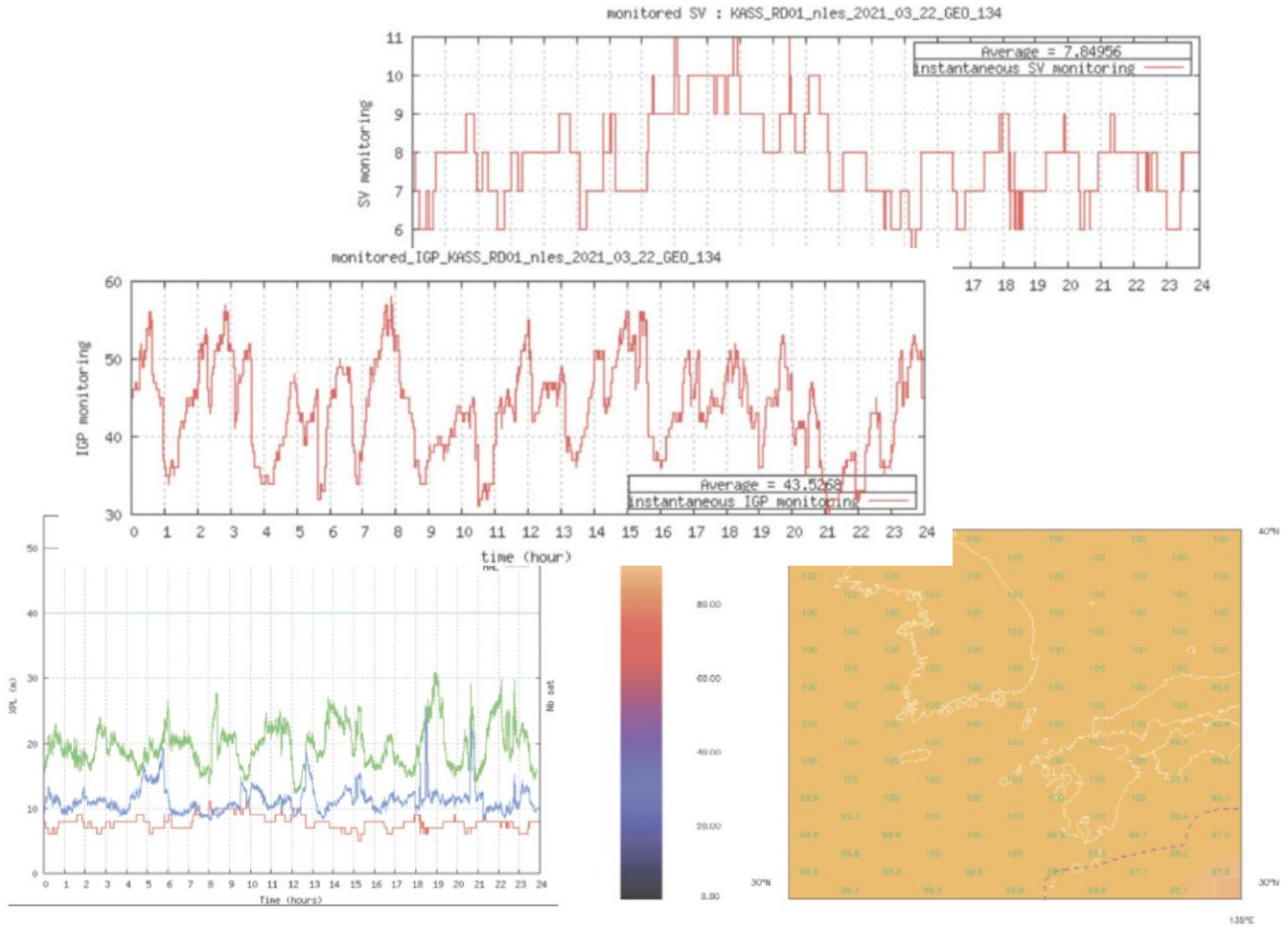
2

KASS Performance

Road Test using car and KASS Accuracy



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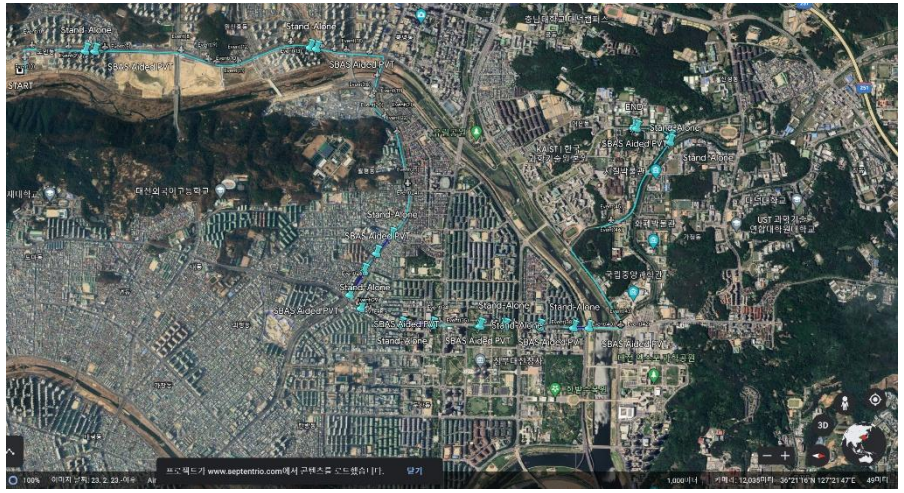
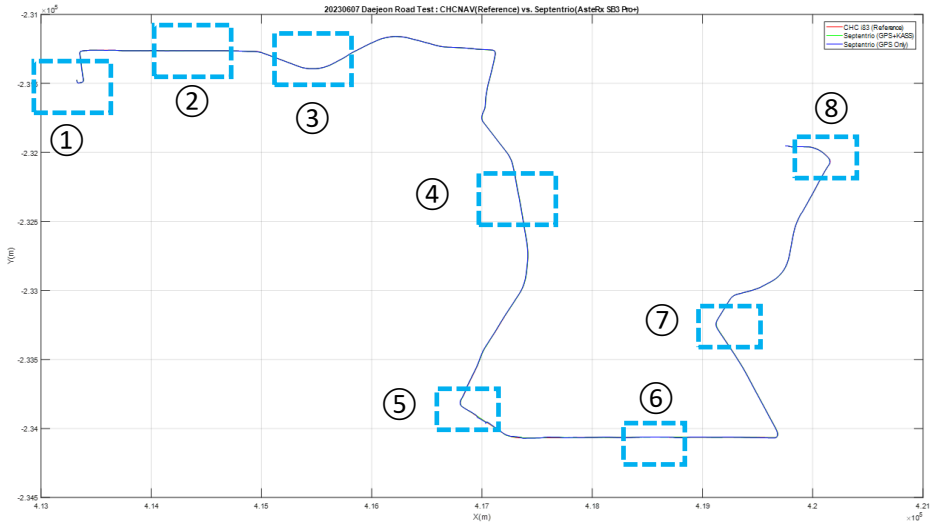
2. KASS Performance (1/4)

❖ KASS Performance : Road Test using Car with MT0/2 (June, 2023)





No.	GPS+KASS (m)	GPS Only (m)	Accuracy improvement rate by KASS (%)	Note
①	0.56m	0.85m	52%	Early start and rotation of vehicle (slow speed)
②	0.25m	0.50m	200%	
③	0.40m	0.10m	-400%	section of high-rise apartments nearby
④	0.15m	1.90m	1,270%	
⑤	0.90m	4.70m	520%	environment with poor GPS signal reception (high-rise apartments)
⑥	0.96m	2.00m	208%	
⑦	0.11m	3.05m	2,770%	environment with poor GPS signal reception (street trees)
⑧	0.64m	1.70m	266%	

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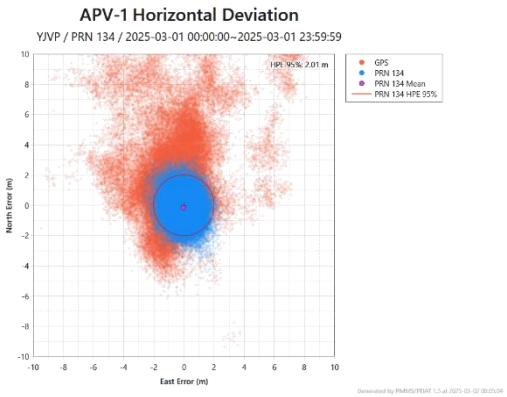
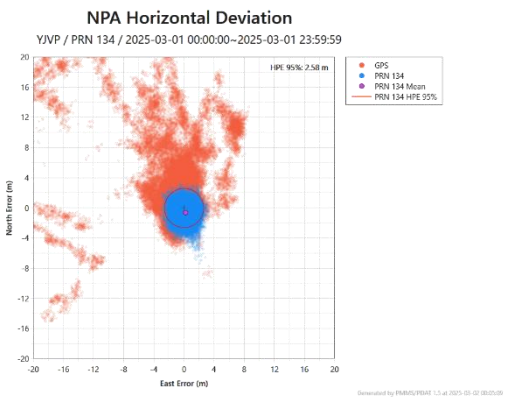
2. KASS Performance (2/4)

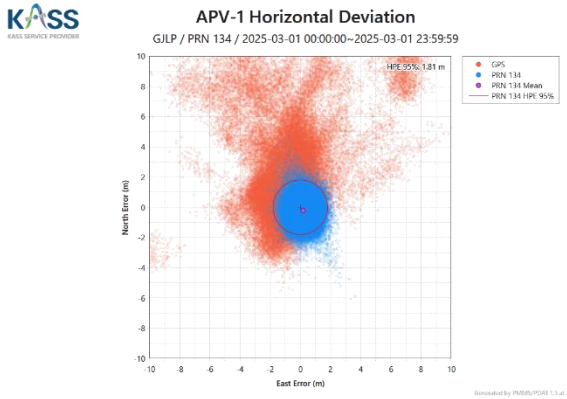
❖ **KASS Performance : Accuracy for 7 KRSs (1st March, 2025) using the first KASS GEO (PRN 134)**

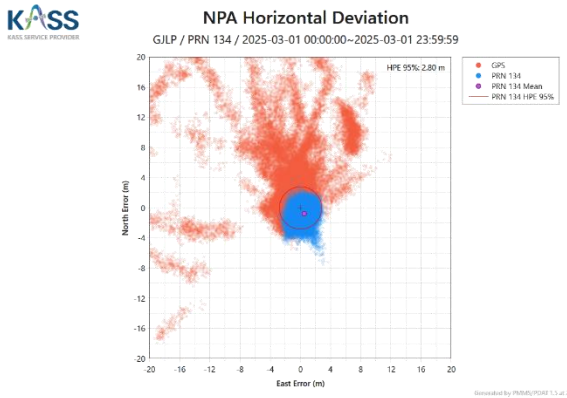
① Yangju VOR/DME



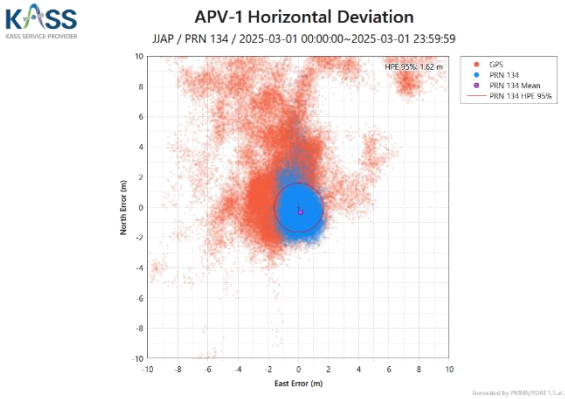


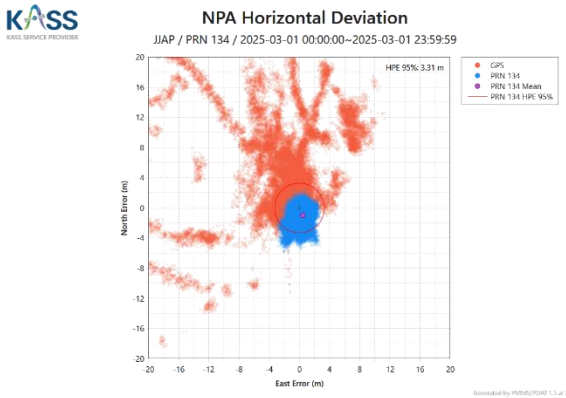
② Gwangju (eLORAN site)





③ Jeju Airport

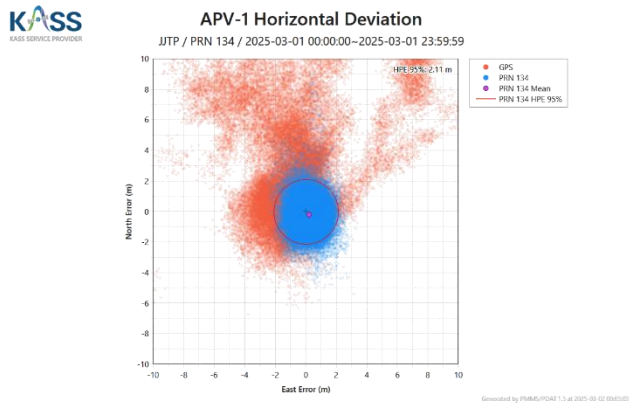




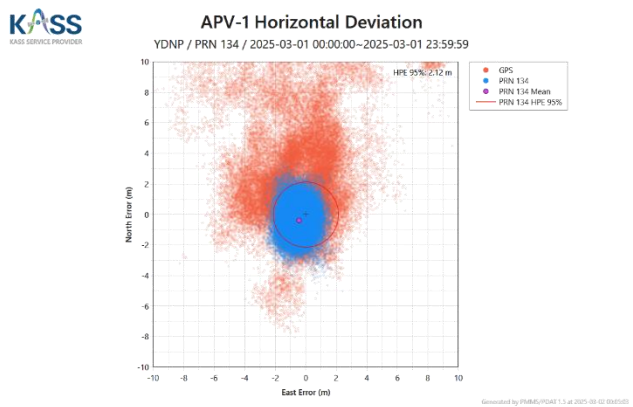
2. KASS Performance (3/4)

❖ **KASS Performance : Accuracy for 7 KRSs (1st March, 2025) using the first KASS GEO (PRN 134)**

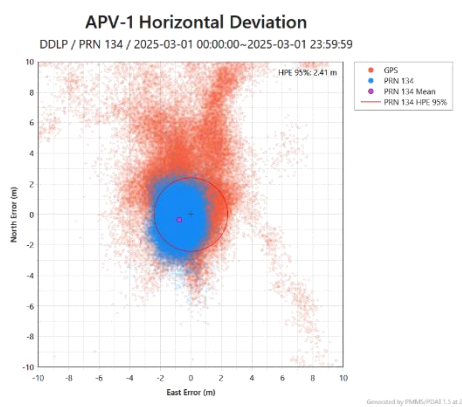
④ Jeju Tracking Station

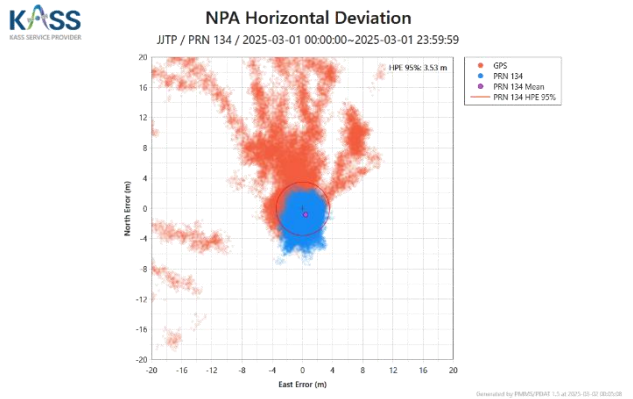


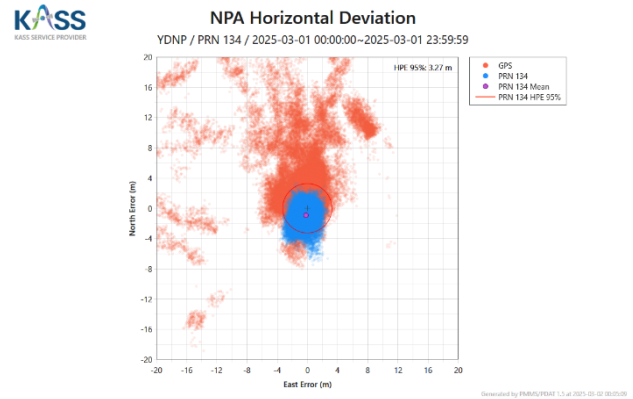
⑤ Yeongdo (NDGPS site)

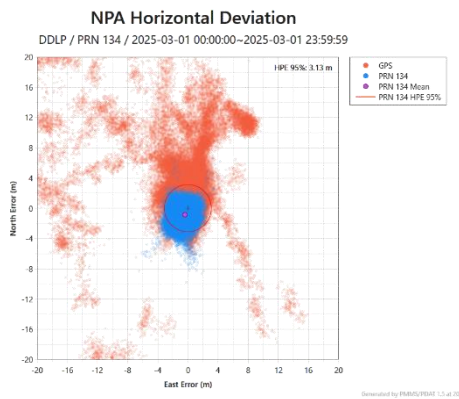


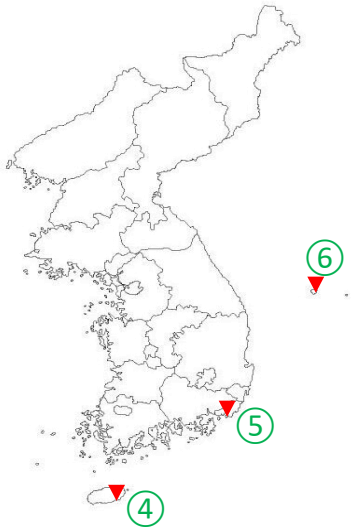
⑥ Dodong LH (Ulleung-island)







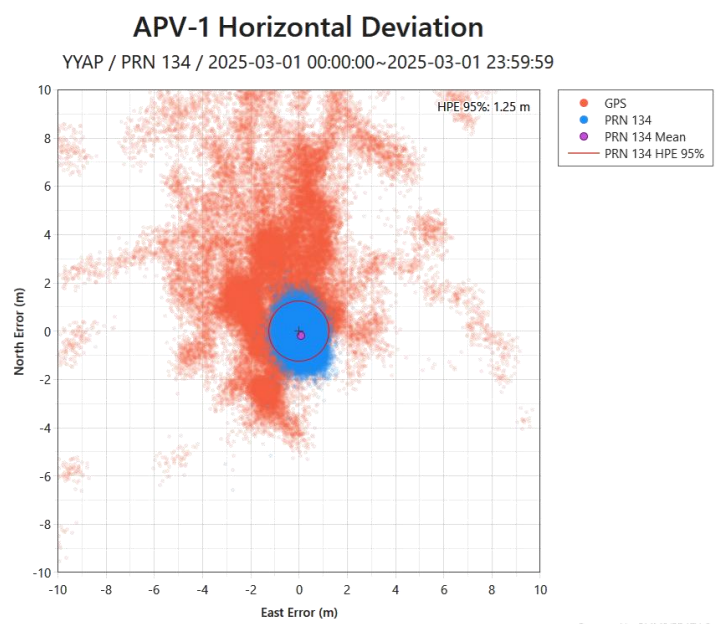


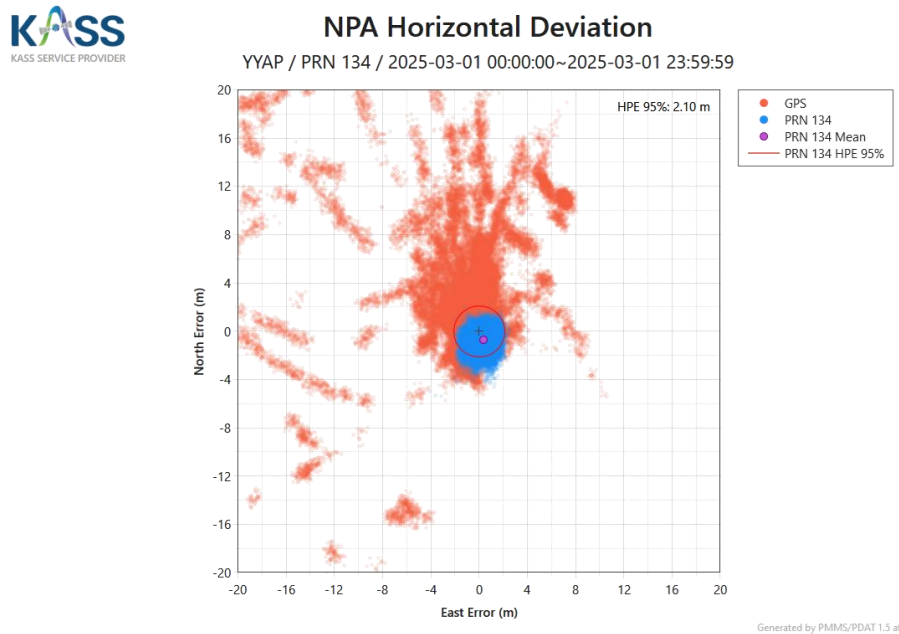


2. KASS Performance (4/4)

❖ **KASS Performance : Accuracy for 7 KRSs (1st March, 2025) using the first KASS GEO (PRN 134)**

⑦ Yangyang Airport





3

KASS Management and Operations

Tools for KASS operations, KASS Maintenance and Operations

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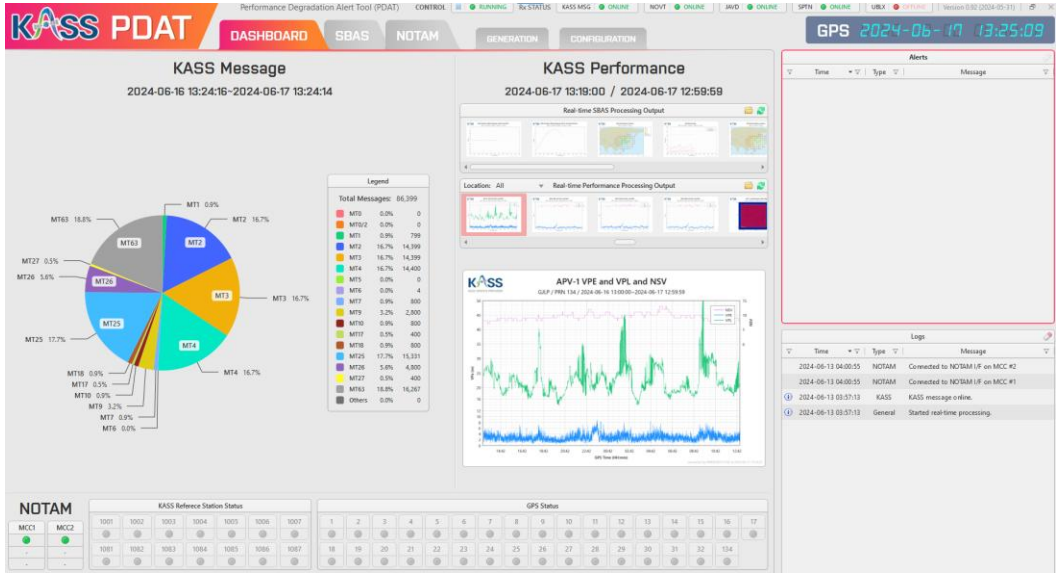
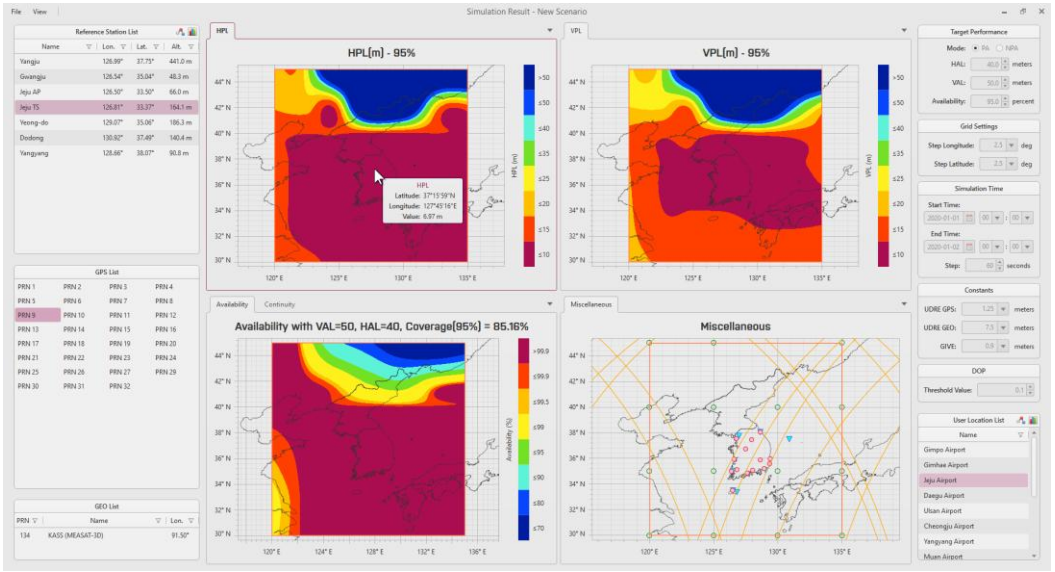
3. KASS Management and Operations (1/5)

❖ Development of tools for KASS operations

- (PDAT) Visualization of KASS Performance Degradation and KASS Message Type Analysis
- (KSVS) KASS Service Volume Simulator



[KASS Performance Degradation Alert Tool]

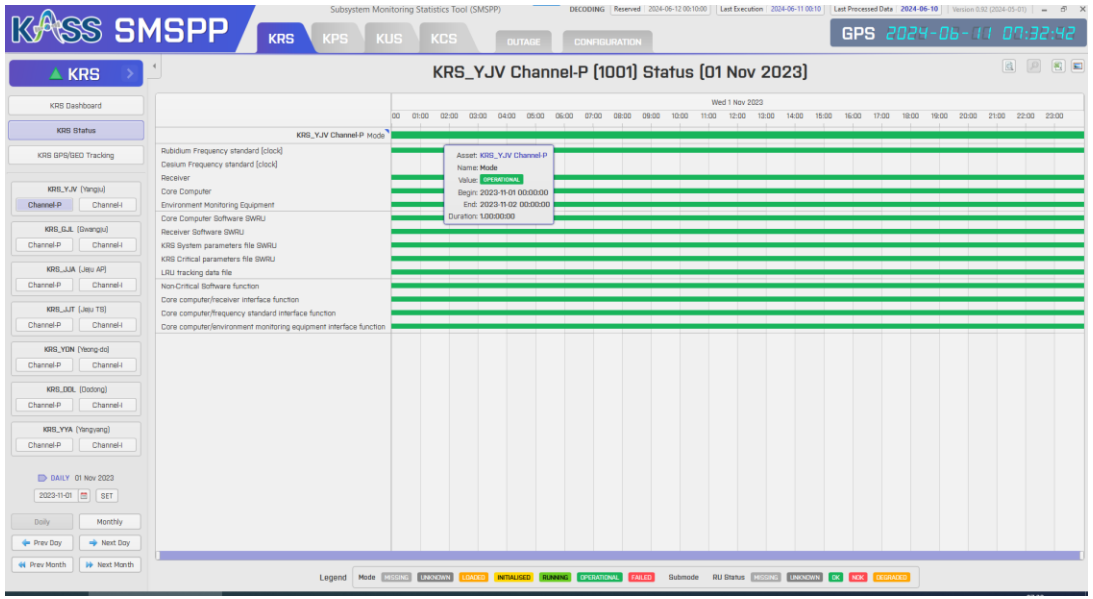


[KASS Service Coverage Simulator]

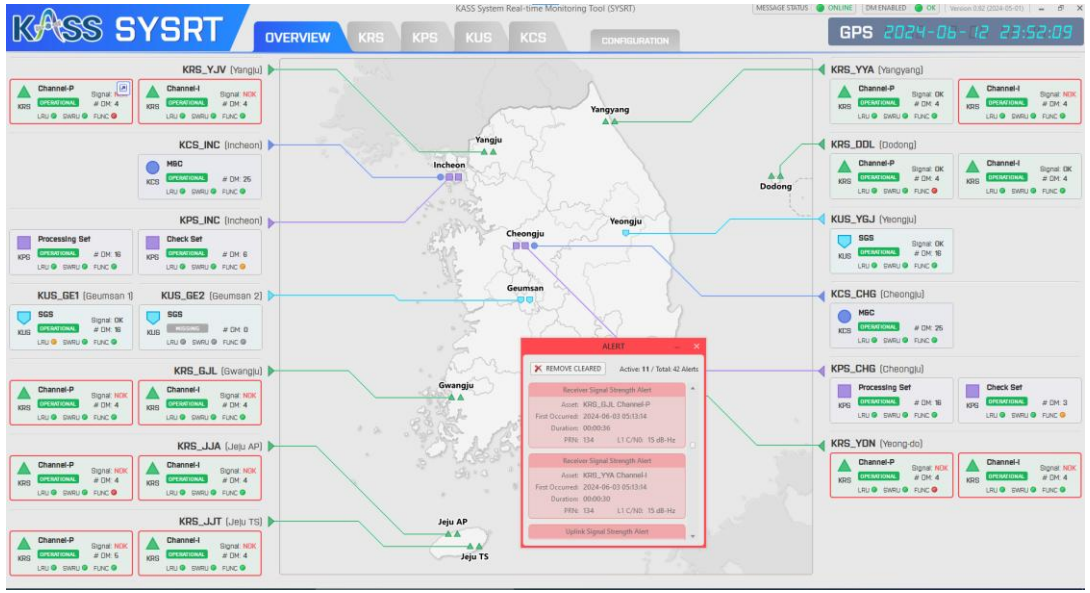
3. KASS Management and Operations (2/5)

❖ Development of tools for KASS operations

- (SMSPP) Check for the outage history of the KASS subsystem
  : Subsystem (Mode and LRU, SWRU status), GPS/GEO tracking, QoS and so on
- (SYSRT) Visualization of Subsystem and equipment status



[KASS System Monitoring Statistics Tool]



[KASS System Real-Time Monitoring Tool]

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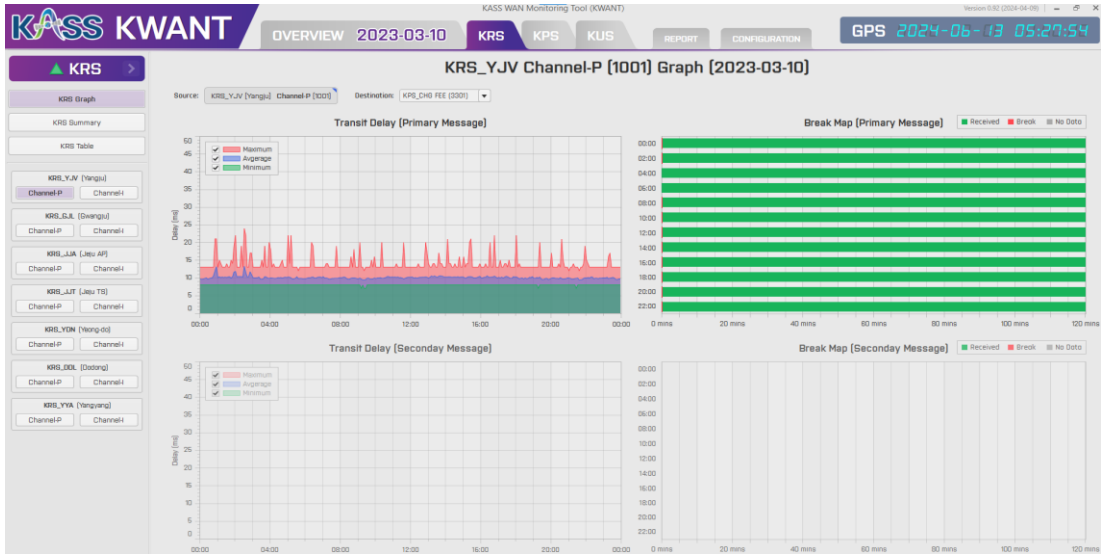
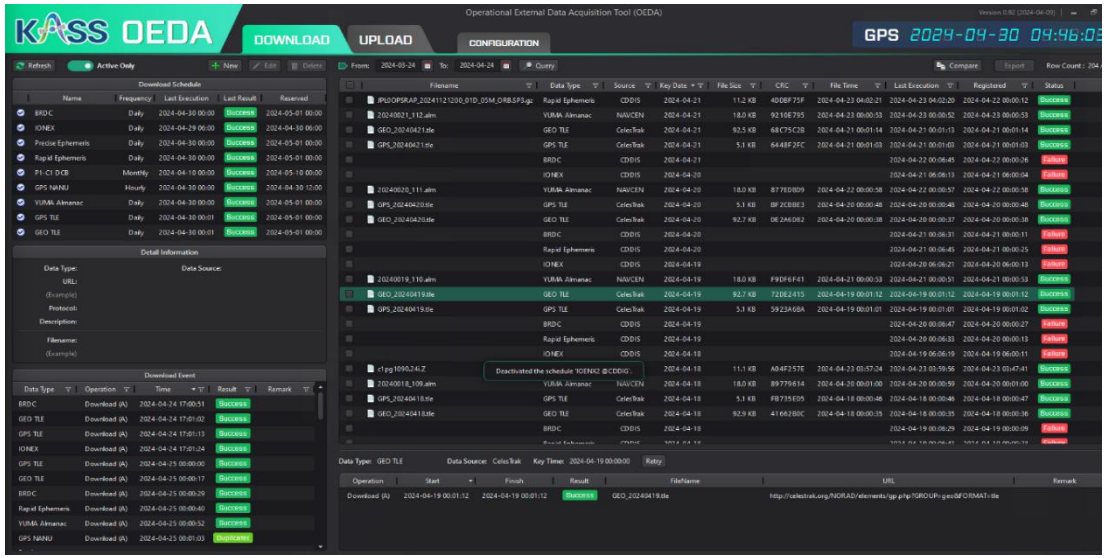
3. KASS Management and Operations (3/5)

❖ Development of tools for KASS operations

- (KWANT) Visualization of Network Performance and FEE(Front-End Equipment) status
- (OEDA) Display data items collected by OEDA and manage download schedule information,
  Display collection history and collection results



[KASS WAN Monitoring Tool]

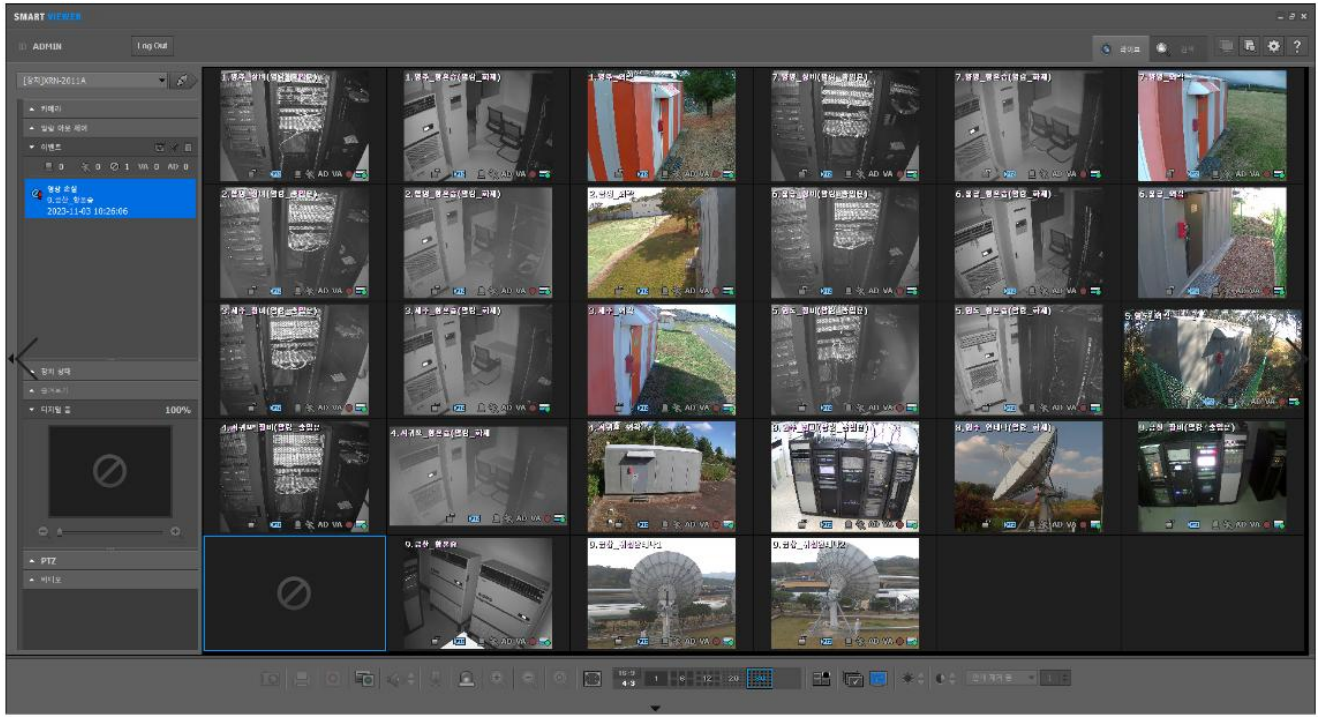


[KASS Operational External Data Acquisition Tool]

3. KASS Management and Operations (4/5)

❖ KASS Maintenance

- All KASS Infrastructure Alarm Monitoring
- Regular / Irregular maintenance



[Indoor/Outdoor Monitoring and Recording of KASS Infrastructure Facilities]

(Before)

(After)

[Subsystem Infrastructure Facilities Check-up and Maintenance Activities]

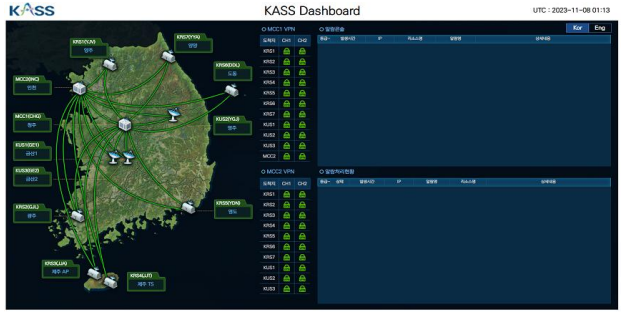
3. KASS Management and Operations (5/5)

❖ KASS Operations

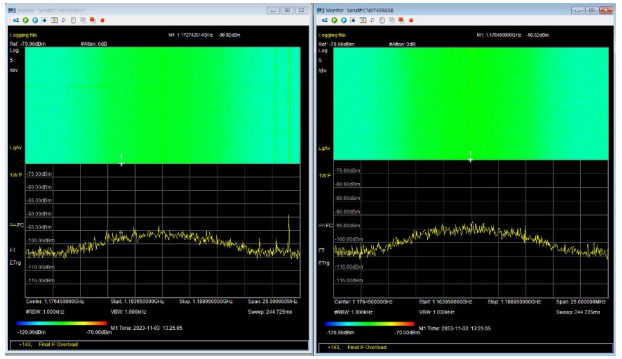
- All KASS Subsystem Monitoring and Control

  * GEO satellite Navigation Payload L/C band signal monitoring

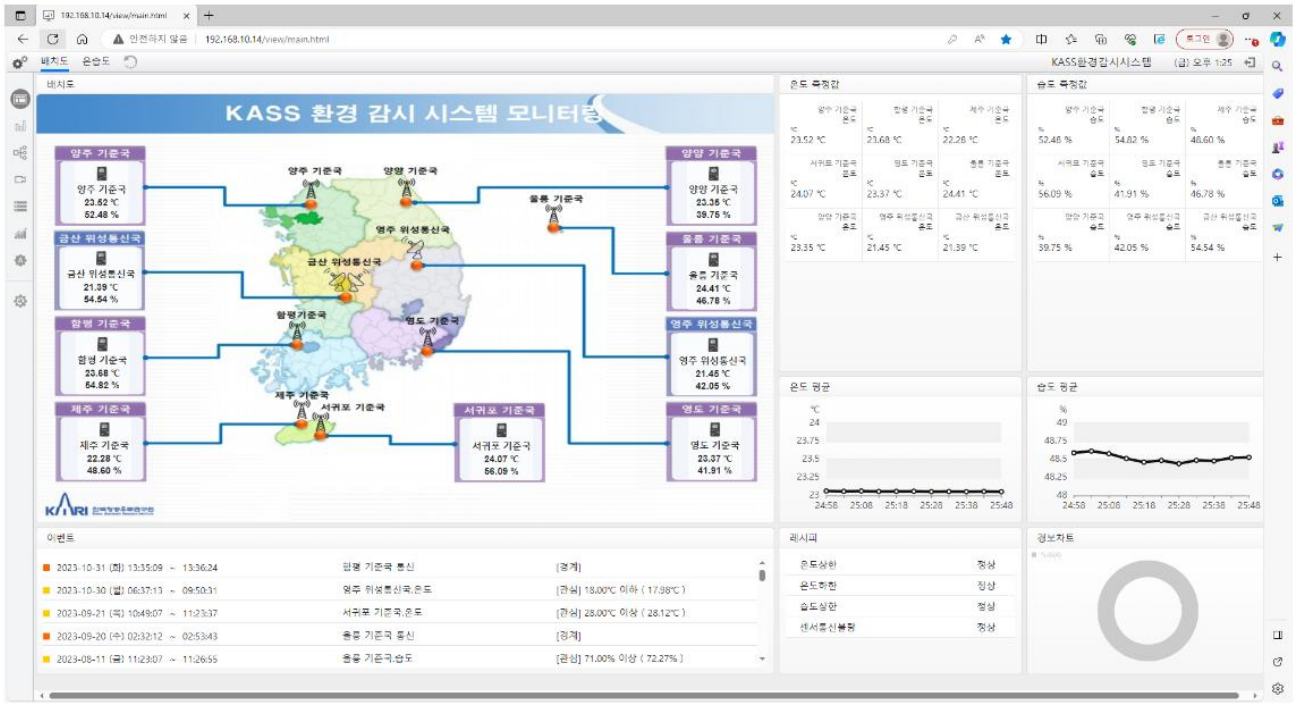
- EMI monitoring on KUS (KASS Uplink Station) site



[WAN Monitoring]



[EMI Monitoring]



[Environmental Monitoring for KRS, KUS]

[GEO Navigation Payload L/C-band signal level Monitoring]

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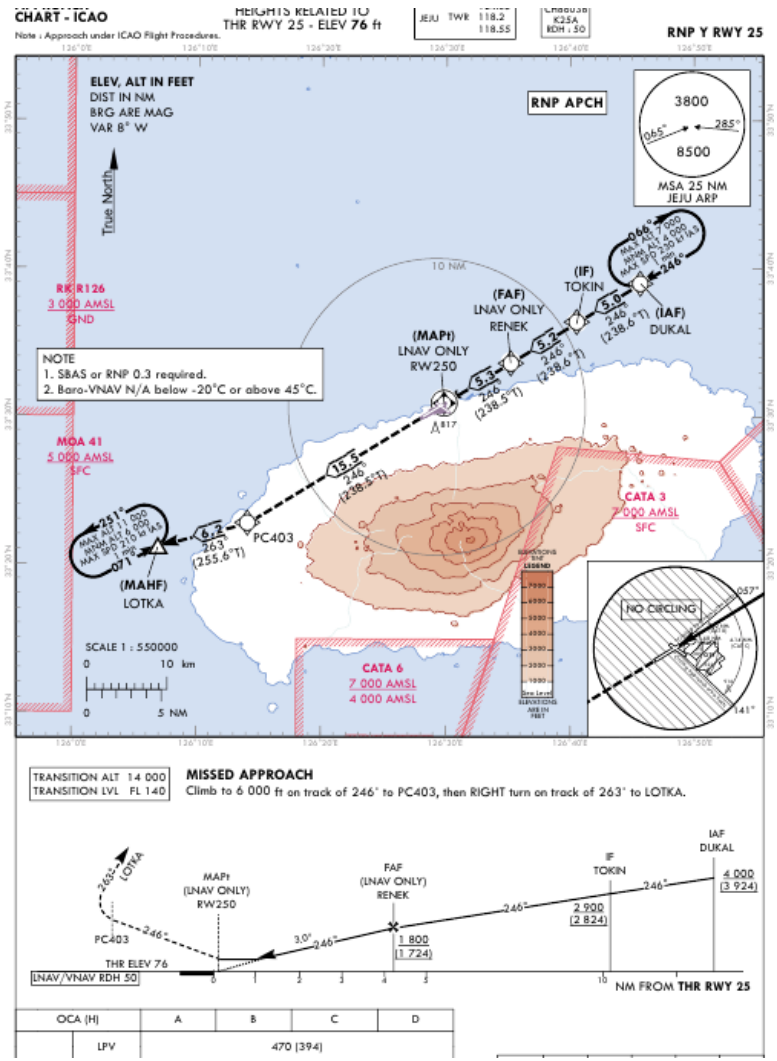
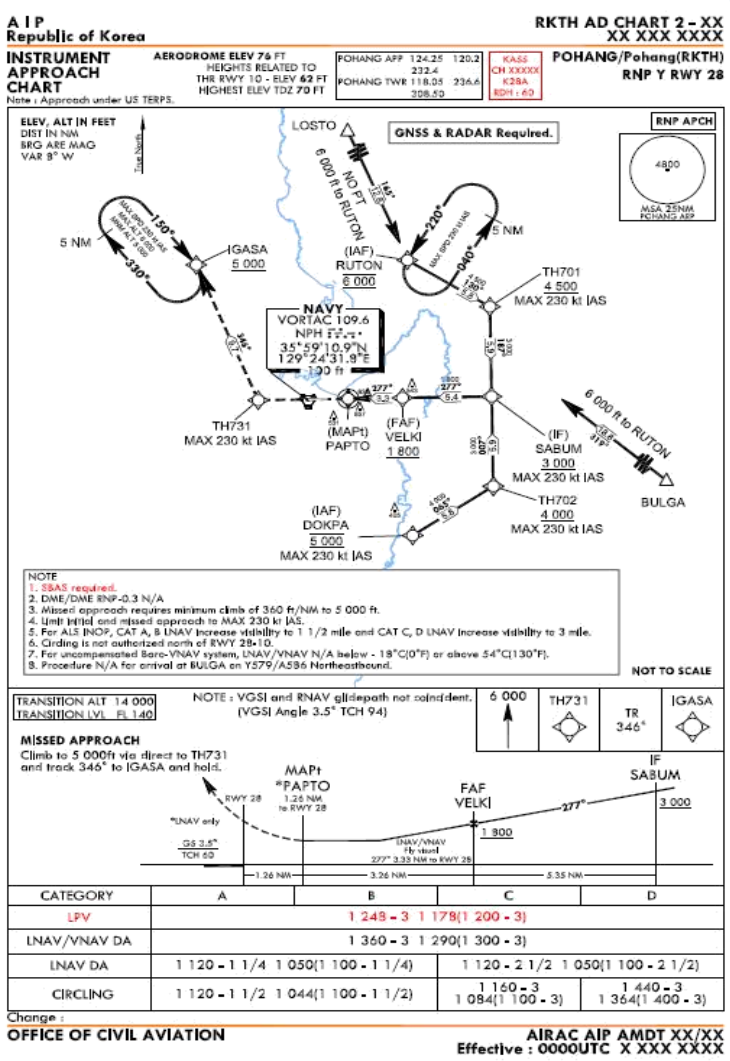
4

Status of SBAS (KASS) Flight Procedure

Status of SBAS APV-I flight procedures





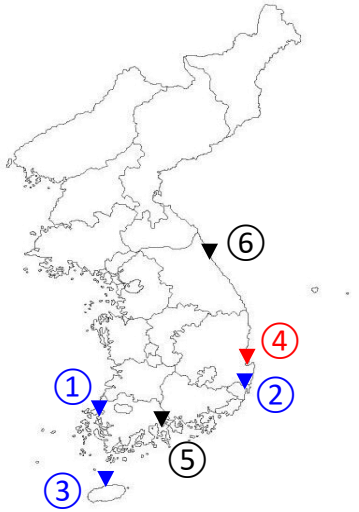
4. Status of SBAS (KASS) Flight Procedure (1/4)

❖ Priority for institution of SBAS APV-I flight procedures

- 2023yr : Established SBAS APCH procedures for Muan INTL airport and Ulsan airport first in terms of PBN maintenance
- 2024yr ~2025yr : Established SBAS APCH procedures for Jeju INTL airport in terms of PBN maintenance
- 2024yr ~2025yr : Pohang-Gyeongju airport SBAS APCH procedures in progress from a PBN maintenance perspective
- 2026yr : **Yeosu, Yangyang airport** SBAS APCH procedures will be established in terms of PBN maintenance

Statistics for 2022yr

No.	Airport	Annual Traffic Volume	Not available APV-I class procedures Traffic Volume*	Traffic volumes that improve over traditional RNP APCH (When applying SBAS APV-I)		Note (August 2025)
				LNAV improvement (Additional traffic volume capable of operating / improvement ratio)	LNAV/VNAV improvement (Additional traffic volume capable of operating / improvement ratio)	
1	Muan	3,445	18	**173 / 5.02**	**131 / 3.80**	Completed
2	Ulsan	3,604	74	17 / 0.47	20 / 0.55	Completed
3	Jeju	89,641	1,014	2,466 / 2.75	920 / 1.03	Completed
4	Pohang-Gyeongju	617	0	1 / 0.16	7 / 1.13	in progress
5	Yeosu	2,546	102	41 / 1.61	5 / 0.20	TBD
6	Yangyang	1,352	13	2 / 0.15	2 / 0.15	TBD



* Depending on weather conditions

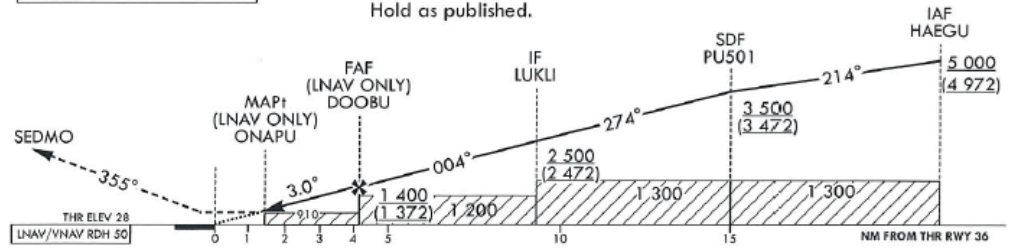
4. Status of SBAS (KASS) Flight Procedure (2/4)

❖ Ulsan Airport

- Establishment of SBAS procedure and Information of WX minima
- Information of remark and hold procedure for SDEMO
- Establishment of FAS data block Information

TRANSITION ALT 14 000
TRANSITION LVL FL 140

MISSED APPROACH
Climb to 4 000 ft on track of 355° to SEDMO.
Hold as published.



CATEGORY			DA(H)/MDA(H)	A	B	C	D
STA	LPV (CG 2.5%)	FULL	740 (712)	3 200 m			
		ALS INOP		3 900 m			
	LPV (CG 5.0%)	FULL	340 (312)	900 m			
		ALS INOP		1 600 m			
	LNAV/VNAV	FULL	810 (782)	3 600 m			
		ALS INOP		4 300 m			
	LNAV	FULL	910 (882)	3 300 m			
		ALS INOP		4 000 m			

Rate of descent	Knots	60	90	120	150	180
	V/V fpm	319	478	637	796	956

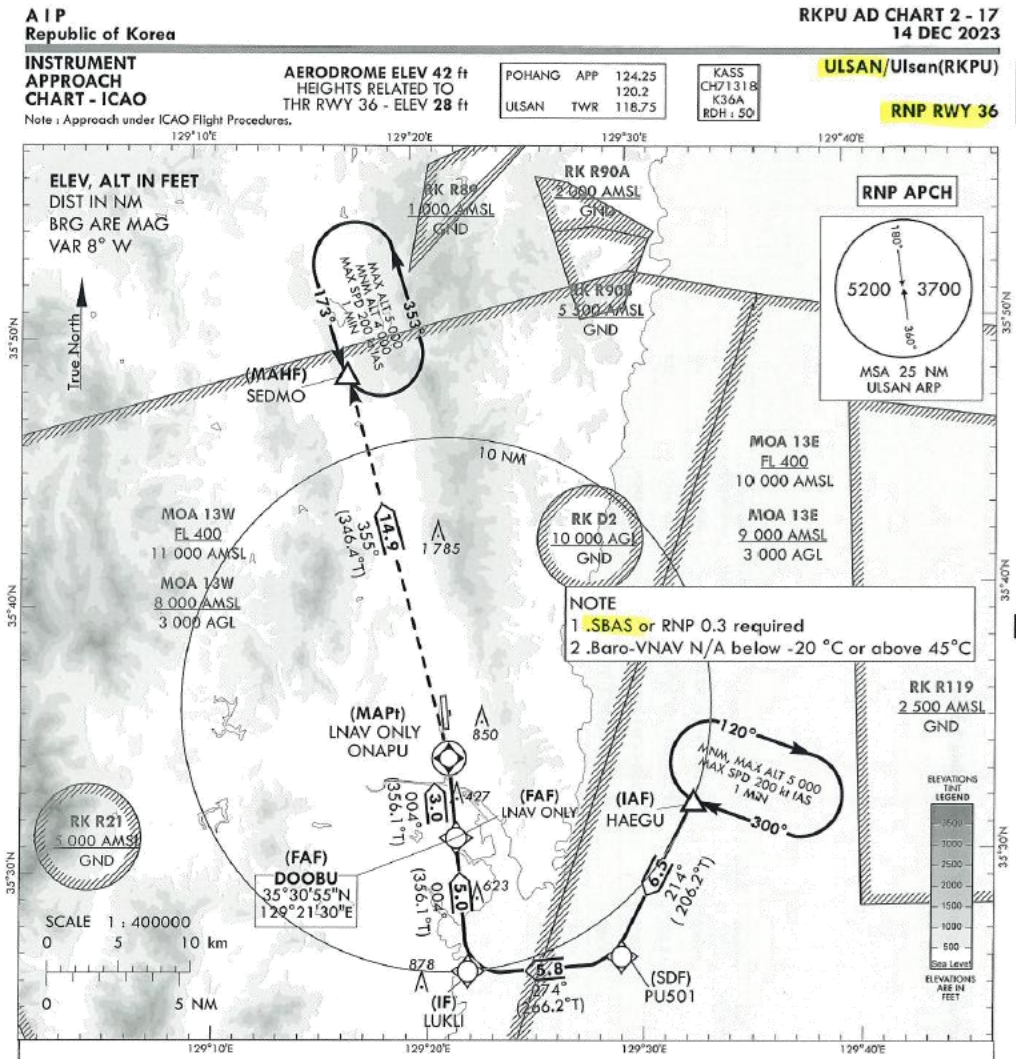
* Timing Not authorized for defining MAPt.
* Circling Not authorized.

Change : Establishment of SBAS procedure and Information of WX minima.

OFFICE OF CIVIL AVIATION

AIRAC AIP AMDT 13/23
Effective : 1600UTC 24 JAN 2024

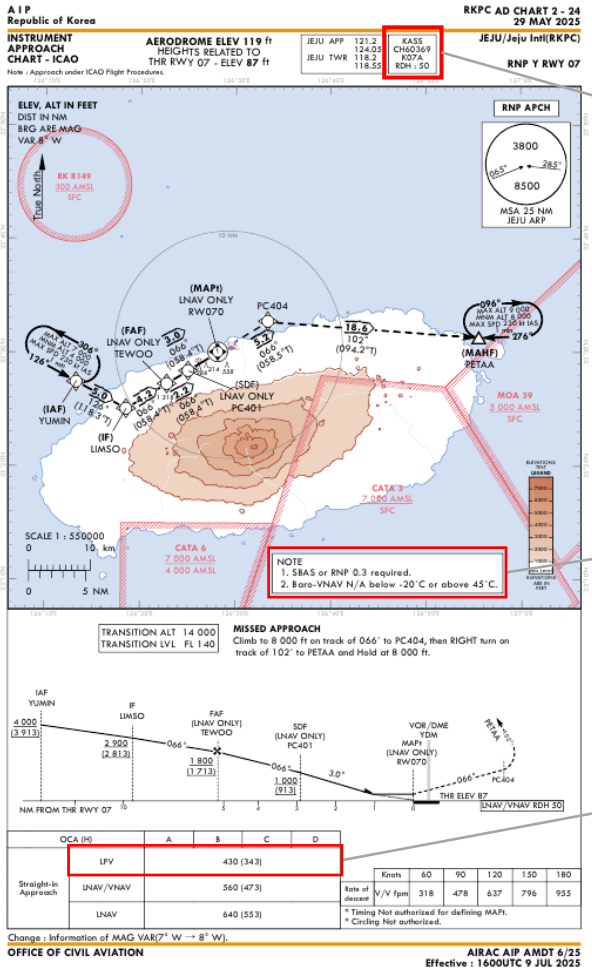
(Example Chart : RNP RWY 36@Ulsan Airport)



4. Status of SBAS (KASS) Flight Procedure (3/4)

❖ Jeju INTL Airport

- ESBAS APV-I class Approach Procedures



Add Channel Information

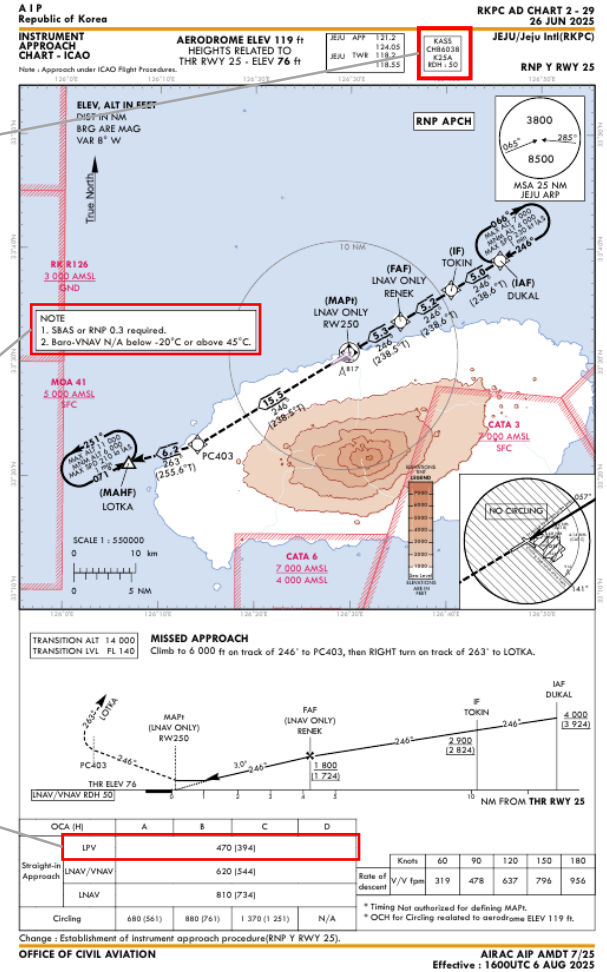
Note modification : SBAS required

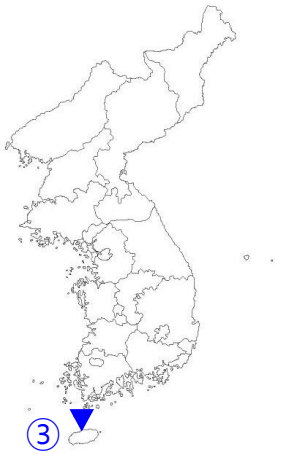
Added LPV minimum

Add APV-I approach procedures to existing RNP approach procedures chart

❖ Target Procedures : 2ea

- RNP RWY 07, 25





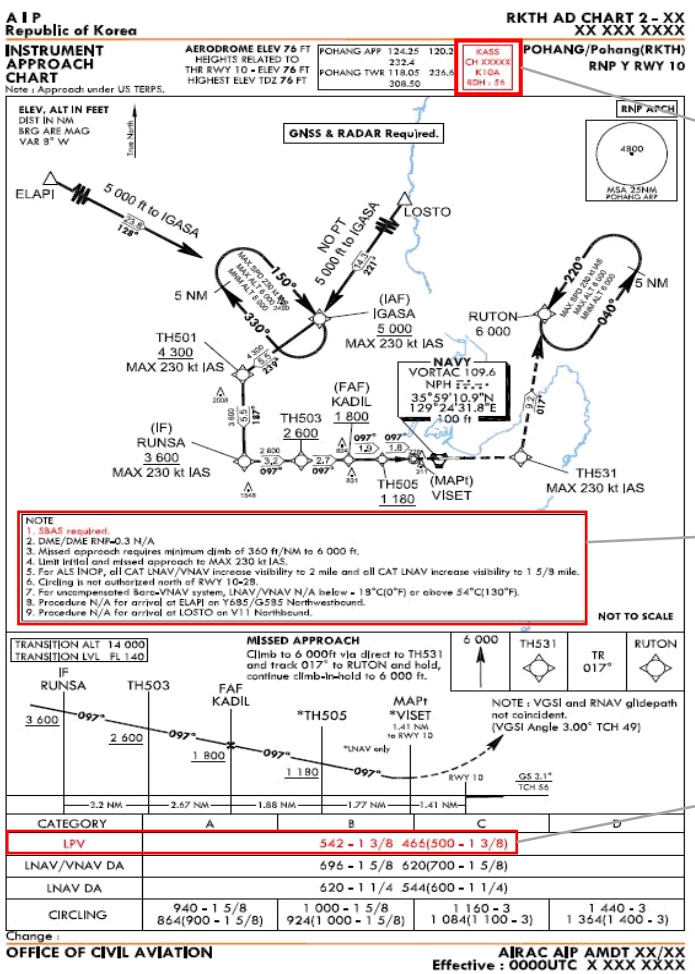
4. Status of SBAS (KASS) Flight Procedure (4/4)

❖ Pohang-Gyeongju Airport

- ESBAS APV-I class Approach Procedures

❖ Target Procedures : 2 (in progress)

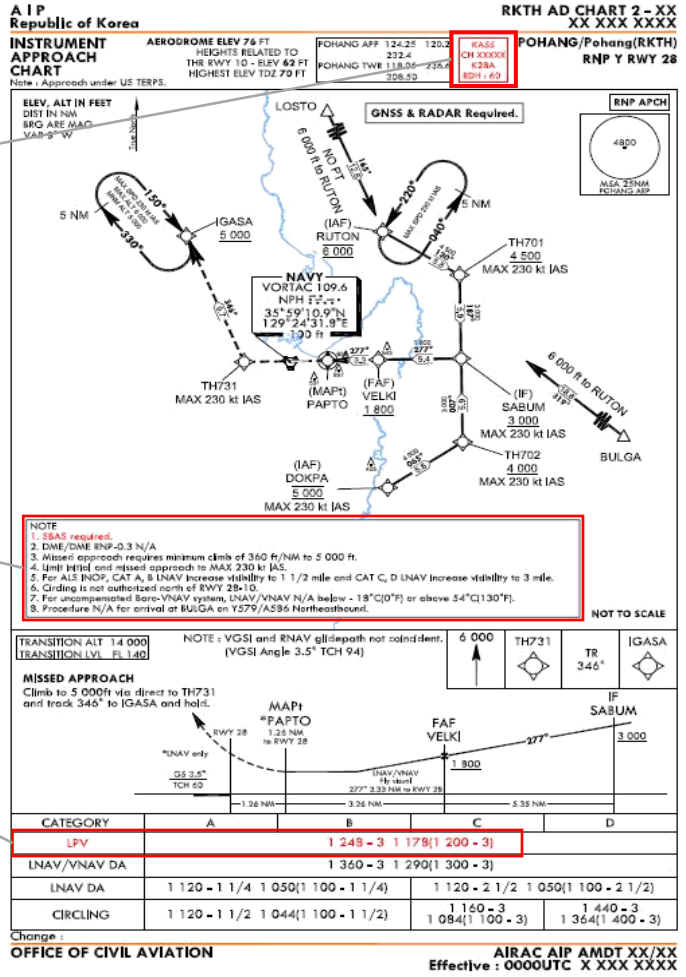
- RNP RWY 10, 28



Add Channel Information

Note modification : SBAS required

Added LPV minimum



5

Status of SBAS (KASS) equipage of national airlines

SBAS equipage rate and Readiness for SBAS service

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5. Status of SBAS equipage of national airlines (1/3)

❖ **Aircrafts equipped with SBAS receiver available in SLS (As of June 2025)**

No.	Airlines	Aircrafts	Aircraft Equipage		SBAS Equipage Rate (SLS available)
		Qty in possession	Satellite Navigation (SBAS)		
			SBAS receiver		
			# of SLS available aircraft		
1	**Koreanair**	155	32		21%
2	**Asiana**	80	0		0%
3	**JInair**	31	0		0%
4	**Jejuair**	43	5		12%
5	**Twayair**	42	1		2%
6	**Airbusan**	20	2		10%
7	**Airseoul**	6	0		0%
8	**Air-incheon**	5	0		0%
9	**Eastarjet**	15	5		33%
10	**Airpremia**	8	0		0%
11	**Aerok**	7	0		0%
	Total	**412**	**43**		**10.5**%

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5. Status of SBAS equipage of national airlines (2/3)

❖ **Readiness for SBAS service in Avionics (As of June 2025)**

No.	Airlines	Aircraft type	Receiver Model	Number of receivers (SBAS equipage)	Number of receivers (SLS available)
1	**Koreanair**	B777-300ER	Rockwell Collins GLU-2100	2	2
		B737NG-800	Honeywell iMMR	2	2
		B737-700	Honeywell RMA-55B	1	1
		B737-8	Rockwell Collins GLU-2100	5	5
		A350	Rockwell Collins GLU-2100	2	2
		A321	Rockwell Collins GLU-2100	10	10
		A220	Rockwell Collins GPS-4000S	10	10
2	**Asiana**	B777-200ER	Honeywell iMMR	9	0
		A321-251NX	Rockwell Collins GLU-2100	13	0
		A350-900	Rockwell Collins GLU-925	13	0
		A350-900	Rockwell Collins GLU-2100	2	0
3	**Jinair**	B737-800/900 (NG)	Honeywell iMMR	16	0
		B737-8 (MAX)	Rockwell Collins GLU-2100	5	0
		B777-200	Rockwell Collins GLU-925	4	0

5. Status of SBAS equipage of national airlines (3/3)

❖ **Readiness for SBAS service in Avionics (As of June 2025)**

No.	Airlines	Aircraft type	Receiver Model	Number of receivers (SBAS equipage)	Number of receivers (SLS available)
4	**Jejuair**	B737-8	Honeywell iMMR	5	5
5	**Twayair**	B737-800	Honeywell iMMR	7	0
		B737-8	Honeywell iMMR	4	0
		A330-300	Honeywell iMMR	1	1
6	**Airbusan**	A321-251	Honeywell iMMR	2	0
9	**Eastarjet**	B737-800	iMMR	1	1
		B737-8	iMMR	1	1
		B737-8	GLU-2100	3	3
11	**Aerok**	A320-200	Honeywell iMMR	2	0
	Total	-	-	**120 (29%)**	**43 (10.5%)**

6

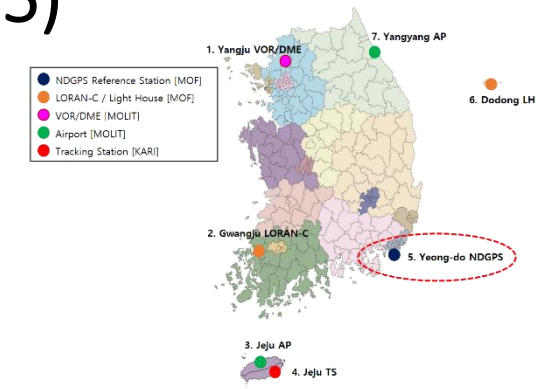
Challenge and Solutions of KASS

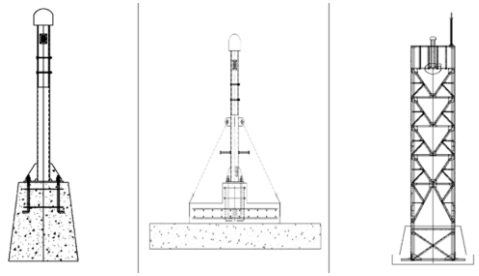
Challenges and Solutions for Successful KASS

6. Challenge and Solutions of KASS (1/5)

❖ Poor RF environment (CH, EMI)

- Mask Elevation requirement : 5°
- Real value of Masking Percentage (5° ~ 20°) : 6.29%
- Real value of Masking Percentage (20 ° ~ 90°) : 0.01%

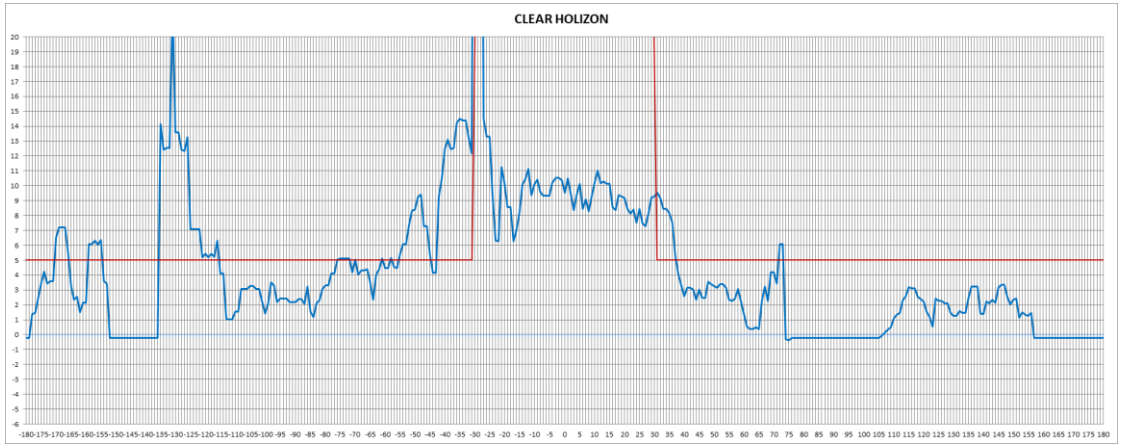




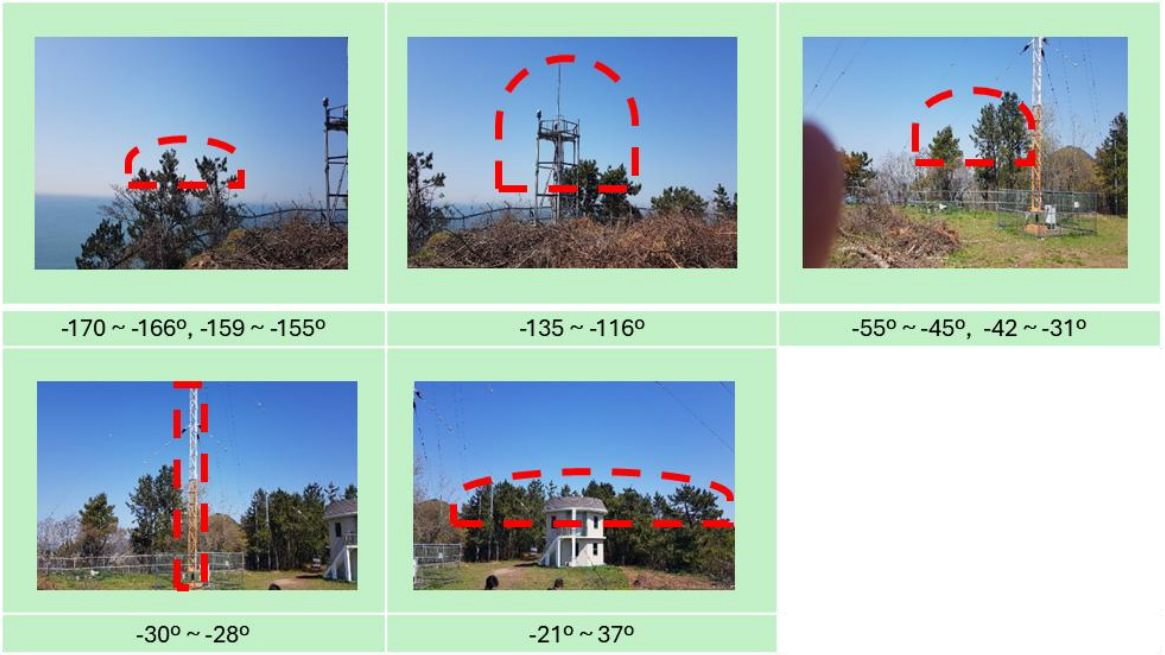
[Antenna Shape : Steel Tower, Steel Pipe]

Panoramic picture :

CH (Clear Horizon) :



Obstacle : ≥ 5°



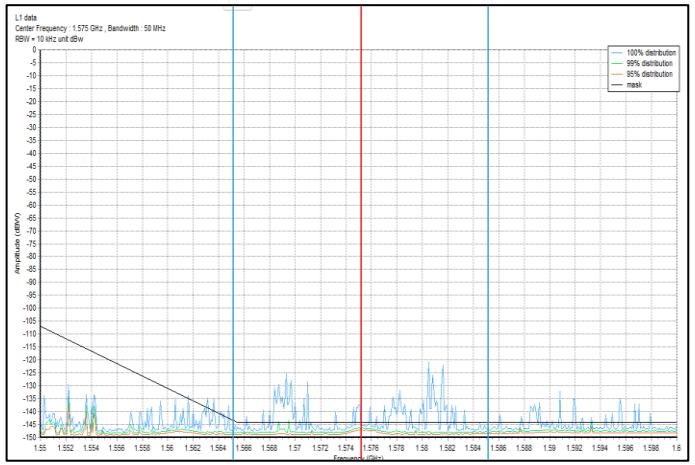
6. Challenge and Solutions of KASS (2/5)

❖ Poor RF environment (CH, EMI)

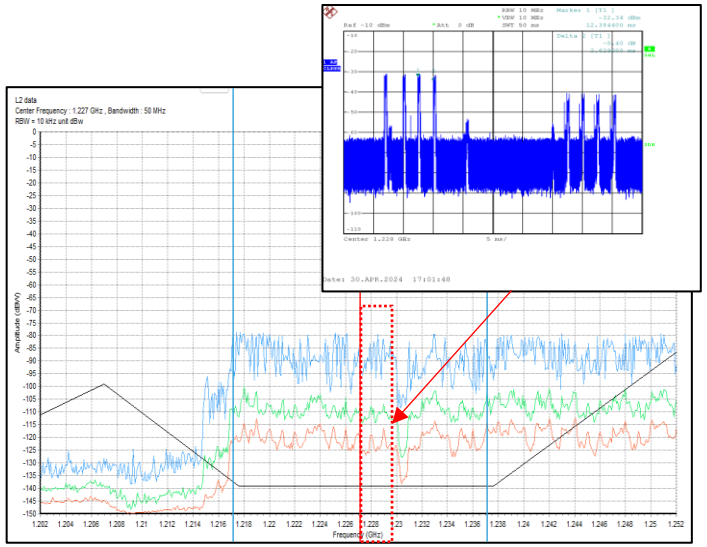
- RFI analysis for GNSS bands during GNSS reference station site construction and regular analysis
- Irregular monitoring of radio interference in the GPS L-band
- If the signal threshold is exceeded, further analyze the pulse width of the interference signal to determine

❖ Interference in the L5 band requires FCA with the cooperation of the military

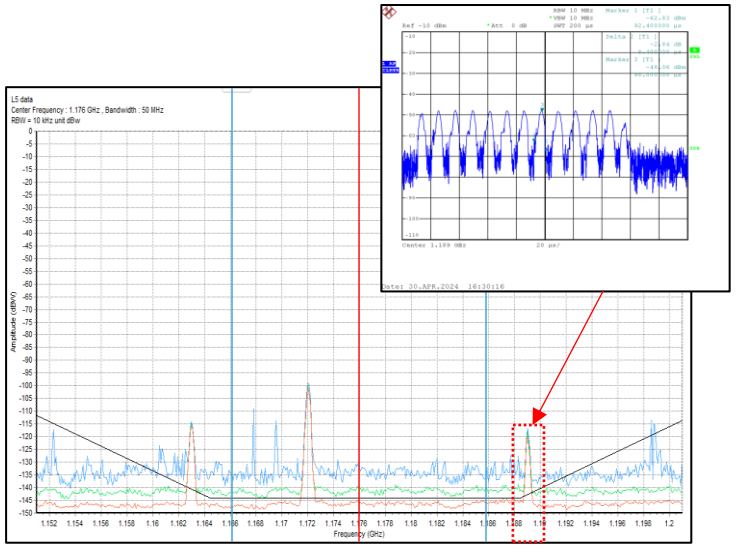
*FCA : Frequency Clearance Agreement



GPS L1 (In/Near band)
(@Incheon site)



GPS L2 (Pulse - Specific frequency)
(@Incheon site)



GPS L5 (In/Near band)
(@Incheon site)

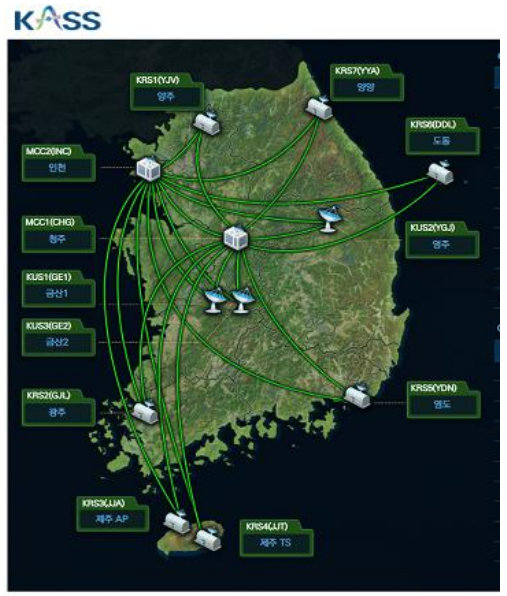
6. Challenge and Solutions of KASS (3/5)

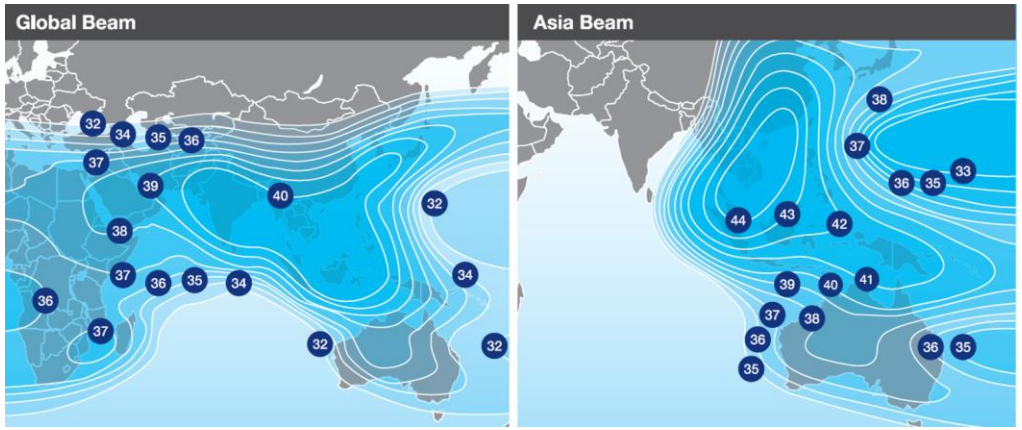
❖ Demanding Requirements of WAN (Wide Area Network)

- Availability requirement : 99.8%
- Continuity requirement : No more than 1 Packet Loss per about 174 days
- Implementing a system to monitor End to End communication line performance
- Redundancy-route service between MCC and each subsystem

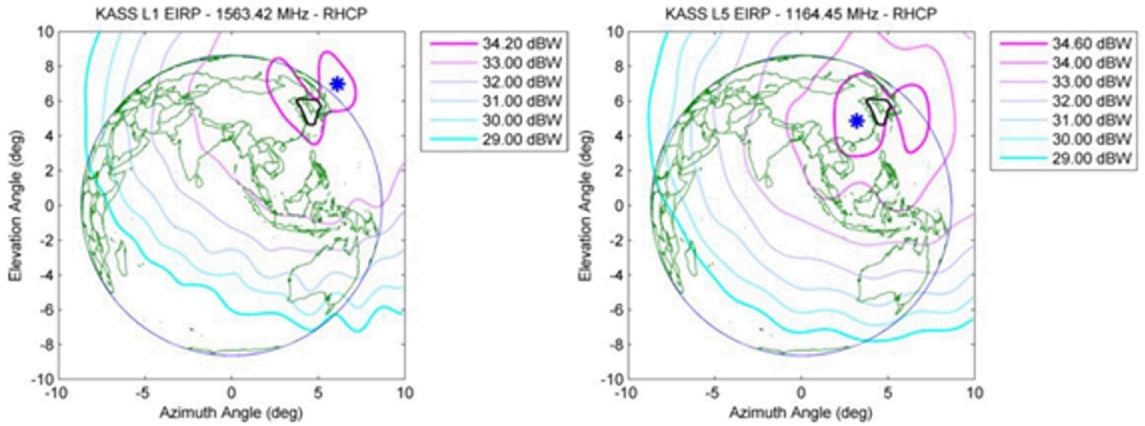
❖ GEO satellites (Orbit, Frequency)

- Orbit : Requires satellites located above the top of the head if possible
- RFI : Uplink Band



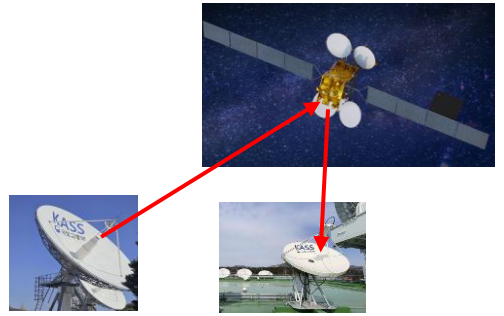


[KASS 1st GEO Uplink C-Band Footprint and EIRP (dBW)]



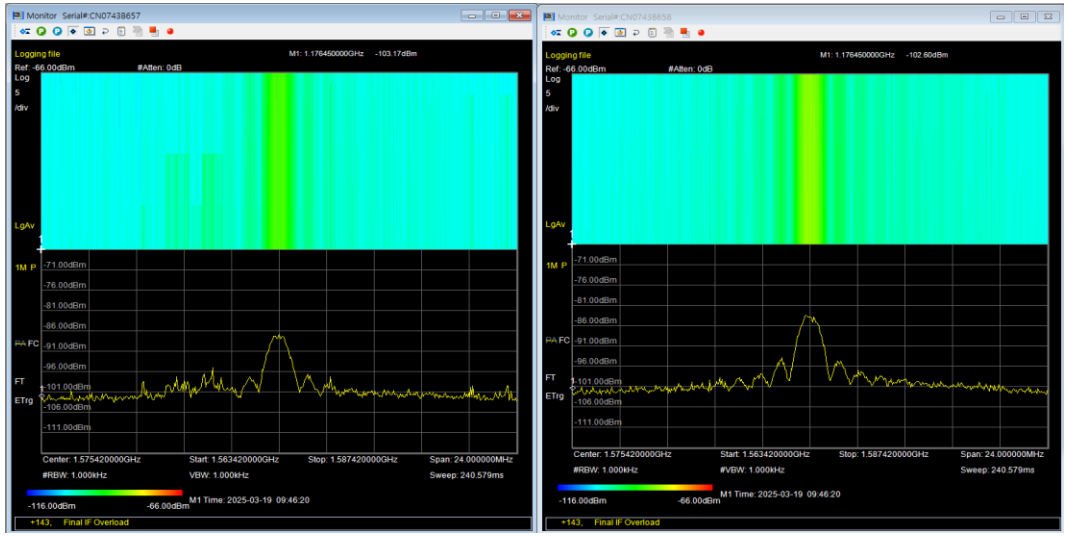
[KASS 1st GEO Downlink L-Band Footprint and EIRP (dBW)]

6. Challenge and Solutions of KASS (4/5)

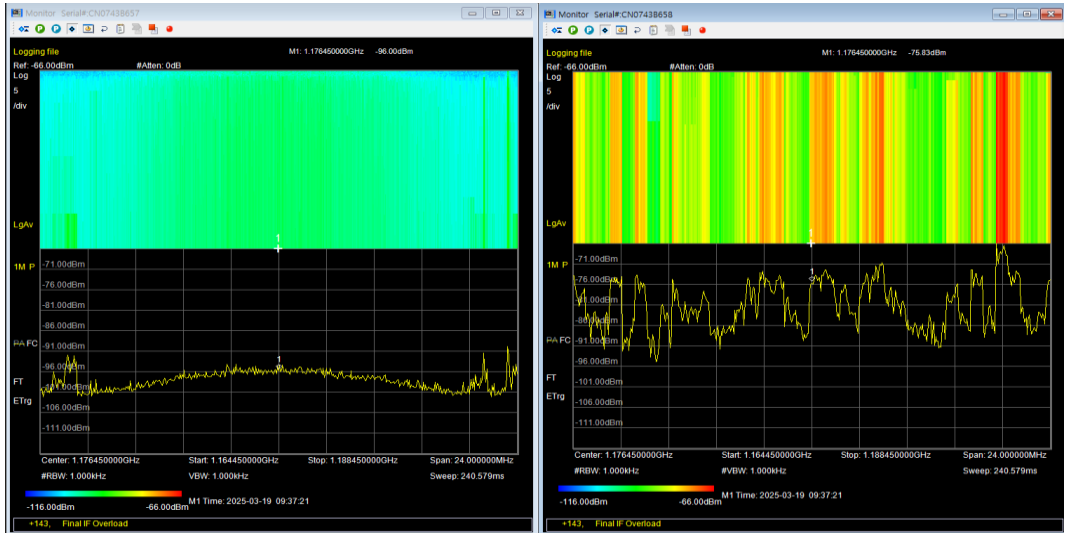


❖ Jamming

- In the band surrounding the GEO L5 center frequency(1176.45 MHz) has a lot of interference signals by time and region
- In particular, it is affecting KUS (KASS Uplink Station) Steering chain, which transmits data to KASS GEO satellites
- Due to an increase in the signal noise ratio of the GEO L5 signal, the steering chain is cut off and switched to a backup SGS (Signal Generation Section of KUS)



Geumsan(left) Yeongju(right) GEO L1 spectrum
(Center Freq.:1575.42 MHz, Span: 24MHz, MAXHOLD)



Geumsan(left) and Yeongju(right) GEO L5 spectrum
(Center Freq.:1176.45 MHz, Span: 24MHz, MAXHOLD)

6. Challenge and Solutions of KASS (5/5)

❖ WAAS GIII Receiver EOL

- End of Life : WAAS GIII Receiver
- Search for WAAS GIII receiver Replacements (e.g. G4)

Hexagon | NovAtel Announces EOL for WAAS-GIII Reference Receiver

NovAtel Inc. is announcing the End of Life for the WAAS G-III Reference Receiver and its variants.

Affected part numbers are:

REF-RCVR-G-III-xxxx

These products will be available for order until:

March 29, 2024 or until inventory is depleted

Shipments may be scheduled for no later than:

December 6, 2024

NovAtel will continue to support and repair these products until:

October 1, 2030 or until parts are no longer available

Please contact your NovAtel Sales representative with any questions.

For a complete listing of NovAtel products at end of life, including the expiration of support and repair for those products, please refer to the discontinued products list on the NovAtel website.

WAAS G4 Early Concept

❖ L2P(Y) termination

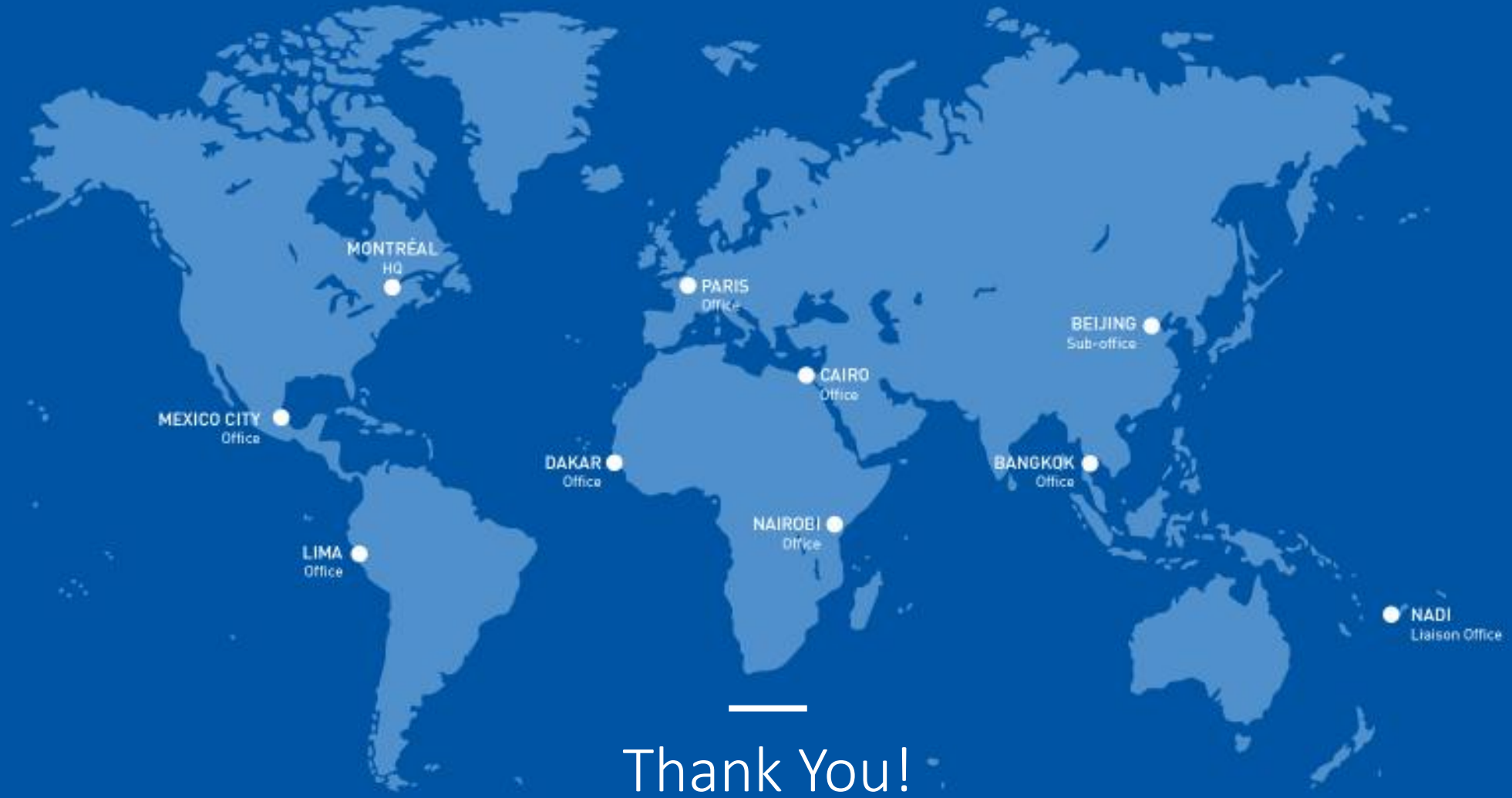
- Dual Frequency (L1, L5) usage : Next gen KASS Preparation
- Algorithms Modification
  : KRS (KASS Reference Station), KPS (KASS Processing Station)

3.2.8 Discontinuation of Codeless and Semi-Codeless GPS Access[11]

The USG commits to maintaining the existing GPS L1 C/A, L1 P(Y), L2C, and L2 P(Y) signal characteristics that enable codeless and semi-codeless GPS access until at least two years after there are 24 operational satellites meeting the following criteria: (1) Broadcasting L5 with Healthy setting as defined in the 2020 SPS PS, (2) assigned PRNs in the range 1 through 32, and (3) located in a primary orbital plane slot as defined the 2020 SPS PS. Barring a national security requirement, the USG does not intend to change these signal characteristics before then. The availability of 24 satellites broadcasting the L5 signal is estimated to occur in 2029. Maintaining the legacy signal characteristics for the stated period-of-time will allow for the orderly and systematic transition of users of semi-codeless and codeless receiving equipment to the use of equipment using modernized civil-coded signals. It is expected that 24 operational satellites broadcasting L2C will be available by 2021, with the corresponding ground segment control capability available by 2023, enabling transition to L2C by 2023. Civilian users of GPS are encouraged to start their planning for transition now.

[11] This paragraph supersedes the previously announced commitment (73 Fed. Reg. 54792) to maintain such signal characteristics through December 31, 2020.

[source]
https://www.navcen.uscg.gov/sites/default/files/pdf/2021_Federal_Rdionavigation_Plan.pdf



Thank You!

ICAO