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GNSS RFI in Republic of Korea

Challenges and associated Regulations

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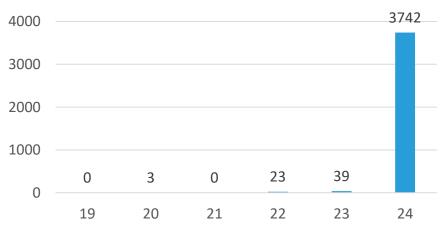


GNSS RFI

Intentional GNSS RFI in RoK

- ❖ The frequency of GPS RFI is increasing in some regions, and related reports are on the rise.
- ❖ It affects aircraft as well as GNSS navigation equipment on sea and land.
- ❖ Airports located in the metropolitan area have issued related NOTAMs to warn against the use of GNSS.

Last 5 Years GNSS RFI



'19	'20	'21	'22	'23	'24
0	3	0	23	39	3,742

GNSS RFI evolution
(from MOLIT)

Report GPS Interference (from MOLIT)

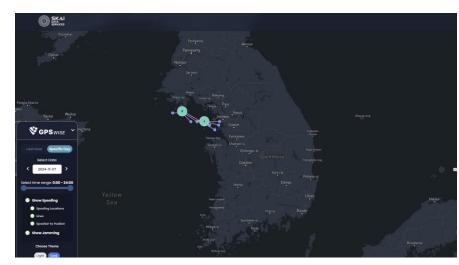


GNSS RFI

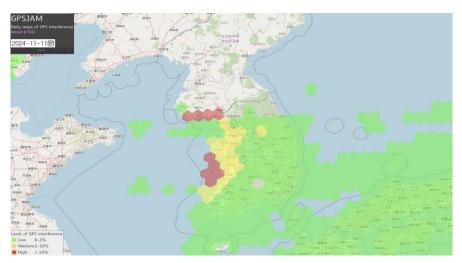
Impact of jamming and spoofing in Korea

GPS Jamming and GPS Spoofing Around the Korean Peninsula

- ❖ Jamming and spoofing occur frequently around the Military Demarcation Area on the Korean Peninsula.
- ❖ As an example: 2024.11.1.~11.10. A total of 331 GPS anomaly reports received, including 279 aircraft and 52 ships



Live GPS Spoofing and Jamming Tracker Map
(from SKAI)



Daily maps of GPS interference (from GPSJAM, 11-11-2024)

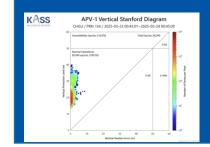


GNSS RFI

Domestic Regulations Concerning GNSS RFI

- ❖ ICAO Annex 10 Volume I : Radio Navigation Aids (domestic regulations)
- laws relating to the definition and management of radio waves
 - ❖ RADIO WAVES ACT, ENFORCEMENT DECREE OF THE RADIO WAVES ACT
- laws relating to aviation safety
 - **❖ AVIATION SAFETY ACT, ENFORCEMENT DECREE OF THE AVIATION SAFETY ACT**
- laws relating to airport facilities
 - ❖ AIRPORT FACILITIES ACT, ENFORCEMENT DECREE OF THE AVIATION SAFETY ACT
- For KASS
 - ❖ Regulations for Operation and Management of KASS









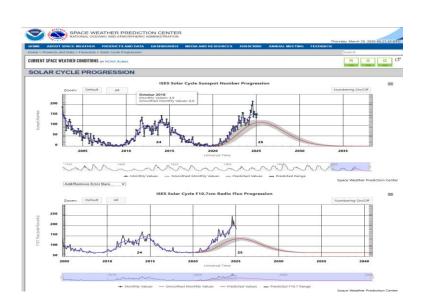
[Pictures captured by NASA's Solar Activity

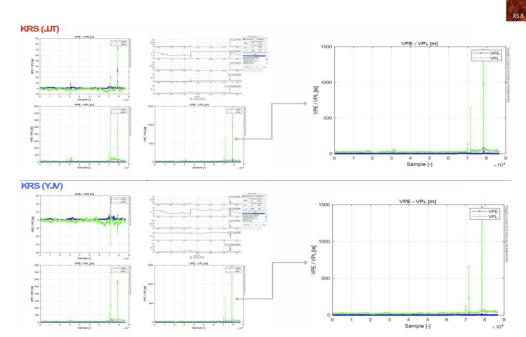
Observatory on May 10th (left) and 11th (right), 2024]

GNSS Performance degradation

Natural GNSS radio frequency interference

- Solar activity affects the activity of the Earth's ionosphere, which in turn affects GNSS performance.
- The sun's solar activity is expected to peak between late 2024 and early 2026, marking the beginning of the 25th sola cycle's maximum.







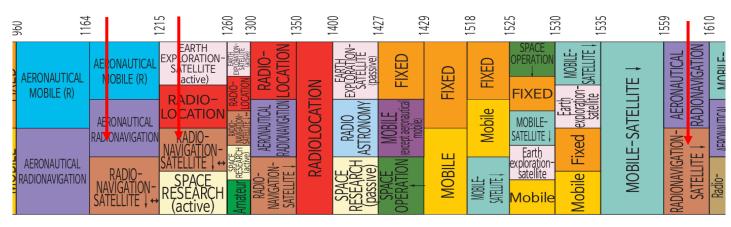
Solar cycle progression (from Space Weather Prediction Center)

GNSS Performance of KASS (on May 10^{th~}11th)

GNSS Performance degradation

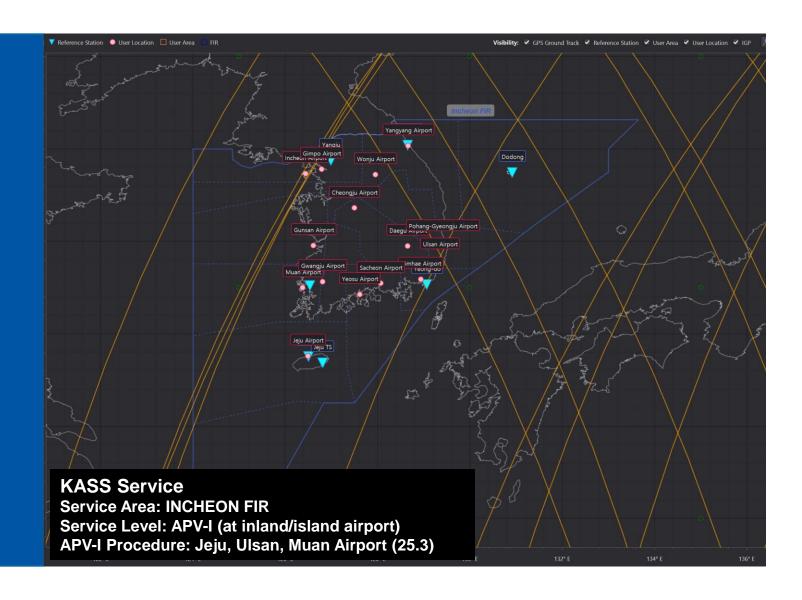
Frequency interference between different equipment

- ❖ GPS L-Band center frequency(L1: 1575.42 MHz, L2: 1227.60MHz L5: 1176.45MHz) has a lot of interference signals by time and region.
 - ❖ AERONUTICAL MOBLIE: (DME[960-1215MHz], TACAN[962-1213MHz])
 - RADIO-LOCATION: (ASSR: Air Route Surveillance Radar [1.25-1.26, 1.34-1.35, 1.35-2.79GHz)
 - Military Applications (Link-16[960-1,215MHz])
 - Unknown frequency
- Equipment with overlapping bands may affect GNSS reception.





03
GNSS RFI
monitoring





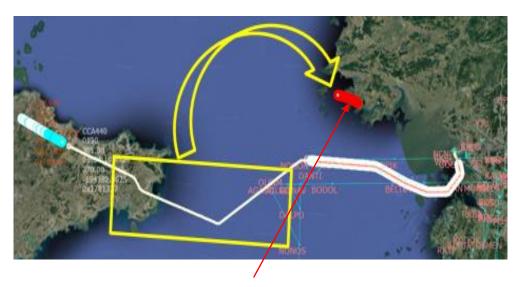
GNSS signal monitoring (from Seoul APP)

Signal analysis results for ARTS(ASR and ADS-B)

- ❖ RFI analysis for ADS-B signal
- ❖ Irregular monitoring of radio interference in the ADS-B(estimating spoofing)
 - ADS-B NIC is 1 to 8



GNSS Jamming (Left ADS-B only / Right MRT)



Estimating Spoofing (White MRT / Red Spoofing)

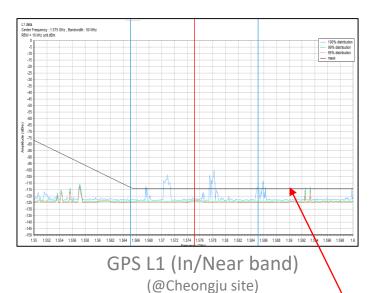


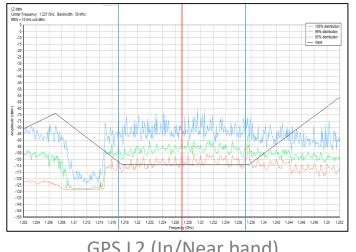
GNSS signal monitoring (from L-Band)

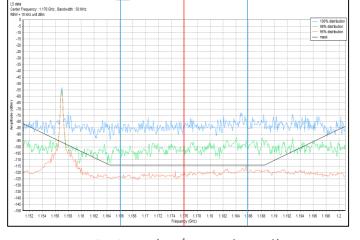
Signal analysis results for GPS L-band (Spectrum analysis) #1



- * RFI analysis for GNSS bands during GNSS reference station site construction and regular analysis
- ❖ Irregular monitoring of radio interference in the GPS L-band







GPS L2 (In/Near band)
(@Cheongju site)

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

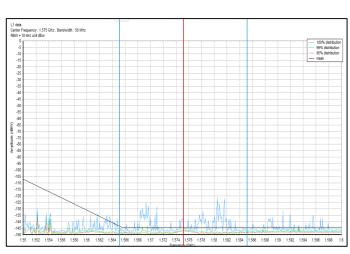


GNSS signal monitoring (from L-Band)

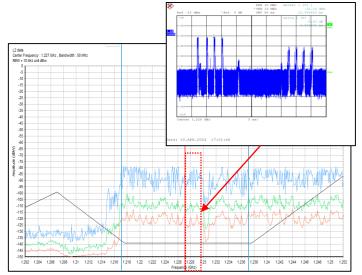
Signal analysis results for GPS L-band (Spectrum analysis) #2



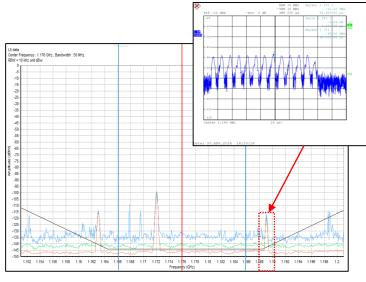
❖ If the signal threshold is exceeded, further analyze the pulse width of the interference signal to determine



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



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



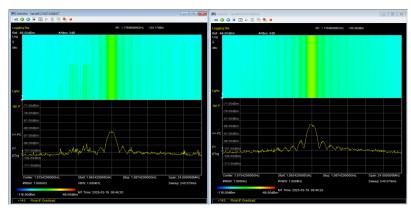
GPS L5 (In/Near band)
(@Incheon site)



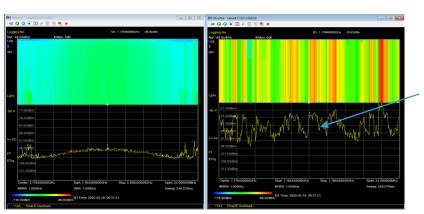
GNSS signal monitoring (from KASS GEO L1/L5)

Real time monitoring & Analysis

- **❖** KASS GEO#1 provides SoL service using the L1 band.
- ❖ 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' 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.



Geumsan and Yeongju's GEO L1 spectrum (Center Freq.:1575.42 MHz, Span: 24MHz, MAXHOLD)



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



GNSS signal monitoring (from KASS GEO L1/L5)

GNSS signal analysis in the area of interest

(GNSS L1/L5 from KRS)

❖ Jamming and Spoofing signals were not detected due to geographic blocking of KRS in the area of interest.

(KASS GEO L1/L5 form KUS)

- Normally, there is no problem in transmitting(C1, C5) and receiving(L1, L5) signals between the KUS and KASS satellites.
- ❖ Intermittent RFI intrusion into the KASS GEO L5 signal occurs, and when strong and with a wide bandwidth, signal dropouts occur. (In this case, switch to automatic backup)



KASS Operating Procedures (Regarding GNSS RFI Occurrence)

Operational procedures in abnormal situations

* KASS operation procedure according to GNSS RFI detection

Receiving GNSS RFI information from external agencies

Analysis if KASS abnormal



Analysis nearby KRS or others RS data from RFI sources



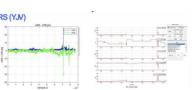
Notification of normal operation

From Central Radio Management Service or Ministry of Science and ICT or NOTAM service





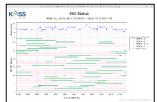


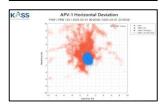


KASS Real-time Anomaly Detection

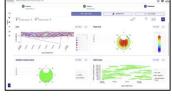


performance is





Analysis if KASS performance is abnormal





Analysis nearby KRS or others RS data from RFI sources





Normal operation

Analysis of the

impact of services



	31-05-300101	15507	00377/24	(95/00)	3405300254	2409012250	UPS KWM OUTROES PREDICTED FOR WA
	24-03-30 91:00	10000	60376/24	DGAXX	2405)00059		GPS RAMI OUTSIGES NEW NOTAM TO FLW
ш	24-05-29 00:47	MINEY	66974/94	DEADX	2005290001		GPS RAMI DUTAGES NEW NOTAM TO FLW
	24-05-29 00:47	1000	69375/24	05400	2405292258	2405312254	GPS RAW OUTLAGES PREDICTED FOR NAA
	24 03-28 00:28	HINNY	60373/04	DEAX	2405260360	2405302258	GPS RAIM DUTAGES PREDICTED FOR NA
	34 05 00 00 28	HIDE	00372/04	25400	2405250000		GPS RAMA OUTHORS NEW YOTAN TO FLW
	24-03-2700.48	2000	00371/24	200,000	2405272306	2405292903	OPS RAIM DUTABLES PREDICTED FOR NAV.
	24 03:27 00:45	HINNY	00370/24	DSAXX	240510025		OPS KNAM OUTHORS NEW NOTAM FOR LW
0	24-03-29-05:55	9900	69393-24	06AXX	2005262310	2405282507	OPS RAMI OUTLAGES PREDICTED FOR WA
	34109-2019/147	1000	20177/01	DOMES	2405230146	2401301500	CAUTIONARY INFO FOR ACIT OPERATING INVINCEOUTRE: PLOTS HIMS REPORTED THAT GPS OGNALS A
	34-05-10/08/41	8100	20453/24	DEWOOL	2605100009	2405221500	CAUTIONARY INFORMATION FOR ACET DIFFERENCE IN NUMBER FIRE SECAUSE OF GROMAGNETIC DISTUR
	24-03-10 09:35	4833	23451/24	DOWN	2005160033	2425225500	CAUTIONARY REPORMATION FOR ACET DISEATING IN INCHEON FIR FILLIES HAVE REPORTED THAT GIFE!
	24 03:11 02:45	EXXX	20420/04	25000	2405 [1024]	2405500247	CAUTIONARY INFORMATION FOR ARCHAPT DREATING INVINCHED/FIRE BECAUSE OF DEGMACHETIC DIS
	34-03-03-00-38	81008	23423/24	200400	2405050631	2405161500	CAUTIONARY INFORMATION FOR ARCHAPT DRENATING INVINCHEON FIRE PILOTS HAVE REPORTED THAT C
	24-03-02-03/03	89300	201995/24	bowns	2000000000	2403091500	CAUTIONARY REPORTANTION FOR ARROWAT DIRECTION BUILDINGS INCOME HAVE REPORTED THAT O
a.	24-04-25-0829	49300	20374/24	DOWN	249455800	2405027500	CAUTIONARY INFORMATION FOR ARICRAFT DIFFRATING INVINCHED/FIRE PROTE HAVE REPORTED THAT C
ġ.	34-94-17-95/89	1118	20351/24	(15000)	2000170600		GPS SIGNALS ARE RELIABLE IN INCHEON FIR
H	24-04-15-04-26	8000	2013/124	DESWOOL	269110026	2414021501	CAUTIONARY INFORMATION FOR ARCHAFT DIFFRATING INVINCIGINARY PLUTS HAVE REPORTED THAT C
0	24-04-00/02/18	HEER	20327/24	DEWOX	2404060218	2404151500	CAUTIONARY INFORMATION FOR ARCRAFT DISPATING IN INCHESS FIRE PLOTS HAVE REPORTED THAT I
	34.0400.09-24	SHUAL	STREET	PERTY	SHILLIAN PROPERTY.	2.018179127	COR PANA CHITACOS AMERICANOS ESPENDA



Conclusion





Conclusion

- ❖ The number of GNSS RFIs within the INCHEON FIR in South Korea is increasing, and there is an increase in RFI-related reports near airports(Incheon & Kimpo airport) in the northern part of South Korea.
- GNSS RFI needs to be monitored because it affects not only aviation but also various fields including maritime affairs.
- South Korea's radio monitoring agency, which monitors GNSS RFI, is also increasingly detecting the influx of strong interference signals.
- To ensure safer aircraft navigation, we are strengthening real-time monitoring of jamming and spoofing and developing response procedures.
- ❖ We are also supporting academic and industrial research on anti-jamming and anti-spoofing.
- GNSS RFI is a major obstacle to transitioning to next-generation navigation system. Therefore, sharing of experiences, including solutions among countries, is necessary.



Thank You

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Southern African

(ESAF) Office

Nairobi

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