

Space Weather Days (ESAC, June 8-9)

División Navegación y Vigilancia



enaire.es



Who we are



Public Business Entity under **Ministry of Transport and Sustainable Mobility**.



Designated by the State for the **provision of air traffic services** in the en-route and approach phases.



5 control centres and 21 control towers, managing nearly 2 million flights per year.

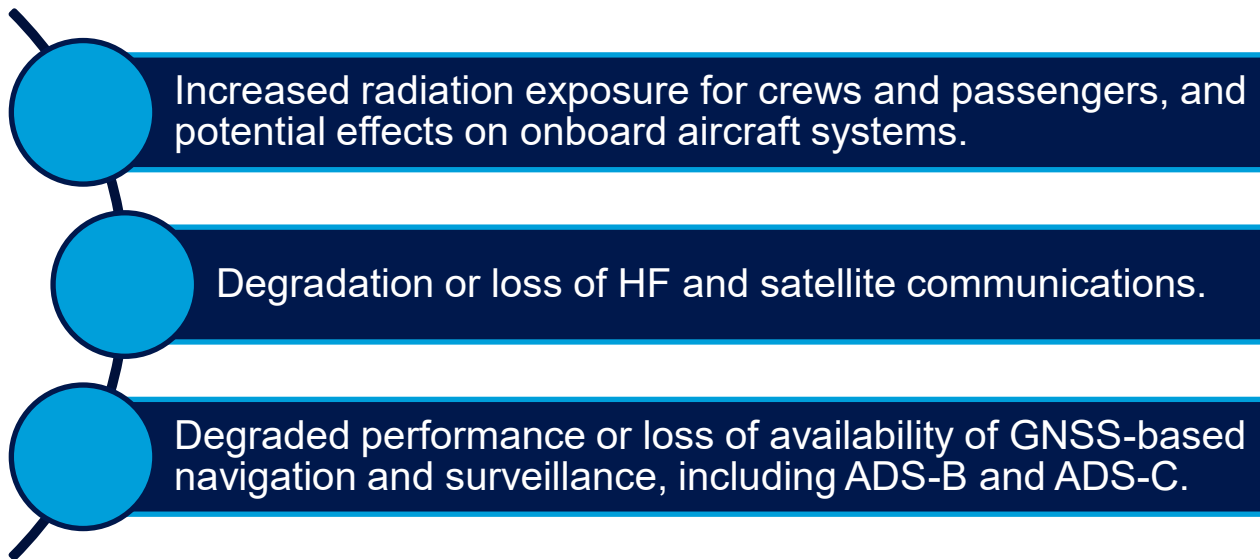


Fourth-largest air navigation service provider in Europe by traffic volume.



Our mission: to **contribute to the development of air transport in Spain** and to **guarantee air traffic safety, fluidity, efficiency and economy**, offering a quality of service in line with the demand of customers and users.

Why space weather matters for aviation

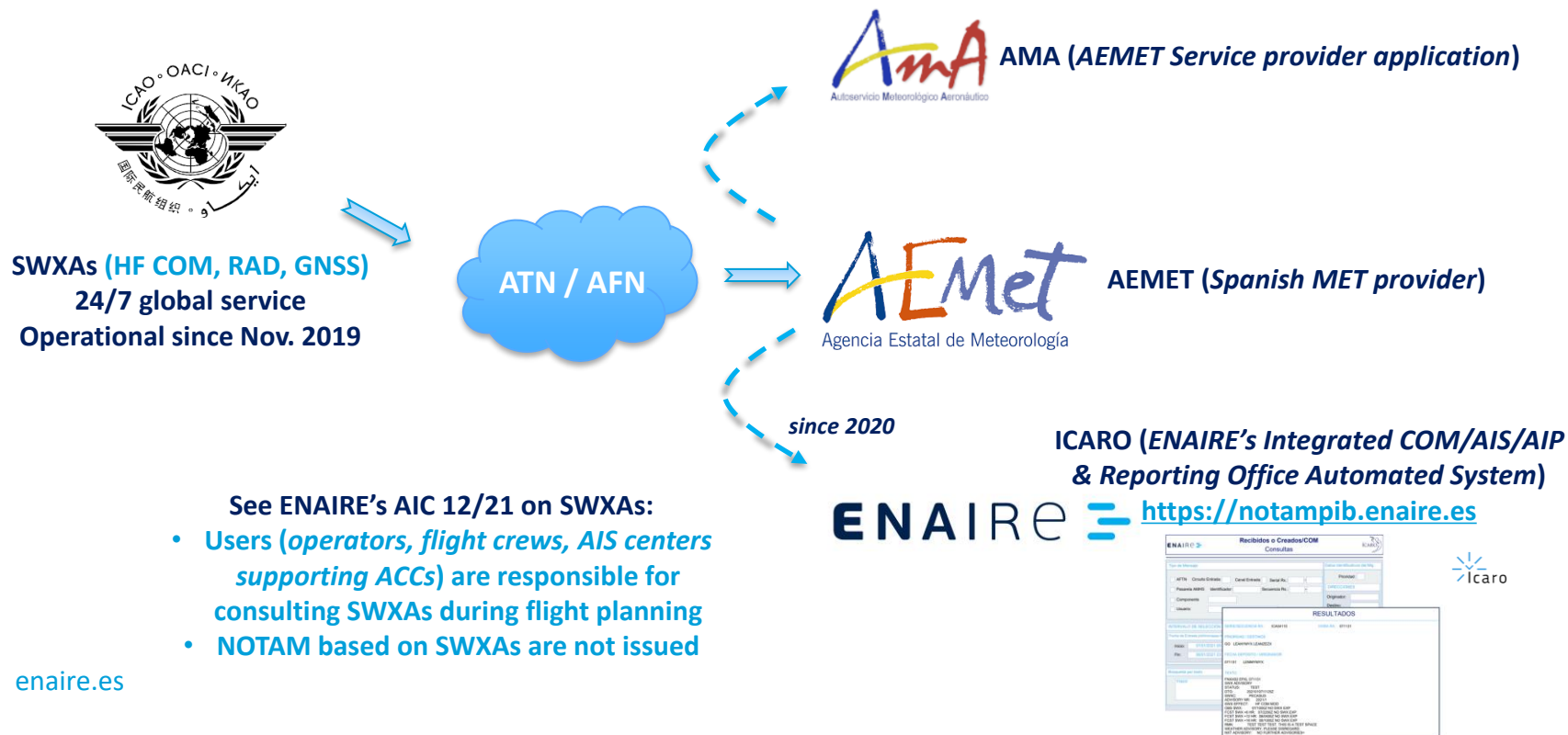


ICAO Doc 10100 "Manual on Space Weather Information in Support of International Air Navigation"

EASA SIB 2012-09 R1 "Effects of Space Weather on Aviation"

EASA SIB 2012-10 R1 "Single Event Effects on Aircraft Systems caused by Atmospheric Radiation"

ENAIRe's use of space weather information



Space weather impacts on GNSS-based navigation in aviation



📶 Space weather can degrade the performance of GNSS augmentation systems such as GBAS and EGNOS.

📶 Driven by solar activity.

📶 Greater impact in equatorial and polar regions, and during equinoxes.

📶 Main ionospheric drivers: delay gradients and scintillation.

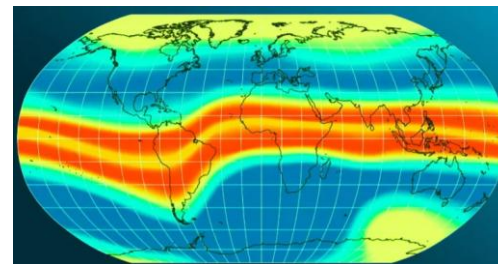
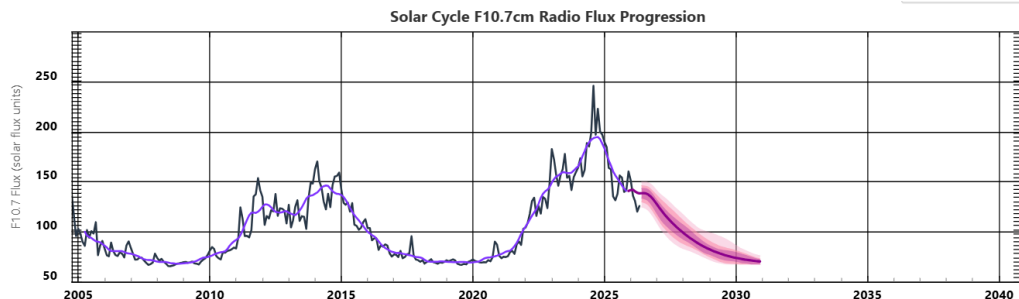
Increased ionospheric gradients primarily affect single-frequency services.

Scintillation is most relevant at equatorial and high latitudes.

📶 Impact on 3D approach operations with GNSS-based vertical guidance (SBAS LPV or GBAS).

📶 Not only accuracy degradation; it is the potential loss of integrity, availability or continuity of GNSS-based services used for approach and surveillance.

↓ Availability
↓ Accuracy
↑ Continuity



Space weather monitoring at Málaga airport using operational GBAS



GBAS station detects GNSS signal disturbance events and we classified it in jammers, system issues (satellite geometry, PRN issues...) and space weather activity.



Since March 2024, an increase of events has been attributed to space weather activity. Mainly at sunset, and particularly on the equinoxes.

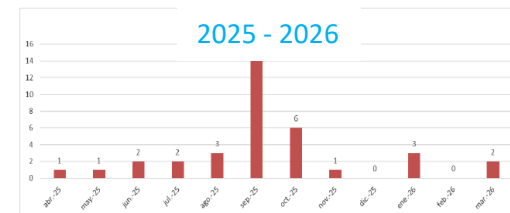
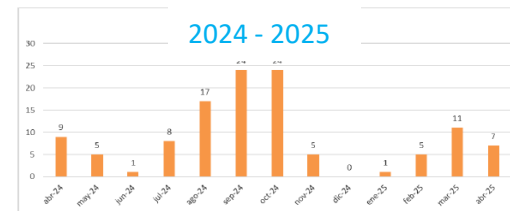


GBAS NOTAMs for LEMG, based on space weather monitoring, issued in 2024 and 2025. So far, not in 2026.



The number of events attributed to space weather during 2025–26 was reduced by 70.25% compared to those in 2024–25.

Events Time Series

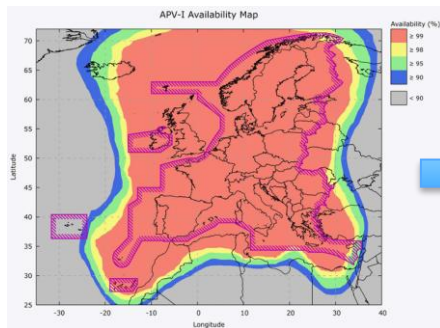


Impact on EGNOS monitored performance

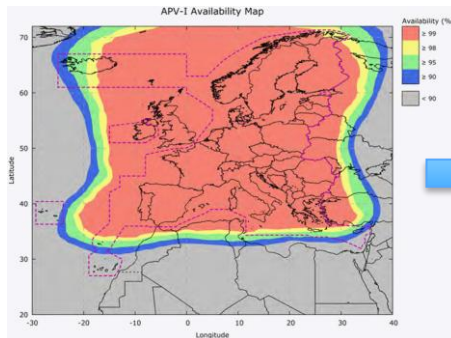
Spain is located at the edge of the EGNOS service area → Greater impact of space weather on performance



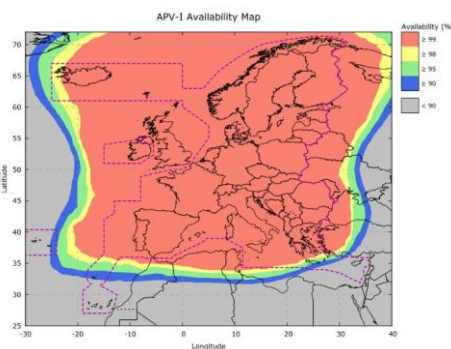
SoL SDD 3.4 (2021)



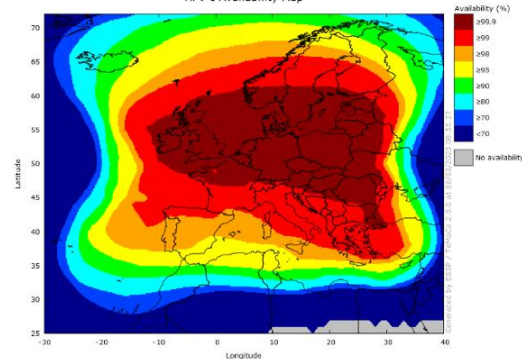
SoL SDD 3.5 (2023)



SoL SDD 3.6 (2024)



Greater impact during equinoxes =
Higher degradation than reflected in
the EGNOS SoL SDD

SIS Op - 22/02/2023 00:00:00 to 07/03/2023 23:59:59
APV-I Availability Map

Impact on monitored performance

Availability below 99% at some airports.

Continuity risk not meeting the SDD commitment at many airports.

EGNOS APV I Continuity (2023)

EGNOS: CONTINUIDAD APV I PRN 123 126/136 (Probabilidad por hora de vuelo)													
ESTACION	ENERO	FEBRERO	MARZO	ABRIL	MAYO	JUNIO	JULIO	AGOSTO	SEPTIEMBRE	OCTUBRE	NOVIEMBRE	DICIEMBRE	ANUAL
LEAL	2.09E-05	2.55E-04	7.48E-04	6.77E-05	1.57E-05	1.12E-05	2.61E-05	6.83E-05	2.78E-04	4.96E-04	1.12E-04	8.60E-05	1.82E-04
LEAM	4.15E-05	2.31E-04	9.85E-04	1.39E-04	2.61E-05	1.68E-05	6.24E-05	8.41E-05	3.71E-04	6.15E-04	1.94E-04	8.60E-05	2.38E-04
LEAS	5.23E-06	1.32E-04	2.20E-04	0.00E+00	1.05E-05	1.12E-05	5.23E-06	6.29E-05	1.36E-04	3.05E-04	5.64E-05	6.50E-05	8.41E-05
LEBA						3.03E-05	3.10E-05	4.20E-05	2.19E-04	4.10E-04	1.37E-04	7.03E-05	1.34E-04
LEBG	5.23E-06	9.66E-05	2.38E-04	0.00E+00	1.05E-05	1.12E-05	5.23E-06	5.25E-05	1.42E-04	3.15E-04	5.95E-05	6.50E-05	8.36E-05
LECB	5.23E-06	8.28E-05	2.33E-04	1.08E-05	1.05E-05	1.12E-05	5.23E-06	4.20E-05	1.31E-04	3.24E-04	6.49E-05	6.57E-05	8.25E-05
LECH	5.23E-06	1.78E-04	4.20E-04	1.62E-05	1.57E-05	1.12E-05	5.23E-06	4.20E-05	1.30E-04	3.39E-04	6.49E-05	6.57E-05	1.09E-04
LECM	1.05E-05	1.10E-04	2.61E-04	5.02E-05	1.05E-05	1.12E-05	5.23E-06	4.84E-05	1.50E-04	3.37E-04	7.26E-05	6.50E-05	9.44E-05
LECO	1.05E-05	1.12E-04	2.15E-04	2.70E-05	1.05E-05	3.51E-05	5.23E-06	7.49E-05	1.10E-04	2.95E-04	6.95E-05	6.50E-05	8.59E-05
LEDA	5.23E-06	8.74E-05	2.68E-04	5.40E-06	1.05E-05	1.12E-05	5.23E-06	4.20E-05	1.35E-04	3.65E-04	5.41E-05	6.57E-05	8.83E-05
LEGE	5.23E-06	8.24E-05	2.15E-04	1.62E-05	1.05E-05	1.12E-05	5.23E-06	4.20E-05	1.23E-04	3.03E-04	6.72E-05	6.57E-05	7.91E-05
LEIB	5.23E-06	2.33E-04	7.57E-04	8.38E-05	1.57E-05	1.12E-05	1.05E-05	5.78E-05	1.71E-04	4.82E-04	9.32E-05	6.57E-05	1.66E-04
LEJR	2.61E-05	2.10E-04	9.61E-04	7.98E-05	1.05E-05	1.12E-05	3.02E-05	5.25E-05	3.34E-04	6.59E-04	2.60E-04	9.12E-05	2.28E-04
LEMD	4.82E-05	1.10E-04	2.65E-04	6.29E-05	1.05E-05	1.12E-05	5.23E-06	4.84E-05	1.49E-04	3.33E-04	7.03E-05	6.50E-05	9.84E-05
LEMG	1.05E-05	2.56E-04	1.04E-03	1.30E-04	1.05E-05	1.68E-05	8.52E-05	6.49E-05	3.10E-04	5.83E-04	2.70E-04	9.12E-05	2.39E-04
LEMH	3.66E-05	1.11E-04	3.75E-04	5.52E-05	1.05E-05	1.12E-05	5.23E-06	4.20E-05	1.33E-04	3.96E-04	1.57E-04	6.57E-05	1.17E-04
LEPA	5.23E-06	1.79E-04	5.11E-04	5.64E-05	1.57E-05	1.12E-05	1.05E-05	4.20E-05	1.53E-04	3.85E-04	1.08E-04	6.57E-05	1.29E-04
LEPP	1.05E-05	9.73E-05	2.58E-04	0.00E+00	1.05E-05	1.12E-05	5.23E-06	5.25E-05	1.20E-04	3.34E-04	6.37E-05	6.57E-05	8.60E-05
LERJ	5.23E-06	1.23E-04	2.38E-04	0.00E+00	1.05E-05	1.12E-05	5.23E-06	5.25E-05	1.19E-04	3.69E-04	7.07E-05	6.50E-05	8.93E-05
LERS	5.23E-06	8.33E-05	2.38E-04	1.08E-05	1.05E-05	1.12E-05	5.23E-06	4.20E-05	1.22E-04	3.74E-04	5.95E-05	6.57E-05	8.60E-05
LESO	5.23E-06	5.79E-05	2.20E-04	0.00E+00	1.05E-05	1.12E-05	5.23E-06	5.25E-05	1.08E-04	3.23E-04	5.56E-05	6.57E-05	7.67E-05
LESU	5.23E-06	6.58E-05	2.04E-04	5.40E-06	1.05E-05	1.12E-05	5.23E-06	4.20E-05	1.29E-04	3.42E-04	6.41E-05	6.57E-05	7.96E-05
LEVC	5.23E-06	2.00E-04	4.47E-04	4.87E-05	1.57E-05	1.12E-05	5.23E-06	4.20E-05	1.37E-04	3.44E-04	1.35E-04	9.53E-05	1.24E-04
LEVX	5.23E-06	8.82E-05	2.37E-04	0.00E+00	1.05E-05	1.12E-05	5.23E-06	5.55E-05	1.27E-04	3.30E-04	5.40E-05	6.50E-05	8.27E-05
LEVX	5.23E-06	1.11E-04	2.16E-04	5.64E-05	1.05E-05	4.47E-05	5.23E-06	5.25E-05	1.39E-04	2.96E-04	7.14E-05	6.50E-05	8.94E-05
LEJX	5.23E-06	6.75E-05	1.87E-04	0.00E+00	1.05E-05	1.12E-05	5.23E-06	7.52E-05	1.17E-04	3.51E-04	6.33E-05	6.50E-05	8.03E-05
GCFV	1.98E-03	3.43E-03	3.35E-03	2.38E-03	8.85E-04	2.67E-04	9.80E-04	1.52E-03	2.88E-03	3.58E-03	1.85E-03	1.17E-03	2.01E-03
GCLA	2.64E-03	4.11E-03	3.69E-03	2.44E-03	8.61E-04	2.20E-04	9.02E-04	1.70E-03	2.88E-03	4.04E-03	1.91E-03	8.87E-04	2.18E-03
GCRR	1.85E-03	3.24E-03	3.36E-03	2.23E-03	8.57E-04	2.77E-04	6.63E-04	1.21E-03	2.59E-03	3.59E-03	1.65E-03	7.62E-04	1.85E-03
GCTS	2.63E-03	4.41E-03	3.98E-03	2.56E-03	1.06E-03	1.90E-04	8.16E-04	1.55E-03	3.08E-03	3.97E-03	1.94E-03	1.32E-03	2.28E-03

EGNOS APV I Availability (2023)

EGNOS: DISPONIBILIDAD APV I GEO SWITCHING PRN 123 126/136 (% tiempo)													
ESTACION	ENERO	FEBRERO	MARZO	ABRIL	MAYO	JUNIO	JULIO	AGOSTO	SEPTIEMBRE	OCTUBRE	NOVIEMBRE	DICIEMBRE	ANUAL
LEAL	99.96	99.33	97.58	99.77	99.99	100	99.97	99.58	99.29	98.79	99.69	99.90	99.49
LEAM	99.95	98.94	96.74	99.55	99.99	100	99.91	99.58	99.08	98.36	99.53	99.87	99.29
LEAS	100	99.73	99.09	100	100	100	99.99	99.65	99.68	99.59	99.95	99.90	99.80
LEBA						99.97	99.98	99.65	99.40	98.95	99.69	99.90	99.65
LEBG	100	99.74	98.98	100	100	100	99.99	99.66	99.65	99.47	99.93	99.94	99.78
LECB	100	99.81	98.89	99.97	100	100	99.99	99.65	99.61	99.28	99.90	99.94	99.75
LECH	100	99.65	98.49	99.96	99.99	100	99.99	99.65	99.57	99.16	99.89	99.94	99.69
LECM	99.99	99.58	98.75	99.98	100	100	99.99	99.65	99.55	99.31	99.88	99.94	99.72
LECO	99.98	99.59	99.01	99.97	100	99.94	99.99	99.65	99.69	99.56	99.94	99.94	99.77
LEDA	100	99.80	98.92	99.99	100	100	99.99	99.65	99.60	99.34	99.91	99.94	99.76
LEGE	100	99.83	98.93	99.97	100	100	99.99	99.65	99.66	99.33	99.93	99.94	99.77
LEIB	100	99.51	97.91	99.85	99.99	100	99.98	99.61	99.50	98.90	99.73	99.94	99.58
LEJR	99.97	98.79	97.23	99.58	100	100	99.97	99.65	99.23	98.67	99.44	99.84	99.37
LEMD	99.96	99.57	98.75	99.98	100	100	99.99	99.65	99.55	99.31	99.89	99.94	99.72
LEMG	99.98	98.79	96.83	99.52	100	99.99	99.96	99.63	99.22	98.59	99.42	99.86	99.32
LEMH	99.95	99.76	98.59	99.91	100	100	99.99	99.65	99.58	99.12	99.80	99.94	99.69
LEPA	100	99.62	98.47	99.91	99.99	100	99.98	99.65	99.54	99.03	99.83	99.94	99.66
LEPP	100	99.82	99.12	100	100	100	99.99	99.65	99.66	99.45	99.93	99.94	99.80
LEJR	100	99.79	99.03	100	100	100	99.99	99.66	99.65	99.45	99.92	99.94	99.78
LERS	100	99.79	98.82	99.97	100	100	99.99	99.65	99.59	99.22	99.90	99.94	99.74
LESO	100	99.87	99.16	100	100	100	99.99	99.66	99.70	99.55	99.95	99.94	99.82
LESU	100	99.86	98.94	99.99	100	100	99.99	99.65	99.64	99.44	99.93	99.94	99.78
LEVC	100	99.54	98.30	99.89	99.99	100	99.99	99.65	99.55	99.14	99.85	99.94	99.65
LEVT	100	99.82	99.07	100	100	100	99.99	99.67	99.68	99.52	99.94	99.94	99.80
LEVX	100	99.48	98.94	99.92	100	99.97	99.99	99.65	99.66	99.22	99.92	99.94	99.75
LEJX	100	99.80	99.10	100	100	100	99.99	99.67	99.69	99.57	99.95	99.94	99.81
GCFV	91.03	79.87	65.97	88.98	97.18	99.23	97.79	95.68	83.84	74.95	85.78	95.55	88.04
GCLA	89.40	77.78	65.86	88.92	96.93	99.05	97.74	95.66	84.06	73.38	85.09	95.18	87.48
GCRR	92.51	81.81	67.55	90.28	97.64	99.36	98.16	96.46	85.16	76.47	86.82	96.19	89.08
GCTS	89.05	76.63	64.47	87.60	96.56	99.07	97.44	95.08	82.87	72.27	83.95	94.63	86.70

Impact on LPV procedures

ESSP



Declares **contingency situations** → Publication of EGNOS Warning NOTAM

From February 2022 to April 2025, contingency situations affected GCRR, GCLA, LEAM, LECH, LEJR and LEVC for a total of 45 weeks.

(G0017/23 NOTAMR G0016/23
Q)LECM/QGAUU/I /NBO/A /000/999/3645N00604W005
A)LEJR B)2303221525 C)2303291559
E)BE AWARE OF POTENTIAL EGNOS UNAVAILABILITIES:
- LPV FLIGHT PLANNING STILL POSSIBLE)

ENAIRE



Weekly reporting and monitoring of EGNOS performance to **AESA**



Publication of operational circulars for **ATC awareness**



Cancellation of LPV procedures in the Canary Islands from 30/11/2022 to present (SUP 201/24) (~3.5 years).



Difficulty performing validation flights for PBN implementation, requiring repeated attempts to find periods with better EGNOS performance.



Limited operational impact so far, due to the low percentage of SBAS-equipped users and the availability of alternative means.

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AIS-ESPAÑA Dirección: APTN: LEANZTA Teléfono: +34 913 213 363 E-mail: aip@enaire.es Web: www.enaire.es	ENAIRE DIVISIÓN DE INFORMACIÓN AERONÁUTICA c/ Campezo, 1. EDIFICIO 2 Kudos Innovation Campus Las Mercedes 28022 Madrid (ESPAÑA)	SUP 237/25 26 DEC 26
AD/ENR CANCEL: SUP 201/24		
SUP 237/25 25DEC25/25DEC26EST NOTE: EST SUP WILL ONLY BE CANCELLED BY NOTAM, SUP OR AIP AMENDMENT.		
AIS-ESPAÑA - TEMPORARY SUSPENSION OF RNP APCH MANOEUVRES TO PUBLISHED LPV MINIMA AT AIRPORTS IN THE CANARY ISLANDS. For the duration of this supplement, the use of RNP APCH instrument approach procedures to LPV minima at airports in the Canary Islands published in the AIP Spain as of the date of publication of this SUP, shall be suspended. The suspension is due to the reduced availability of the EGNOS signal supporting these procedures to below minimum required values, due to the effects of increased solar activity on the EGNOS system from the end of 2022 onwards. This situation is detailed in the Sol. services commitment maps declared by the service provider (ESSP) in its document "Sol. Service Definition Document V3.6". The procedures will not be available for use for the duration of this SUP therefore airspace users shall not be alerted of reduced availability or unavailability of the EGNOS system by the two NOTAM types related to said system and described in the AIC: "Means of notification related to the availability/operational status of Global Navigation Satellite Systems (GNSS) and instrumental procedures with authorised GNSS use" if such NOTAMs are received, they should be ignored. Any additional operational incident shall be notified via NOTAM. AFFECTED AND AVAILABLE PROCEDURES. The currently published instrumental procedures that may be affected and available alternative procedures are given below: GRAN CANARIA: - AD 2 GCLP IAC 8 – RNP (LPV ONLY) RWY 03L: Unusable; - AD 2 GCLP IAC 9 – RNP (LPV ONLY) RWY 03R: Unusable; - AD 2 GCLP IAC 10 – RNP (LPV ONLY) RWY 21L: Unusable; - AD 2 GCLP IAC 17 – RNP (LPV ONLY) RWY 21R: Unusable.		

What ANSPs need from space weather services



Localised **impact** estimations for GNSS-based aviation services to **notify** airspace users, in a timely manner, about predicted or observed space weather events with potential impact on aviation.



Spatial resolution suitable for airport or regional decision-making to take appropriate **mitigation actions** upon space weather events (aircraft descents, alternative routes, alternative CNS means, application of delays). At least 2.5-degree resolution for latitude & longitude should be targeted.



Short-term forecasts with **uncertainty** to take mitigation actions.



Clear distinction between observed and forecast events.



Translation from SWX parameters to operational GNSS performances.



Better **support** for NOTAM/operational decision processes (events lasting 15 min or longer).

Conclusions



-  For ANSPs, the key problem is translating ionospheric activity into operational impact: availability, continuity and procedure usability.
-  The operational consequence is not theoretical: it can affect LPV availability, procedure publication, validation flights and contingency management.
-  What we need from the space weather community is not only indexes, but impact-oriented products that support operational decisions.

Thanks





ICAO space weather advisories at ENAIRE

ENAIRE

Recibidos o Creados/COM
 Consultas

Tipo de Mensaje

☐ AFTN Circuito Entrada: Canal Entrada: Serial Rx.: -

☐ Pasarela AMHS Identificador: Secuencia Rx.: -

☐ Componente

☐ Usuario:

Datos Identificativos del Msj.

Prioridad:

DIRECCIONES

Originador:

Destino:

INTERVALO DE SELECCIÓN

Fecha de Entrada (dd/mm/aaaa h)

Inicio:

Fin:

Búsqueda por texto

RESULTADOS

SERIE/SECUENCIA RX.: ICA04110 HORA RX.: 071131

PRIORIDAD / DESTINOS

GG LEANYMYX LEANZEZX

FECHA DEPÓSITO / ORIGINADOR

071131 LEMMYMYX

TEXTO

FNXX02 EFKL 071131

SWX ADVISORY

STATUS: TEST

DTG: 20210107/1125Z

SWXC: PECASUS

ADVISORY NR: 2021/1

SWX EFFECT: HF COM MOD

OBS SWX: 07/1000Z NO SWX EXP

FCST SWX +6 HR: 07/2200Z NO SWX EXP

FCST SWX +12 HR: 08/0400Z NO SWX EXP

FCST SWX +18 HR: 08/1000Z NO SWX EXP

RMK: TEST TEST TEST. THIS IS A TEST SPACE

WEATHER ADVISORY, PLEASE DISREGARD.

NXT ADVISORY: NO FURTHER ADVISORIES=

Impact on LPV procedures

GCRR. LPV WEF (29/05/2019)

29 weeks under contingency until procedure cancellation

~3.5 years with the procedure cancelled

GCLA. LPV WEF (14/07/2022)

17 weeks under contingency until procedure cancellation

~3.5 years with the procedure cancelled

GCTS. LPV WEF (05/10/2023)

Cancelled immediately after publication

~3.5 years with the procedure cancelled

GCXO LPV WEF (03/10/2024)

Cancelled immediately after publication

~3.5 years with the procedure cancelled

GCLP. LPV WEF (05/09/2024)

Cancelled immediately after publication

~3.5 years with the procedure cancelled

LEJR. LPV WEF (02/12/2021)

14 weeks under contingency

LEAM. LPV WEF (25/05/2017)

7 weeks under contingency

LEVC. LPV WEF (01/02/2018)

5 weeks under contingency

LECH. LPV WEF (21/04/2022)

5 weeks under contingency

