Service de l'Information Aéronautique

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SUBJECT : INTRODUCTION BY ICAO OF A GLOBAL SPACE WEATHER INFORMATION SERVICE IN SUPPORT OF INTERNATIONAL AIR NAVIGATION.

1. INTRODUCTION :

The purpose of this aeronautical information circular is to inform airspace users of the implementation on 7 November 2019, under the aegis of ICAO, of a global space weather information service in support of international air navigation.

Civil aviation may be impacted by phenomena of solar origin, notably with respect to HF communications, GNSS-based navigation and surveillance, satellite communications and augmented radiation aboard aircraft.

ICAO has therefore organized a space weather information service whereby advisories will be disseminated through the Aeronautical Fixed Service (AFS), including the Aeronautical Fixed Telecommunications Network (AFTN) and the Aeronautical (or ATS) Message Handling System (AMHS), in cases of moderate or severe impacts to the 4 domains identified above.

The advisories will be produced by 3 ICAO-designated global centres (ACFJ, PECASUS, SWPC)[1], operating on a rotating basis.

2. THE NATURE OF THE DISTURBANCES :

HF signals are « reflected » by a region around Earth named ionosphere, and GNSS and SATCOM signals pass through the ionosphere. Disturbances to the ionosphere may therefore, more or less severely, disturb the propagation of HF, GNSS and SATCOM signals.

The ionosphere may be disturbed:

A- During sporadic X-ray and/or Extreme UV (EUV) solar emissions (solar flares)
B- By the arrival of solar magnetic material (Coronal Mass Ejections (CME), high speed solar wind streams),
C- By high energy solar particles (mainly protons).

In addition, solar particles, when their energy is exceptionally high, may also, by interacting with atmospheric particles, trigger secondary ionising particle cascades, which increase radiation aboard aircraft.

While X rays and EUV affect the daylight side of Earth, magnetic phenomena and high energy protons affect primarily high northern and southern latitudes, including at nighttime, but may spread to middle latitudes in case of strong solar events.

The change from daytime to nighttime conditions may also cause ionospheric disturbances which may affect equatorial or near equatorial regions.

Lastly, the frequency and intensity of solar phenomena vary according to an 11 year cycle. 2019 corresponds to a solar minimum, and therefore to a low activity period, even if significant events cannot be excluded.

[1] ACFJ (Australia, Canada, France, Japan) – PECASUS (Austria, Belgium, Cyprus, Finland (lead), Germany, Italy, the Netherlands, Poland, the United Kingdom) – The United States)

3. THE ICAO SPACE WEATHER SERVICE ADVISORIES :

The intensity of space weather phenomena in the advisories may be moderate (MOD) or severe (SEV).

The effects may pertain to HF radio communications (HF COM), satellite communications (SATCOM), GNSS-based navigation and surveillance (GNSS), and radiation at aircraft altitudes (RADIATION).

They address observed (OBS) and/or forecast (FCST) effects at T, T+6, T+12, T+24 hours (unless forecasts are not available).

Advisories are updated as often as necessary, but at least every 6 hours, until such time as the space weather phenomena are no longer detected and/or no longer expected to have an impact (NO SWX EXP).

Affected geographic areas are referenced by their latitudes and longitudes, and flight levels (ABV FL) for radiation. Abbreviations are also used:

- High latitudes northern hemisphere (N9000 - N6000) : HNH
- Mid latitudes northern hemisphere (N6000 - N3000) : MNH
- Equatorial latitudes northern hemisphere (N3000 - N0000) : EQN
- Equatorial latitudes southern hemisphere (S0000 - S3000) : EQS
- Mid latitudes southern hemisphere (S3000 - S6000) : MSH
- High latitudes southern hemisphere (S6000 - S9000) : HSH

Some advisories may be for the whole daylight side of Earth (daylight side).

Test or exercise advisories may be issued.

Space weather advisory information relevant to the whole route will be supplied to operators and flight crew members as part of meteorological information.

Note: It is recognized that the horizontal, vertical and temporal resolutions of the advisory are very coarse. The use of 30-degree latitude bands, 15-degree longitude increments, 3,000-foot vertical increments (for radiation), and 6-hour time intervals will at times result in over forecasting the affected airspace. In addition, while an entire latitude band may be forecast to have MOD or SEV space weather, there will often be times that the effect does not cover the entire width of the band or is intermittent or temporary. Users should refer to the remarks section of the advisory for additional information.

4. SPACE WEATHER ADVISORY MESSAGE :

A Space Weather Advisory Message has the following format:

(1) WMO Header (FNXX01, WMO location indicator, UTC date-time of issue of the message)
(2) SWX ADVISORY (message type)
(3) STATUS (either test (TEST) or exercise (EXER) if required)
(4) DTG (Time of Origin - Year/month/date/time in UTC)
(5) SWXC (name of Space Weather Centre)
(6) ADVISORY NR (advisory number; unique sequence for each space weather effect: HFCOM, GNSS, RADIATION, SATCOM)
(7) NR RPLC (number of the previously issued advisory being replaced)
(8) SWX EFFECT (effect and intensity of space weather phenomenon)
(9) OBS (or FCST) SWX (Date and time (in UTC) and description of spatial extent of observed or forecast space weather phenomenon)
(10) FCST SWX +6HR (Date-time (in UTC) of forecast spatial extent of space weather event)
(11) FCST SWX +12HR (as above)
(12) FCST SWX +18HR (as above)
(13) FCST SWX +24HR (as above)
(14) RMK (NIL or free text)
(15) NXT ADVISORY (Year/month/date/time (in UTC) or NO FURTHER ADVISORIES)

The intensity of the space weather phenomena (field 8, SWX EFFECT) is based on the following parameters and thresholds, listed in the First Edition, 2019, of the ICAO Manual on Space Weather Information in Support of International Air Navigation (Doc 10100):

Effect	Sub-effect	Parameter used	MOD	SEV
GNSS	Amplitude Scintillation	S4 (dimensionless)	0.5	0.8
GNSS	Phase Scintillation	Sigma-phi (radians)	0.4	0.7
GNSS	Vertical Total Electron Content (TEC)	TEC units	125	175
RADIATION		Effective dose (micro-Sieverts/hour)*	30	80
HF COM	Auroral Absorption (AA)	Kp index	8	9
HF COM	Polar Cap Absorption (PCA)	dB from 30MHz riometer data	2	5
HF COM	Shortwave Fadeout (SWF)	Solar X-rays (0.1-0.8 nm) ($W\text{-}m^{-2}$)	$1x10^{-4}$ (X1)	$1x10^{-3}$ (X10)
HF COM	Post-Storm Depression	Maximum usable frequency (MUF)**	30%	50%
SATCOM	No threshold has been set for this effect			

* *MOD advisories will only be issued when the MOD threshold is reached between FL250 and FL460. SEV advisories will be issued when the SEV threshold is reached at any FL above FL250.*

** *As compared to a 30-day running median of the critical frequency of the F2 layer (foF2).*

5. EXAMPLES OF ADVISORIES

FNXX01 YMMC 020100
SWX ADVISORY
DTG: 20190502/0054Z
SWXC: ACFJ
ADVISORY NR: 2019/319
SWX EFFECT: HF COM MOD
OBS SWX: 02/0054Z DAYLIGHT SIDE
FCST SWX + 6 HR: 02/0700Z DAYLIGHT SIDE
FCST SWX + 12 HR: 02/1300Z DAYLIGHT SIDE
FCST SWX + 18 HR: 02/1900Z NOT AVBL
FCST SWX + 24 HR: 03/0100Z NOT AVBL
RMK: SOLAR FLARE EVENT IN PROGRESS IMPACTING HF COM ON
DAYLIGHT SIDE. PERIODIC LOSS OF HF COM ON DAYLIGHT SIDE POSSIBLE NXT 12HRS.
NXT ADVISORY: WILL BE ISSUED BY 20190502/0654Z=

FNXX01 EFKL 190300
SWX ADVISORY
DTG: 20190219/0300Z
SWXC: PECASUS
ADVISORY NR: 2019/20
SWX EFFECT: RADIATION MOD
OBS SWX: 19/0300Z HNH HSH E18000-W18000 ABV FL370
FCST SWX + 6 HR: 19/0900Z NO SWX EXP
FCST SWX + 12 HR: 19/1500Z NO SWX EXP
FCST SWX + 18 HR: 19/2100Z NO SWX EXP
FCST SWX + 24 HR: 20/0300Z NO SWX EXP
RMK: RADIATION AT AIRCRAFT ALTITUDES ELEVATED
BY SMALL ENHANCEMENT JUST ABOVE PRESCRIBED
THRESHHOLD. DURATION TO BE SHORT-LIVED

NXT ADVISORY: NO FURTHER ADVISORIES=

FNXX01 KWNP 020100
SWX ADVISORY
DTG: 20190502/0100Z
SWXC: SWPC
ADVISORY NR: 2019/59
NR RPLC: 2019/58
SWX EFFECT: GNSS MOD
OBS SWX: 02/0100Z HNH HSH E18000-W18000
FCST SWX + 6 HR: 02/0700Z HNH HSH E18000-W18000
FCST SWX + 12 HR: 02/1300Z HNH HSH E18000-W18000
FCST SWX + 18 HR: 02/1900Z NO SWX EXP
FCST SWX + 24 HR: 03/0100Z NO SWX EXP
RMK: IONOSPHERIC STORM CONTINUES TO CAUSE LOSS-OF-LOCK
OF GNSS IN AURORAL ZONE. THIS ACTIVITY IS
EXPECTED TO SUBSIDE IN THE FORECAST PERIOD
NXT ADVISORY: 20190502/0700Z=

6. OPERATIONAL REPONSES TO ADVISORIES:

The ICAO service does not define the operational responses to space weather events. Such responses are the responsibility of aircraft operators/flight crew members, which may choose to have operational procedures in place in order to be ready in case of space weather events.

The following general guidelines may however be given:

Depending on the intensity of the phenomena, aircraft operators/flight crew members might choose to fly less exposed routes, or delay their flights until the phenomena have abated.

They might also wish to use alternate means of communication and/or navigation.

HF absorption on the daylight side of Earth (disturbance A in paragraph 2, duration from minutes to hours), in auroral areas (disturbance B in paragraph 2, duration from minutes to hours) and in polar areas (disturbance C in paragraph 2, duration from hours to days) tend to affect the lowest frequencies in the HF band. The upper part of the HF band might be less affected.

The arrival of magnetic material (disturbance B in paragraph 2) may result in physical processes that may impact the upper part of the HF band (Maximum Usable Frequency depression) from hours to days. In that case, the lower HF frequencies might be less affected.

Impacts on GNSS may result in reduced availability of specific GNSS services. This may require, during rare, particularly strong events, the use of alternate navigation means to GNSS SBAS and/or GNSS GBAS approaches with vertical guidance (i.e. for 3D instrument approaches down to LPV minima and/or to GLS minima). For enroute, terminal and 2D instrument approaches, it is unlikely that space weather induced positioning errors would exceed lateral GNSS guidance margins.

Flying at lower altitude and/or latitude decreases radiation aboard aircraft. It should be noted however that solar events which are able to accelerate particles enough for them to result in a significant radiation increase at aircraft altitudes are rare. Since 2000, the 4 radiation events which led to a significant radiation increase at aircraft altitudes occurred on 14 July 2000, 15 April 2001, 20 January 2005, and 13 December 2006. During those events, it is estimated that the radiation dose received during a long-haul flight reaching high latitudes was equivalent to that usually received (from galactic cosmic rays) during a couple of similar long-haul flights.