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REPUBLIC OF SOUTH AFRICA

CIVIL AVIATION AUTHORITY

AERONAUTICAL INFORMATION CIRCULAR

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AIR NAVIGATION SERVICES

METEOROLOGICAL SERVICES

INTRODUCTION BY ICAO OF A GLOBAL SPACE WEATHER INFORMATION SERVICE FOR CIVIL AVIATION

☞ *Indicates changes*

☞ *This AIC replaces AIC 009/2019 Dated 07 NOV 2019.*

1. PURPOSE

1.1. The purpose of this aeronautical information circular is to continue to solicit input from the airspace users in terms of the space weather impact on their systems as defined in Amendment 78 of Annex 3 and PANS-MET, including those in the recently adopted Amendment 82 to Annex 3.

1.2. On the 7 November 2019 the global centres under the aegis of International Civil Aviation Organization (ICAO) started providing advisory services to the civil aviation and this is still ongoing.

1.3. Civil aviation may be impacted by phenomena of solar origin, notably with respect to High Frequency (HF) communications, Global Navigation Satellite System (GNSS)-based navigation and surveillance, Satellite communications (SATCOM) and augmented radiation aboard aircraft.

1.4. ICAO has therefore organised a space weather information service whereby advisories are disseminated through the Aviation 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.

2. BACKCROUND

2.1 Space weather refers to the conditions on the Sun, in the solar wind, magnetosphere, ionosphere and thermosphere that can influence the performance and reliability of space – borne and ground based technological systems.

2.2 As noted in 1.3, the impacts from space weather events are known to affect the areas of communications, navigation, radiation exposure, and avionics within the aviation sector.

2.3 HF signals are reflected by a region around Earth named the ionosphere, and GNSS and SATCOM signals pass through it. Disturbances to the ionosphere may disturb the propagation of HF, GNSS and SATCOM signals and this can range from moderate to severe impact.

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 (HSSW) streams),
C. By high energy solar particles (mainly protons).

2.4 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.

2.5 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.

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

2.7 *The frequency and intensity of solar phenomena vary according to an 11-year sunspot cycle. It should be noted that current solar cycle (solar cycle 25) is expected to reach its peak in 2025 which corresponds to a solar maximum, and therefore a high activity period, with even more significant events that have potential impact on aviation systems to be expected.*

2.8 *The South African National Space Agency (SANSA), as the custodian of the only regional warning centre for space weather in Africa, can provide space weather related information, training and key impact factors that may be of concern to the aviation community.*

2.9 *In November 2018, ICAO designated space weather information providers for the provision of space weather information to international air navigation. The designated providers included three global centres namely: The USA (United State of America), PECASUS (Pan-European Consortium for Aviation Space weather User Services), and ACFJ (Consortium of Australia, Canada, France and Japan). In addition, two regional centres were designated, namely: South Africa and a consortium of the Russian Federation and China. South Africa is represented by SANSA.*

2.10 *The three global centres have been delivering the space weather advisories since 7 November 2019. After CRC's designation as the fourth global centre at the 219th Council Session in April 2020, the 3 centres further coordinated to integrate CRC in the operational framework in November 2021. As of 26 November 2025, South Africa has commenced its participation as a regional centre in the global service framework, providing regional support to global centres by augmenting the African ground-based monitoring data and supplementing forecasting model outputs.*

3. THE ICAO SERVICE ADVISORIES

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

3.2 *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).*

3.3 *The effects address observed (OBS) and/or forecast (FCST) effects at time (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).*

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

Spatial Ranges and Resolution

Element to be forecast		Range	Resolution
Flight level affected by radiation		FL250 – FL600	30
Longitudes for advisories (degrees)		000° –180° (E&W)	15
Latitudes for advisories (degrees)		00° – 90° (N&S)	10
Latitude bands for advisories (degrees and minutes)	High latitudes northern hemisphere (HNH)	N9000 – N6000	30
	Middle latitudes northern hemisphere (MNH)	N6000 – N3000	
	Equitorial latitudes northern hemisphere (EQN)	N3000 – N0000	
	Equitorial latitudes sourthern hemisphere (EQS)	S0000 – S3000	
	Middle latitudes sourthern hemisphere (MSH)	S3000 – S6000	
	High latitudes sourthern hemisphere (HSH)	S6000 – S9000	

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

3.6 *Test or exercise advisories may be issued.*

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

4. A SPACE WEATHER ADVISORY MESSAGE

4.1 *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)*

4.2 *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 (0.0-0.8 nm) (W-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*

5.1. *Example 1*

ZCZC 001
FNXX01 EFKL 301917
SWX ADVISORY
DTG: 20240330/1918Z
SWXC: PECASUS
ADVISORY NR: 2024/189
NR RPLC: 2024/188
SWX EFFECT: GNSS SEV
OBS SWX: 30/1912Z EQN EQS E015 - E045
FCST SWX +6 HR: 31/0200Z NOT AVBL
FCST SWX +12 HR: 31/0800Z NOT AVBL
FCST SWX +18 HR: 31/1400Z NOT AVBL
FCST SWX +24 HR: 31/2000Z NOT AVBL
RMK: SPACE WEATHER EVENT (IONOSPHERIC DISTURBANCE) IN PROGRESS. IMPACT ON GNSS PERFORMANCE

POSSIBLY LEADING TO LOSS OF GNSS SIGNALS AND/OR DEGRADATION OF TIMING AND POSITIONING PERFORMANCE.
NXT ADVISORY: WILL BE ISSUED BY 20240331/0112Z=
NNNN

5.2 Example 2

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=

5.3 Example 3

SWX ADVISORY DTG: 20191108/0100Z
SWXC: ACFJ
ADVISORY NR: 2019/1
SWX EFFECT: HF COM SEV
OBS SWX: 08/0100Z DAYLIGHT SIDE
FCST SWX +6 HR: 08/0700Z DAYLIGHT SIDE
FCST SWX +12 HR: 08/1300Z DAYLIGHT SIDE
FCST SWX +18 HR: 08/1900Z DAYLIGHT SIDE
FCST SWX +24 HR: 09/0100Z NO SWX EXP
RMK: SPACE WEATHER EVENT (SOLAR FLARE) IN PROGRESS IMPACTING LOWER HF COM FREQUENCY BAND ON THE DAYLIGHT SIDE. HIGHER FREQUENCIES MAY BE LESS IMPACTED. FURTHER PERIODIC LOSS OF HF COM ON THE DAYSIDE POSSIBLE NEXT 24 HOURS.
NXT ADVISORY: WILL BE ISSUED BY 20191108/0700Z

6. OPERATIONAL RESPONSES TO ADVISORIES

6.1 The ICAO service does not define the operational responses to space weather events. Such responses are the responsibility of aircraft operators, who will need to have operational procedures in place in order to be ready in case of space weather events.

6.2 The following general guidelines may however be given:

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

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

6.2.3. HF absorption on the daylight side of Earth (disturbance A in paragraph 2.3, duration from minutes to hours), in auroral areas (disturbance B in paragraph 2.3, duration from minutes to hours) and in polar areas (disturbance C in paragraph 2.4, 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.

6.2.4. The arrival of magnetic material (disturbance B in paragraph 2.3) 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.

6.2.5. 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 en-route, terminal and 2D instrument approaches, it is unlikely that space weather induced positioning errors would exceed lateral GNSS guidance margins.

GNSS and SATCOM signals may also be degraded (amplitude and/or phase signal scintillations) in all phases of flight, to the point where the signals can no longer be processed by receivers, which lose lock.

6.2.6. *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.*

7. ***CONCLUSIONS***

7.1 *As noted in paragraph 1, the global space weather information service for civil aviation was implemented in 7 November 2019 and its continuing. It is, therefore, imperative that airspace users become familiar with the advisory formats and derive processes and procedures for interpreting the advisories and utilising the provided information.*

7.2 *SANSA, as the ICAO designated space weather information service for the African region, will provide assistance, training and user awareness to ensure a smooth integration of the information into the aviation systems.*

7.3 *The South African ATM/CNS implementation committee working group on space weather will be working towards developing a concept of operations and associated dissemination and user integration methodology for adoption within the region.*

Airspace users and civil aviation may contact the SANSA Space Weather Centre for assistance, enquiries or to lodge a request for consideration during the implementation phase. The contact details are: rnndanganeni@sansa.org.za and mtshisaphungo@sansa.org.za

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