

MATIETEEN LAITOS ETEOROLOGISKA INSTITUTET NNISH METEOROLOGICAL INSTITUTE

International Cooperation for Space Weather Service Delivery for Aviation

PECASUS - Pan-European Consortium for Aviation Space weather User Services

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Overview

- 1. Space Weather impacts for aviation
- 2. The PECASUS Consortium and different roles
- 3. Global SWX coordination and delivery







FMI space weather services

- Lead centre for PECASUS Consortium, the global Space Weather Centre for aviation designated by ICAO
- Auroras Now! Service for auroral tourism
 - Input: Near-Real-Time data from ground-based instruments maintained by FMI
 - E-mail alerts
- 24/7 space weather service
 - 24/7 monitoring as part of FMI multi-hazard early warning service
 - Scientist on call continuously available to support the duty officers
- Contributions to the Space Situational Awareness program of the European Space Agency (ESA):
 - Space weather impact in power lines and natural gas pipelines
 - Auroras and cloudiness in Fennoscandia
 - Ionospheric conditions for radio communication





Process for new services for aviation

- 2011 IATA requested ICAO for space weather services for civil aviation
- 2014 ICAO decided to develop space weather service centers (SWXCs)
- 2017 ICAO asked its member states about their interests to provide SWX
 - 8 states and 1 consortium (PECASUS) expressed their willingness to be audited
 - 2018/02 Audit of all candidates
- June 2018: ICAO Council approved a new version of Annex 3 with specification of SWX services
- October 2018: Air Navigation Commission (ANC) made final recommendation of 3 global and 2 regional SWX centres:
 - Global: PECASUS, US and ACFJ (consortium of Australia, Canada, France, Japan)
 - Regional: China/Russia & South Africa
- November 2018: ICAO Council designated three global and two regional centres
- December 2018 onwards: Ad-hoc coordination group under the ICAO MET Panel MISD to develop coordination of SWX provision





Space weather impact areas of interest for civil aviation

- Radiation at flight altitudes
 - Flights across polar areas
 - Air crew: Accumulated doses
- Problems in Global Navigation Satellite Systems (GNSS) and SATCOM
 - Errors in positioning
 - Scintillation in the signal amplitude and phase
- Disturbances in HF communication
 - Anomalous propagation paths
 - Variations in the usable frequencies





Effects on flight

- Pilots can take SWX Advisories into account in route planning e.g. by adjusting the flight altitude
- Problems in HF-communication can in some cases be overcome by using higher frequencies than in normal conditions
- SWX advisories will enhance the overall situational awareness of ANSPs while managing multiple flights in a coordinated manner
- For Operators, the advisories will be a useful additional asset when planning potential rerouting and consequent impacts on fuel consumption and crew scheduling.







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PECASUS Partners

- 1. The Finnish Meteorological Institute (FMI): management and verification aspects of the network and serves as the master gateway for international dissemination according to the ICAO regulations.
- The Solar-Terrestrial Centre of Excellence of Belgium (STCE): scientific and technical production of the advisories, which are composed from input by the Expert Groups (EG). STCE is the lead of Flight Radiation and Satellite Communications EGs
- 3. The Met Office (UK) provides the PECASUS backup services in the cases of malfunction of the Main Hub or Advisory Production Hub.
- 4. The German Aerospace Center (DLR) maintains advanced services for ionospheric background information to support high-precision positioning and navigation in Europe and globally and is the lead for GNSS EG
- 5. Space Research Center of the Polish Academy of Sciences (SRC) maintains continuous now-casting of regional ionospheric conditions over Europe, East Asia and Australia and provides forecasts on HF radio signal intensities at mid-latitudes and is the lead for HF EG
- 6. The Seibersdorf Laboratories (SL, Austria) leads work on radiation exposure due to cosmic radiation and support STCE on the RAD service
- 7. Istituto Nazionale di Geofisica e Vulcanologia (INGV, Italy) monitors continuously ionospheric and geomagnetic conditions for HF communication and for reliable GNSS services in the Mediterranean area and support the GNSS EG
- 8. Royal Netherlands Meteorological Institute (KNMI) conducts worldwide monitoring of ionospheric conditions for GNSS validation purposes using data from the Dutch aviation industry
- 9. Frederick University (FU, Cyprus) provides systematic measurements of ionospheric state in the far southeastern Mediterranean area and supports the GNSS EG





Joint effort by nine European countries





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Concept of Operations



PECASUS

PECASUS SWXC will provide information on prevailing and forthcoming SWX in advisories compatible with the standardized ICAO formats

The advisories will be given as a 24/7 service and in the areas of

- 1. High Frequency (HF) communications
- 2. Satellite Communications (SAT)
- 3. Navigation and surveillance based on Global Navigation Satellite Systems (GNSS), and
- 4. Radiation exposure (RAD) at flight altitudes
- Advisories will be based on Near-Real-Time (NRT) observations of
 - Coronal mass ejections (CMEs) and high-speed streams
 - Geomagnetic storms
 - Solar radiation storms
 - Solar flares
 - Solar radio bursts
 - Ionospheric activity







Radiation (RAD) service

RAD	Moderate	Severe
Effective radiation dose (microS/hour)	30	80

AVIDOS Sample Maps for Historical GLE42, Sep. 28th, 1989



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HF service

HF	Moderate	Severe
Kp-index	8	9
dB from 30 MHz riometer data	2 dayside	5⊦dayside
X-ray flux (0.1-0.8 nm) (W/m²)	1x10 ⁻⁴ (X1)	1x10 ⁻³ (X10)
MUF depression	30%	50%







GNSS/SATCOM service

GNSS	Moderate	Severe
Amplitude Scintillation (S4) (dimensionless)	0.5	0.8
Phase Scintillation (Sigma-Phi) (radian)	0.4	0.7
Total Electron Content (TEC) (TEC Units)	125	175

Scintillation measurement stations





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Example of space weather advisory message (HFCOM effects)

SWX ADVISORY DTG: SWXC:

ADVISORY NR: SWX EFFECT: OBS SWX: FCST SWX +6 HR: FCST SWX +12 HR: FCST SWX +18 HR: FCST SWX +24 HR:

RMK:

20161108/0100Z DONLON*

2016/1 HF COM SEV 08/0100Z DAYLIGHT SIDE 08/0700Z DAYLIGHT SIDE 08/1300Z DAYLIGHT SIDE 08/1900Z DAYLIGHT SIDE 09/0100Z NO SWX EXP

PERIODIC HF COM ABSORPTION AND LIKELY TO CONT IN THE NEAR TERM. CMPL AND PERIODIC LOSS OF HF ON THE SUNLIT SIDE OF THE EARTH EXP. CONT HF COM DEGRADATION LIKELY OVER THE NXT 7 DAYS. SEE WWW.PECASUS.ORG

NXT ADVISORY:

20161108/0700Z





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