Space Weather
International Guidance

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Outline

- Provisions and guidance on SWx at the global level
  - Current focus
  - What was done so far
  - What will be done

The global Space Weather partners

EUROCONTROL

Global cooperation to address global interests

- Why is there a global interest?
  - Recognition of the relationship between Space Weather events and ATM operations
  - Promoting global harmonization via a commonly defined operating environment with global standards for Space Weather products and services

Some clarification

- Why is there a global interest?
  - Recognition of the relationship between Space Weather events and ATM operations
  - Promoting global harmonization via a commonly defined operating environment with global standards for Space Weather products and services
- Why is this handled by the MET-section in ICAO?
  - Issue initially approached from a information requirements perspective
  - Space Weather info has similarities with ‘other’ Weather info
- Why do we need WMO?
  - When we discuss Weather we always need WMO……

WMO -- ICAO

- ICAO has a joint responsibility with World Meteorologica Organization (WMO) for Aeronautical MET
  - Working arrangements (1953)

- Two UN specialized agencies with dedicated roles and responsibilities
  - ICAO: Requirements and the use of MET
  - WMO: How (the core MET capability aspects)

- *Centres of Expertise on Space Weather: States that have an interest in Space Weather delegated the responsibility for Space Weather activities to their national MET service (WMO member)*

Space Weather is slightly different ....

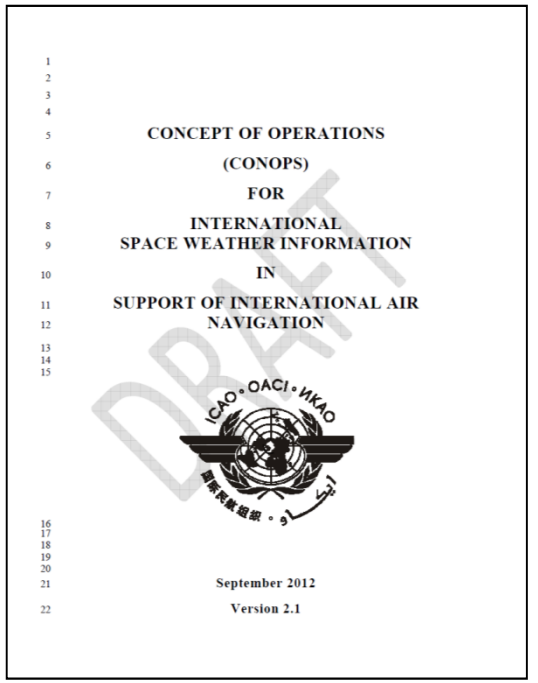
Ross Paulson photogra

The ICAO (MET) framework

- Well defined structure of Operations Groups
  - Support the Air Navigation Bureau with the Operations of defined ICAO functions
- These ICAO functions are operated by (volunteering) States
- International Airways Volcano Watch Operations Group (IAVWOPSG) is mandated to address Space Weather
  - Volcanic Ash
  - Accidental release of nuclear material

The ICAO developments till now

- Concept of Operations for International Space Weather information in Support of International Air Navigation
  - First round of comments were requested Q1/Q2 2012 (State Letter)
  - 2nd draft available, discussed this week


CONCEPT OF OPERATIONS
(CONOPS)
FOR
INTERNATIONAL
SPACE WEATHER INFORMATION
IN
SUPPORT OF INTERNATIONAL AIR
NAVIGATION
DRAFT
September 2012
Version 2.1

http://www.icao.int/safety/meteorology/iavwopsg/IAVWOPSG%20Meetings%20Metadata/IAVWOPSG.7.WP.019.8.pdf

One example:

- Define impact related classification of Space Weather events
- NOAA scales are the reference
  - Radiation Storm Events
  - Radio Black Events
  - Geomagnetic Storm Events

			•Flux level of ≥ 10 MeV particles (ions)*	•Number of events when flux level was met**
•S 5	•Extreme	•Biological: unavoidable high radiation hazard to astronauts on EVA (extra-vehicular activity); passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. *** Satellite operations: satellites may be rendered useless, memory impacts can cause loss of control, may cause serious noise in image data, star-trackers may be unable to locate sources; permanent damage to solar panels possible. Other systems: complete blackout of HF (high frequency) communications possible through the polar regions, and position errors make navigation operations extremely difficult.	•10^5	•Fewer tha 1 per cycle
•S 4	•Severe	•Biological: unavoidable radiation hazard to astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk.*** Satellite operations: may experience memory device problems and noise on imaging systems; star-tracker problems may cause orientation problems, and solar panel efficiency can be degraded. Other systems: blackout of HF radio communications through the polar regions and increased navigation errors over several days are likely.	•10^4	•3 per cycl
•S 3	•Strong	•Biological: radiation hazard avoidance recommended for astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk.*** Satellite operations: single-event upsets, noise in imaging systems, and slight reduction of efficiency in solar panel are likely. Other systems: degraded HF radio propagation through the polar regions and navigation position errors likely.	•10^3	•10 per cyc
•S 2	•Moderate	•Biological: passengers and crew in high-flying aircraft at high latitudes may be exposed to elevated radiation risk.*** Satellite operations: infrequent single-event upsets possible. Other systems: effects on HF propagation through the polar regions, and navigation at polar cap locations possibly affected.	•10^2	•25 per cyc
•S 1	•Minor	•Biological: none. Satellite operations: none. Other systems: minor impacts on HF radio in the polar regions.	•10	•50 per cyc

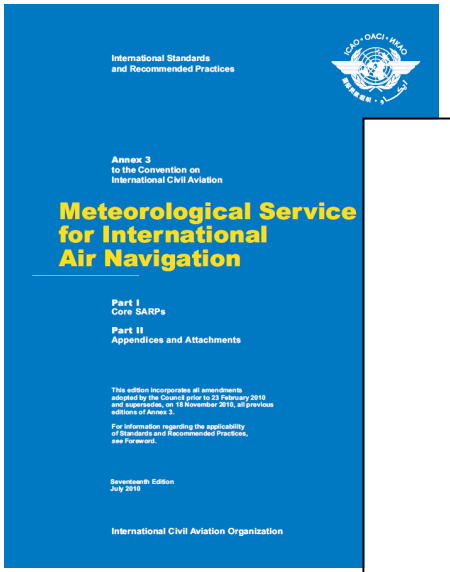
•R 5	•Extreme	•HF Radio: Complete HF (high frequenc entire sunlit side of the Earth lasting for results in no HF radio contact with mari this sector. Navigation: Low-frequency navigation s general aviation systems experience outa Earth for many hours, causing loss in po navigation errors in positioning for seve Earth, which may spread into the night s		
•R 4	•Severe	•HF Radio: HF radio communication bla side of Earth for one to two hours. HF ra time. Navigation: Outages of low-frequency n increased error in positioning for one to of satellite navigation possible on the su		
•R 3	•Strong	•HF Radio: Wide area blackout of HF ra radio contact for about an hour on sunlit Navigation: Low-frequency navigation s hour.		per cycle)
•R 2	•Moderate	•HF Radio: Limited blackout of HF radio communication on sunlit side, loss of radio contact for tens of minutes. Navigation: Degradation of low-frequency navigation signals for tens of minutes.	•M5 ($5x10^{-5}$)	•350 per cycle (300 days per cycle)
•R 1	•Minor	•HF Radio: Weak or minor degradation of HF radio communication on sunlit side, occasional loss of radio contact. Navigation: Low-frequency navigation signals degraded for brief intervals.	•M1 (10^{-5})	•2000 per cycle (950 days per cycle)

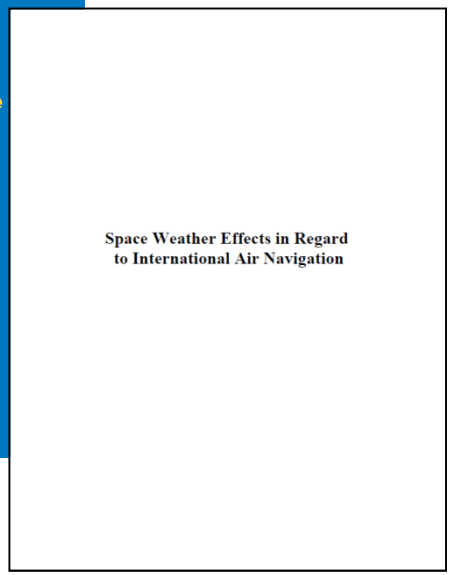
			•Kp values* determined every 3 hours	•Number of storm events when Kp level was met; (number of storm days)
•G 5	•Extreme	•Power systems: widespread voltage control problems and protective system problems can occur, some grid systems may experience complete collapse or blackouts. Transformers may experience damage. Spacecraft operations: may experience extensive surface charging, problems with orientation, uplink/downlink and tracking satellites. Other systems: pipeline currents can reach hundreds of amps, HF (high frequency) radio propagation may be impossible in many areas for one to two days, satellite navigation may be degraded for days, low-frequency radio navigation can be out for hours, and aurora has been seen as low as Florida and southern Texas (typically 40° geomagnetic lat.)**.	•Kp=9	•4 per cycle (4 days per cycle)
•G 4	•Severe	•Power systems: possible widespread voltage control problems and some protective systems will mistakenly trip out key assets from the grid. Spacecraft operations: may experience surface charging and tracking problems, corrections may be needed for orientation problems. Other systems: induced pipeline currents affect preventive measures, HF radio propagation sporadic, satellite navigation degraded for hours, low-frequency radio navigation disrupted, and aurora has been seen as low as Alabama and northern California (typically 45° geomagnetic lat.)**.	•Kp=8, including a 9-	•100 per cycle (60 days per cycle)
•G 3	•Strong	•Power systems: voltage corrections may be required, false alarms triggered on some protection devices. Spacecraft operations: surface charging may occur on satellite components, drag may increase on low-Earth-orbit satellites, and corrections may be needed for orientation problems. Other systems: intermittent satellite navigation and low-frequency radio navigation problems may occur, HF radio may be intermittent, and aurora has been seen as low as Illinois and Oregon (typically 50° geomagnetic lat.)**.	•Kp=7	•200 per cycle (130 days per cycle)
•G 2	•Moderate	•Power systems: high-latitude power systems may experience voltage alarms, long-duration storms may cause transformer damage. Spacecraft operations: corrective actions to orientation may be required by ground control; possible changes in drag affect orbit predictions. Other systems: HF radio propagation can fade at higher latitudes, and aurora has been seen as low as New York and Idaho (typically 55° geomagnetic lat.)**.	•Kp=6	•600 per cycle (360 days per cycle)
•G 1	•Minor	•Power systems: weak power grid fluctuations can occur. Spacecraft operations: minor impact on satellite operations possible. Other systems: migratory animals are affected at this and higher levels; aurora is commonly visible at high latitudes (northern Michigan and Maine)**.	•Kp=5	•1700 per cycle (900 days per cycle)

The ICAO ‘further’ plan

- Derive SWx information services requirements
  - In the form of a Standard and Recommended Practice (SARP) that will be added to ICAO Annex 3
  - Supporting Manual on the effects of Space Weather on International Air Navigation

    (Discussion started this week)
- *WMO to assist in capacity building of technical/infrastructure capability of MET service providers to provide SWx Information services*





The SARP proposal (summarised)

- Proposal developed by Australia, New Zealand, the United States and IATA, introducing:
  - ‘Space Weather Centres’ (SWXC) in analogy with VAAC
  - The provision for aircraft to report space weather
  - The provision to inform flight crew on space weather
  - Provisions for a ‘product’ named: Space Weather Notice for Aviation (SWNA)
  - References on SWx methodologies and SWx effects in the Manual on *Space Weather Effects in regard to International Air Navigation*

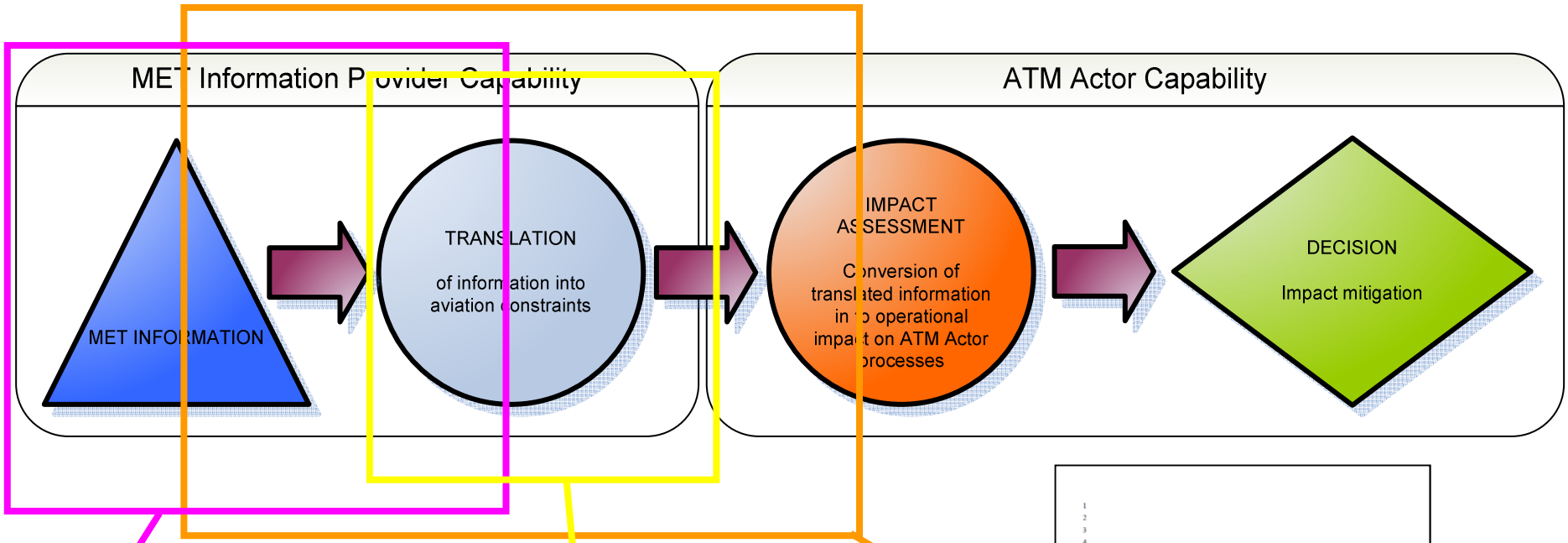
The SWNA (initial draft for discussion)

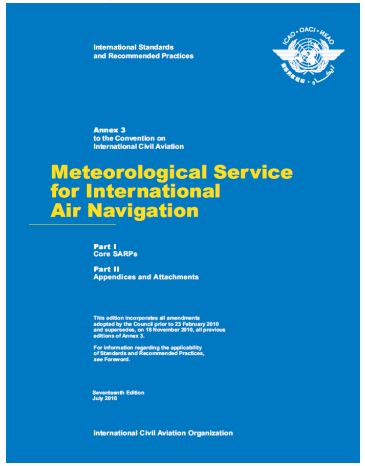
Table A2-3. Template for notice message for space weather information

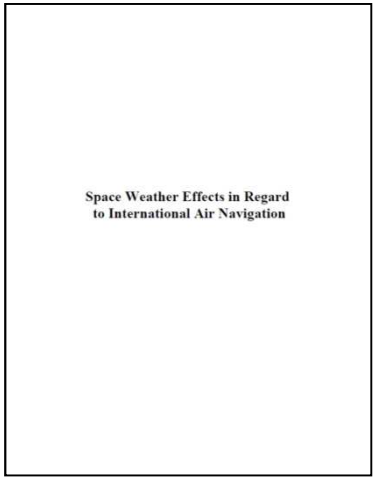
Key: M = inclusion mandatory, part of every message;
O = inclusion optional;
= = a double line indicates that the text following it should be placed on the subsequent line.

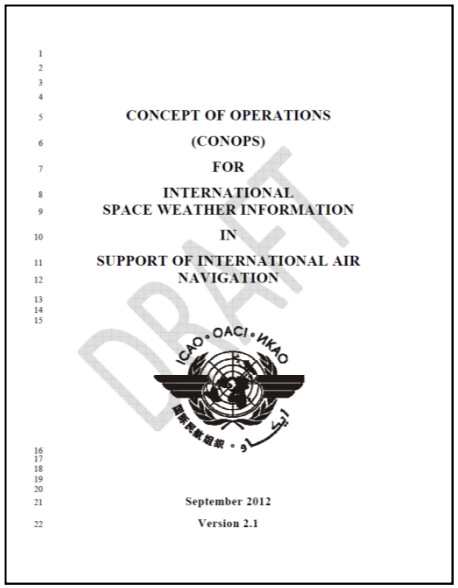
	Element	*Detailed content*	*Template(s)*	*Examples*
1	Identification of the type of message (M)	Type of message	SWNA	SWNA
2	Time of origin (M)	Year, month, day, time in UTC	DTG: nnnnnnnn/nnnnZ	DTG: 20121108/0113Z
3	Space weather type	Type of space weather event (geomagnetic storms, solar radiation storms, radio blackout)	SPACE WEATHER TYPE: GEOMAGNETIC STORM *or* SOLAR RADIATION STORM *or* SOLAR RADIO BLACKOUT	SPACE WEATHER TYPE: GEOMAGNETIC STORM
3	Name of SWXC (M)	Name of SWXC	SWXC: nnnnnnnnnn	SWXC: BOULDER
4	AREA (M)	Area of the globe affected	AREA: nnnnnnnnnn	AREA: NP-60N SP-70S NP-80N SP-80S
5	Notice number (M)	Number with year in full and unique message number	NOTICE NR: nnnn/[n][n][n]n	2013/1
6	Current colour code[1] (M)	Current aviation colour code	CURRENT AVIATION COLOUR CODE: RED *or* ORANGE *or* YELLOW *or* BLUE	CURRENT AVIATION COLOUR CODE: RED
7	Previous colour code[1]	Previous aviation colour code	PREVIOUS AVIATION COLOUR CODE: RED *or* ORANGE *or* YELLOW *or* BLUE	PREVIOUS AVIATION COLOUR CODE: ORANGE
8	Space weather details (M)	Concise statement that describes the activity	SPACE WEATHER DETAILS: Free text up to 256 characters	SPACE WEATHER DETAILS: ....
9	Onset of event (O)	If known, specify time of onset. Year, month, day, time in UTC	ONSET OF EVENT: nnnnnnnn/nnnnZ	ONSET OF EVENT: 20121108/0100Z
10	Duration of event (O)	If known, specify the expected duration of effects. Year, month, day, time in UTC	DURATION OF EVENT: nnnnnnnn/nnnnZ	DURATION OF EVENT: 20121108/1200Z
11	Remarks (O)	Brief comments on related topics (monitoring data, recent history of solar eruptions, etc.)	RMK: Free text up to 256 characters	RMK: ....
12	Contact (O)	Names, phone numbers (voice/fax), email addresses	CONTACT: Free text up to 256 characters	CONTACT: ....
13	Next notice (M)	Year, month, day, time in UTC	NXT NOTICE: nnnnnnnn/nnnnZ *or* Free text up to 256 characters *or* NO FURTHER NOTICE	NXT NOTICE: 20121108/0600Z NXT NOTICE: WILL BE ISSUED WHEN SPACE WEATHER CONDITIONS WARRANT CHANGING THE AVIATION COLOUR CODE OR WHEN A SIGNIFICANT SPACE WEATHER EVENT OCCURS WITHIN THE CURRENT COLOUR CODE. NXT NOTICE: NO FURTHER NOTICE

Consolidated view









Conclusion

- Provisions and guidance on SWx at the global level
  - Current focus
    - Development of SWx Information Provision provisions
    - Development of ‘effects on air navigation’ notion
  - What was done so far
    - First versions of CONOPS and Manual on Space Weather effects available
  - What will be done
    - Development of ICAO SARPs
    - Improving Manual on ‘effects’

First step in a commonly defined operating environment with global standards for Space Weather products and services

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Decision making process: Mid-2014 – Mid-2015

Publication: Mid-2016

Entry into force: November 2016

First step in a commonly defined operating environment with global standards for Space Weather products and services