ICAO NAT Region workshop on Radiation Exposure at Aircraft Altitudes

(virtual event 18 March 2026)

The ICAO EUR/NAT Office organised a virtual workshop, as a follow up to the NAT Space Weather Exercise NAT SWX 2025, on radiation aspects, and the following presentations were provided to the SWX experts:

1) Radiological protection from cosmic radiation in aviation by François Trompier, French Authority for Nuclear Safety and Radiation Protection (ASNR)
2) Cosmic ray-induced radiation doses in the terrestrial atmosphere by Nicolas Fuller, Karl-Ludwig Klein, Observatoire de Paris, Meudon, France
3) Space weather radiation impacts and mitigation for aircraft Including preliminary flight data from event of 11 November 2025 by Clive Dyer, Keith Ryden, Fan Lei, Paul Morris, Ben Clewer, Fraser Baird, Chris Davis, Surrey Space Centre in collaboration with MOSWOC
4) Radiation event 11/12 Nov 2025 by Klaus Sievers, Member, IFALPA ATS Committee

The French Authority for Nuclear Safety and Radiation Protection (ASNR) highlighted the main principles of radiological protection, established by the International Commission for Radiological Protection (ICRP), which is not an intergovernmental organization such as ICAO, but composed of international panels of eminent experts in radiological protection, and which has been publishing recommendations since 1928. It was recalled that, based on recommendations from the ICRP:

- The overall objective of radiological protection is to contribute to an appropriate level of protection for people and the environment against the harmful effects of radiation exposure, **without unduly restricting desirable human activities that may be associated with such exposure**.

- To prevent deterministic effects in humans and to reduce the risk of stochastic effects **as far as reasonably practicable**.

It should be noted that epidemiological studies have shown a link between cumulative dose and an increased risk of cancer at dose levels above 80 mSv. Even though for exposure below 80-100 mSv no statistical evidence exists, it is internationally assumed that a linear relationship without threshold exists between small amount of radiation dose and probability of cancer.

The Paris Observatory recalled that the typical exposure during a transatlantic flight is in the order of 0.08 mSv. That exposure is usually caused by secondary ionizing particle cascades resulting from the collisions of cosmic particles (Galactic Cosmic Rays, GCR) with atmospheric particles.

Rarely, a Ground Level Enhancement, GLE, caused by secondary ionizing particle cascades resulting from the collisions of high energy solar particles (mainly protons) with atmospheric particles, occurs and increases radiation at aircraft altitudes. The energy of the incident solar particles would have to be at least 200 MeV in order to produce secondary particle cascades above 10 km, and at least 430 MeV in order to reach ground level. It was recalled that radiation exposure (GCR, GLE) decreases with decreasing altitude and decreasing geomagnetic latitude.

GLEs can be detected on Earth by ground-based neutron monitors. The high energy channels of the GOES satellites are also useful to detect the arrival of high energy solar protons (300-700 MeV), but the 10 MeV and 50 MeV channels are irrelevant for radiation at aircraft altitudes in view of the above-mentioned energy levels.

It has been observed that most of the 77 GLEs which have been recorded would not have exceeded the ICAO MOD (30 µSv/h) and SEV (80 µSv/h) thresholds, while a few have significantly increased radiation exposure according to some radiation models. For instance:

The 23 February 1956 GLE was the strongest on record in recent history and radiation exposure at FL 400 and high latitudes during the first 4 hours of the GLE would have been about 9 mSv (Mishev et al.), still quite distant from the 80-100 mSv doses where data show an increase in cancers. Even though highly exceptional, stronger GLEs than the 1956 GLE cannot be ruled out.

The 20 January 2005 GLE would have multiplied by 2 or 3, to about 0.25 mSv, the typical radiation exposure on a transatlantic flight in the northern hemisphere. The increase in exposure would have been higher in the southern hemisphere, where the maximum dose rate at FL370 is estimated to have been 700 µSv/h for a few minutes.

More recently, a GLE occurred on 11th November 2025, and it is estimated by some radiation models that radiation exposure for a transatlantic flight would have been multiplied by 1.8. It was mentioned that the peak intensity and time profiles of GLEs differ, and that the occurrence of such events cannot currently be predicted with any reliability.

Various ICRP publications talk about radiation exposure in aviation, particularly ICRP Publication 132, which is titled “Radiological Protection from Cosmic Radiation in Aviation”.

To put exposure figures into perspective, the yearly total exposure of the French population ranges from 2 mSv to 14 mSv (6.4 mSv on average). The exposure from a Whole-Body medical scan is in the order of 10-12 mSv and of a chest X-ray about 0.1 mSv.

The ICRP recommends that the exposure of the public during planned exposure situations (such as the transit of a nuclear convoy through a town) be kept under 1 mSv.

It also recommends that the exposure of workers (occupational exposure) during planned exposure situations be kept under 20 mSv/year, averaged over defined 5-year periods (100 mSv in 5 years), with the further provision that the effective dose should not exceed 50 mSv in any single year (ICRP 103 Paragraph 244). In aviation, the exposure of flight crews is considered as occupational exposure (ICRP 132 Paragraph 42).

During a particularly strong GLE, such as the 23 February 1956 GLE, the conceptus of a pregnant flight crew could potentially be exposed to more than 1 mSv, and it is recalled that ICRP recommends that the working conditions of a pregnant worker, after declaration of pregnancy, should be such as to ensure that the additional dose to the embryo/fetus would not exceed about 1 mSv during the remainder of the pregnancy (ICRP Publication 132, Paragraph 72).

ICRP 132 Paragraph 65 recommends that airline management inform concerned aircraft crew about radiation and cosmic exposure through ad-hoc educational programmes or training sessions. Information could also be provided to crew at safety meetings.

Different States may have different radiological protection provisions. For example, in the European Union, several ICRP recommendations have been transposed by Euratom Directive No. 2013/59/EURATOM of 5 December 2013. Some States have implemented flight crew exposure monitoring programs, in order to verify compliance with the ICRP recommended occupational exposure dose limits.

Concerns were expressed about inconsistencies between the existing radiation models, which would benefit from more inflight radiation verification measurements during GLEs, and the time/process it might take for flight crews to be made aware of an ICAO radiation advisory. Activities aimed at measuring radiation in situ during GLEs were presented. In view of the preceding shortcomings and recalling that ICAO already requires aircraft operating above 49000 feet to be equipped with radiation detectors, views were expressed that the equipage of more aircraft with radiation detectors might be a way forward worth investigating, keeping in mind the ICRP recommendation of reducing radiation exposure as far as reasonably practicable. In keeping with ICRP radiological protection principles, care should be taken to avoid radiation exposure mitigating actions which would unreasonably increase risks to the travelling public.