An Approach to Cosmic Radiation Dose Assessment of RAF Aircrew

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Introduction

The Military Aviation Authority stipulates that 'Aviation Duty Holders and Commanders should take appropriate measures to assess the exposure to cosmic radiation when in flight, of those members of aircrew who are liable to be subject to cosmic radiation in excess of 1 mSv per year.' [1] This requirement is similar regulation 148(1) in The Air Navigation Order 2009 (which does not apply to Military aircraft) requiring assessment of aircrew exposure to cosmic radiation.

The RAF have participated in a number of trials designed by Dstl personnel to assess the exposure to cosmic radiation. These included installing active radiation monitoring equipment to TriStar aircraft on flights to the Falkland Islands and a large scale study into the accuracy of using passive personal dosimetry in determining personal dose received, compared against computational assessment [2].

Recent discussions between Dstl personnel identified a threshold dose estimate above which a more thorough computational dose assessment would be required.

Identifying affected aircrew

The RAF operate a wide variety of aircraft ranging from fast fighter jets, traditional jet airliners and cargo transport aircraft to surveillance aircraft. These aircraft operate at differing altitudes, fly at different speeds and in different locations all of which are dictated by operational requirements.

Operational aircraft, and personnel that support them are divided into 2 groups:

- 1 Group - Fast jest aircraft: Tornado GR4 and Typhoon
- 2 Group - Air transport (AT), air-to-air refuelling (A-A-R) and Intelligence, surveillance, targeting and reconnaissance (ISTAR) aircraft

A first step in identifying those members of aircrew who are likely to be exposed to a cosmic radiation dose in excess of 1 mSv per year can be achieved using computational assessment tools such as Cari-6 [3]. With details of typical routes flown, altitudes and hours flown typical maximum doses can be determined.

This approach reflects the guidance produced by the Department for Transport [4]. In cases where estimated doses are above 1 mSv but below 6 mSv, no further action is required except that the dose estimation be recorded. To ensure that predicted doses are not underestimating dose received by aircrew, it is recommended that a cut-off dose of 4 mSv be applied, which would require a more detailed assessment of the persons exposure using computational assessment.

1 Group

Typically fighter aircraft are not flown above 24,500 ft. It is generally accepted that aircrew flying below 26,000 ft will not receive a dose in excess of 1 mSv. There are occasions though, surveillance operations and transit to operational theatre, that fighter aircraft will fly at altitudes greater than 26,000 ft.

Based upon figures provided by the RAF the typical annual dose that is likely to be received 1 Group aircrew will be below the threshold level of 1 mSv (Figure 1).

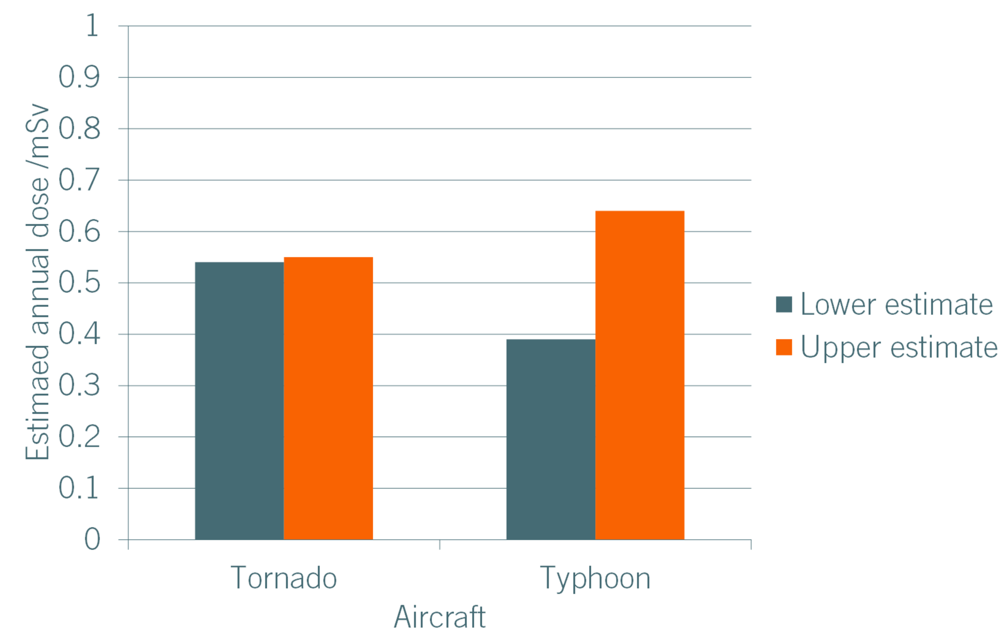
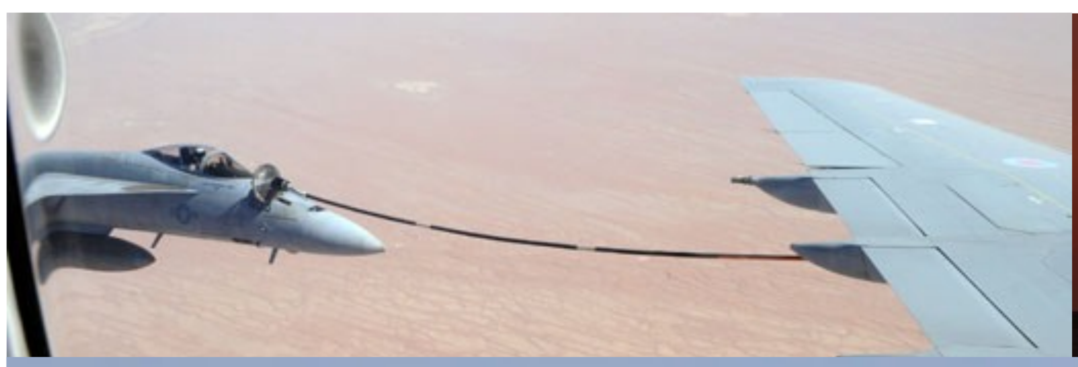
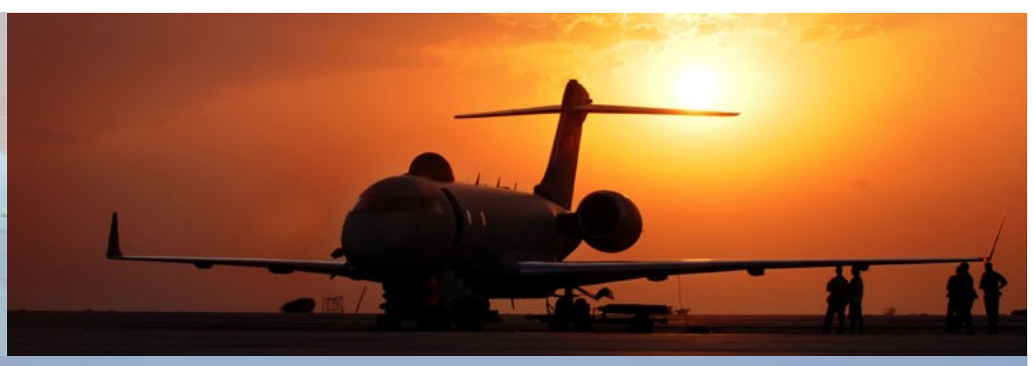


Figure 1 Comparison of annual doses to aircrew of selected 1 Gp aircraft based upon typical annual flying hours (130 hrs Typhoon, 180 hrs Tornado)

The dose estimates presented in Figure 1 have been calculated for flights at polar latitudes, as these represent the worst case dose estimates, for the maximum number of hours flown by aircrew of these aircraft. The majority of flights by these aircraft are below 24,500 ft, resulting in the 'lower estimate' (typical dose rate 3 μSv h⁻¹). The 'upper estimate' reflects the amount of flying by these aircraft above 24,500 ft, assuming an average flight altitude of 39,000 ft (typical dose rate of 6 μSv h⁻¹).





Some 1 Group aircraft have a flight ceiling in excess of 45,000 ft—where the dose rate is approximately quadruple that at 24,500 ft. It would take approximately 90 hrs for a pilot to receive a dose in excess of 1 mSv at 45,000 ft, which is an unlikely scenario.

2 Group

AT and A-A-R aircraft will routinely fly at higher altitudes and for longer periods of time than 1 Group aircraft. This results in a very different dose profile (Figure 2).

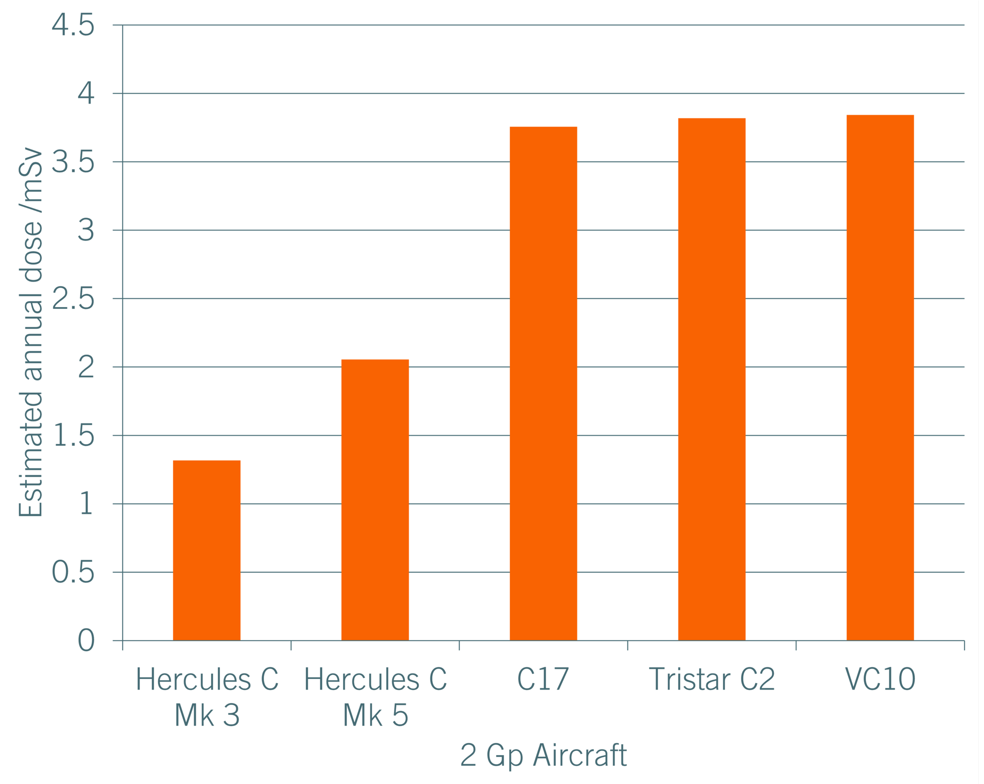


Figure 2 Comparison of annual doses to aircrew of selected 2 Gp aircraft based upon typical annual flying hours (900 hrs all types)

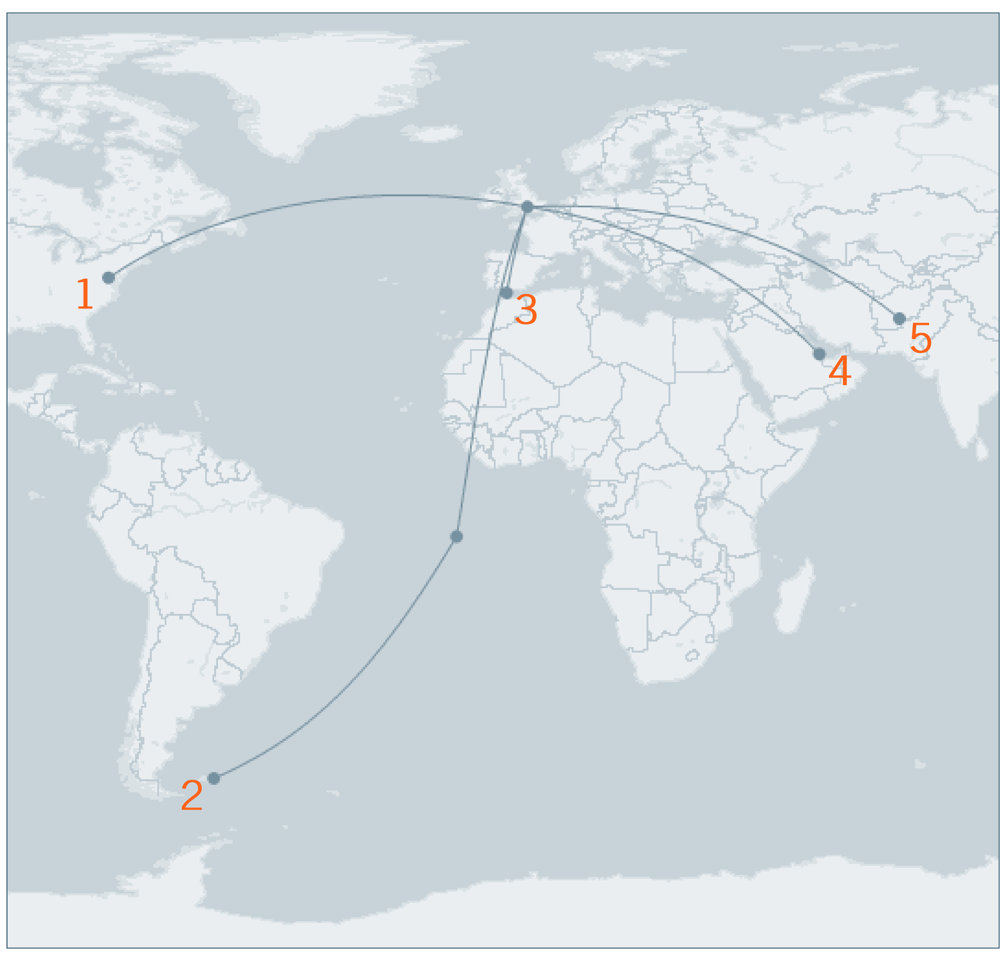
This dose profile was constructed from a weighted average of typical operational flights for these aircraft over the period Jan-2011—Dec-2011 using Cari-6 and presumed a 'great circle' distance from RAF Brize Norton to a selection of destinations. In reality, aircrew may fly some routes more frequently than others and distances may be longer owing to restrictions on flying through certain airspace. For aircrew serving on all five types of aircraft there is the potential to receive doses above 1 mSv. The doses on the turbo-prop aircraft (Hercules) are much lower owing to the lower altitude at which they operate. Aircrew flying on-board C17, Tristar and VC10 aircraft have the potential to receive dose approaching 4 mSv depending upon route flown, frequency and solar activity.

ISTAR aircraft tend to operate non standard/circular flight paths, returning to the same location. Exact flight profiles are not available and this means that it is difficult to make computational predictions of dose. These aircraft typically fly at altitudes of between 33,000 and 45,000 ft flying for durations of at least 11 hours which can be extended with A-A-R. Owing to the higher altitudes and extended periods flown, RAF personnel on board ISTAR aircraft may be receiving some of the highest doses of all RAF personnel.

Proposed monitoring programme

Owing to the dose profile associated with the 1 and 2 Group aircraft, Commanders of 2 Group squadrons will have to ensure that the radiation dose received by aircrew are being assessed.

Dstl has proposed that, to minimise the burden on squadrons in making this assessment, a 'cosmic dose rate coefficient' be calculated based upon typical 2 Group flight profiles. This coefficient would be revised quarterly or if there is a major change to flight profiles. An example of how this may be calculated is presented in Figure 3. The dose rates were calculated using Cari-6 for flights at an altitude of 35,000 ft.



Route (Origin: Brize Norton)	% of flights	Dose rate /μSv h⁻¹
Route 1 →Washington	0	5.4
Route 2 →Falklands	0	5.5
Route 3 →Gibraltar	25	3.8
Route 4 →Doha	0	3.3
Route 5 →Kandahar	75	3.7
Dose rate coefficient	Average	4.3
	Weighted Average	3.7

Figure 3 Suggested cosmic dose rate coefficient calculation method

Either an average dose for all flight profiles can be used or a weighted average based upon the service personnel's flight log—selecting the flights that closely represent that in the log.

Aircrew log each flight; recording origin, destination and duration. Log book entries are reviewed monthly. It is suggested that during this review the dose received would be calculated:

$$\text{Cosmic dose rate coefficient} \times \text{Hours flown} = \text{Estimated Dose}$$

If the estimated dose exceeds 333 μSv (1/12 of 4 mSv) in any one month, then a more thorough computational assessment of dose will be carried out, taking greater account of the actual altitudes and routes flown to provide a refined estimation of the dose received.

Next steps

This proposal has been put forward to the RAF as a suggested way of complying with the MAA regulation, but it is not the only method under consideration. The RAF are also considering the use of a combined neutron and TLD dosimeter to asses the dose of 2 Group aircrew.

Discussions with the RAF are on going.

References
[1] Military Aviation Authority Regulatory, Fly 2000 Series Regulatory Articles, Regulation 2310(7)
[2] Assessment of dose to RAF aircrew due to cosmic radiation exposure DSTL/TR23054, L Jones and S Lee, 2007
[3] Available for download at: http://www.faa.gov/education_research/research/med_humanfacs/aeromedical/radiobiology/CARI6/index.cfm
[4] Protection of air crew from cosmic radiation: Guidance material, Department for Transport, May 2003

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