



Radiation Protection



● NO 156 — EVALUATION OF THE IMPLEMENTATION OF RADIATION PROTECTION MEASURES FOR AIRCREW

EUROPEAN COMMISSION

RADIATION PROTECTION N° 156

Evaluation of the implementation of radiation protection measures for aircrew

Final report of contract TREN/06/NUCL/S07.66018

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FOREWORD

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Under the terms of the Treaty establishing the European Atomic Energy Community, the Community, amongst other things, establishes uniform safety standards to protect the health of workers and of the general public against the dangers arising from ionizing radiation. The standards are approved by the Council, on a proposal from the Commission, established taking into account the opinion of the Group of Experts referred to in Article 31 of the Treaty. The most recent version of such standards is contained in Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation.

Directive 96/29/Euratom requires that special protection measures have to be implemented aimed at providing appropriate radiological protection for air crew. Article 42 stipulates that

“Each Member State shall make arrangements for undertakings operating aircraft to take account of exposure to cosmic radiation of air crew who are liable to be subject of exposure to more than 1 mSv per year. The undertakings shall take appropriate measures, in particular:

- to assess the exposure of the crew concerned,*
- to take into account the assessed exposure when organising working schedules with a view to reducing the doses of highly exposed air crew,*
- to inform the workers concerned of the health risks their work involves,*
- to apply Article 10 to female air crew,”*

In 2006, the Commission launched a study with the objective to assess and evaluate the current operational implementation of these requirements. The contract was awarded to BRENK Systemplanung who prepared three questionnaires specifically designed to receive information from different actors in this area, namely civil aviation authorities, aircraft operators and radiation protection authorities. Although response to the questionnaires, in particular from major airlines, was not fully satisfactory, the information collected is sufficient to gain an overview on the status of operational implementation of radiation protection measures for aircrew in each Member State.

The report provides a brief introduction into the subject including scientific information on cosmic radiation, typical exposure to air crew, measurement of cosmic radiation, and modelling of exposure to air crew, as well as the legal background. An extended chapter of the report contains a compilation of information on national legislation, use of dose registers, and operational implementation of the regulation for each country included in the study.

Augustin Janssens

Head of Radiation Protection Unit

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1 INTRODUCTION

Directive 96/29/Euratom, the Basic Safety Standards (BSS), has been published 13 May 1996, laying down basic safety standards for the health of workers and members of the general public against the dangers of ionizing radiation. Article 42 of the directive deals with the protection of air crews. EU member states have transposed the directive into national legislation. The details of the implementation of the directive vary greatly between member states. However, as aviation is an international business, it would be desirable that radiation protection was regulated in a similar way in at least all Member States of the EU, if not world-wide.

This study provides an overview of the status of the implementation of Article 42 of the Directive. It has been the aim to collect up-to-date information from civil aviation authorities, radiation protection authorities and aircraft operators as well as from the existing legislation in all EU Member States and to compile a picture of the current situation as well as of areas where improvement would be desirable or where there is room for harmonisation among Member States.

2 OBJECTIVES, SCOPE AND STRUCTURE OF THE PROJECT

2.1 Objectives

It is the aim of this project to first collect data on the implementation of the requirements of the BSS in various EU Member States and other countries, to compare these data and to draw conclusions with respect to initiatives the European Commission could take with respect to harmonisation. Differences in the ways the requirements of the BSS are transposed into national legislation may include:

- choice of dose limits and/or constraints lower than /in addition to that of the directive,
- procedures for the determination of the exposure,
- requirements for dose minimisation below the limits (ALARA),
- reporting requirements and
- inspection and enforcement.

Therefore, the evaluation and comparison of data concentrates on these fields and tries to identify other fields where either harmonisation has already been achieved or where a higher degree of harmonisation would be desirable.

2.2 Scope of the Project

The scope of the study includes the Member States of the EU, Candidate States of the EU, Norway and Switzerland.

Within these countries, data is sought to be obtained from different sources, shedding light on the subjects to be dealt with from different angles. Addressees for data acquisition include

- governmental bodies, e.g. ministries, agencies and other, as well as international organizations and associations,
- national aviation authorities and EASA,
- airlines.

In addition, data on special subjects may also be obtained from the aviation industry and the industry in the sector of radiation safety.

Data acquisition is performed via questionnaires. Separate questionnaires are developed and sent to the three groups of addressees:

1. National civil aviation authorities (CAA),
2. Airlines and other aircraft operators,
3. Radiation protection authorities,

as the data that is sought to be obtained from each group differs.

2.3 Structure of the Project

The project has been structured into five work packages (WP) that are shortly summarised in the following:

2.3.1 WP1: Collection of Information

The first work package comprises the data collection, which comprises aviation authorities, radiation protection authorities as well as airlines and other aircraft operators. The first step is to compile lists of addresses and contact partners within these organisations for data collection. Data collection is done via questionnaires that are tailored to the various groups of addressees.

2.3.2 WP2: Description of Legal Framework and Experiences

In the second work package, the legal framework, provisions and the experiences are described for all states included in this study. The legal framework may include dose limits and other types of limits for air crews, definition and attribution of responsibilities, monitoring, medical surveillance, responsibilities of airlines / aircraft operators and of air crews, interfaces radiation protection - aviation regulation and interfaces between national and international organisation.

2.3.3 WP3: Comprehensive Evaluation

In this work package, the information gathered in WP1 and WP2 is evaluated, taking into account the following criteria:

Degree of implementation

It is described in how far the implementations represent a one-to-one transformation of the requirements of the BSS or whether a higher degree of protection (e.g. lower limits/constraints) has been adopted. Particular attention is given to in how far the Candidate States, Norway and Switzerland have adopted similar or compatible legislation.

Degree of harmonisation

It is described whether the implementations in the various states are compatible with each other. This includes in particular the degree of protection and the administrative compatibility of the implementations.

Quantification of dose reduction

A quantification of the effect of the implementation of the legislation in terms of the maximum individual and the collective dose is attempted, based on the results of WP2. In particular, a comparison with situation before and after the implementation of the

directive is aimed at. The quality of the quantification of the dose reduction depends largely on the quality of the raw data available.

Quantification of costs

A quantification of the effect of the implementation of the legislation in terms of the cost for the air industry is attempted, based on the results of WP2. For the degree of quantification, the same caveat as above applies.

Quantification of efficiency

A cost-benefit analysis is performed. Where possible, an evaluation of cost per dose reduction is aimed at.

2.3.4 WP4: Suggestions for Measures for Optimisation and International Harmonisation

Based on the results of WP3, the possibilities for optimisation are discussed. Particular attention is paid to the aims harmonisation of the degree of protection, harmonisation of the organisation of the radiation protection, with regard of the simplification for the industry and cost-benefit optimisation. It is discussed, in what way initiatives of the Commission can contribute to the realisation of these aims.

2.3.5 WP5: Project Management, Reports and Presentation

The last work package comprises all work related to the project management, to the preparation of reports and to the presentation of results. It extends from the beginning to the end of the project.

2.4 Structure of the Report

This report is structured as follows:

- Section 3 gives an introduction to exposure to aircrew by cosmic radiation and presents data for exposure and its variation from a large number of actual flights,
- Section 4 presents the methods and status of data acquisition from civil aviation authorities, from airlines and aircraft operators and from radiation protection authorities,
- Section 5 gives a country-by-country overview of the information that has been compiled from the regulatory framework and from the answers to the questionnaires,
- Section 6 presents an evaluation of the answers received to the questionnaire grouped according to topics,

- Section 7 presents the conclusions from the acquired data and draws overarching conclusions from the information in sections 4 to 6,
- Section 8 provides the references.

This report is accompanied by a CD-ROM containing all questionnaires received from civil aviation authorities, airlines and aircraft operators and radiation protection authorities. This CD-ROM also contains the letter of introduction that has been issued by the European Commission to support the data acquisition..

3 BACKGROUND

The topic of cosmic radiation and its effect on humans has been dealt with in various overviews and papers. The following summary of the most important points has been compiled from various sources, mainly [WHO 05] and [EUR 04]. This summary has been included in this report to provide an overview of the main factors influencing the doses received by aircrew and passengers and to help understanding the background of regulations and measures for control and reduction of doses presented in sections 5 and 6.

3.1 Cosmic Radiation

Cosmic radiation is a form of ionizing radiation. Radiation particles constantly travel through the universe and reach the Earth's atmosphere. Cosmic Radiation mainly consists of primary particles (e.g., protons, electrons, and heavier ions) and secondary particles (e.g. neutrons) formed when these particles reach the Earth's atmosphere. At sea level cosmic radiation contributes about 13% to the natural background radiation. The origin of this particle radiation is from sources outside the solar system. The radiation is isotropic and constant over time. In addition, there are very rare solar flares (see below) with a duration ranging from minutes to several hours.

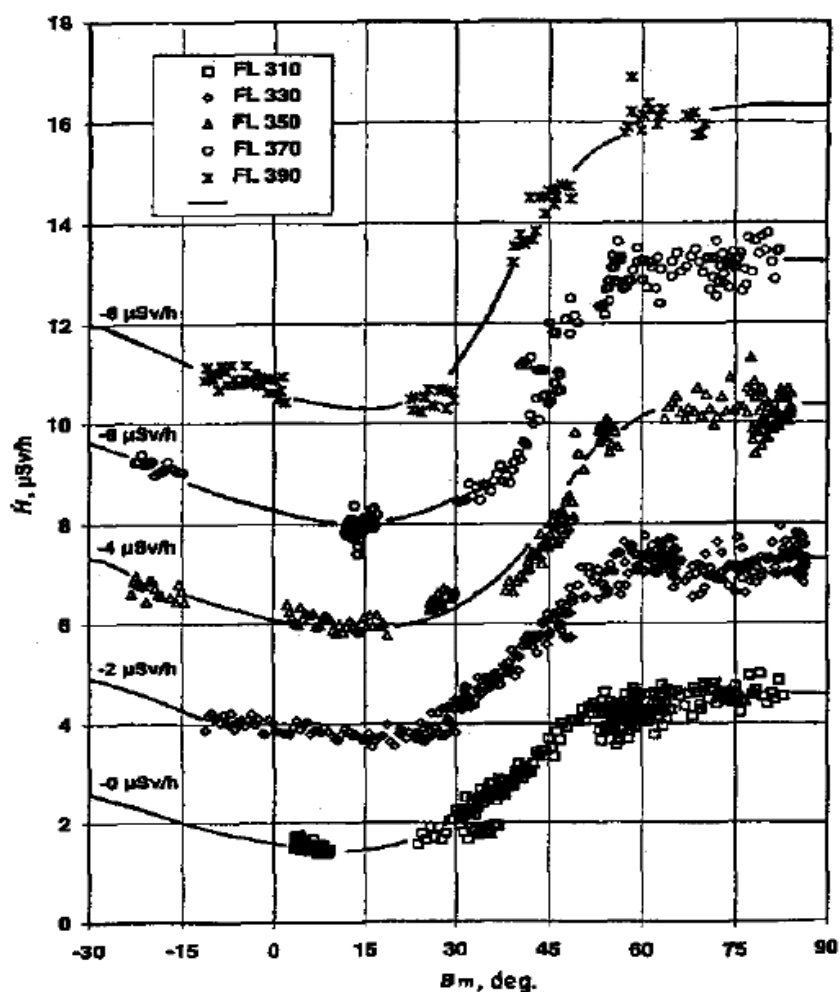
Cosmic radiation is different from other forms of ionizing radiation. For example, nuclear industry workers or medical personnel are mostly exposed to gamma-radiation and X-rays. In contrast, neutrons contribute up to 50% of the effective radiation dose that aircrew and air travellers receive from cosmic radiation. The biological effects of these neutrons and cosmic radiation in general are not fully understood at this time, which is one reason why health studies of aircrew are being conducted worldwide.

The level of cosmic radiation in the Earth's atmosphere depends primarily on four factors, listed here in order of their importance in contributing to radiation levels:

1. **Altitude:** The Earth's atmospheric layer provides significant shielding from cosmic radiation. At higher altitudes, this shielding effect decreases, leading to higher levels of cosmic radiation. The radiation exposure at conventional aircraft flight altitudes of 30.000 - 40.000 feet (9 - 12 km) is about 100 times higher than on the ground. Cosmic radiation particles may be electrically charged and are thus deflected by the Earth's magnetic field, which is the reason why doses of cosmic radiation become larger at higher latitudes towards the Earth's magnetic poles.
2. **Geographic Latitude:** The Earth's magnetic field deflects many cosmic radiation particles that would otherwise reach ground level. This shielding is most effective at the equator and decreases at higher latitudes, essentially disappearing at the poles. As a result, there is approximately a doubling of cosmic radiation exposure from the equator to the magnetic poles. Figure 1 provides an overview of the dependence of the dose rate from cosmic radiation as a function of the geographical latitude. Above about 55° latitude, the exposure level shows a plateau which reflects the fact that at this latitude the geomagnetic cut-off effect is equal to the effect of absorption of the particles in the atmosphere.

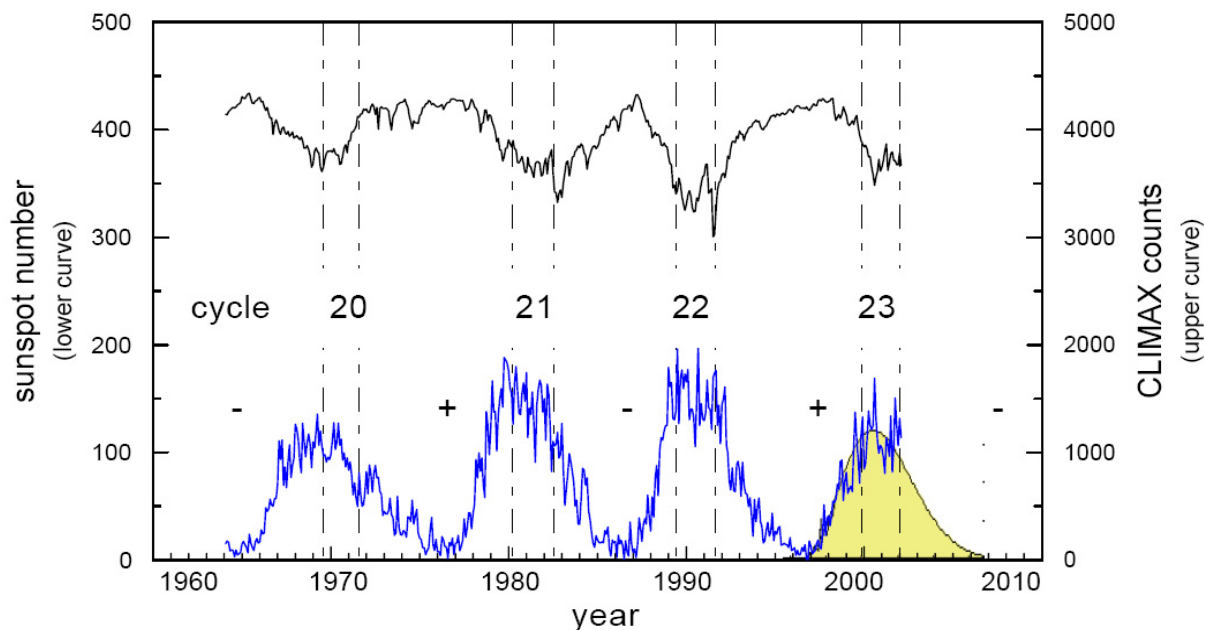
3. Normal Solar Activity: The Sun's activity varies in a predictable way with a cycle of approximately 11 years. Higher solar activity leads to lower cosmic radiation levels and vice versa, due to the resulting magnetic field of the Sun deflecting radiation away from the Earth. As an example, the neutron flux at ground level, which is primarily caused by the cosmic radiation, is shown as a function of time and in connection with the solar activity (indicated by the sunspot number) in Figure 2.
4. Solar Proton Events (SPEs) (also sometimes called "solar particle events" or "solar events"): Occasionally large explosive ejections of charged particles occur on the sun. They can lead to sudden increases in radiation levels in the atmosphere and on Earth, the solar proton events. SPEs are not predictable, and levels of radiation caused by an SPE are not uniform over the Earth. Large SPEs in which significant levels of cosmic radiation reach Earth are rare events. The number of very large fluence SPEs per solar cycle is extremely variable, ranging from 0 to 8 per solar cycle.

Figure 1: Dose rates at different flight levels (FL) as a function of the geographical latitude [REI 03]



N.b.: there is an offset of 2 $\mu\text{Sv/h}$ for adjacent curves for better differentiation

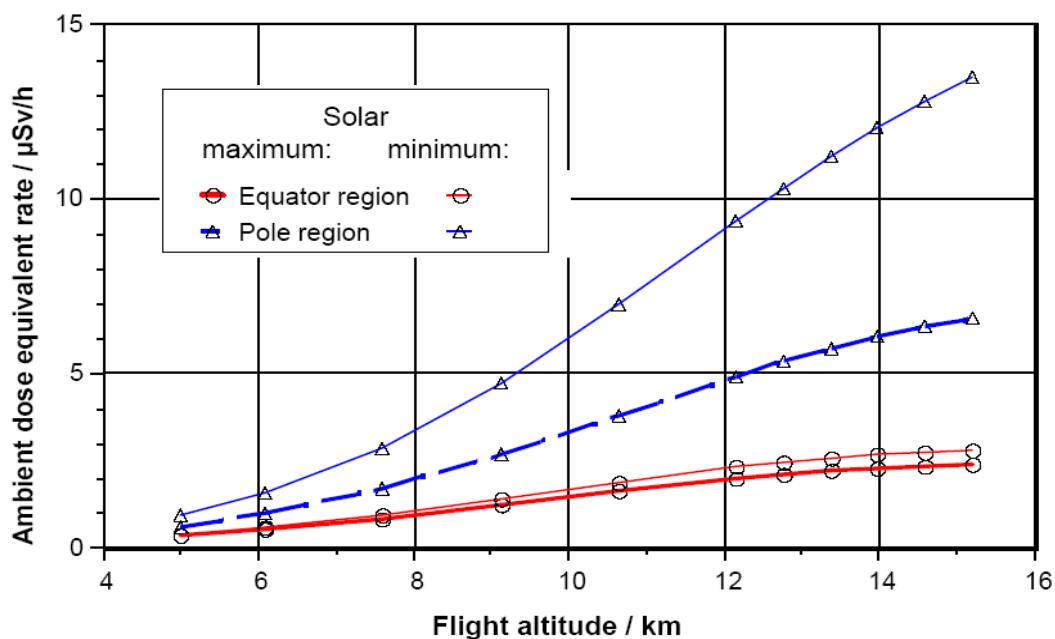
Figure 2: Sunspot number (lower curve) and monthly averaged climax neutron monitor count rate per hour (divided by 100) for solar cycles 20 through 23 (from 1964 to begin of 2002, estimations until 2008) (from [EUR 04]).



The vertical dashed lines indicate the periods (around 2 years each) of solar reversal; +/- specifies the respective polarity of the field model of NASA Johnson Space Center. The shaded area is the solar activity predicted by the NASA Marshall Space Flight Center.

A combination of the influences of altitude and latitude (Figure 1) as well as solar activity (Figure 2) on the (calculated) dose rates is shown in the diagram of Figure 3.

Figure 3: Calculated ambient dose equivalent rate, $dH^*(10)/dt$, for conditions close to solar maximum activity (Jan.1990) and close to solar minimum (Jan. 1998), both at zero-meridian ($\lambda=0^\circ$) and geographic latitude ϕ of 0° (red lines) resp. 90° (blue lines) [EUR 04]



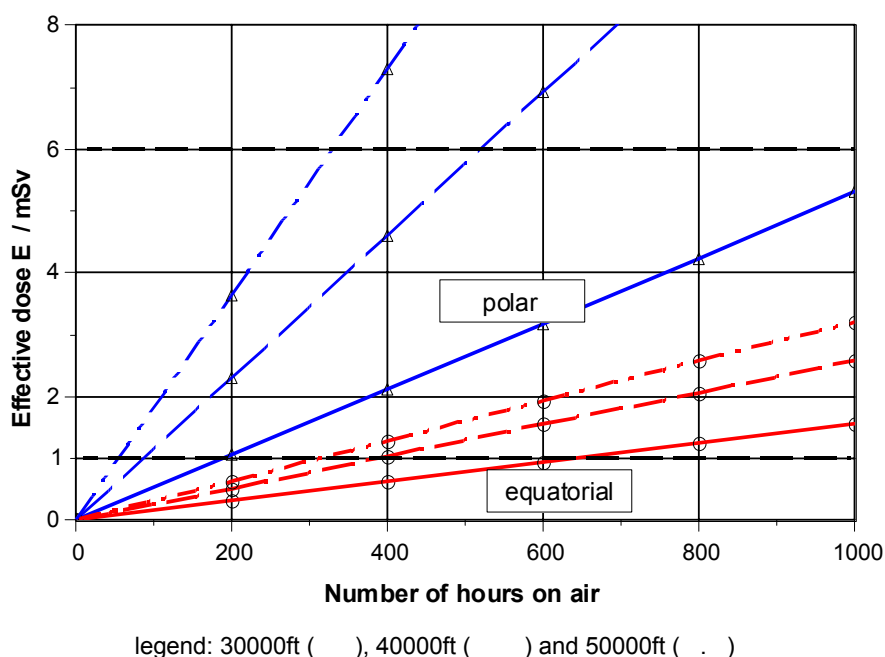
3.2 Typical Exposure of Air Crew

The exposure of aircrews can be calculated if the height, latitude and flight duration is known. Thus, it is possible to determine the exposure by computational methods, by direct measurements or by a combination of both. While radiation protection e.g. by shielding is not feasible, the total exposure per year can be influenced by assigning aircrews to specific routes or by the choice of the altitude and route of flights. However, changing a flight's route to lower latitudes and altitudes has heavy adverse effects on fuel consumption and flight duration. The conflicting goals suggest a need for an optimisation (ALARA) procedure.

The dose rate for typical flight situations is in the range of a few μSv per hour, but varies strongly with altitude and latitude, as addressed in section 0. Doses from cosmic radiation thus become larger with increasing altitude. The typical exposure of aircrews performing long-distance flights is of the order of a few mSv per year.

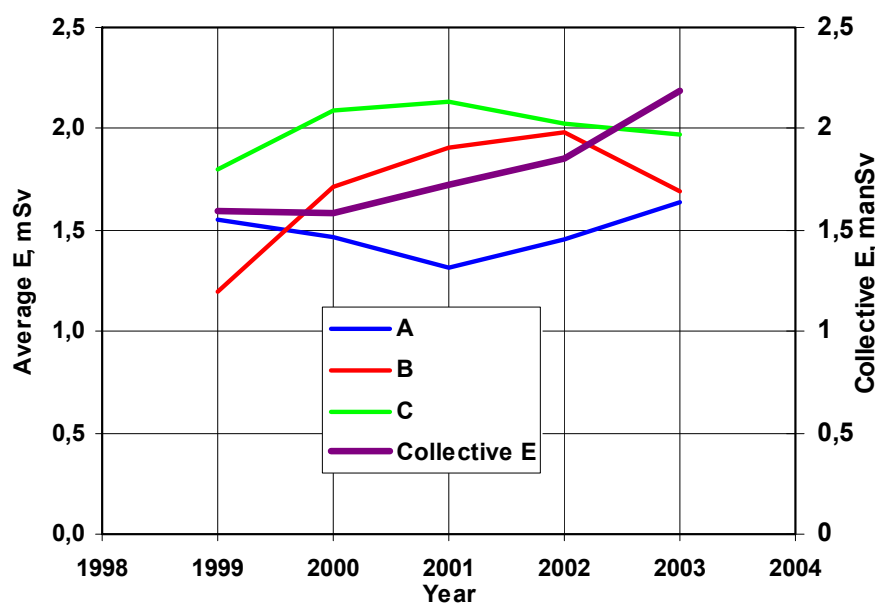
Starting from the data on the average dose rate as a function of geographical latitude and of flight level, as e.g. shown in Figure 1, the duration until a certain dose has been reached can be calculated. Figure 4 shows the minimum number of flight hours needed to obtain an annual dose of 6 mSv in a period of solar minimum in two different areas (polar and equatorial) and three flight altitudes. It can be seen that air crew on long-haul flights in polar routes are likely to obtain doses in the range of 6 mSv/a if they are on regular duty on such flights, while this is less likely or unlikely on flights in lower altitudes and lower latitudes.

Figure 4: Minimum number of flight hours needed to obtain annual dose of 6 mSv (Jan. 1998, solar minimum) in polar and equatorial regions for three flight altitudes [WHO 05]



Typical dose distributions for airlines that also cover long distances show that typical average doses are in the range between 1 and 2.5 mSv/a, as shown in Figure 5, with some variation according to the number of flights, flight routes etc. This figure also indicates that some fluctuation in the average doses of personnel of a specific airline as well as in the collective dose of personnel of various airlines in a country can be expected.

Figure 5: Evolution of the annual average dose and collective dose (E) with time for three airlines in the Czech Republic [FRA 03]



The dose values for aircrew from single flights are today usually obtained from computer programmes modelling and integrating the dose rates along the flight path in the various altitudes. These computer models are validated by measurements carried out in some aircrafts. An overview of results is provided in section 3.3.

3.3 Methods for Measurements of Cosmic Radiation in Aircraft and Computer Software for Modelling Exposure

3.3.1 Available Measurement Techniques

Measurements of cosmic radiation in aircraft have to register all relevant types of particles. At altitudes between 9 km and 20 km, the dose equivalent is due primarily to electrons and neutrons; the neutron component varies between 30 % and 50 %. The neutron component increases much faster with increasing geomagnetic latitude than the ionising component. [SSK 98]

Reference measurements are conducted with TEPCs (tissue-equivalent proportional counters), which are capable of measuring $H^*(10)$ directly, or to use several detectors that can register the various types of radiation (i.e. ionisation chambers, proportional or scintillation counters for the ionising component and so-called rem counters for the neutron

component) [SSK 03]. The TEPC is a good reference instrument that is suitable for the complex radiation composition during flights at altitudes on the order of 10 km or above. The measurements are based on the absorbed dose in tissue equivalent material. This is the reason why the exact composition of the radiation field does not need to be known.

A typical TEPC has a sensitive volume in the form of a small cylinder (e.g. with a diameter of 5 cm and a length of 5 cm) that is filled at low pressure (33 hPa) with a gas that is "equivalent" to biological tissue (e.g. a gas based on propane: 50% C₃H₈, 40% CO₂ and 5% N₂). Such a detector simulates a very small biological structure (length of a few μm) located inside the organism at a depth of e.g. 1 cm. It is sensitive to directly ionising particles (ions, electrons and gamma rays) as well as to neutrons via the charged secondary particles created by them in the walls of the counter. It measures the energy depositions of each particle in its volume, with the entire deposited energy being obtained by integrating the contributions of all particles. This is the basis for calculation of the equivalent dose, which is in this way derived from measurement of the energy losses of all particles crossing the detector, independent of the type of radiation. The equivalent dose can therefore be determined without correction factors depending on the type of radiation.

One of the problems of a TEPC is its relatively low sensitivity, which results in higher statistical uncertainties than observed with other devices. Furthermore, events from low-LET particles are much more frequent than high LET-particles, but contribute less to the total dose equivalent. Thus, the uncertainty analysis is more complicated.

A TEPC is not easy to handle and needs skilled personnel for operation and readout. It is therefore mainly used for calibration purposes, while many routine measurements on board of aircrafts are carried with other types of detectors; mainly photon and neutron monitors. The measurement results from both instruments have to be added to obtain the total dose that would be measured by a TEPC directly.

Other types of instruments that can be used to measure a part of the particle spectrum are electronic dosimeters, which can display the personal dose directly. The use of uncomplicated routine area dosimeters for individual radiation types that have been laboratory tested under reference conditions may be practicable in aircraft in cases where the composition of the radiation field can be regarded as largely constant and where it is therefore sufficient to measure only one part of the radiation field. Such devices would need to be calibrated against a TEPC on measuring flights. [SSK 03]

The TEPC is widely used for determining dose data during flights. In an overview study reported in [EUR 04], the tissue equivalent proportional counter (TEPC) was the experimental device favoured by eight groups, who employed it either as the only instrumentation or in combination with other devices, as shown in Table 1. Other types of detectors, which were used less frequently, are neutron detectors, high pressure ionisation chambers and scintillation dose rate meters.

Table 1: List of data sets available for the calculation of integral aviation doses during experimental flights (from [EUR 04])

Institution	Author(s) or primary investigator	Number of measurements	Period of time	Measured integral data (method)
IRSN	Bottollier	8	1996-1998	TEPC
SSI	Kyllönen/Lindborg	20	1998-2003	TEPC
NRPB	Bartlett/Hager	18	1997-2002	Track detectors and TLDs
DIAS	O'Sullivan/Zhou	18	1993-2002	Track detectors
ANPA	Tommasino	24	1997-2002	LINUS, IC, TEPC, ANPA-stack
GSF	Schraube/Regulla	21	1990-1993	NM, NMX, Sci, IC
Uni Kiel	Reitz/Beaujean	27	1996-2003	DOSTEL
CAS	Spurny	86	1991-1999	TEPC + multidetector
PTB (ACREM)	Schrewe	39	1997-1999	NM, NMX, Sci, IC
ARCS (ACREM)	Beck	39	1997-1999	TEPC, IC, NM, GM
RMC	Lewis	65	1999	TEPC
IBERIA	Saez-Vergara	69	2001	TEPC, SWENDI, IC, etc.
NPL	Taylor	46	2000	TEPC

LINUS, NM, NMX, SWENDI = neutron moderator detectors - TEPC = tissue equivalent proportional counters
 IC = high pressure ionisation chamber - Sci = scintillation dose rate meter

The actual installation of any of such measurement devices in an aircraft is subject to a number of rules and permits, which cannot be further outlined here. A short overview of such requirements can be found in [SSK 98].

3.3.2 Computer Models

The use of computer models to determine the dose to aircrew on specified flight routes is pursued since the 1980s. Computer programs for routine use have been developed in the early 1990s. A short overview is given e.g. in [SSK 03] and [EUR 04].

As described in [EUR 04], there are a number of radiation transport codes used to calculate the radiation field at aircraft altitudes and at sea level produced by galactic cosmic radiation, for example LUIN, FLUKA, GEANT, LAHET, MCNPX and MARS. There are similar number of methods in current use, which are based on the results of such calculations to compute dose to aircraft crew, for example:

- CARI (using the LUIN-code that is based on a general analytical solution of the transport equation of the cosmic radiation field),
- EPCARD (using FLUKA MC-calculations of the radiation field under all solar and geomagnetic conditions),

- FREE (FREEv1.0 was originally based on data of the transport code LUIN, while during recent years an improved code, PLOTINUS, became available as database of FREE, which takes into account short-term variations of the solar modulation, too),
- PC-AIRE (using experimental measurements with fitting, i.e. using a hybrid method with analytical fits to $H^*(10)$ experimental data and a scaling ratio to convert to effective dose results based on LUIN and on FLUKA calculations),
- SIEVERT (using the data from CARI, and since January 2004 from EPCARD), and
- the algorithm of Pelliccioni (using FLUKA).

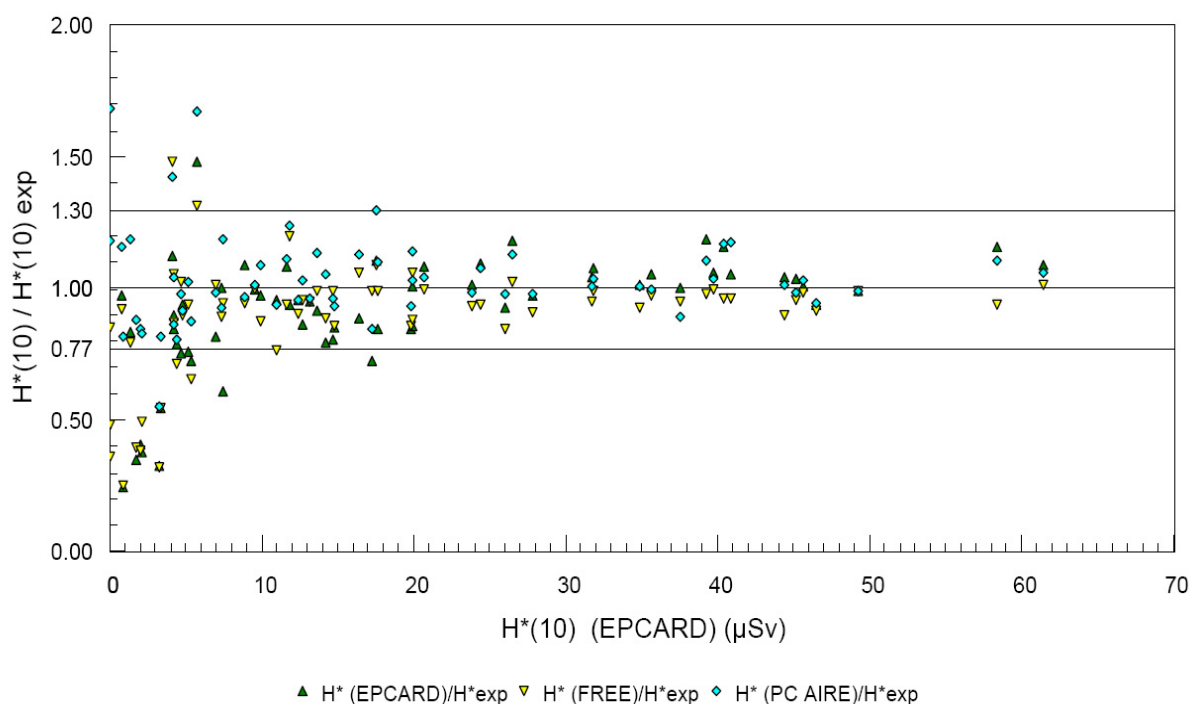
At present, none of these consider the influence of the aircraft on the particle fluence. More information on the calculation methods and the use of these codes can be obtained in the extensive Appendix B of [EUR 04].

3.3.3 Comparison between Results of Computer Models and Dose Measurements

A broad comparison between results of measurement and of computer codes is drawn in the document RP 140 [EUR 04]. This comparison has been carried out in a phenomenological way between calculated radiation doses obtained along civil flight routes and with experimental data for a number of flights, for which data were available either from integrating (passive or active) devices or dose rate measuring instruments after integration over the time differential data. Four computer codes were used in this study: CARI, EPCARD, FREE and PCAIRE.

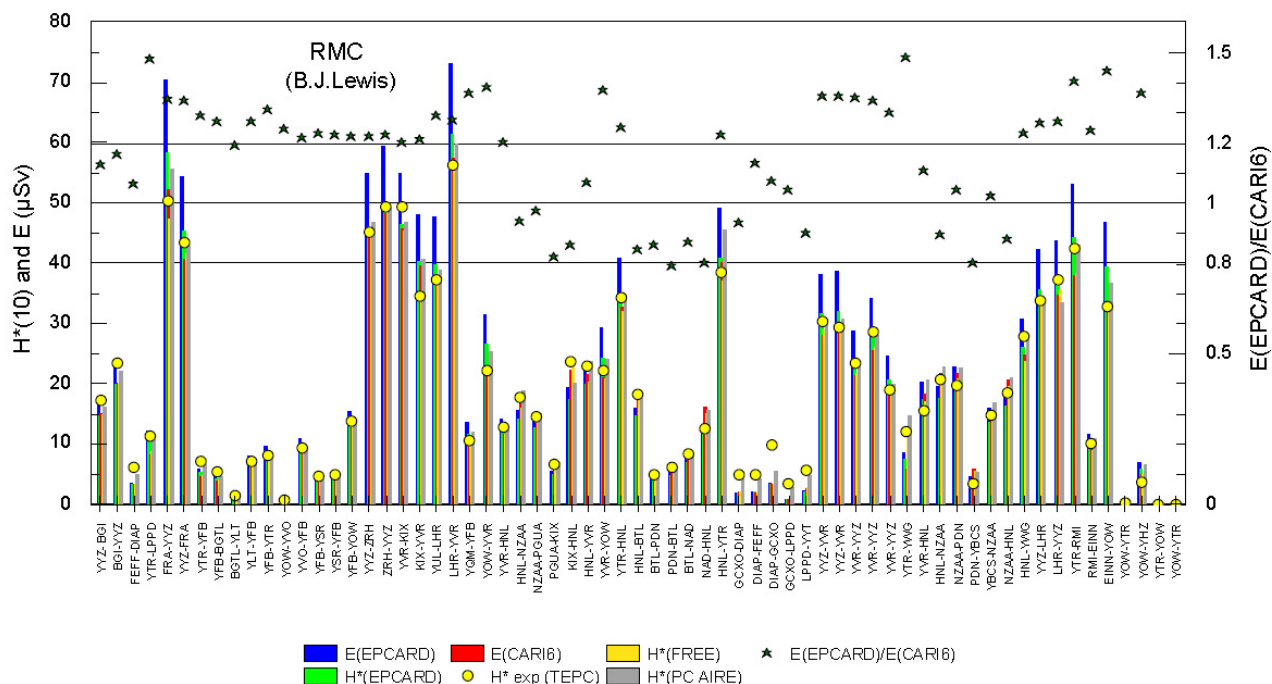
Figure 6 shows one of the graphical representations of the comparison provided in [EUR 04], plotting the ratio of calculated route doses to experimental data of RMC, when using EPCARD, FREE and PCAIRE. While the abscissa shows the integral dose for the entire flight, the ordinate shows the ratio between the results calculated with the three programs. It becomes obvious that the scatter (i.e. the uncertainty of the calculations) decreases with increasing dose.

Figure 6: Ratio of calculated route doses to experimental data of RMC, when using EPCARD, FREE and PCAIRE [EUR 04]



While Figure 6 provides an overview of all data included in the comparison in [EUR 04], it does not show the variability of measurements and computed dose data for specific flights. Numerous evaluations from all working groups listed in Table 1 are provided in [EUR 04], which is the reason why only one illustrative example can be reproduced here. Figure 7 shows the data provided by RMC (Royal Military College of Canada, Kingston, Ontario) for 65 individual flights, obtained by the various computer codes (coloured bars) and by measurements (yellow dots). It further shows the ratio between results from EPCARD and CARI6. A general tendency of overestimation of measured doses by computer codes, especially for higher doses, can be observed. In addition, the ratio between the doses calculated by EPCARD and by CARI6 is mostly larger than 1 (the blue bar is almost always longer than the other bars). This is a tendency which is visible also in most other comparisons provided in [EUR 04].

Figure 7: Calculated doses and experimental findings for flights of RMC (1999) (from [EUR 04])



With respect to conclusions on the evaluation of solar events in measurements, RP 140 [EUR 04] comes to the following conclusion: “There were insufficient relevant experimental results to be able to determine the influence of solar particle events. It is strongly recommended that solar events are considered in future studies.”

A further overview of results obtained by computer codes and from measurements has been provided in the paper [LEW 02]. This paper comes to the conclusion that the agreement between measurements and results from computer models is generally quite satisfactory:

“(1) A tissue-equivalent proportional counter (TEPC) was utilised to conduct an extensive series of in-flight measurements to investigate aircrew radiation exposure at jet aircraft altitudes during a solar cycle. The spectral data have yielded over 1600 data points (5 min average). These results agree very well with those from instruments measuring low and high LET radiation separately. A semi-empirical model has been developed from these data to describe the ambient dose equivalent rate as a function of position (vertical cut-off rigidity), altitude (atmospheric depth) and date (solar modulation) for route dose prediction of aircrew exposure. The model has been extended up to an altitude of 32 km based on balloon-borne experiments. Using the most recent data acquired on 14 flights (i.e. during solar maximum conditions), a correlation that is experimentally derived is now available for the prediction of solar cycle effects. However, continued measurement over the solar cycle is needed in order to ascertain which representation best characterises the changing solar modulation (i.e. the heliocentric potential parameter of the FAA or the deceleration parameter of the NASA–JSC). This analysis is in good agreement with other experimental work conducted

at the PTB and with the atmospheric-transport calculations of LUIN and FLUKA.

- (2) *The model has been developed into a computer code, PCAIRE, for global dose prediction using a great circle route calculation (e.g. between various waypoints or the departure and arrival airport locations) by summing the dose rates over the given flight path.*
- (3) *PCAIRE is in good agreement with CARI-6 and EPCARD, which have been derived from transport code analysis (i.e. at a heliocentric and modulation potential near 650 MV). The PCAIRE code has been further validated against an independent set of TEPC route-dose measurements on 26 subsonic flights up to 12.4 km and five high-altitude NASA ER-2 flights up to 21 km (i.e. near solar minimum conditions). An effective dose calculation is also possible with PCAIRE using conversion ratios developed from an analysis with LUIN and FLUKA. However, further work is needed to rationalise a ~20% discrepancy in the effective dose between the two transport codes (which presumably arises from the use of different boundary conditions).*
- (4) *A simple correlation-type model has been proposed for the estimation of solar flare exposure to aircrew. This correlation has been developed using TEPC data acquired on board the International Space Station, routine monitoring of the proton flux with the GOES-8 satellite, various ground-level neutron counting stations around the world, and transport code calculations. The model is in agreement within a factor of ~2.5 with a trans-Atlantic flight measurement made during GLE 60 as part of the DOSMAX project. It is also consistent with a TEPC measurement on a northern First Air flight in Canada during a S4-level solar flare event on 10 November 2000, where no exposure was indicated at 8.8 to 9.4 km.”*

These results show that there is today a substantial basis of measurement results, with which the models for dose rates in various altitudes and at various latitudes and thus the models for doses to aircrew can be compared. Such measurements have formed a solid basis for providing good computer models for calculation of doses to aircrew that to a large extent can replace measurements of individual doses.

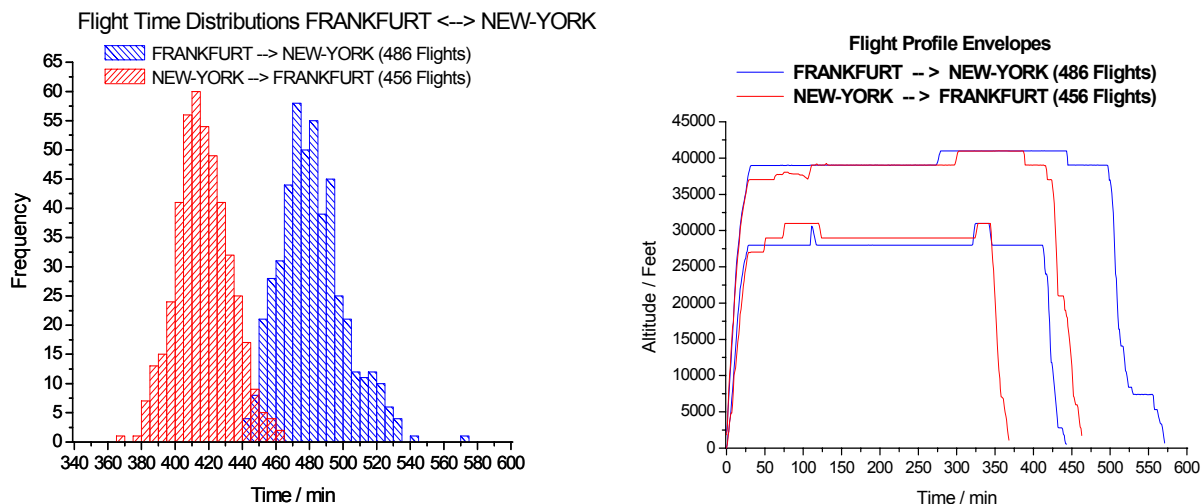
3.3.4 Variability of Exposure on Specific Flight Routes

The routes that a specific flight may take between its point of origin and its point of destination can vary significantly, depending on weather conditions, winds, air traffic, optimisation of flight altitude and fuel consumption etc. This can have a substantial effect on the resulting dose for the personnel on board the aircraft. A very recent study has been carried on 942 individual flights between Frankfurt and New York [FEL 08], notably illustrating this fact.

The enveloping details for the flight route are shown in Figure 8. The left picture shows the flight time distributions for both directions, centred around about 410 minutes (New York →

Frankfurt) and around 480 minutes (Frankfurt → New York). The flight route envelopes are provided in the right picture, showing generally a lower bound around 27,000 feet and an upper bound around 40,000 feet.

Figure 8: Flight route details for the flights analysed in [FEL 08]: enveloping data



The situation and especially the distribution variability of flight routes becomes obvious from Figure 9, showing density plots of each flight leg analysed in [FEL 08], in the left picture for flights from Frankfurt to New York, in the right picture for the opposite heading. Here, the two axes represent the longitude and latitude, while the intensity of shading represents the frequency with which flights passed these coordinates. The red line shows a great circle route for comparison. Figure 10 condenses these data into lines enveloping the flight routes both to the North and South in the left picture, as well as into a representation of the deviation from great circle routes in the right picture.

Figure 9: Flight leg density plots, from [FEL 08]

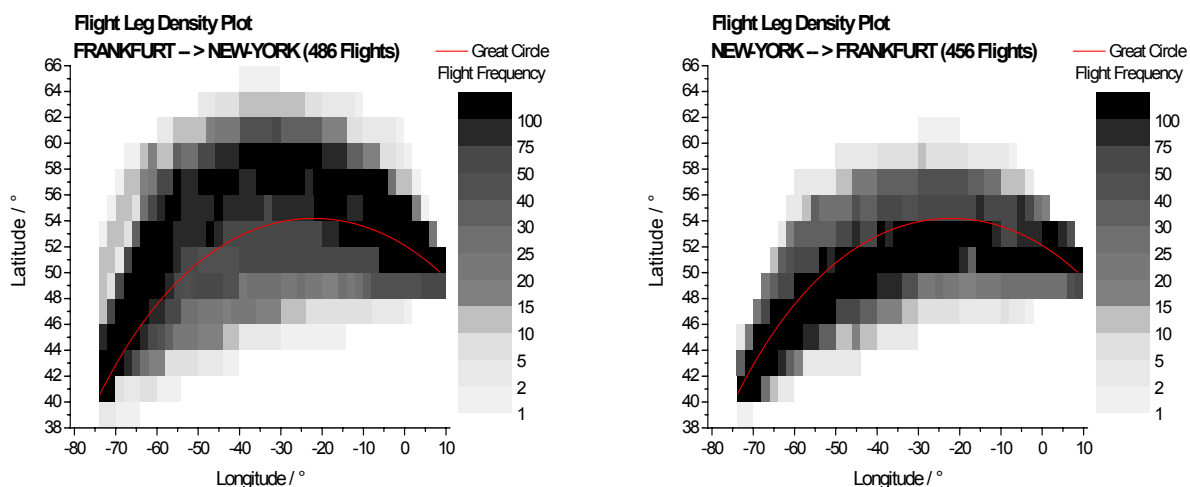
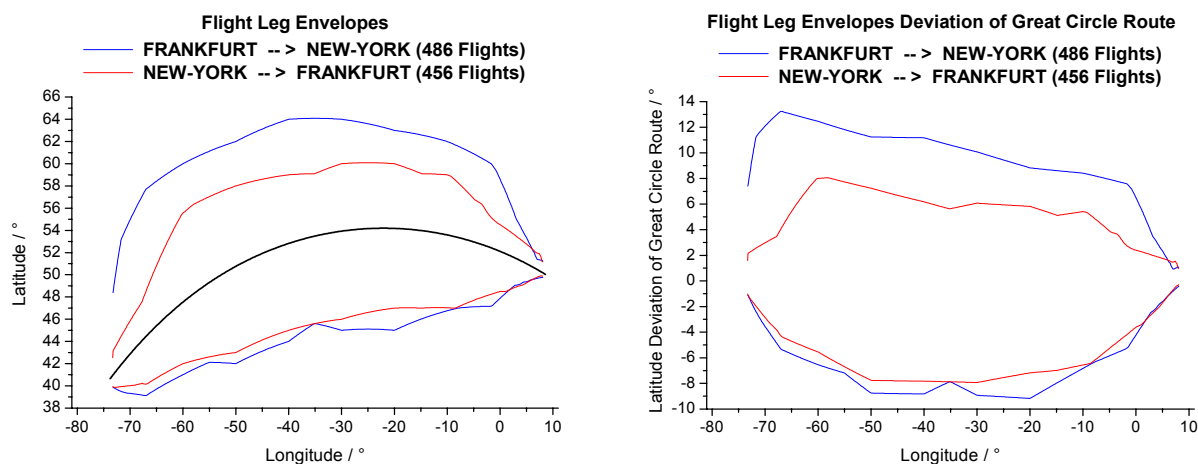


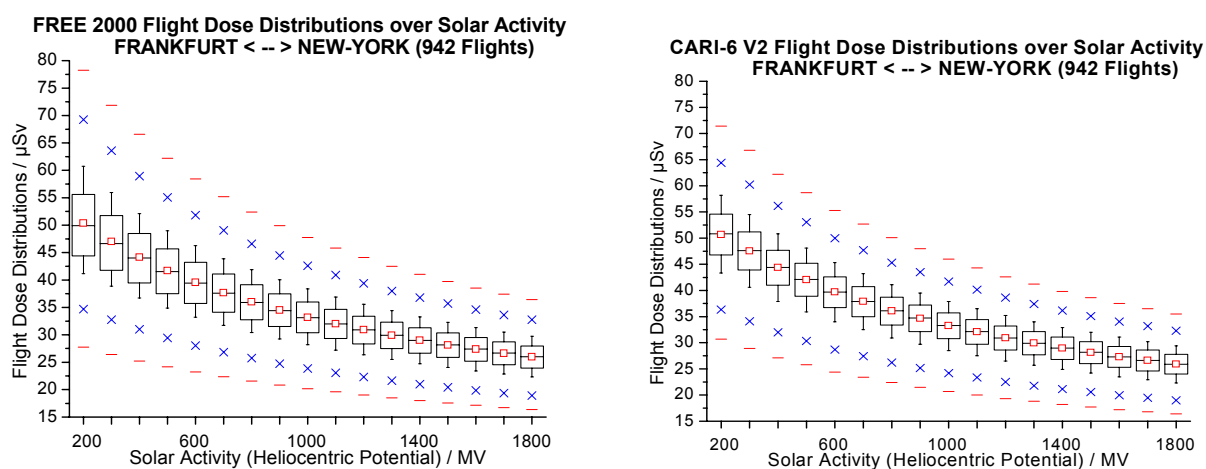
Figure 10: Flight leg envelopes and deviations from great circle routes, from [FEL 08]



It can be seen that the variability of routes between the same origin and destination is quite substantial, varying over about 20° of latitude on westbound flights and over more than 15° of latitude on eastbound flights. It can therefore be estimated that the corresponding doses for these flights will also vary significantly.

The results of the dose data evaluation are shown in Figure 11. The two pictures show the results using the computer codes FREE 2000 and CARI-6, as a function of solar activity. The symbols denote the median and mean value (horizontal line and circle in the middle of the distribution, almost identical), the 0.95 and 0.05 quantile (symbol "x"), the 0.9 and 0.1 quantile (upper and lower end of the vertical line), and the 0.75 and 0.25 quantile (upper and lower end of the vertical bar). It becomes obvious that for any solar activity, the ratio between maximum and minimum dose value is more than 2. This means that it is essential to use the planned or for a higher accuracy the actual flight path as a basis for dose calculation, while it would not be adequate to use the great circle as an approximation.

Figure 11: Flight dose distributions obtained by the computer codes FREE 2000 and CARI-6 as a function of solar activity, from [FEL 08] (see text for explanation of symbols; note: suppressed zero scale on the ordinate)



A further study carried out between 2003 and 2004 has been reported in [WIS 08], where doses on routes between Frankfurt and Dallas as well as between Frankfurt and New York have been investigated. The results are shown in Table 2. It can be observed that the variability of doses on each route (standard deviation) is about 10 % of the average value, which corresponds to the observations in [FEL 08] presented above.

Table 2: Doses and their variability on routes between Frankfurt and Dallas and between Frankfurt and New York [WIS 08]

Route	# of flights	mean flight time [h]	mean altitude [km]	mean dose per route [μ Sv]	min. dose [μ Sv]	max. dose [μ Sv]
Frankfurt - Dallas	18	10.3	10.67	49.8 \pm 4.4	43.7	56.1
Dallas – Frankfurt	16	9.2	10.76	43.6 \pm 3.2	39.3	48.8
Frankfurt – New York	13	8.0	10.67	37.0 \pm 4.2	29.4	44.0
New York - Frankfurt	13	7.0	10.94	33.8 \pm 3.3	30.2	39.3

3.4 Legal Background

3.4.1 Requirements of the EURATOM Basic Safety Standards

The legal requirements for determination of doses to air crew are first of all laid down in Article 42 of the EURATOM Basic Safety Standards [EUR 96]:

“Article 42 – Protection of Air Crew

Each Member State shall make arrangements for undertakings operating aircraft to take account of exposure to cosmic radiation of air crew who are liable to be subject to exposure to more than 1 mSv per year. The undertakings shall take appropriate measures, in particular:

- *to assess the exposure of the crew concerned*
- *to take into account the assessed exposure when organizing working schedules with a view to reducing the doses of highly exposed aircrew*
- *to inform the workers concerned of the health risks their work involves*
- *to apply Article 10 to female air crew”*

Interpretation of these requirements into the more technical level is provided in recommendation RP 88: “Recommendations for the Implementation of Title VII of the European Basic Safety Standards Directive (BSS) concerning significant Increase in Exposure due to Natural Radiation Sources” [EUR 97]. RP 88 contains recommendations on Article 42 in chapter 4 that are summarised in the following points:

- execution of national studies to assess magnitude of doses to aircrew
- controls:
 - no further controls for aircrew with < 1 mSv/a
 - doses 1 – 6 mSv/a: individual dose estimates required
 - doses > 6 mSv/a: “highly exposed aircrew” – record keeping, medical surveillance
- employers should explain risk due to radiation to their staff
- control of occupational exposure to pregnant women
- air couriers and exceptionally frequent flyers are not mentioned in the BSS, but dose determination should be similar to that of aircrew
- computer programs may be used for determining the doses below 6 mSv/a
- aircraft capable of operating in altitudes > 15 km should carry in-flight active monitors to detect variations in radiation levels (esp. solar flares).

3.4.2 Operations of the Joint Aviation Authorities (JAR-OPS)

The Operations of the Joint Aviation Authorities (JAA) within the Joint Aviation Requirements (JAR), abbreviated as JAR-OPS, contain standards for aviation. Any commercial airline within the European Union flying jet or propeller aircraft has to comply with these standards. Compliance is governed through the issuance of an Air Operator Certificate (AOC) and an Operator's Licence (OL). There are two paragraphs of JAR-OPS that are of high relevance for the survey performed in this project, parts of which are reproduced in the following. These JAR-OPS directly transpose the requirements of the EU BSS into aviation specific regulations.

3.4.2.1 JAR-OPS 1.390 Cosmic radiation

“(a) An operator shall take account of the in-flight exposure to cosmic radiation of all crew members while on duty (including positioning) and shall take the following measures for those crew liable to be subject to exposure of more than 1 mSv per year (See ACJ OPS 1.390(a)(1));

1. *Assess their exposure*
2. *Take into account the assessed exposure when organising working schedules with a view to reduce the doses of highly exposed crew members (See ACJ OPS 1.390(a)(2));*
3. *Inform the crew members concerned of the health risks their work involves (See ACJ OPS 1.390(a)(3));*
4. *Ensure that the working schedules for female crew members, once they have notified the operator that they are pregnant, keep the equivalent dose to the foetus as low as can reasonably be achieved and in any case ensure that the dose does not exceed 1 mSv for the remainder of the pregnancy;*

5. *Ensure that individual records are kept for those crew members who are liable to high exposure. These exposures are to be notified to the individual on an annual basis, and also upon leaving the operator.*

(b)

1. *An operator shall not operate an aeroplane above 15 000 m (49 000 ft) unless the equipment specified in JAR-OPS 1.680(a)(1) is serviceable, or the procedure prescribed in JAR-OPS 1.680(a)(2) is complied with.*
2. *The commander or the pilot to whom conduct of the flight has been delegated shall initiate a descent as soon as practicable when the limit values of cosmic radiation dose rate specified in the Operations Manual are exceeded. (See JAR-OPS 1.680(a)(1)).*

3.4.2.2 JAR-OPS 1.680 Cosmic radiation detection equipment

“(a) An operator shall not operate an aeroplane above 15 000 m (49 000 ft) unless:

1. *It is equipped with an instrument to measure and indicate continuously the dose rate of total cosmic radiation being received (i.e. the total of ionizing and neutron radiation of galactic and solar origin) and the cumulative dose on each flight, or*
2. *A system of on-board quarterly radiation sampling acceptable to the authority is established (See ACJ OPS 1.680(a)(2))”*

3.4.2.3 ACJ OPS 1.390(a) (1) - Assessment of Cosmic Radiation

1 In order to show compliance with JAR-OPS 1.390(a), an operator should assess the likely exposure for crew members so that he can determine whether or not action to comply with JAR-OPS 1.390(a)(2), (3), (4) and (5) will be necessary.

a. Assessment of exposure level can be made by the method described below, or other method acceptable to the Authority:

Table 3: Hours exposure for effective dose of 1 Millisievert (mSv)

Altitude (feet)	Kilometre equivalent	Hours at latitude 60°N	Hours at equator
27 000	8.23	630	1330
30 000	9.14	440	980
33 000	10.06	320	750
36 000	10.97	250	600
39 000	11.89	200	490
42 000	12.80	160	420
45 000	13.72	140	380
48 000	14.63	120	350

Note: This table, published for illustration purposes, is based on the CARI-3 computer program; and may be superseded by updated versions, as approved by the Authority.

The uncertainty on these estimates is about $\pm 20\%$. A conservative conversion factor of 0.8 has been used to convert ambient dose equivalent to effective dose.

b. Doses from cosmic radiation vary greatly with altitude and also with latitude and with the phase of the solar cycle. Table 1 gives an estimate of the number of flying hours at various altitudes in which a dose of 1 mSv would be accumulated for flights at 60° N and at the equator. Cosmic radiation dose rates change reasonably slowly with time at altitudes used by conventional jet aircraft (i.e. up to about 15 km / 49 000 ft).

c. Table 3 can be used to identify circumstances in which it is unlikely that an annual dosage level of 1 mSv would be exceeded. If flights are limited to heights of less than 8 km (27 000 ft), it is unlikely that annual doses will exceed 1 mSv. No further controls are necessary for crew members whose annual dose can be shown to be less than 1 mSv.

3.4.2.4 ACJ OPS 1.390(a) (2) - Working Schedules and Record Keeping

Where in-flight exposure of crew members to cosmic radiation is likely to exceed 1 mSv per year the operator should arrange working schedules, where practicable, to keep exposure below 6 mSv per year. For the purpose of this regulation crew members who are likely to be exposed to more than 6 mSv per year are considered highly exposed and individual records of exposure to cosmic radiation should be kept for each crew member concerned.

3.4.2.5 ACJ OPS 1.390(a) (3) - Explanatory Information

Operators should explain the risks of occupational exposure to cosmic radiation to their crew members. Female crew members should know of the need to control doses during pregnancy, and the operator consequently notified so that the necessary dose control measures can be introduced.

3.4.2.6 JAR-OPS 1.680 Cosmic radiation detection equipment

(a) An operator shall not operate an aeroplane above 15 000 m (49 000 ft) unless:

- (1) It is equipped with an instrument to measure and indicate continuously the dose rate of total cosmic radiation being received (i.e. the total of ionizing and neutron radiation of galactic and solar origin) and the cumulative dose on each flight, or
- (2) A system of on-board quarterly radiation sampling acceptable to the authority is established (See ACJ OPS 1.680(a) (2))

3.4.2.7 ACJ OPS 1.680(a) (2) - Quarterly Radiation Sampling

1. Compliance with JAR-OPS 1.680(a) (2) may be shown by conducting quarterly radiation sampling during aeroplane operation using the following criteria:

a. The sampling should be carried out in conjunction with a Radiological Agency or similar organisation acceptable to the Authority;

b. Sixteen route sectors which include flight above 49 000 ft should be sampled every quarter (three months). Where less than sixteen route sectors which include flight above 49 000 ft are achieved each quarter, then all sectors above 49 000 ft should be sampled.

c. The cosmic radiation recorded should include both the neutron and non-neutron components of the radiation field.

2. The results of the sampling, including a cumulative summary quarter on quarter, should be reported to the Authority under arrangements acceptable to the Authority.

3.4.3 Recent Regulations of the European Commission

In December 2007, the European Commission has issued a regulation on common technical requirements and administrative procedures applicable to commercial transportation by aeroplane [EUR 07B].

In the field of aviation safety, in 1991 Council Regulation 3922/91 was adopted to harmonise the technical requirements and administrative procedures in the field of civil aviation. EC Regulation 1899/2006 subsequently inserted an Annex III, otherwise known as EU-OPS, to Regulation 3922/91 with the aim of enhancing aviation safety and promoting harmonisation of rules in commercial air transport within the European Union. The EU-OPS contain operating rules for commercial air transport aeroplanes including provision for the issue of air operator certificates (AOC) to commercial air transport operators. In December 2007, Commission Regulation 8/2008 was adopted, updating the technical requirements set out in Annex III.

With respect to doses to aircrew, the requirements [EUR 07B] are similar to the requirements outlined in section 3.4.2 above.

3.5 The European Aviation Safety Agency (EASA)

According to the description of the Agencies within the EU [EUR 08], the European Aviation Safety Agency (EASA) is described as follows:

“The European Aviation Safety Agency is an agency of the European Union which has been given specific regulatory and executive tasks in the field of aviation safety. The Agency constitutes a key part of the European Union’s strategy to establish and maintain a high uniform level of civil aviation safety in Europe.” “The European Aviation Safety Agency was established by Council Regulation (EC) No 1592/2002 of the European Parliament and of the Council of 15 July 2002 (OJ L 240, 7.9.2002).”

“The Agency’s mission is twofold. It shall provide technical expertise to the European Commission by assisting in the drafting of rules for aviation safety in various areas and providing technical input to the conclusion of the relevant international agreements. In addition, the Agency has been given the power to

carry out certain executive tasks related to aviation safety, such as the certification of aeronautical products and organisations involved in their design, production and maintenance. These certification activities help to ensure compliance with airworthiness and environmental protection standards.

The European Aviation Safety Agency certifies products from civil aviation altogether, including general and business aviation. It is important to note that its remit does not cover aviation security (prevention of illegal actions against civil aviation like hijacking, for instance). This comes under the remit of the Community law applied by the Member States.

The Community legislator has already decided that, in the longer term, these competencies should be progressively enlarged to all other areas of civil aviation safety, notably to air operations and flight crew licensing. Pending this being confirmed by an extension of the basic regulation's scope, these items remain a national competency."

The EASA thus concentrates a significant part of the decisions that formerly rested with the civil aviation authorities of the Member States and contributes to a harmonised set of rules as well as to harmonisation in their implementation. This is summarised in the description of the EASA [EAS 08]:

"Where Community law is implemented at Member State level, the Agency assists the Commission in overseeing its effective application and its uniform understanding. The necessary standards are therefore being developed and maintained properly, uniformly and consistently across the European Union. Accordingly, the Agency conducts inspections of undertakings as well as national authorities throughout the EU, both to monitor the application of EU rules on aviation safety, and to assess the effectiveness of these rules. The Agency also provides technical training, which is essential to achieve overall consistency and high level standards."

"The Agency's Rulemaking Directorate contributes to the production of all EU legislation and implementation material related to the regulation of civil aviation safety and environmental compatibility. It submits opinions to the European Commission and must be consulted by the Commission on any technical question in its field of competence. It is also in charge of the related international co-operation. Experts within the Rulemaking Directorate have direct contact with all relevant stakeholders, and make use of the knowledge available within industry and national administrations across the European Union."

Table 4 contains an overview of EASA Members:

Table 4: EASA Members [EAS 08]

State	Departments
Austria	Bundesministerium für Verkehr, Innovation und Technologie; Austrocontrol
Belgium	Service Public Fédéral Mobilité et Transports - Direction Générale Transport Aérien; Federale Overheidsdienst Mobiliteit en Vervoer
Bulgaria	Civil Aviation Administration
Cyprus	Ministry of Communications and Works - Department of Civil Aviation (DCA)
Czech Republic	Civil Aviation Authority; Ministry of Transport
Denmark	Statens Luftfartsvesen (CAA - DK)
Estonia	Ministry of Economic Affairs and Communications
Finland	CAA Finland
France	Direction Générale de l'Aviation Civile
Germany	Bundesministeriums für Verkehr, Bau und Stadtentwicklung (BMVBS) Luftfahrt-Bundesamt
Greece	Hellenic Civil Aviation Authority
Hungary	PLA Polgári Légiközlekedési Hatóság- Civil Aviation Authority Hungary
Iceland*	Icelandic Civil Aviation Administration
Ireland	Department of Transport; Irish Aviation Authority
Italy	Ente Nazionale per l'Aviazione Civile
Latvia	Civil Aviation Administration of Latvia
Liechtenstein	Landesverwaltung Liechtenstein
Lithuania	Civil Aviation Administration
Luxembourg	Direction de l'Aviation Civile du Luxembourg
Malta	Department of Civil Aviation
Norway*	Luftfartstilsynet - Civil Aviation Authority Norway
Poland	Civil Aviation Office; Ministry of Transport
Portugal	Instituto Nacional de Aviação Civil
Romania	Romanian civil aeronautical authority
Slovak Republic	Ministry of Transport, Posts & Telecommunications/Directorate General of Civil Aviation; Civil Aviation Authority
Slovenia	Ministry of Transport; Civil Aviation Authority
Spain	Ministerio de Fomento - Aviación Civil
Sweden	Luftfartsstyrelsen (Swedish Civil Aviation Authority)
Switzerland	Federal Office of Civil Aviation (FOCA); Bundesamt für Zivilluftfahrt (BAZL)
The Netherlands	Inspectie Verkeer en Waterstaat (IVW) - Airworthiness and Inspections info can be found under 'Lucht'
United Kingdom	Department for Transport; Civil Aviation Authority

*) Since 1st June 2005 Norway and Iceland have participated in the Agency (and are hence members of the Management Board without voting rights) under article 55 of Regulation 1592/2002 as a result of Decisions No 179/2004, No 15/2005 and 16/2005 of the EEA Joint Committee which incorporate the Basic Regulation and its implementing rules into Annex XIII to the EEA Agreement.

4 DATA ACQUISITION FROM CIVIL AVIATION AUTHORITIES, AIRCRAFT OPERATORS AND RADIATION PROTECTION AUTHORITIES

4.1 General Approach

The general approach pursued in this project was to collect up-to-date data by sending out questionnaires to the three relevant addressees that can provide information on the implementation of radiation protection measures for aircrew, namely civil aviation authorities, aircraft operators and radiation protection authorities. As these addressees deal with different aspects of the overarching topic, the questionnaires were tailored to meet the data that these addressees can provide. In total, the three types of questionnaires deal with the following topics:

- Organisational structure

Questions related to the aviation authority and the responsibility for dose registration in the country and to the groups of supervised personnel.

- Existing airlines and aircraft operators

Questions related to airlines existing in the country, their addresses and whether they are under the scope of radiation protection. Further questions relate to the number of staff of these airlines being supervised.

- Aircraft Classification and Radiation measurement equipment on board

Questions related to the number of aircraft in different categories and the numbers that are equipped with radiation measurement equipment. Further questions related to the way this measurement equipment is checked.

- Dose limits / Action levels / Actions¹

Questions related to the dose limits that are applicable to the various groups of personnel. Further questions related to intervention levels or constraints, i.e. those dose levels at which certain actions are taken for specific groups, and to the measures being taken in such cases.

¹) In the questionnaires sent to civil aviation authorities, radiation protection authorities, aircraft operators, the term “intervention levels” has been used instead of “action levels”, as this is not an uncommon term in this context. However, the terms “intervention” and “intervention levels” have specified meanings in the EURATOM Basic Safety Standards [EUR 96], indicating certain actions and levels at which intervention measures should be considered. While “interventions” are defined as any “human activity that prevents or decreases the exposure of individuals to radiation from sources which are not part of a practice or which are out of control”. The term “action level” is used in the main part of this report to signify an intra-enterprise constraint that will cause actions (in the sense of “intervention measures”), to prevent reaching dose limits.

- Exposure database

Questions related to the way in which dose calculation is carried out (computer programs), on data that are stored in a database, and on the information that is given to the flight personnel on a routine basis or on request.

- Communication with legal institution (radiation protection authorities)

Question on whether radiation protection authorities exist in that country and whether it is responsible for dose data collection.

- Miscellaneous

Various questions on planned changes to the structure (mainly with a view to the role of EASA) and suggestions for improvement.

Before questionnaires were sent out on a large scale, prototype questionnaires were sent to a few civil aviation authorities and airlines in order to receive suggestions for improvement. In addition, the European Commission was asked to provide an official letter of introduction explaining the purpose of the project and the purpose of data collection via questionnaires as well as the fact that the two companies Brenk Systemplanung GmbH and HG Qualitätsmanagement have been commissioned by the European Commission to carry out this data collection.

The first contact was established with civil aviation authorities, as these authorities can provide not only all relevant data on the general approach and the relevant legislation in their countries, but also have an overview of the airlines. The questionnaire therefore contained a section on the airlines, both in general terms and in relation to a list of airlines, which the civil aviation authorities were asked to provide for further direct contacts. The full questionnaire is reproduced in section 4.3. This set of questionnaires was disseminated in the first third of the project. Two reminding letters were sent out to those civil aviation authorities that had not answered to our questionnaires.

In parallel to civil aviation authorities, major airlines (“flag carriers” and other large IATA airlines) were contacted with a questionnaire relating to the implementation of the general requirements, the approaches to dealing with dose limits and action levels, the number of exposed personnel etc. The full questionnaire is reproduced in section 4.4. It was hoped that answers provided by the airlines would help interpreting the answers received by the civil aviation authorities and identifying areas for improvement as seen from the perspective of practical application of the regulations. This set of questionnaires was disseminated shortly after the questionnaires to civil aviation authorities. Two reminding letters were sent out to those airlines that had not answered to our questionnaires.

The third group of addressees were the radiation protection authorities. As their main responsibility usually lies with setting standards for radiation protection for aircrew and for administration of dose records of occupationally exposed personnel, including aircrew (if aircrew belongs to this group in a particular country), the questionnaire was tailored more to these topics. The full questionnaire is reproduced in section 4.5. The

initial plan had been to send out this third set of questionnaires soon after the other two sets and to use the answers received to this questionnaire to fill in gaps possibly left open in the answers from civil aviation authorities as well as additional means for quality assurance (any contradictions between answers provided by civil aviation authorities and radiation protection authorities triggering an enquiry). However, as it became clear during the second third of the project that the return of answers from civil aviation authorities was non-satisfying, dissemination of this third questionnaire was slightly postponed for taking stock of data not yet adequately covered that could perhaps be obtained from the radiation protection authorities. Finally, the questionnaire to radiation protection authorities was adapted accordingly and sent out at the beginning of the last third of the project. The return of answers from radiation protection authorities was much better than from the other two groups of addressees.

Contact to airlines aimed at receiving information that is complementary to that provided by the CAAs. A questionnaire tailored to airlines and aircraft operators was developed. When contacting airlines and aircraft operators, it was intended to cover all types and sizes of companies, i.e. national flag carriers, low-cost carriers, commercial business carriers, and non-commercial business carriers.

It was clear from the start that only a small percentage of replies would be received, either because private companies might not see benefit in answering at all and could not afford staff to spend time in preparing answers, or because these aircraft operators would not have any radiation protection issue at all because of operation in low altitudes.

Data acquisition from radiation protection authorities is to be seen as a complementary approach to the main data sources referred to above, namely the civil aviation authorities and the airlines and aircraft operators. The data collection from radiation protection authorities has therefore been started only after a coherent picture of the data that would become available from the other sources had been obtained.

4.2 Status of Data Acquisition

4.2.1 Civil Aviation Authorities

The CAAs of all states listed in section 2.2 have been contacted by mid-2007. By April 2008, 15 answers have been received. While some of those countries provided immediate response, other countries answered only after additional inquiry. 18 countries did not reply despite at least one reminding letter. All letters sent out to CAAs have been accompanied by an official letter of DG TREN explaining the purpose of this project and the importance of providing answers. The status is summarised in Table 5

The replies received from the CAAs are very comprehensive, both in number and in accuracy of the data provided. Most of these replies also contain an exhaustive list of airlines and aircraft operators in the particular countries. Contacts to airlines and aircraft operators have been made mainly on the basis of these lists.

Table 5: Contacted CAAs and status of replies (End of January 2008)

Country	CAA	Reply received
Austria	Bundesministerium für Verkehr, Innovation und Technologie	no
Belgium	SPF Mobilité et Transports, Direction générale du Transport aérien	no
Bulgaria	Directorate General	no
Croatia	Civil Aviation Authority	yes
Cyprus	Department of Civil Aviation	yes
Czech Republic	Civil Aviation Authority	yes
Denmark	Civil Aviation Administration - Denmark	yes
Estonia	Ministry of Economic Affairs and Communication	yes
Finland	Civil Aviation Authority	yes
France	Director General of Aviation	no
Germany	Luffahrt-Bundesamt	yes
Greece	Hellenic Civil Aviation Authority	no
Hungary	National Transport Authority	yes
Ireland	Irish Aviation Authority	no
Italy	ENAC-Ente Nazionale per l'Aviazione Civile	yes
Latvia	Civil Aviation Agency	yes
Lithuania	Civil Aviation Administration	yes
Luxembourg	Direction de l'Aviation Civile	yes
Malta	Department of Civil Aviation	no
Norway	Civil Aviation Authority	yes
Poland	Civil Aviation Office	yes
Portugal	Instituto Nacional de Aviacao Civil	no
Republic of Macedonia	Civil Aviation Agency	no
Romania	Romania Civil Aeronautical Authority	yes
Slovak Republic	Civil Aviation Authority	no
Slovenia	Ministry of Transport	no
Spain	Ministerio de Fomento	no
Sweden	Swedish Civil Aviation Authority	no
Switzerland	Bundesamt für Zivilluftfahrt BAZL	yes
The Netherlands	Ministry of Transport, Public Works and Water Management	yes
Turkey	Ministry of Transport and Communications	no
United Kingdom	Head of Aeromedical Section UK CAA	no
United Kingdom	Secretary UK Health Protection Agency	no

4.2.2 Airlines and Aircraft Operators

While the number of airlines that have been contacted amounts to several hundred, only a total of 16 filled-in answers were received until the end of April 2008. Additional answers were received from a number of airlines indicating that because of low altitudes, radiation protection was no issue and that no staff member was occupationally exposed. A list of the major airlines ("flag carriers" and others) that were

contacted is given in Table 6 together with an indication whether they provided a full answer.

Table 6: List of major airlines that have been contacted together with indication of answers until April 2008

Country	Airline	Reply
Austria	Austrian Airlines	no
Austria	Lauda Air Luftfahrt GmbH	no
Belgium	European Air Transport	no
Belgium	SN Brussels Airlines	no
Belgium	TNT Airways S.A.	no
Bulgaria	Hemus Air	no
Croatia	Croatia Airlines d.d.	yes
Cyprus	Cyprus Airways Public Limited	no
Czech Republic	Czech Airlines	yes
Denmark	Cimber Air A/S	no
Estonia	Estonian Air	yes
Finland	Blue 1	yes
Finland	Finnair	yes
France	Air France	no
France	CCM Airlines	no
France	Corsair	no
Germany	Air Berlin	no
Germany	Blue Wings ag	no
Germany	Cirrus Airlines Luftfahrtgesellschaft mbH	yes
Germany	dba Luftfahrtgesellschaft mbH	no
Germany	Deutsche Lufthansa AG	no
Germany	European Air Express (E.A.E.) Luftverkehrsgesellschaft mbH	no
Germany	Eurowings Luftverkehrs AG	no
Germany	Hahn Air Lines GmbH	no
Germany	Hapag Lloyd	no
Germany	LTU Lufttransport-Unternehmen GmbH	no
Germany	Lufthansa Cargo	no
Germany	Lufthansa CityLine GmbH	no
Greece	Aegean Airlines S.A	no
Greece	Hellas Jet	no
Greece	Olympic Airlines S.A.	no
Hungary	MALEV	no
Ireland	Aer Lingus	no
Ireland	Air Contractors (UK) Limited	no
Ireland	City-Jet	no
Italy	Air One S.p.A.	no
Italy	ALITALIA S.p.A.	no
Italy	Alpi Eagles S.p.A	no

Country	Airline	Reply
Italy	Blue Panorama	no
Italy	Italfly s.r.l.	yes
Italy	Meridiana S.p.A.	yes
Latvia	Air Baltic	no
Lithuania	FlyLAL - Lithuanian Airlines	no
Luxembourg	Cargolux Airlines International S.A.	yes
Luxembourg	Luxair	yes
Macedonia	MAT - Macedonian Airlines	no
Malta	Air Malta p.l.c.	no
Netherlands	Denim Air B.V.	no
Netherlands	KLM Royal Dutch Airlines	no
Norway	SAS Norge	no
Norway	Wideroe	yes
Poland	LOT Polish Airlines Headquarter	yes
Portugal	PGA-Portugália Airlines	no
Portugal	SATA Air Acores	no
Portugal	TAP - Air Portugal	yes
Romania	S.C. Carpatair S.A.	yes
Romania	TAROM S.A.	yes
Slovenia	Adria Airways	no
Spain	Air Europa	no
Spain	Air Nostrum	no
Spain	Binter Canarias	no
Spain	IBERIA L.A.E., S.A.	no
Spain	Spanair	yes
Sweden	Malmö Aviation	no
Sweden	SAS	no
Sweden	Skyways	no
Switzerland	Swiss International Air Lines Ltd.	yes
Turkey	Atlasjet Airways	no
Turkey	Onur Air	no
Turkey	Pegasus Airlines	no
Turkey	Turkish Airlines General Management	no
UK	bmi	no
UK	British Airways plc	no
UK	DHL Air Ltd.	no
UK	flybe.British European	no
UK	GB Airways	no
UK	Virgin Atlantic Airways	no

4.2.3 Radiation Protection Authorities

The list of radiation protection authorities to which the questionnaire presented in section 4.5 has been sent is provided in Table 7. 14 full replies have been received until April 2008, an additional reply was received in August 2008.

Table 7: List of radiation protection authorities

Country	Radiation protection authority	Reply
Austria	Federal Ministry of Agriculture, Forestry, Environment and Water Management - Div. Radiation Protection (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft - Abt. V/7 – Strahlenschutz)	no
Belgium	HPD Health Physics Department - Federal Agency for Nuclear Control	yes
Bulgaria	Chief State Health Inspector, Ministry of Health	yes
Croatia	State Office for Radiation Protection (Drzavni Zavod za Zastitu od Zracenja)	yes
Cyprus	<i>(dose register kept by civil aviation authority, radiation protection authorities not involved)</i>	-
Czech Republic	State Office for Nuclear Safety	yes
Denmark	National Institute of Radiation Hygiene (Sundhedsstyrelsen)	yes
Estonia	Radiation Protection Centre	no
Finland	STUK - Radiation and Nuclear Safety Authority	yes
France	IRSN - Insitute for Radiation Protection and Nuclear Safety (Institut de Radioprotection et de Surete Nucleaire)	no
Germany	Federal Office for Radiation Protection (Bundesamt für Strahlenschutz)	yes
Greece	Greek Atomic Energy Commission	yes
Hungary	<i>(no dose assessment for aircrew)</i>	-
Ireland	Radiological Protection Institute of Ireland	yes
Italy	Ministry of Health (Ministro della salute)	no
Latvia	Radiation Safety Centre	yes
Lithuania	<i>(according to civil aviation authority, no doses are assessed for aircrew)</i>	-
Luxembourg	<i>(no public central dose register, radiation protection authorities not involved)</i>	-
Malta	Occupational Health & Safety Authority	no
Norway	NRPA - Norwegian Radiation Protection Authority	no
Poland	National Atomic Energy Agenca	yes
Portugal	ITN / Department of Radiological Protection and Nuclear Safety (DPRSN)	yes
Republic of Macedonia	Radiation Safety Directorate	no
Romania	<i>(according to civil aviation authority, no doses are assessed for aircrew)</i>	-
Slovak Republic	Nuclear Regulatory Authority of the Slovak Republic	no
Slovenia	Slovenian Nuclear Safety Administration	yes
Spain	Spanish Council of Nuclear Security (CSN - Consejo de seguridad nuclear)	no
Sweden	Swedish Radiation Protection Authority (SSI - Statens strålskyddsinstitut)	yes
Switzerland	<i>(no public central dose register, radiation protection authorities not involved)</i>	-
The Netherlands	Ministry of Social Affairs and Employment	yes
United Kingdom	Health Protection Agency Centre for Radiation, Chemical and Environmental Hazards	no

4.2.4 Overall Assessment of the Status

The number of replies received both from civil aviation authorities and from radiation protection authorities is lower than initially expected. The fact that two authorities were contacted independently, however, ensured that for most countries at least one reply has been received. Although the information received in both sets of questionnaires is not entirely redundant, it has generally been possible to gather sufficient data and to get a general impression of the situation and of relevant questions from the reply to only one questionnaire.

Unfortunately, the number of replies received from airlines is very much smaller than expected. As only a very limited number is available, it is not possible to use them as an independent information source in a broad sense that would highlight experience from the operator.

When judging the willingness to reply to our questionnaires, it must of course be kept in mind that the authorities may have felt a certain obligation to send a reply, as this study has been initiated by the European Commission. This, however, would not be the case for airlines to which filling in the questionnaire only means additional work. On the other hand, lack of answers could also be interpreted in the way that there is little to complain, as providing a reply would have given the airlines the opportunity to voice any dissatisfaction with the current situation or to suggest measures for improvement.

4.3 The Questionnaire to Civil Aviation Authorities

The questionnaire to civil aviation authorities aims at collecting information on the organisational structure in the country and in the authority itself, the role and scope of the dose register, data on the airlines, the number of airplanes and the personnel that is under radiation protection, data on dose limits, action levels², prescribed actions when nearing or exceeding these values as well as on dose monitoring and record keeping.

1. Organisational structure
 - 1.1. Is your organisation involved in the process of dose registration for air crew members?
 - 1.2. Does your organisation have an own department for managing the protection of flight crew against cosmic radiation?
 - If so, please state the name of the department and the amount of Individuals that is / are responsible for this area.
 - If not, is there a responsible person in your organisation who is managing the concerns of a cosmic radiation programme?If applicable, please state the name of the responsible person in your

²) As stated in footnote 1 on page 33, the terms “intervention level” and “intervention” have been used in the questionnaires instead of “action level” and “preventive actions”.

organisation.

If not applicable, please state the organisation or the name of the responsible person in your country.

- 1.3. Is the dose registration in your country supervised by your organisation?
If yes, which methods are applied to check it?
 - check with Software Database
 - check on the basis of hardcopies
 - check by visit the Airline
 - others:If not, who is responsible for supervision of the compliance with the regulation?
- 1.4. Is the dose registering regulated for:
 - a) occupational transport (proceeding) of the flight personnel?
 - b) frequent flyers (business passengers)?
 - c) freelancers (flight personnel)?
 - d) personnel with jobs in more than one airline air crew?
- 1.5. Are preventive actions taken when flight personnel reach their action level?
If yes, what kind of preventive actions do you take at which action level?
- 1.6. Is there any person in your organisation who is responsible for flight crew members with questions about radiation safety?
- 1.7. Has training concerning the risks of occupational exposure from radiation for air crew members been implemented?
If yes, is your organisation responsible for checking the training?
- 1.8. How many person-hours per year are spent within your organisation with respect to the cosmic radiation programme on the whole?
2. Airlines in your country
 - 2.1. Commercial Air Transport Operators
 - 2.1.1. How many commercial airlines/operators are registered in your country?
 - 2.1.2. Please provide the business addresses of the commercial airlines/operators registered in your country in Appendix II to this questionnaire.
 - 2.2. Non-commercial air transport organisations
 - 2.2.1. How many non-commercial aircraft operators are registered operating in your country?
 - 2.2.2. Please provide the business addresses of the non-commercial aircraft operators registered in your country in Appendix II to this questionnaire.
 - 2.3. Are all airlines/operators under the scope of radiation protection?
If not:
 - a) how many non-commercial operators are not under the scope of radiation protection?
Please state the reason(s) for exclusion:
Please provide a table of the non-commercial aircraft operators that are not under the scope of radiation protection in Appendix II to this questionnaire.
 - b) how many commercial airlines/operators are not under the scope of radiation

protection?

Please state the reason(s) for exclusion.

- 2.4. Commercial Air Transport Operators Crew Member
 - 2.4.1. How many cabin crew members are under the scope of radiation protection in your country?
 - 2.4.2. How many flight deck crew members are under the scope of radiation protection in your country?
- 2.5. Non-Commercial Air Transport Organisations Crew Members
 - 2.5.1. How many cabin crew members are under the scope of radiation protection in your country?
 - 2.5.2. How many flight deck crew members are under the scope of radiation protection in your country?
- 2.6. How many person-hours are spent in your organisation for managing radiation protection of air crew?
3. Aircraft Classification and Radiation measurement equipment on board
 - 3.1. Airplanes above 20 t Maximum Take-Off Mass
 - 3.1.1. How many airplanes are registered in your country?
 - 3.1.2. How many airplanes have radiation measurement equipment on board?
 - 3.2. Airplanes above 14 t up to (and including) 20 t Maximum Take-Off Mass
 - 3.2.1. How many airplanes are registered in your country?
 - 3.2.2. How many airplanes have radiation measurement equipment on board?
 - 3.3. Airplanes above 5.7 t up to (and including) 14 t Maximum Take-Off Mass
 - 3.3.1. How many airplanes are registered in your country?
 - 3.3.2. How many airplanes have radiation measurement equipment on board?
 - 3.4. Airplanes above 2 t up to (and including) 5.7 t Maximum Take-Off Mass
 - 3.4.1. How many airplanes are registered in your country?
 - 3.4.2. How many airplanes have radiation measurement equipment on board?
 - 3.5. Airplanes up to (and including) 2 t Maximum Take-Off Mass
 - 3.5.1. How many airplanes are registered in your country?
 - 3.5.2. How many airplanes have radiation measurement equipment on board?
 - 3.6. Is your organisation responsible for the check of the radiation measurement equipment?
If yes, in what time period is the check of the radiation measurement equipment?
 - 3.7. Which internal organisation is responsible for control, checking and calibrating of onboard dose measurement equipment?
 4. Dose limits / Action levels / Preventive Action

- 4.1. Please state the national action levels (mSv/a) for
generally flight crew members
pregnant / breastfeeding flight crew members
persons under the age of 18 years
others
- 4.2. Do any action levels exist
 - a) for personnel that reached the action level?
If yes, what kinds of preventive actions are taken?
 - b) for pregnant / breastfeeding personnel?
If yes, what kinds of preventive actions are taken?
- 4.3. Is there any preventive action planned to protect the flight crew or the passengers against high exposure originated from solar events?
If yes, what kind of preventive action is planned?
- 4.4. Has there been any preventive action(s) to protect the flight crew or the passengers against high exposure originated from solar events in the past?
If yes, what kind of preventive action?
5. Exposure database
 - 5.1. What kind of software to calculate individual doses for flight crew personnel is accredited in your country?
EPCARD / CARI6 / FREE / PCAIRE / SIEVERT / others
 - 5.2. Is it prescribed, that flight crew personnel are to be informed about their doses?
If yes:
 - generally monthly or yearly?
 - upon reaching his / her action level?
 - 5.3. Is there a fixed time period for which the collected data have to be stored in your country?
If yes, how is this time period regulated?
 - 5.4. Is the database protected against loss of data?
 - 5.5. How is the access to the database regulated?
6. Communication with legal institution (radiation protection authorities)
 - 6.1. Do you have a legal institution in your country that is responsible to collect the data on doses?
If yes, please state the name of the organisation
7. Miscellaneous
 - 7.1. Are there any changes planned to the points mentioned above until 2010?
If yes, please indicate these changes
 - 7.2. Do you have suggestions for improvement ?
If yes, please indicate the suggestions

Annotations / Comments

4.4 The Questionnaire to Airlines and Aircraft Operators

The questionnaire to airlines and other aircraft operators aims at collecting information on the role of the aircraft operators in determining doses to their personnel, in collecting and storing this information, on the awareness of dose levels and actions to be taken when members of their staff approach these dose levels or constraints, on information to the personnel etc. Some questions provide identical information to the ones posed to CAAs (section 4.3) and serve as a cross-check.

1. Organisational structure:
 - 1.1. Who or which division is responsible for the personal dose calculation for your organisation?
(you may also paste or attach an organisation chart)
 - 1.2. Who or which division is generally responsible for record keeping of the personal doses of your flight crew in your organisation?
 - 1.3. Who or which division is responsible for flight crew members with questions about radiation safety in your organisation?
2. Aircrafts and Radiation measurement equipment on board
 - 2.1. How many airplanes of the following categories are registered in your organisation? How many of them have radiation measurement equipment on board?
 - 2.1.1. Airplanes above 20 t maximum take-off mass: total / with measurement equipment
 - 2.1.2. Airplanes with 14 - 20 t maximum take-off mass: total / with measurement equipment
 - 2.1.3. Airplanes with 5.7 - 14 t maximum take-off mass: total / with measurement equipment
 - 2.1.4. Airplanes with 2 – 5.7 t maximum take-off mass: total / with measurement equipment
 - 2.1.5. Airplanes with less than 2 t maximum take-off mass: total / with measurement equipment
 - 2.2. Which internal or external organisation is responsible for the control check / calibrating of the onboard dose measurement?
3. Flight Crew: How many of the following flight personnel are employed in your operation, and how many of these are dose monitored? Please provide the most recent figures available.
 - 3.1. Cockpit crew (payroll) - total / monitored - a) male; b) female
 - 3.2. Cabin crew (payroll) - total / monitored - a) male; b) female
 - 3.3. Sky/air marshals - total / monitored
 - 3.4. Freelancers and others - total / monitored

4. Dose calculation:
 - 4.1. Please provide an overview of the national and company regulations governing determination of doses for air crew
 - 4.2. Are the dose calculations carried out by your company (in-house) or by a contractor? (If so, which company?) in-house / contractor
 - 4.3. What kind of software do you use to evaluate the personal dose?
 - 4.4. Is the dose calculated by planned or by real flight route?
 - 4.5. Are solar flares implemented in the dose calculation?
5. Dose measuring:
 - 5.1. Is the calculated dose data supported by measuring equipment onboard?
 - a) If yes, what is the legal basis for carrying out the measurements?
 - b) If yes, is it an active or passive monitoring?
(active: continuous, real-time measurement; passive: dose meters with films)
 - c) If yes, how many airplanes are equipped with measuring equipment? (see section 2)
 - d) If yes, how often are the calculated dose data evaluated by measuring?
 - e) If yes, does the measurement procedure depend on the altitude?
 - f) If yes, which measurement procedure in which altitude?
 - 5.2. What kind of influence does the measured dose have on the calculated dose?
 - 5.3. In which intervals does calibration of onboard dose measurement instruments occur?
6. Dose limits / Action levels / Preventive action
general flight personnel = air crew (cockpit, cabin, sky marshals, others)
women with reproductive capacity = up to ~ 45 years of age
 - 6.1. Which occupational dose limits (mSv/a) are legally binding
 - a) for general flight personnel?
 - b) for pregnant / breastfeeding personnel?
 - c) others?
 - 6.2. Which action levels (mSv/a) are legally binding
 - a) for general flight personnel?
 - b) for pregnant / breastfeeding personnel?
 - c) others?
 - 6.3. Which occupational dose limits (mSv/a) are internally binding
 - a) for general flight personnel?
 - b) for pregnant / breastfeeding personnel?
 - c) others?
 - 6.4. Which action levels (mSv/a) are internally binding
 - a) for general flight personnel?
 - b) for pregnant / breastfeeding personnel?
 - c) others?

- 6.5. What kind of preventive action do you take
 - a) for personnel that reached the action level?
 - b) for pregnant / breastfeeding personnel?
- 6.6. Are preventive action taken (or have they / will they been taken) to protect the flight crew against high exposure originating from solar events?
7. Exposure database:
 - 7.1. What kind of data do you store in your personnel dose database (e.g. personnel data, flight number, route etc.)? (charts may be attached)
 - 7.2. Is the database kept in-house or by an external contractor? (If so, which company?)
 - 7.3. How is the dose registering regulated for
 - a) occupational transport of your flight personnel?
 - b) Freelancers (flight personnel) and personnel with jobs in more than one airline?
 - 7.4. How long are the collected data kept?
 - 7.5. Which persons or institutions have access to these data?
8. Communication with the authorities
 - 8.1. Which national authority in your country is responsible for your organisation to collect the dose data?
 - 8.2. In which time intervals are the dose data transferred to the national authority?
 - 8.3. What kind of data do you send to the national authority (e.g. personnel data, only >1mSv, personnel number etc.)?
9. Instructions for the flight crew
 - 9.1. Is information about the risks of occupational exposure to radiation provided to your crew members?
 - 9.2. If yes, what kind of information is given and how often are they repeated?
 - 9.3. If yes, who is responsible for the information about the risks?
10. Medical control
 - 10.1. Does the medical check-up for your flight personnel include aspects of radiation protection?
 - 10.2. If yes, which aspects?
11. Changes
 - 11.1. How did dose rates for general flight personnel develop since assessment of the crew concerned became obligatory?
Average dose rates increased / stayed the same / decreased
Maximum dose rates increased / stayed the same / decreased
 - 11.2. How did dose rate for pregnant / breastfeeding women develop since assessment of the crew concerned became obligatory?

Average dose rates increased / stayed the same / decreased
Maximum dose rates increased / stayed the same / decreased

12. Efforts and Costs

The European Commission would like to learn more about the effects regulations have on the effort necessary to comply with these regulations. We would therefore ask you to fill in the following questions on a purely voluntary basis. The questionnaires are treated fully confidentially.

12.1. How much effort does your company invest into the assessment of exposure of air crew

Additional work time necessary per year: ___ person-hrs/month
Costs (without internal labouring costs): ___ €/y

12.2. How much effort puts your company in measures to minimise dose rates

Additional work time necessary per year: ___ person-hrs/month
Costs (without internal labouring costs): ___ €/y

12.3. How much effort is necessary for information or training of the personnel concerned

Additional work time necessary per year: : ___ person-hrs/month
Costs (without internal labouring costs): ___ €/y

12.4. How much effort is necessary for communication and reporting to the aviation authorities and/or governmental bodies

Additional work time necessary per year: : ___ person-hrs/month
Costs (without internal labouring costs): ___ €/y

12.5. How do you assess the efficiency of the measures necessary for radiation protection in your company?

Annotations / Comments

4.5 The Questionnaire to Radiation Protection Authorities

The questionnaire to radiation protection authorities aims at collecting information on the database on doses of occupationally exposed personnel in the respective countries. The questions also serve as a cross-check to those posed to the CAAs (section 4.3). In addition, they are meant as additional input for those countries where no answer has been provided by the CAAs or the major airlines.

1. Contact details (details of the person who has filled and returned the questionnaire)
2. Legislation implementation:
 - 2.1. By which laws or decrees is the protection of the flying personnel (aircrew) regulated in your country? (you may also paste or attach the relevant text of the legislation – preferably in English – or add an internet reference on the laws/decrees)
 - 2.2. (For EU member and candidate countries only) When was (or will be) the revised European Union Basic Safety Standard Directive (BSS 96/29/EURATOM, published in 1996) transformed into national legislation in your country?
3. What is the role of your organisation with respect to data on doses for aircrew?

- a) dose data are managed
- b) dose data are directly passed on from the airlines / air transport operators
- c) dose data are passed on from companies compiling the dose data on behalf of the airlines / air transport operators
- d) dose data are obtained from the Civil Aviation Authority
- e) other

Please answer the questions in sections 4 and 5 if your organisation is directly involved in data exchange on doses for aircrew with airlines / air transport operators or with companies compiling these data on behalf of the airlines / air transport operators.

4. Airlines in your country

4.1. Commercial Airlines / Air Transport Operators

4.1.1. How many commercial airlines/operators in your country are under the scope of radiation protection?

4.1.2. What is the criterion for putting commercial airlines/operators under the scope of radiation protection?

4.2. Non-commercial air transport organisations

4.2.1. How many non-commercial airlines/operators your country under the scope of radiation protection?

4.2.2. What is the criterion for putting non-commercial airlines/operators under the scope of radiation protection?

4.3. Commercial Air Transport Operators Crew Members

How many of the following flying personnel are monitored for personal dose in your country? Please provide the most recent figures available.

Figures refer to 31 December 2007 30 June 2007

4.3.1. How many cabin crew members are under the scope of radiation protection in your country? male: ___ persons / female ___ persons

4.3.2. How many flight deck crew members are under the scope of radiation protection in your country? male: ___ persons / female ___ persons

4.4. Non-Commercial Air Transport Organisations Crew Members

4.4.1. How many cabin crew members are under the scope of radiation protection in your country? male: ___ persons / female ___ persons

4.4.2. How many flight deck crew members are under the scope of radiation protection in your country? male: ___ persons / female ___ persons

5. Dose limits / Action levels / Preventive action:

general flight personnel = air crew (cockpit, cabin, sky marshals, others)

5.1. Which occupational dose limits are legally binding in your country for general flight personnel?mSv/a
for pregnant / breastfeeding personnel?mSv/a
othersmSv/a

5.2. Which action levels are legally binding in your country for flight personnel in general?mSv/a
for pregnant / breastfeeding personnel?mSv/a
others?mSv/a

5.3. What kind of preventive action do you take / has to be taken for personnel that reached the action level?
for pregnant / breastfeeding personnel that reached the action level?

- 5.4. Are preventive action taken to protect the flight crew against high exposure originating from solar events?
6. Dose database:
- 6.1. Please describe the scope and role of the database for doses from occupational exposure in your country:
- the data of all occupationally exposed persons (i.e. from practices and work activities) are kept in a single database
 - the data of persons who are occupationally exposed by natural radiation (air crew, NORM industries etc.) are collected in a separate database
 - the database for doses from occupational exposure of aircrew is kept separately from all other databases on occupational exposure
 - other:
- 6.2. What kind of software to calculate individual doses for flight crew personnel is accredited in your country?
EPCARD / CARI6 / FREE / PCAIRE / SIEVERT / others:
- 6.3. Is it prescribed, that flight crew personnel are to be informed about their doses?
 Yes No
- If yes:
generally monthly or yearly / by reaching his / her action level / others
- 6.4. What kind of data do you store in your personnel dose database? (you may also paste or attach a chart)
- 6.5. How long are these records kept?
- 6.6. Which persons or institutions have access to the database?
7. Average Dose / Dose distribution
- 7.1. What is the average dose of personnel registered in the personnel dose database?
For general flight personnel?mSv/a
for pregnant / breastfeeding personnel?mSv/a
othersmSv/a
- 7.2. Please provide a typical dose distribution with respect to the following dose intervals (last set of available data):
- | | | |
|-------------|-------|---------|
| < 1 mSv/a | | Persons |
| 1 – 6 mSv/a | | Persons |
| > 6 mSv/a | | Persons |
- 7.3. If you have got a more detailed interpretation of dose distribution for flight personnel in your, please attach a table or chart
8. Changes
- 8.1. How did dose rates for general flight personnel develop since assessment of the crew concerned became obligatory?
Average dose rates increased: stayed the same: decreased:
Maximum dose rates increased: stayed the same: decreased:
- 8.2. How did dose rate for pregnant / breastfeeding women develop since assessment of the crew concerned became obligatory?
Average dose rates increased: stayed the same: decreased:
Maximum dose rates increased: stayed the same: decreased:
9. Responsibilities / Communication with Civil Aviation Authorities and Airlines:
- 9.1. Who is responsible for collecting the data on radiation exposure for aircrews in your country?

- a) your organisation
- b) the civil aviation authority
- c) the airline(s) themselves
- d) other (please specify)

9.2. Who is responsible for storing and managing the data on radiation exposure for aircrews in a central database in your country?

- a) your organisation
- b) the civil aviation authority
- c) the airline(s) themselves
- d) other (please specify)

9.3. In which time intervals are the collected dose data transferred to the organisation in charge of the central database?

9.4. What kind of data are sent from the organisation in charge of collecting the data (e.g. personnel data, only >1mSv, personnel number etc.)?

Annotations / Comments

5 COUNTRY SPECIFIC INFORMATION

5.1 Overview

This section contains a compilation of information for each country included in this study (sections 5.2 to 5.32). The fundamental requirements by the EURATOM Basic Safety Standards and the general provisions by JAR-OPS have been dealt with in section 3.4.

5.2 Austria

5.2.1 Legislation

The basic legislation on radiation protection of aircrew is found in the Act on Radiation Protection (Strahlenschutzgesetz - Bundesgesetz über Maßnahmen zum Schutz des Lebens oder der Gesundheit von Menschen einschließlich ihrer Nachkommenschaft vor Schäden durch ionisierende Strahlen – StrSchG) where the regulations on aircrew are contained in section 36k as follows [STR 04]:

“Schutz des fliegenden Personals vor Exposition durch kosmische Strahlung

§ 36k. (1) *Unternehmer und sonstige Arbeitgeber haben die Exposition des fliegenden Personals durch kosmische Strahlen zu berücksichtigen, soweit diese den Dosisgrenzwert für Einzelpersonen der Bevölkerung im Kalenderjahr überschreiten kann. Sie haben geeignete Maßnahmen zu ergreifen, um insbesondere*

- 1. die Exposition des fliegenden Personals zu ermitteln,*
- 2. bei der Aufstellung der Arbeitspläne der ermittelten Exposition im Hinblick auf eine Verringerung der Dosen für stark exponiertes Personal Rechnung zu tragen,*
- 3. das betreffende Personal über die gesundheitlichen Gefahren zu informieren,*
- 4. den Schutz analog § 30 Abs. 3 und 4 für weibliche Mitglieder des fliegenden Personals zu gewährleisten.*

Die Ermittlungsergebnisse müssen spätestens sechs Monate nach dem Einsatz vorliegen.

- (2) Der Bundesminister für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft legt im Einvernehmen mit dem Bundesminister für Verkehr, Innovation und Technologie und dem Bundesminister für Landesverteidigung durch Verordnung fest, welche Schutzmaßnahmen zu ergreifen sind, die Grundzüge, nach welchen Verfahren die Exposition des*

fliegenden Personals zu ermitteln ist, ob und unter welchen Voraussetzungen ärztliche Untersuchungen durchzuführen sind und wie und in welcher Form die Meldungen über die ermittelte Exposition an das Zentrale Dosisregister weiterzuleiten sind.

- (3) *Die Ermittlung der Exposition des fliegenden Personals gemäß Abs. 1 Z 1 hat durch für die Dosiermittlung des fliegenden Personals akkreditierte Stellen oder durch vom Bundesminister für Land und Forstwirtschaft, Umwelt und Wasserwirtschaft im Einvernehmen mit dem Bundesminister für Verkehr, Innovation und Technologie und dem Bundesminister für Landesverteidigung zugelassenen Stellen zu erfolgen. Der Bundesminister für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft hat im Einvernehmen mit dem Bundesminister für Verkehr, Innovation und Technologie und allenfalls dem Bundesminister für Landesverteidigung durch Verordnung die Kriterien für diese Zulassung festzulegen.*
- (4) *Dem Ansuchen um Zulassung zur Durchführung der Expositionsermittlung des fliegenden Personals ist ein umfassender Nachweis über das Vorhandensein der notwendigen personellen und technischen Ausstattung der ansuchenden Stelle anzuschließen.“*

5.2.2 Dose Register

The Central Radioactivity Register and Central Dose Register are operated by the Federal Office for the Environment (*Umweltbundesamt*) in Vienna. It is based on the Radiation Protection Ordinance of Austria of 2005. Data of whole body measurements as well as of internal doses are included.

Data is transmitted from dosimetry labs using a web interface via upload of CSV files. High security is maintained by using a transaction code for data transmission. Dosimetry labs have access to their own data in the register.

Workers are registered using a unique number, based on the social insurance number. Only workers of category A are registered. Radiation passport data are fully included in the database.

5.2.3 National Practice

From Austria, neither the *Bundesministerium für Verkehr, Innovation und Technologie* nor the *Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft* or the Airlines *Lauda Air* or *Austrian Airline* answered to the questionnaire. Thus only public available documents could be evaluated.

5.3 Belgium

5.3.1 Legislation

Regulatory body for radiation protection in Belgium is the Federal Agency for Nuclear Control (FANC), established in 2001 [MOL 04]. Belgium legislation regarding radiation protection is governed by *Wet van 15 April 1994 betreffende de bescherming van de bevolking en van het leefmilieu tegen de uit ioniserende stralingen voortspruitende gevaren en betreffende het Federaal Agentschap voor nucleaire controle* [FAN 94], adapted by *Koninklijk Besluit van 20 juli 2001 houdende algemeen reglement op de bescherming van de bevolking, van de werknemers en het leefmilieu tegen het gevaar van de ioniserende stralingen* (Belgisch Staatsblad van 30 augustus 2001), which is cited below.

The scope of the act as stated in article 1 includes natural radiation as formulated in paragraph 3:

“ALGEMENE BEPALINGEN

Artikel 1. - Toepassingsgebied

Dit reglement is van toepassing op alle handelingen die een risico kunnen inhouden tengevolge van de blootstelling aan ioniserende stralingen die worden uitgezonden, hetzij door een kunstmatige, hetzij door een natuurlijke stralingsbron, wanneer de natuurlijke radionucliden worden bewerkt of zijn bewerkt geweest omwille van hun radioactieve eigenschappen, hun splijtbaarheid of omwille van hun kweekeigenschappen, in het bijzonder:

...

3. op elke andere handeling die een risico kan inhouden ten gevolge van ioniserende stralingen.

Het is eveneens van toepassing, overeenkomstig de bepalingen van de artikelen 9 en 20.3, op de beroepsactiviteiten die niet worden vermeld in het vorige lid, maar waarbij natuurlijke stralingsbronnen aanwezig zijn en die kunnen leiden tot een aanzienlijke verhoging van de blootstelling van personen, die vanuit het oogpunt van stralingsbescherming niet mag verwaarloosd worden.

...

Het is evenmin van toepassing op het natuurlijk stralingsniveau, dit wil zeggen op straling tengevolge van in het menselijk lichaam aanwezige radionucliden, noch op de kosmische straling ter hoogte van het aardoppervlak, noch op de bovengrondse blootstelling aan radionucliden in de onverstoorde aardkorst.”

This means, cosmic radiation belongs to the scope of the act as long as the impact is increased by height for people not working at ground level. Aviation is directly addressed in article 4, as follows:

“Art. 4. - Beroepsactiviteiten waarbij natuur-lijke stralingsbronnen aangewend worden

De beroepsactiviteiten bedoeld in het tweede lid

van artikel 1 zijn de volgende:

...

3. de exploitatie van vliegtuigen.”

This means aviation is explicitly mentioned for being an occupation to be ruled by this act.

Occupational exposure to natural radiation is regulated in article 9, where paragraph 4 explicitly rules aviation:

“Art. 9. - Stelsel van toepassing op de be-roepsactiviteiten waar natuurlijke stralings-bronnen aangewend worden

9.1. *De beroepsactiviteiten bedoeld in artikel 4 dienen het voorwerp uit te maken van een aangifte gericht aan het Agentschap.*

Deze aangifte moet, in drie exemplaren, aan het Agentschap toegestuurd worden en omvat:

1° de naam, voornamen, hoedanigheid en woonplaats van de persoon die de aangifte indient en eventueel de maatschappelijke benaming van de onderneming, haar maatschappelijke, administratieve en exploitatiezetels, de namen en de voornamen van de bestuurders of zaakvoerders, de identiteit van de exploitant, de naam en voornaam van het hoofd van de inrichting;

...

4° voor de ondernemingen die vliegtuigen exploi-teren:

- de beschrijving van de methodes en voor-waarden voor het meten of de schatting van de doses ten gevolge van de blootstelling van het vliegtuigpersoneel aan kosmische straling;*
- de resultaten van de meting of de schatting van de blootstelling van het vliegtuigper-soneel aan kosmische straling.*

...

9.3...

...

Voor de ondernemingen die vliegtuigen exploiteren dient het ondernemingshoofd, indien de dosisniveaus, vastgesteld in artikel 20.3, voor beroepshalve blootgestelde personen, worden overschreden of kunnen worden, onverminderd de maatregelen die door het Agentschap worden opgelegd krachtens de bepalingen van dit artikel:

- *de individuele doses te bepalen van het personeel, ten gevolge van de blootstelling aan kosmische straling;*
- *rekening te houden met deze dosisschattingen bij het opstellen van de werkschema's, teneinde hoge doses bij het vliegtuigpersoneel te vermijden;*
- *de betrokken werkers te informeren over de gezondheidsrisico's die hun werk met zich meebrengt;*
- *artikel 20.1.1.3 toe te passen voor het vrouwelijke vliegtuigpersoneel."*

Thus article 9.1 defines reporting duties for operators. Paragraph 1 gives rules applicable for all professions. As given in the fourth paragraph, operators have to report to the Belgium Radiation Protection Agency "Federaal Agentschap voor Nucleaire Controle", (F.A.N.C.) about dose reduction measures and the results of those. In article 9.3 further duties of the operator are listed. These are to inform personnel about health risks related to cosmic radiation, dose assessment and the reduction of exposure by roster optimisation. Moreover for female employees article 20.1.1.3 has to be respected:

"20.1.1.3. Geen enkele persoon onder de 18 jaar mag worden tewerkgesteld op een arbeidsplaats waardoor hij/zij in de categorie van beroepshalve blootgestelde personen zou komen te vallen.

De bescherming van het ongeboren kind mag in geen geval lager liggen dan deze van de personen van het publiek. Hieruit volgt dat vanaf het ogenblik van de bekendmaking van de zwangerschap, de voorwaarden waaraan de zwangere vrouw wordt onderworpen in het kader van haar werk, zodanig moeten zijn dat de dosis die door het ongeboren kind wordt opgelopen zo laag als redelijkerwijze mogelijk is en gedurende de totale duur van de zwangerschap zeker beneden 1 millisievert blijft. Indien deze dosis reeds werd overschreden op het ogenblik dat de zwangerschap werd bekendgemaakt, dan zal de zwangere vrouw niet meer mogen werken op een arbeidsplaats waar ze het risico loopt te worden blootgesteld aan ioniserende stralingen.

Gedurende de periode van de borstvoeding en/of gedurende de ganseperiode van de zwangerschap, volgend op de bekendmaking van de zwangerschap, mag geen enkele vrouw nog werken op een plaats waar ze beroepshalve het risico loopt op radioactieve besmetting van het lichaam."

That means that individual accumulated doses for pregnant air crew members are not to rise above 1 mSv during the whole pregnancy. Breastfeeding women should not work in workplaces, where they are exposed to ionising radiation at all.

In article 20 the action levels for occupational exposure are defined, where paragraph 23 is dedicated to aviation:

“20.3. Dosisniveaus te gebruiken voor de toepassing van artikel 9.3, in het kader van de blootstelling aan natuurlijke stralingsbronnen

De beroepsactiviteiten die aanleiding geven tot blootstelling aan natuurlijke stralingsbronnen, vallen geheel of gedeeltelijk onder de bepalingen die van toepassing zijn op de handelingen in het kader van dit reglement, overeenkomstig de bepalingen van artikel 9, ingeval van:

...

- de exploitatie van vliegtuigen waarbij de blootstelling van het vliegtuigpersoneel aanleiding kan geven tot effectieve doses die groter zijn dan 1 millisievert per jaar.”

Thus, regulations of the act are valid for flight crews that are likely to receive personal doses above 1 mSv a year.

5.3.2 Dose Register

The National Dose Register is driven by the Medical Department in Belgium. Employers have to report individual annual dose data to the register before March of the following year. Dose data has to be kept for 30 years by the employer, raw data 5 years by the dosimetry services. The profession is referenced using the NACE-code. Aviation would be I 62.00 in NACE, thus recording of aviation doses technically is no problem [MOL 04].

5.3.3 National Practice

SPF Mobilité et Transports, Direction générale du Transport aérien and the three Airlines *European Air Transport, SN Brussels Airlines* and *TNT Airways S. A.* did not answer to the questionnaires.

5.3.3.1 Radiation Protection Authority

The *Federal Agency for Nuclear Control (FANC)* in Belgium is responsible for dose data management for air crew members. The data is directly passed from airlines. In Belgium there are 11 commercial and 39 non-commercial operators included in radiation protection. As non-commercial airlines have not yet made aware of the issue and there is no appropriate policy yet, in practice there are only the 11 commercial ones to be supervised.

The total amount of crew members being monitored is 603, for those, where the operators gave further information about gender and workplace, those are given in Table 8.

Table 8: Number of monitored crew members (> 1 mSv/a)

Crew	male	female
cabin crew	42	110
flight deck crew	56	6
sum	98	116

Due to Belgian legislation there are only action levels but no dose limits for air crew. The action level is 1 mSv/ for general and 1 mSv/pregnancy for pregnant women. For personnel reaching this limit, the operator has to do dose evaluation and optimise work schedules for dose reduction. Additionally concerned crew members have to be informed about health risks and about their personal dose. Besides legal regulations, FANC asked the operators to inform the airlines medical officers of concerned employees. There is no regular information of aircrew members about their doses.

Dose data of air crew is not yet collected in any database. This is however under development.

There is no accreditation for dose calculation software in Belgium. Companies use EPCARD, CARI6, FREE, PCAIRE, SIEVERT, IASON-FREE and GLOBALOG.

The average dose of air crew members reached in Belgium is 1.85 mSv/a. There are 316 persons not reaching action level, 603 with personal doses between 1 and 6 mSv/a, and nobody exceeding the dose of 6 mSv/a. As data collection started in 2007 only, it is not possible to interpret development of doses. This is also the reason why dose data collection is still under development.

5.4 Bulgaria

5.4.1 Legislation

The Civil Aviation Act, denomination of July 5, 1999, promulgated *Official State Gazette* Issue No. 94 of December 1, 1972; amended and supplemented, SG 37/2006, contains all public relations pertaining to civil air navigation in the Republic of Bulgaria as well as to ensuring its safety and security. Radiation protection of air crew members is not regulated by this act, though. Provisions for radiation protection of aircrew as contained in JAR-OPS and ACJ-OPS are applied.

Radiation protection for the public and for occupationally exposed people is in detail regulated in the Regulation on Basic Norms of Radiation Protection. This regulation, published in 2004, is the national implementation of 96/29/EURATOM. Provisions relevant for aircrew radiation protection are made as follows:

“CHAPTER I

GENERAL PROVISIONS

Article 1 (1) *The subject of this Regulation are the basic requirements and measures for radiation protection in case of carrying out activities utilizing nuclear energy and sources of ionizing radiation (SIR) within the meaning of the Act on the Safe Use of Nuclear Energy.*

(2) *The requirements of this Regulation shall also apply to activities, where the presence of natural radiation sources leads to an increase in the exposure of workers and members of the public.*

(3) *This Regulation shall not apply to exposure of persons caused by:*

- 1. cosmic radiation prevailing at ground level;*
- 2. potassium-40 content in human body;*
- 3. radionuclides content in different materials undisturbed by human activity;*

...

Section II

Special requirements for women, being exposed workers, for apprentices and students and in case of specially authorised exposures

Article 14 (1) *Every woman, being exposed worker, should inform the Head of the undertaking immediately after the pregnancy is ascertained by submission of medical conclusion.*

(2) *The notification under paragraph 1 is not a reason for suspension from work but it is the obligation of the undertaking to ensure such working conditions that protection of the child to be born is comparable with that provided for members of the public, the equivalent dose to the child to be born should be as low as reasonably achievable but in any case should not exceed 1 mSv during the remainder of the pregnancy.*

(3) *As soon as a nursing woman informs of her condition the Head of the undertaking should ensure such conditions of employment, where there is no likelihood of radioactive contamination of the body of the nursing woman.*

...

CHAPTER VI

LIMITATION OF EXPOSURE DUE TO NATURAL SOURCES

Article 39 (1) *The Minister of Health shall determine in an order the work activities, where the exposure to natural sources cannot be disregarded from the radiation protection point of view, such as: work in spa resorts, underground and overhead sites, caves, flights with aircraft, work with or storage of materials and wastes with increased content of natural radionuclides, causing substantial increase in exposure of members of the public or workers.*

(2) *For the activities under paragraph 1 the Minister of Health prescribes the necessary measures of radiation protection and decrease of the exposure.*

Article 40 (1) *The effective annual doses of persons occupied with any professions, productions and activities, determined pursuant to Article 38, paragraph 1, 16 must not exceed, under working conditions with 6 mSv, the exposure to the local natural radiation background.*

(2) *The requirement of paragraph 1 applies also to the exposure of air crews to cosmic radiation, where the undertaking is obliged:*

- 1. to establish and register the exposure of air crews, when there is a probability that the effective dose exceeds 1 mSv;*
- 2. to fulfil the requirements of Article 14 with respect to female air crews.*

(3) *No effective dose limit is set for exposure of the population to natural sources.”*

5.4.2 Dose Register

As given in article 40, paragraph 2, a register for the exposure data of air crews will be established in Bulgaria. There is no information available about the state of this project at the moment.

5.4.3 National Practice

The Bulgarian *Directorate General, Ministry of Health* and the airline *Hemus Air* did not answer to the questionnaire, thus the evaluation is based only on the public available documents.

5.5 Croatia

5.5.1 Legislation

Radiation protection in Croatia is regulated by the *Act on Ionising Radiation Protection and Safety of Ionising Radiation Sources (30. May 2006)* [CRO 06]. The scope of the Act relating to natural radiation is stated in Article 4 as follows:

“Article 4

This Act does not apply to the natural level of ionising radiation of cosmic, Earth's crust or human origin, where not modified by the action of man."

Thus the act does not regulate radiation protection for aircrew exposed to cosmic radiation. Nevertheless, the dose limit regulations for workers and for pregnant and breastfeeding women should be mentioned as formulated in the act:

"Dose limits for exposed workers

Article 13

The effective dose for exposed workers in normal conditions during work must not exceed 100 mSv in a period of five consecutive years, provided that the effective dose must not exceed 50 mSv in any year of the five-year period.

Article 14

Taking into consideration the dose limits prescribed in provisions of Articles 11 and 13 of this Act, the exposure limits for certain organs and tissues of the human body, exposure limits for persons undergoing training or instruction for working with ionising radiation sources, exposure limits in special circumstances owing to implementation of interventions in an emergency event as well as the limits between an area under supervision and an area under special supervision shall be prescribed by an ordinance to be issued by the minister competent for health.

Protection during pregnancy and breastfeeding

Article 15

The holder of the authorisation or beneficiary shall arrange for an exposed female worker to work during pregnancy at a work post where the effective dose does not exceed 1 mSv.

Breastfeeding women shall not occupy a work post where there is a possibility of radioactive contamination."

These limits are not aimed on air crew as illustrated above, but give a general insight into Croatian radiation protection.

In Croatia the Ministry of Health and the Health Inspectorate are responsible for occupational radiation protection in general. The Croatian Institute for Radiation Protection (Državni Zavod Za Zaštitu od Zračenja), established in 1999, formulates standards and methods for radiation protection. The supervision and enforcement of measurements is due to the Sanitary Inspection Department of the Ministry of Health [NEA 04].

The Croatia 2007 Progress Report [CEC 07] states:

“Progress has been good in the area of nuclear safety and radiation protection. A law on protection from ionising radiation and safety of ionising radiation sources has been adopted.

This is supplemented by a package of implementing legislation relating to ionising radiation and exposure to such radiation.

...

*Good progress can be reported in the field of **health and safety at work**. Legal alignment has continued with the adoption of legislation aiming at transposing the acquis on mineral extracting industries, carcinogens and mutagens as well as asbestos.”*

As radiation protection as one means of health and safety at work is not explicitly mentioned, probably there are no special regulations regarding the exposure to cosmic radiation of air crew members.

5.5.2 Dose Register

The National Health Inspectorate collects dose data for occupational exposed workers.

5.5.3 National Practice

5.5.3.1 Radiation Protection Authority

The State Office of Radiation Protection of Croatia attested the above mentioned assumption that in Croatia there is no legislation regarding radiation protection of air crew members. Being a candidate nation for the European Community, Croatian radiation protection authority pronounced the implementation of BSS 96/29/EURATOM in Croatian national law as soon as possible. The rest of the questionnaire was thus of no interest regarding Croatia and thus no answers have been provided.

5.5.3.2 Civil Aviation Authority

The Civil Aviation Authority of Croatia informed us by Mail, that there are no airlines registered in Croatia flying above 49.000 ft. The questionnaire was not answered by the CAA.

5.5.3.3 Operators

Though Croatia Airlines did not fill in the questionnaire, they sent an email addressing the topic in a more general way. There is no system for air crew radiation protection at this airline. The airline does not operate with flights above FL390. The operator launched an assessment study in 2000, which showed annual average doses of 3 mSv for personnel on Airbus-aircrafts. Thus the company decided to ground all female crew members getting pregnant at once. The total numbers of crew members at Croatia Airlines are to be found in

Table 9: Crew members of Croatia Airlines

Crew category	Male	Female
Cockpit	125	3
Cabin	35	190

5.6 Cyprus

5.6.1 Legislation

Radiation protection in Cyprus is legally governed by the Protection from Ionizing Radiation Law of 2002 and the relevant Regulations issued under the above framework law [EUR 07]. Unfortunately all documents to be found are written in Greek

5.6.2 Dose Register

The national regulatory authority keeps data of about 350 occupationally exposed workers in Cyprus. They are working in activities which are licensed. Occupations in the scope of monitoring are from the medical and industrial sector, aviation is not mentioned.

5.6.3 National Practice

5.6.3.1 Civil Aviation Authority

The Cyprus Civil Aviation Authority answered the questionnaire. The SRU department of this authority is supervising the dose monitoring of air crew by visits at the airlines. Doses during transport flights of personnel are registered, too. There is no information programme for flight members in Cyprus. Though Cyprus legislation defines action levels for air crew doses, there is no regulation of the kind of preventive action and until today, the action levels have never been reached. As the supervision by CAA is confined to visits, the hours spent to conduct supervision are very limited.

In Cyprus there are three commercial airlines which are all under radiation protection. This means 385 cabin and 234 flight deck crew members under radiation protection. One of them, *Cyprus Airways Public Limited*, had been asked to answer the questionnaire, but did not do so.

In sum there are 85 aircrafts in Cyprus, none of which are equipped with radiation measurement techniques.

The dose levels from JAR-OPS 1, groupings and levels are implemented in Cyprus legislation. Pregnant staff member are not allowed to fly any longer after reaching the third month of pregnancy. There are no other preventive actions nor have there ever been any.

For dose assessment in Cyprus CARI6 is used. Personnel are informed about health risks, their personal dose and any time action levels are reached. Data has to be kept for at least one year and is collected by the CAA.

There are no improvements or changes in this radiation protection system planned in Cyprus.

5.7 Czech Republic

5.7.1 Legislation

Part Three of the *Regulation No. 307/2002 Coll. of 13 June 2002 on Radiation Protection*, issued by the State Office for Nuclear Safety, forms the basis for radiation protection to aircrew. The relevant parts of the legislation are reproduced in the following:

“PART THREE - WORK ACTIVITIES ASSOCIATED WITH INCREASED EXPOSURE TO NATURAL SOURCES

[For the implementation of the Act, Section 4 paragraph 7) b), Section 6 paragraph 2, 3 b), c) and d), Section 8 and Section 9 paragraph 1 h)]

§ 87 - Workplaces with a Possibility of Significantly Increased Exposure to Natural Sources

Workplaces where an increased exposure to natural radiation sources may be expected are as follows:

a) Aircraft boards in flights at an altitude over 8 km;

§ 88 - Scope of Measurements and Keeping Records on Results

.....

c) at aircrew members operating on airplane boards at an altitude over 8 km by determining an aircrew flight schedule, flight parameters and other parameters which are important for calculation of an effective dose in compliance with the approved methods and by calculation of an effective dose per calendar year;...

d) ...

(4) The data measured and the annual effective doses per calendar year for the persons performing work at the workplaces where the guidance levels under Section 90 paragraph 2 a) and b) have been exceeded, as well as for the aircrew members operating on airplane boards at an altitude over 8 km, shall be

filed during the whole period of their working life and afterwards until the persons have or would have attained the age of 75 years, but in any case not less than 30 years from the termination of the work involving exposure.

(5) The Office's state system of records of exposure of individuals shall be notified once a year in summary directly or through a person who performs the approved dosimetric service of the names, surnames, birth registration numbers, if assigned, and the data of effective doses of all the persons performing work activities in the environment with a significantly increased exposure to natural radiation sources under Section 91.

§ 90 - Guidance Levels

(1) For the members of aircrews who operate on airplane boards at an altitude over 8 km, the guidance level for the reduction of exposure to cosmic rays shall be an effective dose of 1 mSv per calendar year. If this guidance level might be exceeded, the members of aircrews shall be informed on the magnitude of their exposure and the health risk, and radiation protection optimisation shall be performed. For this purpose, the exposure of individual aircrew members shall be evaluated, and based on this evaluation their flight schedules shall be prepared and/or modified.

...

(3) Working conditions of pregnant women shall be modified in accordance to Section 23 paragraph 2 for work activities with an increased exposure to natural sources.

§ 91 - Significantly Increased Exposure to Natural Sources

(1) For persons performing work activities at the workplace laid down under Section 87 b), c), d) and e) and if after applying countermeasures corresponding to the optimisation of radiation protection it shall not be possible to reduce effective doses per calendar year for such persons below 6 mSv, and as well as for aircrews members if it is not possible to reduce an effective dose below 1 mSv, radiation protection shall be ensured in the scope and the manner that is applied for controlled areas of the workplaces where radiation activities are performed. ..."

5.7.2 Dose Register

Central registers for licenses, occupational exposure, ionising radiation sources, approvals issued by Státní Úřad pro Jadernou Bezpečnost (SUJB) and inspections have been created since 1997 on the basis of Czech legislation. They are implemented as ORACLE databases.

The Central Register of Occupational Exposure (CROE) contains:

- personal data: name, surname, date of birth, place of birth specific birth date number, special registration number, start of registration, end of registration, degree of education, type of source, type of exposure, profession, history of employment;
- dosimetric data: personal dose equivalent (Hp(10), Hp(0.07)), neutron Dose Registered separately, annual total effective dose, equivalent dose (skin), doses to extremities, committed effective dose, monitoring period doses, annual doses, 5-year doses, lifetime doses;
- employer data.

5.7.3 National Practice

As both authorities and one airline answered to our questionnaire, there is a good information base for the evaluation of the practical radiation protection in Czech Republic.

5.7.3.1 Radiation Protection Authority

The *State Office for Nuclear Safety (Státní Úřad pro Jadernou Bezpečnost, SUJB)* kindly answered our questionnaire for radiation protection authorities.

BSS 96/29/Euratom was implemented in Czech legislation in July 2002 by introduction of the above mentioned regulation 307/2002. *SUJB* gets dose data directly from the operators. Currently there are 6 airlines under the scope of radiation protection (this is one more than mentioned by the CAA to fly above FL 250). The criterion for inclusion into radio protection programme is the execution of flights in altitudes above 8 km.

At the end of 2007 there were thus about 1700 or 1800 air crew members under radiation protection in the Czech Republic.

SUJB stated the action level to be 1 mSv a year for general personnel and did not mention different figures for pregnant or breastfeeding women. The preventive action taken is to inform personnel about health risks and try to optimise rostering to reduce doses. Thus preventive action means the inclusion into radiation protection programme.

Dose limits are given for general flight personnel to 20 mSv/a, and for pregnant staff to 1 mSv/year. In practice, pregnant staff members in Czech Republic stop flying at all.

All data of occupationally exposed workers is stored in one single database. For air crew the limit for storing data is 1 mSv as mentioned above in §91. The doses are calculated using CARI6. Any crew member reaching 1 mSv year is informed.

The average dose for general air crew members in Czech Republic is 2.2 mSv/a. The average and maximum doses did not change since implementation of radiation protection.

5.7.3.2 Civil Aviation Authority

The Civil Aviation Authority kindly answered our questionnaire. In Czech Republic the responsibility for dose registration of air crew lies at the State Office of Nuclear Safety (SUJB). Supervision of radiation protection measurements is conducted by visits to the airlines.

Frequent flyers, transport flights of crew member and freelancer are not monitored. There is no regulation of action levels. But if the doses should rise above critical values, modification of rosters and medical checks of crew members are planned. CAA is not responsible for the information about health risks but checks if training of air crew in this regards is correctly conducted. The hours spent by CAA in radiation protection supervision by the authority are not known.

There are 17 commercial airlines in Czech Republic, of which 5 are flying above FL 250, all of those are under monitoring, meaning all flight deck and crew members.

The number of aircrafts was not given by the CAA, but there is no measurement equipment on board of planes in Czech Republic, as there are no aircrafts flying above FL 490.

With action levels of 6 mSv a year for general crew and 1 mSv a year for pregnant staff, the dose limits are in accordance with international legislation. Preventive actions for reducing dose in case of reaching these limits are medical checks and the adaptation of flight rosters. These techniques are valid for general crew and pregnant women all the same. No prevention for solar events originated radiation is planned due to unpredictability of such events.

Dose assessment is carried out by calculation with CARI6. Crew is informed about health risks, their personal dose (once a year) and the reaching of action levels, though since today action levels have never been reached. Dose records have to be kept until a crew member reaches the age of 75 or at least until 40 years after the last flight of the crew member.

The central database with the dose data is protected against data loss. Access to the data is regulated by the State Office for Nuclear Safety.

The Czech Republic does not plan to change anything regarding the dose monitoring of air crew before the year 2010.

5.7.3.3 Operators

Regarding *Czech Airlines*, which answered our questionnaire; there are 674 male and 804 female crew members. *Czech Airlines* operates with 53 aircrafts, all of them with take-off masses above 14 t, but none of them flying above FL 490. *Czech Airlines* does not employ freelancers.

At *Czech Airlines* the companies Training Centre is responsible for health information, which is given once a year and permanently published in the intranet and the OPS manual.

The regular medical check of crew at *Czech Airlines* does not include special aspects of radiation protection. Since dose assessment for crew was introduced both, average and maximum dose of general crew members increased due to a change in the flight roster, which led to a reduction of flights to the Far East and an increase of flights to the United States on higher altitudes. Regarding pregnant staff, all women decided to stop flying as soon as their pregnancy became known.

For *Czech Airlines*, the dose calculations are carried out by the Nuclear Physics Institute of the Academy of Sciences of the Czech Republic as contractor. These calculations include solar flares and the real routes instead of flight plans. *Czech Airlines* conducted some active, real time measurements during representative flights in 1999, 2003 and 2007 to support dose calculations. The data is reported to the State Office for Nuclear Safety once a year.

Czech Airlines has an internal database (Health & Safety at Work Protection/Human Resources Division) with dose data in addition, which collections personnel numbers and effective doses.

The current practice of radiation protection for air crew of *Czech Airlines* causes yearly costs of about 33.000 €. This sum is continually growing since the start of monitoring. The effect of the measurements is found to be satisfactory for this airline, though surprisingly most of the personnel themselves are not interested in their individual exposure at all.

5.8 Denmark

5.8.1 Legislation

Aviation in Denmark is governed by the *Air Navigation Act Order, Consolidated Act no. 1484 of 19 December 2005*, issued by the Ministry of Transport and Energy. However, it does not contain provisions on radiation protection for aircrew. The Civil Aviation Administration (Statens Luftfartsvæsen, AIS / Luftfartsinformationstjenesten, Copenhagen) has issued guidelines on the Control of the Exposure to Cosmic Radiation of Air Crew in the Nordic Countries (document AIC B-04 / 03), in which recourse is made to the JAR-OPS. This document is reproduced in the following (including the references) [AIS 03]:

“Dose rates from cosmic radiation vary strongly with altitude and also with latitude and with the phase of the solar cycle. The exposure of air crew to cosmic radiation can be significantly increased dependent on rostering.

The Nordic Radiation Protection and Civil Aviation Authorities have agreed on the following interpretation of requirements for the control of the exposure to

cosmic radiation of air crew in the Nordic countries. The interpretation take due account of the requirements in JAR-OPS 1.390 and 1.680 regarding cosmic radiation (ref. 1), the revised European Basic Safety Standards Directive (ref. 2) and the guidance made by the European Commission in transposing the Directive into national legislation (ref. 3).

- 1. Operators of aircraft in commercial air transport registered in a Nordic country or operating on a Nordic AOC (Air Operator Certificate) shall take the exposure of air crew (both flight deck and cabin crew) to cosmic radiation into account in accordance with these recommendations if the annual effective dose to a crew member can exceed 1 mSv³.*
- 2. The operator (employer) shall inform the air crew of the risks of occupational exposure to cosmic radiation. Female air crew shall know of the need for early declaration of pregnancy in view of the risks of exposure for the child to be born.*
- 3. Effective doses to air crew can be estimated by the operator by using route doses calculated with a suitable computer programme⁴ taking generic or specific flying circumstances into account. Other means of estimating the exposure to air crew shall be approved by the National Radiation Protection Authority in cooperation with National Civil Aviation Authorities to ensure adherence to JAR-OPS 1. Operators, who before each traffic season can demonstrate annual average crew radiation exposure well below 6 mSv based on the average flying pattern and expected average number of flight duty hours, can use actual duty hours as a scaling factor for estimating individual effective doses. The average crew radiation exposure estimate must take into account the varying flying pattern of different groups of crew members, if applicable.*
- 4. The operator shall after each calendar year estimate the effective dose to each individual crew member in accordance with paragraph 3 and inform the crew member of his/her effective dose.*
- 5. Once a year before 01 March the operator shall forward the following information regarding the previous calendar year to the national radiation protection authorities: Statens Institut for Strålehygiejne; Knapholm 7; DK-2730 Herlev; Denmark*

³⁾ For flights operating below 26.000 ft (~ 8 km) the annual effective dose to a crew member will not exceed 1 mSv. Similar, the recommendations do not apply if the operator can demonstrate that due to the general operating practices of the company, it is very unlikely that the dose to the crew (or a well defined group of crew members) will exceed 1 mSv.

⁴⁾ At present no approval procedure has been agreed upon. Examples of computer programs which have demonstrated an agreement with measured values available within acceptable uncertainty limits are CARI-6 (ref. 4), EPCARD-3.1 (ref. 5) and FREE-1.0 (ref. 6).

- (a) *A summary of the estimated yearly effective doses to the air crew (Number of crew members in each 1 mSv interval (< 1 mSv, 1-2 mSv, 2-3 mSv, 3-4 mSv, etc.)).*
- (b) *A list of crew members with an estimated yearly effective dose equal to or above 6 mSv (Full name, national identification number and estimated dose in accordance with national legislation on personal registries).*
6. *When organising working schedules the operator shall take into account the estimated effective doses with a view to reduce individual yearly doses at for those individuals whose yearly effective dose is estimated to be at or above 6 mSv.*
7. *When a pregnant crew member informs the operator of her condition, the operator shall ensure that the working schedule for female crew members, once they have notified the operator that they are pregnant, keep the equivalent dose of the foetus as low as can reasonably be achieved and in any case ensure that the dose does not exceed 1mSv for the remainder of the pregnancy.”*

References:

1. JAR-OPS 1, Amendment 3.
2. Directive 96/29/Euratom of 13 May 1996 laying down basic standards for the protection of the health of workers and the general public against the dangers from ionizing radiation.
3. Recommendations for the Implementation of Title VII of the European Basic Safety Standards Directive (BSS) Concerning Significant Increase in Exposure due to Natural Radiation Sources, European Commission 1997.
4. Information about and download of CARI-6: <http://www.cami.jccbi.gov/AAM-600/610/600radio.html>.
5. Information about and download of EPCARD-3.1: http://www.gsf.de/epcard/deu_start.php
6. Information about FREE-1.0: Technische Universität Graz, Institut für Technische Physik, Peter.Kindl@TUGraz.at or felsberg@sbox.tu-graz.ac.at.

To assist operators in implementing necessary measurements, Statens Luftfartsvæsen published a flyer to inform operators about cosmic radiation and the above mentioned legislation [SLV 06].

5.8.2 Dose Register

5.8.3 No information found. National Practice

With answers from both Danish authorities, there is a lack of information about the view of operators in evaluation of the national practices in the following sections.

5.8.3.1 Radiation Protection Authority

The *National Institute of Radiation Protection* in Denmark is engaged in management of air crew dose data. There are 11 airlines under radiation protection. As CAA (see 5.8.3.2) mentioned 46 operators, 35 do not have personnel reaching the level of 1 mSv/a. The total number of crew (flight deck and cabin, male and female) thus being monitored is 4708 for Denmark.

The occupational dose limit is 20 mSv/a for general personnel and 1 mSv/pregnancy for pregnant women. Dose data of air crew members is stored in a general database together with all data of occupationally exposed workers. For air crew personnel estimated annual doses are stored, if they exceed 6 mSv/a.

Dose assessment is done using EPCARD, CARI6 or FREE. Personnel are informed regularly about their personal dose. All data is stored "forever" in the national database. In 2006 the average dose for air crew members was 2.1 mSv/a acquired by 4761 persons. 1274 of them did not reach the level of 1 mSv/a, 3487 had doses beneath 6 mSv/a. Nobody exceeded the limit of 6 mSv/a.

Over all the average and the maximum dose rate of general crew personnel increased since the start of the program.

5.8.3.2 Civil Aviation Authority

The Civil Aviation Administration of Denmark kindly answered our questionnaire. The authority's Working Environment Department, consistent of one person, is responsible for the supervision of dose registration of air crew. Supervision is conducted by the use of a database to collect the dose records, by hardcopies of reported data and by visiting the airlines.

Dose registering is conducted for all employees of registered Danish airlines; thereby it does not matter if a person flies on duty or just for transportation. All routes are assessed. At reaching action levels for general crew, the operator is contacted by CAA and has to change rosters to reduce exposure. For pregnant women preventive action means to stop to fly at all.

The CAA has to control the implemented information of crew members about health risks and provides information from dose registry. The supervision of radiation protection is part of the general inspection of airlines and thus there are no numbers about the hours spent available. All 46 commercial airlines are included into radiation protection program of Denmark. As none of the Danish aircrafts flies above 49 500 ft, none is equipped with measurement equipment.

Action levels in Denmark are, according to JAR-OPS 1 at 6 mSv for general crew and 1 mSv for pregnant women. There is no special level for crew members under the age of 18, because there are no such employees in Danish aviation. Regarding increased radiation from solar events, those are part of dose calculation and thus influence the personal doses and the reaching of action levels.

In Denmark dose calculation is conducted using EPCARD, CARI6 and FREE. The airlines are responsible for dose assessment and accumulation. The reports on specialised paper form are once a year sent to the radiation protection authority, which collects data, gives a copy to the CAA and publishes a yearly national report regarding radiation protection. Crew members are informed regularly about their doses and additionally in case of reaching action levels. Data has to be kept by operators.

There are no plans to change anything about the currently applied radiation protection system for air crews in Denmark until 2010.

5.9 Estonia

5.9.1 Legislation

The Estonian Radiation Protection Centre (ERPC) was established in 1996. Estonia is member of the EU since 1. May 2004. A new Radiation Act entered into force at the same time. Radiation Protection for air crew is regulated in section 49 of the Radiation Act:

“Section 49 – Increased natural radiation

(1) Work activities within which the presence of natural radiation sources may lead to a significant increase in the exposure of workers or of members of the public are the following:

(...)

3) work of air crews in high-altitude flights.

(...)

(3) In order to protect air crew who, due to exposure to cosmic radiation, are liable to be subject to exposure in excess of the annual effective dose limit of public exposure established by this Act, the employer shall:

1) organise assessment of the doses resulting from the exposure;

2) take into account the assessed exposure when organising work schedules;

3) inform the workers concerned of the health risks their work involves;

4) *apply special measures for the protection of the health of female workers during pregnancy and breastfeeding.*"

5.9.2 Dose Register

The central dose register was created in 1999 according to regulation "*The Statue of the State Dose Register of Exposed Workers*". A new regulation of the government "*Maintenance of the State Dose Register of Exposed Workers*" entered into force on 19. July 2004.

The Dose Register database is in continuing development (for better data processing).

5.9.3 National Practice

The questionnaire was answered by the radiation protection authority and one airline.

5.9.3.1 Radiation Protection Authority

The radiation protection authority of Estonia pointed out that six commercial airlines and three non-commercial aircraft operators are registered but that none of these airlines and aircraft operators is under the scope of the radiation protection. The authority states as a reason (with reference to JAR-OPS 1.680) that none of these airlines and aircraft operators will operate above 15,000 m. For the same reason, none of the cabin or flight deck crew members are under the scope of radiation protection.

5.9.3.2 Operators

Estonian Air kindly answered our questionnaire. *Estonian Air* operates 6 aircrafts with more than 20t of maximum take-off mass and 2 with a mass between 14 and 20 tons. All regards of radiation protection are covered by the Flight Operations Department. In the end of 2006, *Estonian Air* employed 168 flight crew members of both genders; none of them was monitored, as they are all likely to receive doses below 1 mSv. Nevertheless, crew members are informed about health risks of cosmic radiation once a year by the Flight Operations Director.

Dose calculation is conducted by flight operation department, too. The sun activity is averaged by the yearly sum on latitude 60°N and a flight watch is taking block hours for calculation. There is no measurement equipment on board of any aircraft of *Estonian Air*.

For pregnant staff reaching the action level of 1 mSv, instant grounding would be induced, though at the moment, crew members aware of pregnancy stop flying at once. *Estonian Air* collects flight numbers, routes and time as part of their personnel database. This data might be used to reproduce doses of employees. The data is stored for 12 months after a crew member stops employment with *Estonian Air*. As personal doses are not reaching 1 mSv a year, there is no reporting to what authority ever.

5.10 Finland

5.10.1 Legislation

Finnish radiation protection is ruled out by the *Radiation Protection Act (592/1991)*. Natural radiation is governed by this act as follows (from unofficial translation):

“CHAPTER 3 Definitions

Section 8 Radiation

For the purposes of this Act, the term:

...

4) Natural radiation shall denote ionizing radiation originating in space, or from radioactive substances occurring in nature and not used as radiation sources.

...

Section 11 Radiation practices

The term radiation practices shall denote:

1) the use of radiation,

2) operations or circumstances in which human exposure to natural radiation causes or may cause a health hazard.

...

CHAPTER 12 Natural radiation

Section 45 Reports on radiation exposure

Anyone using naturally occurring earth, stone or other materials, or materials produced as a result of using these materials, in industrial or comparable operations shall investigate the radiation exposure caused by these practices in a manner acceptable to STUK if it is found, or if there is reason to suspect, that the operations constitute radiation practices. The same obligation shall apply to an employer if it is found, or if there is reason to suspect, that the radiation exposure originating from natural radiation and occurring in the employer's working facilities or other workplace causes or is liable to cause detriment to health.

If the party required to make such an investigation fails to do so, then STUK shall be empowered to issue an order to this effect.

...

Section 49 Authority to issue decrees

Detailed provisions on the regulatory control of radiation exposure due to natural radiation shall be issued by decree.

(Radiation Decree, chapter 7) ”

Thus the more practical regulations are to be found in the *Radiation decree (1512/1991)*. Radiation Protection basics for air crew are regulated in the above mentioned chapter 7, section 28 of the Radiation decree:

“Protection of air crew

If an investigation referred in section 45 of the Radiation Act indicates that the effective dose caused by cosmic radiation to the air crew may exceed 1 mSv per year, then the responsible party shall:

- 1) maintain records of employee work shifts on flights and, as necessary, plan the shifts so that exposures which considerably exceed the levels typical for aviation work may be prevented,*
- 2) inform the employees of the health hazards of radiation, of the exposure levels typical in aviation work and of the results of exposure assessments,*
- 3) arrange the work of a pregnant worker in accordance with the requirements of section 5*
- 4) arrange the medical surveillance of employees in accordance with the principles stipulated in the Radiation Act.”*

More detailed regulations are given in the *guide ST 12.4 from 20 June 2005 - radiation safety in aviation* – by STUK, the Finish radiation and nuclear safety authority [STU 05], which from legal view is a directive really.

After general provisions about cosmic radiation, the dose limits and protection measurements are described as follows:

“3 Dose constraints and maximum values

The effective dose due to cosmic radiation received by an aircrew worker may not exceed 6 mSv per annum. This dose constraint is an operations specific maximum value imposed pursuant to section 7 of the Radiation Decree (1512 of 1991) in order to ensure realisation of the principle of optimisation prescribed in section 2 of the Radiation Act.

Under section 5 of the Radiation Decree, a foetus must be protected in the same way as a member of the population. When a woman has announced her pregnancy, her work must be organised so that the equivalent dose received by

the foetus will be as small as reasonably achievable. The equivalent dose during the remainder of the pregnancy is under no circumstances allowed to exceed 1 mSv.

If a person is exposed at work to other ionising radiation in addition to cosmic radiation, then the exposure to the said other radiation must also be determined. Care must also be taken to ensure that the total radiation exposure does not exceed the maximum values prescribed in sections 3–5 of the Radiation Decree.

4 Investigation of radiation exposure due to cosmic radiation

A party engaged in aviation operations must determine the exposure caused to aircrews by cosmic radiation if it is found, or if there is cause to suspect, that the annual effective dose may exceed 1 mSv. The Radiation and Nuclear Safety Authority (STUK) is empowered to order a party engaged in aviation operations to perform such an investigation if the said party otherwise fails to do so (section 45 of the Radiation Act).

The report of the investigation is to be submitted to STUK. The report must specify the most common flight routes and altitudes used by an airline, together with aircraft types and contact details. It must also include an estimate of the annual radiation dose received by aircrews, of ordinary route doses and of annual maximum flying times. The estimate may be made in the manner shown in appendix A or using a calculation method suitable for cosmic radiation dose estimation (see chapter 6).

If the report provided by the party engaged in aviation indicates that the workers are exposed to so much cosmic radiation that the annual effective dose may exceed 1 mSv (section 27 of the Radiation Decree), then the operation constitutes a radiation practice under section 11 of the Radiation Act. The party engaged in aviation is then deemed to be a responsible party, as defined in this ST-Guide.

5 Protection of aircrews

The responsible party must arrange the radiation protection of aircrews in accordance with the requirements of section 28 a of the Radiation Decree (no. 1512 of 1991) and of this chapter. This ST-guide also applies to any workers belonging to outside enterprises who are working for the responsible party. As an employer, it is the duty of the said outside enterprise to ensure that these matters are properly managed (section 37 a of the Radiation Act).

5.1 Limitation of radiation exposure

The responsible party must maintain records of employee work shifts. Work shifts and flight routes must be planned to ensure that the worker's annual effective dose does not exceed 6 mSv.

The flight work of a pregnant woman must be organised so that the equivalent dose received by the foetus will be as small as reasonably achievable. The equivalent dose during the remainder of the pregnancy is under no circumstances allowed to exceed 1 mSv. If the effective dose due to cosmic radiation received by the woman is less than 1 mSv, then the equivalent dose received by the foetus shall also be considered to be less than 1 mSv.

To ensure that the radiation dose received by the foetus is minimised, the worker must notify the responsible party of her pregnancy immediately after the pregnancy has been verified.

5.2 Monitoring of radiation exposure

Monitoring of radiation exposure involves determining individual radiation doses and dose recording. Individual doses may be determined using the methods explained in chapter 6. For the purpose of dose recording, the responsible party must record the following details for each worker:

- *name*
- *identity number*
- *duties*
- *result of dose determination*
- *factors affecting radiation exposure, including flight times and routes.*

Human beings are also exposed to minor levels of cosmic radiation at ground level. This radiation exposure is not due to work, and so it is not taken into account when determining the radiation exposure caused by aviation operations.

5.3 Monitoring of abnormal radiation exposure

A powerful and sudden solar flare can increase cosmic radiation in the upper atmosphere. Steps must be taken to prepare for sudden solar flares when flying at altitudes of more than 15,000 metres. Aviation regulation JAR-OPS 1.680, Cosmic radiation detection equipment, sets out the requirements for measuring instruments and alternative dose determination methods for companies engaged in aviation operations at altitudes of more than 15,000 metres.

5.4 Health surveillance

The health of workers must be surveyed in the manner stipulated for health examinations of persons engaged in work involving special health risks in the Occupational Health Care Act (no. 1383 of 2001) or in the Decree of the Council of State (no. 1485 of 2001) issued pursuant to the said Act. Aviation regulations also include requirements on occupational health care of aircrews.

The need for medical examinations as part of health surveillance must be considered on the basis of the workplace report referred to in section 3 of the Decree of the Council of State and of the requirements of aviation regulations. There is no need to conduct regular medical examinations of aircrews for reasons of radiation protection.

5.5 Informing aircrews

The responsible party must inform workers of cosmic radiation and its health drawbacks, and advise them of typical exposure levels at work. When beginning work and during the course of the work, the worker must be provided with adequate information concerning the regulations and guidelines for monitoring exposure to cosmic radiation, and concerning the degree of exposure caused by the worker's duties and the health impact of the said degree of exposure. Women shall also be advised of radiation protection during pregnancy, and must be encouraged to notify the employer of any pregnancy immediately after the pregnancy has been verified.

The responsible party must take care to ensure that each individual worker is notified annually of the results of monitoring of radiation exposure.

6 Methods of determining radiation exposure

An appropriate calculation programme of proven reliability must be used for determining exposure to cosmic radiation. Reliability may be demonstrated, for example, by means of international comparisons.

The calculation programme must

- be suitable for determining cosmic radiation dosages*
- be documented and tested*
- yield results in the form of effective dose or ambient dose equivalent (see Appendix B and Guide ST 7.2)*
- be precise: the uncertainty of results at a confidence level of 95 per cent may not exceed -33 per cent or +50 per cent.*

Examples of calculation programmes of proven reliability are CARI, EPCARD and FREE.

7 Notifications to the Radiation and Nuclear Safety Authority

The responsible party must submit the information and documents referred to in this chapter to STUK for supervision of radiation exposure arising from aviation operations. The right of STUK to conduct inspections and receive information is prescribed in section 53 of the Radiation Act.

7.1 Notifiable details on initiating radiation exposure monitoring

The responsible party must advise STUK of the method that it uses to determine radiation exposure and demonstrate that the calculation programme meets the requirements imposed in chapter 6. An account must also be provided of the information that is entered into the calculation programme and of the accuracy of the results.

If the radiation exposure of workers is determined by an external enterprise, then the responsible party must notify STUK of the address of the said enterprise. The responsible party must also provide an account of how radiation exposure is determined and how proper information exchange is arranged.

7.2 Details to be notified to the Dose Register

The responsible party must annually notify the results of radiation exposure monitoring for entry in the Dose Register of STUK. The notifiable information comprises the identifying details, the duties and the result of dose determination for the worker. The responsible party must also notify the route doses and flight profiles used in calculating individual doses. Route doses must be calculated at least once a year.

The information for the immediately preceding calendar year must be notified to the Dose Register by no later than the end of January. Data transfer must comply with separate instructions issued by STUK.

It is the duty of every Finnish employer to ensure that the radiation exposure of its Finnish employees is also notified to the Dose Register when the employee is working for a foreign airline (section 35 of the Radiation Act)."

The national implementation of BSS 96/29/EURATOM in Finland was thus completed in 2000.

5.10.2 Dose Register

The national Dose Register of Finland, driven by STUK, was object to some modernizations between 2005 and 2007. This was required among other things, because the structure of occupations available was not up to date. This seems to be a hint that additional groups, probably air crew, had to be added. This guess is based on the date of the above cited guide, being published in 2005.

Among the dose data registered is one value for the effective dose resulting from cosmic radiation. Additionally in source classification there is an entry for "cosmic radiation" available [LEH 04].

Regarding the practices of data collection for air crew doses, STUK dedicated one paragraph of the annual report for 2003 to this topic [STU 04]:

“3.4 Cosmic Radiation

Section 28 a of the Radiation Decree (Amendment 1143/1998) requires monitoring of radiation exposure and medical surveillance to be arranged for aircraft crews on the same principles as for those engaged in radiation work where the effective dose of crew members may exceed 1 mSv per year.

The exposure of aircraft crews to cosmic radiation has been monitored in Finland since 1992. The doses are estimated using a special computation program. The calculation is based on the flight routes and flying times of aircrews and on changes in the cosmic radiation dose rate at altitudes of 8–12 kilometres. The individual doses sustained by aircrews from cosmic radiation have been recorded in the Dose Register since 2001.”

5.10.3 National Practice

With the *Finnish Civil Aviation Authority*, the Radiation and Nuclear Safety Authority (*STUK*), *Finncomm airlines* and the airline *Blue 1* kindly answering our respective questionnaires, there is a fairly broad base for evaluation of daily practice in Finnish radiation protection of air crew members.

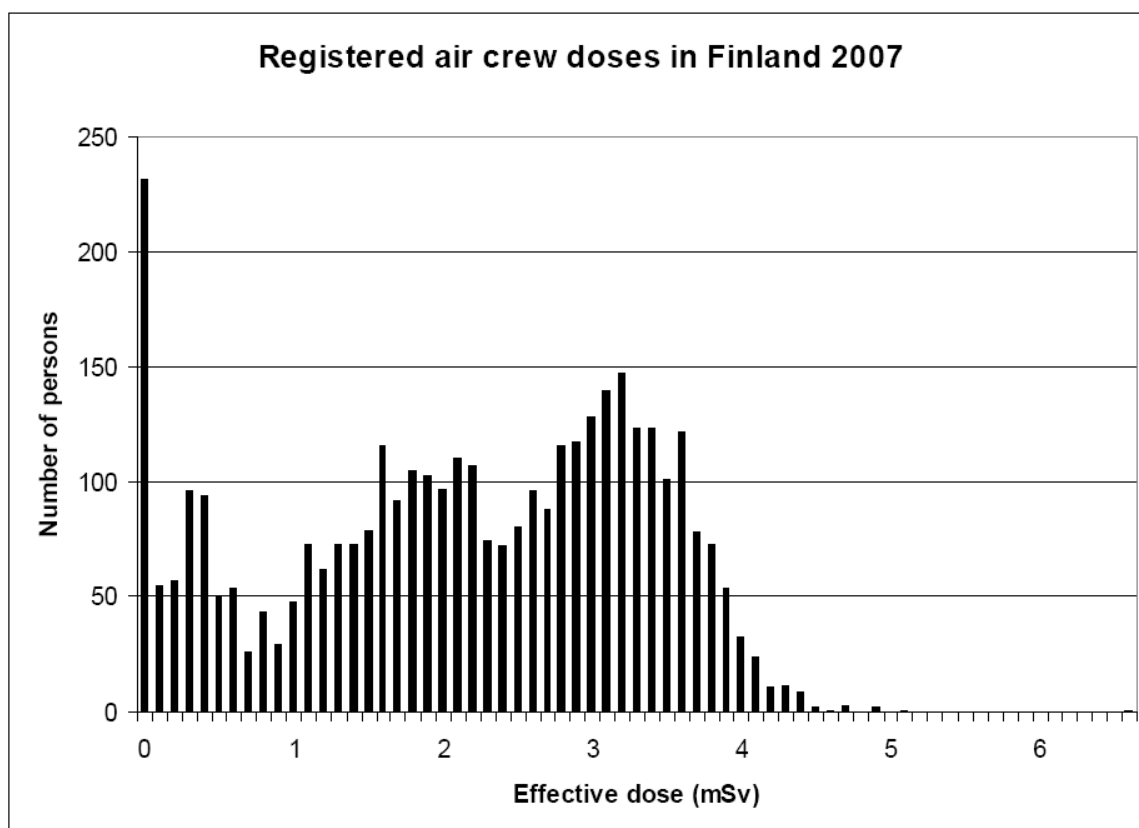
5.10.3.1 Radiation Protection Authority

STUK gets dose data reports directly from airlines and collects them in the above mentioned national dose register together with data of other job groups. The data is kept until the worker has reached the age of 75 or at least 30 years after termination of exposed work. Access to the database is restricted to *STUK* but workers and employers might ask for their relevant data.

In Finland there are 6 air operators under radiation protection, because the annual dose of air crews is expected to exceed 1 mSv/a. There is no differentiation between commercial and non-commercial flight operators in Finland.

At the end of 2007 the monitored crew members were 322 male and 2261 female in cabin crews and 1089 male and 36 female in flight deck crews.

Figure 12: Air crew doses in Finland 2007 (kindly provided by STUK)



All dose limits and action levels in Finland correspond with JAR-OPS 1. For dose calculation only CARI6 and EPCARD are accepted by *STUK*. For any other tool, proven reliability has to be demonstrated. The calculated doses are reported to *STUK* once a year. Personnel are informed about their doses regularly.

In Figure 12, *STUK* provided a detailed profile of doses in 2007. The overall average dose of all crew members was 2.1 mSv/a. As the graph shows, 737 persons remained beneath 1 mSv/a. 2971 persons received doses between 1 mSv/a and 6 mSv/a. Since the beginning of dose registration the average dose rates increased in Finland. There was no information about the maximum dose rates enclosed.

5.10.3.2 Civil Aviation Authority

Radiation protection for air crew members is conducted by the Flight Operations Inspections department of the CAA in Finland. The responsibility for the compliance with the above mentioned regulations lies at *STUK*, though.

In Finland, transportation flights of crew members are monitored, too, as are freelancer's doses and persons who work for several airlines at the same time. Frequent flyers are not under the scope of radiation protection.

If air crew members' doses reach more than 1 mSv a year, the operator is responsible to conduct health and dose monitoring the same way as for radiation workers. Thus, 1 mSv is the action level in Finland. Rosters have to be managed to obtain doses never reaching 6 mSv. There is no special protection to avoid augmented doses by solar events.

The information of air crew members about the health risk from cosmic radiation is obligatory in Finland. CAA does check compliance of operators. All of the tasks connected to air crew radiation protection take about 40 men hours a year for CAA. Work expenses were much higher during the setup of the system.

There are six operating commercial airlines in Finland. As not all of them fly at relevant altitudes, not all of them are monitored. The exact number has not been provided by Finnish CAA. Altogether there are 2090 cabin crew and 1045 flight deck crew members to be monitored. This monitoring takes CAA less than 40 hours a year.

The software tools used in Finland for dose assessments are EPCARD and CARI6. The employees are regularly informed about their personal dose. There is no additional information about reaching action levels. The data is collected at *STUK* in a database for a period of 12 months after leaving occupation at the airline. Access to the data is regulated by the law on individual's information protection.

The now established system is not to be changed before 2010.

5.10.3.3 Operators

Both Finnish airlines (*Blue 1* and *Finncomm airlines*) use only aircrafts with more than 20 t take-off mass maximum. The number of crew members together is 212 male and 252 female, deck and cabin crew together. At *Finncomm airlines* all of them are monitored. At *Blue 1*, there are 10 male and 45 female employees, who are not monitored.

Blue 1 has incorporated radiation protection rules in the Operation and Cabin Safety Manuals. Updates of both of the documents are reviewed by CAA.

Both airlines do dose calculation by themselves. For *Blue 1*, CARI is used. In case of *Finncomm airlines* the calculation is based on precalculated doses for the routes. *Blue 1* integrated this calculation with their crew rostering software for automation. The calculations for *Blue 1* are based on the actual work schedule of personnel, using estimated height profiles for the flights, due to missing exact information. The geographical routes are not asked for in CARI.

There is no measurement equipment in any aircraft of those two operators. Both airlines store the dose data in internal databases and report to *STUK*. *Blue 1*, however, reports problems in employment of freelancers or crew members who work for other international airlines. The problems are due to the fact that dose assessment is a European regulation and international airlines do not provide the data needed to correctly accumulate personal doses.

5.11 France

5.11.1 Legislation

French radiation protection legislation is governed by *Decree no. 2003-296*, which is the national implementation of European Council Directive 96/29/EURATOM and by section 2 of chapter III of part III of book III of the first part of the *Public Health Code* (public) as well as by book II, title III, chapter I, section VIII of the *Labour code* (workers) [NEA 03]. For regulation of occupational exposure there are *decrees 2002-460 of 4 April 2002* concerning the protection of individuals against the dangers arising from ionising radiation and *2003-296 of 31 March 2003* concerning worker protection against the hazards of ionising radiation. The above mentioned decrees regulate radiation from artificial sources and from the manipulation of natural sources for its fertile and fissile properties [ASN 07].

There is no regulation of air crew exposure to cosmic radiation to be found in French legislation.

Radiation protection of workers is conducted by the *Autorité de Sûreté Nucléaire (ASN)* and by the *Institut de Radioprotection et de Sûreté Nucléaire (IRSN)* [ASN 07].

5.11.2 Dose Register

Since the beginning of 2005, data input to the France National Dose Register *Système d'Information de la Surveillance l'Exposition aux Rayonnements Ionisants (SISERI)* is provided through a secure internet access directly by employers. Air operators are already part of the system. Occupational doctors and qualified experts for radiation protection have access to data of employers they are monitoring.

5.11.3 National Practice

Unfortunately, none of the authorities or airlines asked for cooperation answered our questionnaires yet.

5.12 Germany

5.12.1 Legislation

Radiation protection for air crew is regulated in the German *Strahlenschutzverordnung (Radiation Protection Ordinance) §103 of 21. July 2001*:

“Chapter 4**Cosmic Radiation****§ 103***Protection of Flying Personnel against Exposure to Cosmic Radiation*

- (1) *Anyone operating aircraft registered in the German Aircraft Register according to § 3 of the Air Traffic Act of 1 August 1922 (BGBl. I, p. 681) in the revision of 27 March 1999 (BGBl. I, p. 550) in the relevant applicable version, commercially or within the scope of an economic enterprise, or any entrepreneurs whose headquarters are in the area of application of this Ordinance and who operate aircraft registered in another country and employ personnel in accordance with the German labour laws must determine the cosmic radiation that the flying personnel is exposed to during the flight including the transportation time according to § 4, para. (1), first sentence of the second executive ruling for the operating regulations for aircraft apparatus of 12 November 1974 (BGBl. I, p. 181), last changed by ordinance of 6 January 1999 (Bundesanzeiger p. 497), in the relevant applicable version, according to the provision of the second sentence, insofar as the effective dose through cosmic radiation may exceed 1 mSv per calendar year. The determination results must be submitted no later than six months after use.*
- (2) *For the flying personnel the limit for the effective dose through cosmic radiation is 20 mSv per calendar year. The compulsory dose reduction according to § 94 can be achieved especially if work schedules are set up and air routes and flight profiles are determined.*
- (3) *The limit for the sum of the effective doses of occupationally exposed persons determined in all calendar years is 400 mSv. The competent authority may, in consultation with a medical doctor according to § 64, para. (1) first sentence, permit additional occupational radiation exposure if the effective dose is not more than 10 mSv per calendar year and if the occupationally exposed person consents thereto. Consent shall be given in writing.*
- (4) *If a limit has been exceeded in the calendar year in violation of para. (1), first or second sentence, continued employment as occupationally exposed person shall only be permitted if the exposure in the following four calendar years, taking into consideration the previously exceeded limit, is limited such that the sum of the doses does not exceed five times the given limit. If the limit is exceeded to such an extent that previous employment under application of the first sentence cannot be continued, the authority may, in consultation with a medical doctor, permit exemptions from the first sentence according to § 64, para. (1) first sentence.*

- (5) *For an unborn child exposed to radiation owing to its mother's occupation the limit for the sum of the dose from external and internal radiation exposure from the time of the announcement of the pregnancy to its completion is 1 mSv.*
- (6) *The person responsible according to para. (1) shall instruct the flying personnel at least once per calendar year on the ramifications of cosmic radiation for one's health and on the processing and utilization of personal data for the purpose of monitoring dose limits and compliance with radiation protection regulations; women shall be instructed that, given the risks of radiation exposure for the unborn child, a pregnancy shall be announced as early as possible. This instruction may be part of requisite education in accordance with other regulations. The person responsible according to para. (1) shall record the content and date of the instruction and such record shall be signed by the person instructed. He shall keep the records for 5 years after the date of instruction and submit the same to the competent authority upon request.*
- (7) *The person responsible according to para. (1) shall*
- 1. record the results of the dose determination according to para. (1) without delay,*
 - 2. in accordance with para. (1)*
 - a) keep the records until the monitored person has completed or would have completed the age of 75, however, at least 30 years after the termination of the respective employment.*
 - b) erase the records 95 years after the birth of the person concerned.*
 - c) submit the records to the monitored person or the competent authority upon request or deposit them with a body to be assigned by this authority.*
 - d) in the event of a change of employment inform the new employer of the records upon request if further engaged in employment as an occupationally exposed person.*
 - 3. inform the competent authority without delay of the exceeding of the limit for the effective dose according to para. (2) first sentence, stating the reasons, the persons affected and determined doses,*
 - 4. in the event of subpara. 3 inform the persons affected of the effective dose without delay.*
- (8) *The person responsible according to para. (1) shall submit the effective dose determined and the data specified in § 112, para. 1, subparas. 2 and 3 to the Federal Civil Aviation Authority or to a body designated by the Federal Civil*

Aviation Authority for forwarding to the Radiation Protection Register at least twice yearly. Information from the Radiation Protection Register shall be given to the person responsible according to para. (1) insofar it is required for the performance of his duties. § 112, para. (4), first sentence, subparas. 1 and 3 and second sentence shall be applied.

- (9) *The person responsible according to para. (1) may only grant employment or continued employment of persons where a determination according to para 1 has shown that an effective dose of more than 6 mSv per calendar year may be exceeded if they have been examined by a medical doctor according to § 64, para. (1), first sentence within the respective calendar year and if the person responsible according to para. (1) is in possession of a certificate issued by that medical doctor stating that no health objections to such employment exist. The documents requested for the respective application of § 61, para. (1), first sentence must be submitted to the medical doctor according to § 64, para. (1), first sentence without delay. The medical doctor shall send the medical certificate to the person responsible according to para. (1), first sentence to the person exposed to radiation and, in the event of medical concerns, also to the competent authority without delay. The examination can take place within the scope of the examination by the aviation medical doctor. “*

For the implementation of a radiation protection system by the operators, the companies had an adaptation period of two years, before the regulations had to be strictly followed [LEB 03]. Luftfahrt-Bundesamt published procedural requirements regarding the implementation of radiation protection in 2005 [LBA 05]:

„Meldungen entsprechend Strahlenschutzverordnung

1. Zweck

Die kosmische Strahlung trägt zur natürlichen Strahlenexposition der Bevölkerung bei. Bei längerem Aufenthalt in Flughöhen, wo die terrestrische Strahlung sehr gering ist, kann der kosmische Anteil an der Exposition durch natürliche Strahlung den des terrestrischen Teils überschreiten. Die Internationale Strahlenschutzkommission (ICRP) hat 1990 empfohlen, beim fliegenden Personal die in großen Höhen auftretende Exposition durch die kosmische Komponente als Teil der beruflichen Strahlenexposition zu berücksichtigen. Die Europäische Union hat den Empfehlungen der ICRP folgend Regelungen zum Strahlenschutz in die EU-Grundnorm aufgenommen, die mit § 103ff der neuen Strahlenschutzverordnung (StrlSchV) auch in deutsches Recht übernommen wurden.

Die Bestimmung der Ortsdosis (Umgebungs-Äquivalentdosis) auf den Flugrouten hat sich dafür als geeignetes Verfahren erwiesen. Den Verpflichteten ist vom Gesetzgeber freigestellt, sie durch Messung oder Rechnung zu ermitteln. Seitens des Luftfahrt-Bundesamtes wird empfohlen, auf

Basis der Flugdaten die Ortsdosis rechnerisch zu ermitteln und durch Integration der Ortsdosiswerte die aufgenommene Routendosis zu bestimmen.

Die vorliegende Muster-Verfahrensanweisung enthält Informationen über die Meldungen, die die Verpflichteten entsprechend § 103ff StrSchV durchzuführen haben.

In JAR-OPS 1.390, 1.680(a)(1)(2) sowie in ACJ OPS1.390(a)(1)(2)(3) sind die entsprechenden Vorschriften der europäischen Luftfahrtgesetzgebung zu diesem Thema enthalten. Sie entsprechen weitgehend den Regelungen der Strahlenschutzverordnung, sehen allerdings die Speicherung von Angaben der jährlich aufgenommenen Dosisleistung erst ab einem Grenzwert von 6 mSv/Jahr vor.

2. Anwendungsbereich

Diese Verfahrensanweisung gilt für die Verpflichteten.

Verpflichtet ist, wer Flugzeuge, die in der deutschen Luftfahrzeugrolle nach § 3 des Luftverkehrsgesetzes in der Fassung der Bekanntmachung vom 27. März 1999 (BGBl. I S.550) in der jeweils geltenden Fassung eingetragen sind, gewerblich oder im Rahmen eines wirtschaftlichen Unternehmens betreibt, oder wer als Unternehmer mit Sitz im Geltungsbereich der Strahlenschutzverordnung Flugzeuge betreibt, die in einem anderen Land registriert sind und Personal, das in einem Beschäftigungsverhältnis gemäß dem deutschem Arbeitsrecht steht, einsetzt.

3. Begriffsbestimmung

Ortsdosis (Umgebungs-Äquivalentdosis)

Die Ortsdosis ist das Produkt aus der Energiedosis in einem genormten Weichteilgewebe (ICRU-Weichteilgewebe) und einem festgelegten Qualitätsfaktor.

Effektive Dosis

Die effektive Dosis ist die Summe der Organdosen, jeweils multipliziert mit dem zugehörigen Gewebe-Wichtungsfaktor. Dabei ist über alle aufgeführten Organe und Gewebe zu summieren.

Die Strahlungs- und Gewebe-Wichtungsfaktoren sind Ergebnisse aus physikalischen und strahlen-biologischen Erfahrungen. Sie repräsentieren (als Kompromiss) den derzeitigen Stand der Erkenntnis.

Routendosis

Die Routendosis ergibt sich aus der zeitlichen Integration über die Ortsdosis entlang des Flugweges.

Die Einheit der genannten Dosiswerte ist das Sievert (Einheitenzeichen Sv).

4. Zuständigkeiten

Zuständig für die Übermittlung der Dosisbelastung des fliegenden Personals sind die Betreiber der Luftfahrzeuge, in denen dieses Personal beschäftigt wird.

5. Beschreibung

5.1 Vorbereitung

Nach § 103ff StrlSchV besteht die Verpflichtung zur Ermittlung der kosmischen Strahlenexposition von Personen des fliegenden Personals in Flugzeugen, wenn die zu erwartende effektive Dosis 1 mSv im Kalenderjahr übersteigt. Geht der Verpflichtete davon aus, dass diese Dosis nicht erreicht wird, so hat er dem LBA die Einhaltung des Grenzwertes nachzuweisen.

Die nachfolgend angegebenen Kriterien ermöglichen eine einfache Prüfung, ob die Dosischwelle erreicht werden kann. Diese Kriterien beschreiben jedes für sich die Einhaltung des 1 mSv -Schwellenwertes, wobei deren Aussagekraft in der Reihenfolge zunimmt, gleichzeitig aber auch der Ermittlungsaufwand.

Wird eines dieser Kriterien erfüllt, so ist der Nachweis für die Einhaltung des Schwellenwertes erbracht.

1. Kriterium:

Es wird nur Fluggerät mit einer maximalen Flughöhe von 6 000 m eingesetzt.

Bei diesen Flughöhen wird die Dosis von 1 mSv erst bei mehr als 770 Flugstunden erreicht. Der Nachweis kann durch Angabe des eingesetzten Fluggerätes (z. B. Hubschrauber) erbracht werden.

Meldungen über die Dosisbelastung an das LBA sind nicht erforderlich.

Das Unternehmen hat dem LBA schriftlich zu erklären, aus welchem Grund der Schwellwert von 1mSv für das Personal nicht erreicht wird.

2. Kriterium:

Die Jahresflugzeit ist auf Flughöhen unter 14 000 m beschränkt und die Flugzeit beträgt weniger als 100 Stunden auf beliebigen Flugrouten.

Meldungen über die Dosisbelastung an das LBA sind nicht erforderlich.

Das Unternehmen hat dem LBA schriftlich zu erklären, aus welchem Grund der Schwellwert von 1mSv für das Personal nicht erreicht wird.

3. Kriterium:

Auf der Basis der jährlichen Flugzeit, der maximalen Flughöhe und der Flugrouten lässt sich aus dem folgenden Diagramm (Abb. 1) ablesen, ob das Kriterium $< 1 \text{ mSv}$ im Kalenderjahr erfüllt ist.

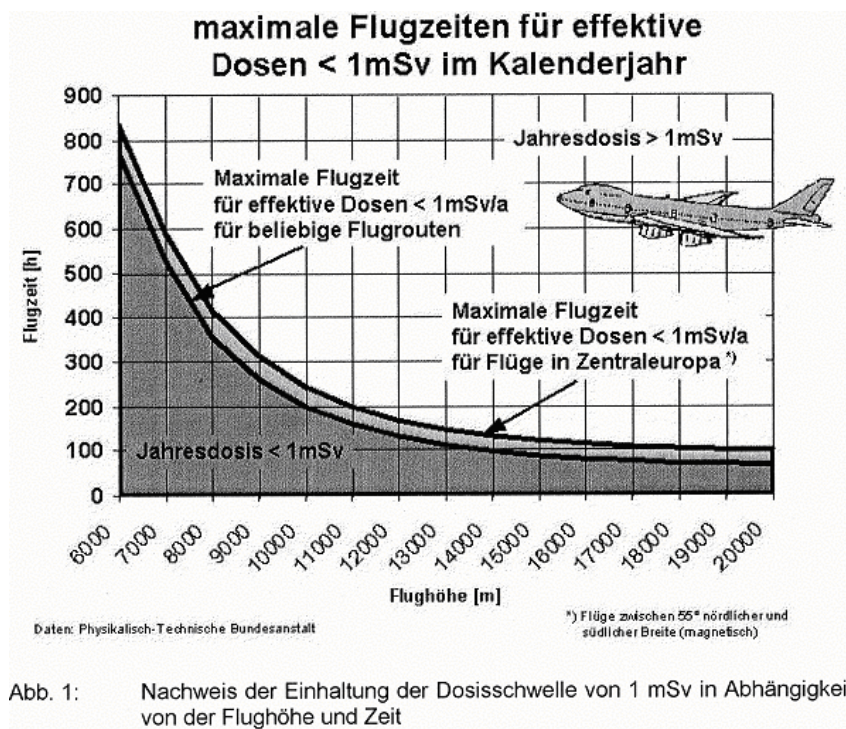


Abb. 1: Nachweis der Einhaltung der Dosischwelle von 1 mSv in Abhängigkeit von der Flughöhe und Zeit

Meldungen über die Dosisbelastung an das LBA sind nicht erforderlich.

Das Unternehmen hat dem LBA schriftlich mitzuteilen, wie ermittelt worden ist, dass der Schwellwert von 1 mSv für das Personal nicht erreicht wird.

4. Kriterium:

Auf der Basis der zu erwartenden jährlichen Flugzeit, der maximalen Flughöhe und der Flugrouten wurde die Dosis mit einem zugelassenen Dosisberechnungsprogramm oder entsprechenden Messverfahren ermittelt. Eine Dosis von 1 mSv im Kalenderjahr wurde dabei nicht erreicht. Der Ermittlungsaufwand des 4. Kriteriums entspricht dem der Überwachung des fliegenden Personals, da alle Flüge mit den einzelnen Flugdaten berücksichtigt werden müssen.

Meldungen über die Dosisbelastung an das LBA sind nicht erforderlich.

Das Unternehmen hat dem LBA schriftlich mitzuteilen, wie ermittelt worden ist, dass der Schwellwert von 1 mSv für jede einzelne Person aus dem fliegenden Personal nicht erreicht wird.

Ein derartiges Vorgehen gibt das Standard-Verfahren im Flugbetrieb eines Unternehmens wieder. Eine Neubewertung der Situation ist immer dann erforderlich, wenn sich die Ausgangsbasis z. B. durch den Einsatz anderen Fluggeräts, andere Flugrouten oder anderen Personaleinsatzzeiten ändert oder aber mindestens alle fünf Jahre.

5.2 Durchführung

- a. Wurde anhand der o. g. Kriterien vom Verpflichteten festgestellt, dass keine Überschreitung des Grenzwertes von 1 mSv/Jahr zu erwarten ist und hat er ein entsprechendes Schreiben an das LBA (Adresse siehe unten) gesandt, so erhält der Verpflichtete vom LBA eine befristete Freistellungsbescheinigung. Änderungen der Voraussetzungen sind dem LBA unverzüglich mitzuteilen.*
- b. Nach Prüfung mit den o.g. Kriterien und Feststellung, dass die Gefahr der Überschreitung des Wertes 1 mSv/Jahr für das Personal existiert, hat der Verpflichtete das LBA unter der Adresse*

*Luftfahrt-Bundesamt
Fachbereich U 2
Herrn Dr. Korrell
Postfach 3054
38020 Braunschweig*

zu informieren und mitzuteilen, für wie viele Personen der Verpflichtete Dosismeldungen abzugeben hat.

- c. Im LBA wird das Unternehmen von nun an als Verpflichteter/Betreiber geführt*
- d. Dem Verpflichteten wird schriftlich vom LBA eine Nutzerkennung und das Passwort zur Teilnahme am elektronischen Übermittlungsverfahren mitgeteilt. Des Weiteren erhält er Formatangaben zur Anmeldung seiner Mitarbeiter (Personenmeldung) und zur Dosismeldung. Die letztgenannten Informationen sind für den Verpflichteten auch im Internet abrufbar.*
- e. Der Verpflichtete hat anhand der erhaltenen Vorgaben per Datenübertragung sein fliegendes Personal anzumelden. Das LBA meldet im Gegenzug für jede Person ein eindeutiges Personenkennzeichen zurück.*
- f. Wenn der Verpflichtete dem unter 1. (Zweck) angegebenen Vorschlag des LBA - der Berechnung der Dosiswerte - folgt, kann er anhand der in den Nachrichten für Luftfahrer veröffentlichten Angaben über die vom LBA zugelassenen Dosis-Ermittlungsprogramme ein Programm auswählen und für sein Personal die Dosis berechnen.*

- g. Für Personen, die im Meldungszeitraum eine Dosis erhalten haben, hat der Verpflichtete per Datenübertragung die Dosismeldung abzugeben.*
- h. Dem Verpflichteten wird empfohlen, dem Personal das vom LBA zugeteilte Personenkennzeichen schriftlich mitzuteilen. Das Personal ist dann in der Lage, bei einem Arbeitsplatzwechsel dem neuen Arbeitgeber diese Information zu übergeben und auf diese Weise Fehlermeldungen bei den erneuten Dosismeldungen zu vermeiden.*
- i. Auf elektronischem Wege überträgt das LBA die Dosiswerte in regelmäßigen Abständen an das Strahlenschutzregister.*
- j. Bei Änderungen im Personalbestand (Neuzugang) wird dem Verpflichteten empfohlen neues Personal nach bereits vorhandenen Personenkennzahlen zu befragen. Bei bekanntem Personenkennzeichen ist keine erneute Personenanmeldung erforderlich. Es können ohne weitere Maßnahmen Dosismeldungen übermittelt werden. Nur wenn eine Person noch nicht beim LBA angemeldet ist, ist eine Personenanmeldung vorzunehmen. Bei Personalabgang sind keine weiteren Maßnahmen gegenüber dem LBA (Abmeldung o.ä.) erforderlich.*

5.3 Nachbereitung

Das LBA prüft anhand der vorliegenden Meldungen und in beim Verpflichteten durchzuführenden Audits:

- ob der Verpflichtete dafür gesorgt hat, dass die Grenzwerte 20 mSv, 400 mSv oder 1 mSv (für Schwangere) nicht überschritten werden.*
- ob die effektive Dosis richtig und rechtzeitig ermittelt worden ist.*
- ob das fliegende Personal rechtzeitig und richtig belehrt worden ist.*
- ob der Verpflichtete die Aufzeichnungen über die Unterrichtung des Personals richtig und vollständig geführt hat, sie mindestens fünf Jahre aufbewahrt und sie der Behörde auf Verlangen vorlegt.*
- ob die Ergebnisse der Dosisermittlung richtig und rechtzeitig aufgezeichnet wurden.*
- ob die Aufzeichnungen über die Ergebnisse der Dosisermittlung vollständig und für die vorgeschriebene Dauer aufbewahrt werden.*
- ob diese Aufzeichnungen spätestens 95 Jahre nach Geburt der betreffenden Person gelöscht werden.*
- ob der Verpflichtete die Aufzeichnungen der überwachten Person rechtzeitig vorlegt.*

- *ob der Verpflichtete eine Mitteilung über das Überschreiten einer festgelegten Dosis richtig, vollständig und rechtzeitig gemacht hat.*
- *bei welchen Personen der Grenzwert von 6 mSv/Jahr bzw. 20 mSv/Jahr erreicht wird,*
- *sind bei Überschreitung dieses Wertes die gesetzlich geforderten Folgemaßnahmen (ärztliche Untersuchung und Bescheinigung, Entscheidung über Beschäftigung bzw. Weiterbeschäftigung) rechtzeitig und vollständig durchgeführt worden,*
- *in welcher Weise hat das Unternehmen versucht, die aufgenommene Dosis zu reduzieren.*

6. *Dokumentation*

Durch die Anwendung dieses Rundschreibens entsteht die nachstehend angegebene Dokumentation:

- a. Elektronische Aufzeichnungen über den Verpflichteten,*
- b. Schriftwechsel zwischen Verpflichtetem und LBA,*
- c. Elektronische Aufzeichnungen über das Personal des Verpflichteten,*
- d. Dosismeldungen zu diesem Personal,*
- e. Auditprotokolle von den beim Verpflichteten durchgeführten Audits,*
- f. Elektronische Aufzeichnungen über Meldungen an das Strahlenschutzregister.“*

Furthermore, there is a list of frequently asked question published at http://www.lba.de/nn_54122/DE/Technik/Umweltschutz/Strahlenschutz/FAQs.html__nnn=true to provide further assistance to operators. The FAQ list includes a simplified approach to calculate doses for flights of crew members with foreign airlines, for example to get to the next starting point for a flight [KOR 06].

The software used for dose calculation has to be accredited by the Physikalisch-Technische Bundesanstalt in Berlin [LEB 03], [PTB 03].

In March 2003 the BfS published an information flyer about cosmic radiation exposure of aircrew [BFS 03]. After general information about cosmic radiation in aircrafts, the flyer also informs about radiation protection and the duties of operators regarding the protection of their crew members.

5.12.2 Dose Register

The radiation protection register (Strahlenschutzregister) (SSR) is run by the Bundesamt für Strahlenschutz (BfS) [FRA 04]. Air crew monitoring data is included

since 2003. For reporting of air crew data, an internet portal has been provided by Luftfahrt-Bundesamt (LBA), using digital signatures for secure data transfer. LBA and BfS check the accumulative dose of persons working for several operators. Thus personnel being exposed to doses below the limit of 1 mSv in each employment will not be monitored, because no data is being reported to the national register. In total there are records of about 300 000 persons included in the Dose Register, about 33 000 of them in aviation. Those approximately 11 % of persons were exposed to about 50 % of the over all dose registered [KOR 06].

5.12.3 National Practice

As both German authorities and one operator answered to our respective questionnaires, the answers give a good overview of the practice of the national system for radiation protection of air crews.

5.12.3.1 Radiation Protection Authority

The German Radiation Protection Authority, *Bundesamt für Strahlenschutz (BfS)*, is responsible for air crew dose data management. The data is obtained from the Civil Aviation Authority, *Luftfahrt-Bundesamt*. The dose data of all occupations is collected in one single database. The dose records are kept a maximum of 30 years after the retirement of the exposed person. Only *Bundesamt für Strahlenschutz* has access to the database. The responsibility for data collection is given to the CAA, the radiation protection authority, the airlines themselves and other not closer defined institutions. The database to store the data is driven at *Bundesamt für Strahlenschutz*. Transfer of data is conducted monthly.

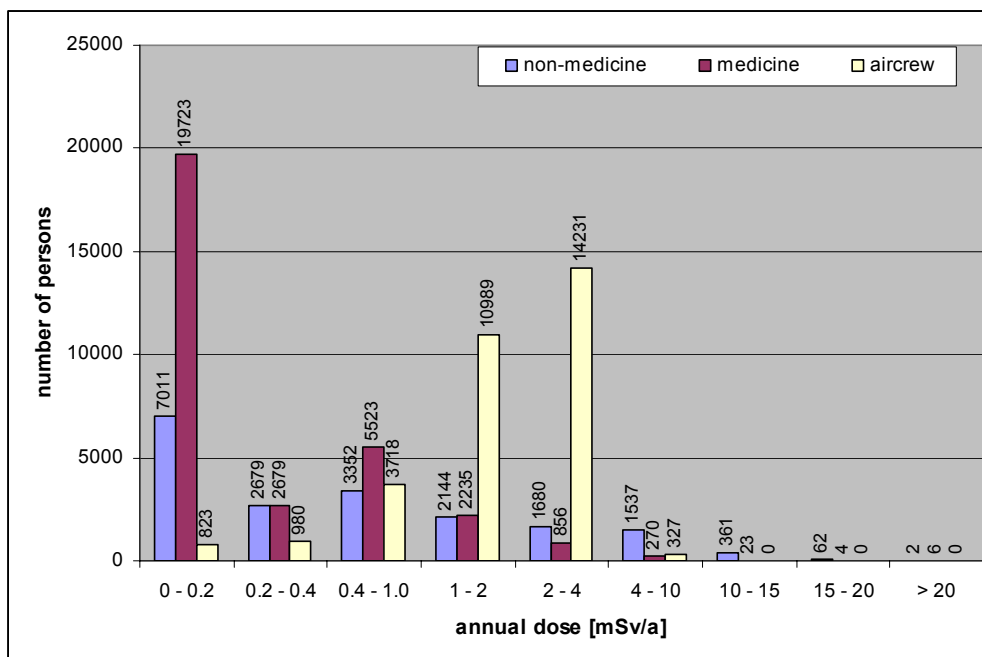
Pregnant air crew in Germany are due to *Maternity Protection Act of 2002* not allowed to fly. For crew members in general, the action level is 6 mSv/a. Reaching action level leads to a preventive medical exam through an accredited medical professional.

For dose calculation EPCARD, FREE and PCAIRE are accredited in Germany. There is no regulation about information of crew members about their doses.

In 2006 the average dose for general flight personnel was 2.2 mSv/a. The dose distribution in the same year was:

5641 persons	< 1 mSv/a
26725 persons	1 – 6 mSv/a
57 persons	> 6 mSv/a

The distribution of the exposure to all types of occupationally exposed personnel in Germany in the year 2005 is shown in Figure 13. It can be observed that the aircrew contribute substantially to the occupational exposure in the range above 1 mSv/a, in which range the number of persons occupied in the nuclear industry or in medicine is rapidly declining.

Figure 13: Exposure of occupationally exposed personnel in Germany in 2005 (cited in [WIS 08])

Due to solar activity, the average and maximum dose rates increased since the beginning of air crew monitoring. This can be seen by comparing the above cited data with [KOR 06] mentioning no person receiving doses above 6 mSv/a before 1.1.2006.

5.12.3.2 Civil Aviation Authority

German CAA, *Luftfahrt-Bundesamt*, is part of the radiation monitoring system for air crew members. The tasks are covered by the department T2 for Environmental protection (1 person) and by half a person from the department of information technology. The total time spent for the organisation of the radiation protection system for air crew members at the CAA is estimated to 2.200 – 2.500 h/a. For the management of radiation protection for crew members about 1700 h/a are spent.

The supervision of dose registration by operators is conducted by use of a database and by visits at airlines. Freelancers working for airlines and the occupational transport of crew members are both monitored. Frequent flyers are not included in radiation monitoring.

The action levels are given in Table 10.

Table 10: German action levels and preventive actions taken

dose	group of personnel	preventive action
1 mSv	pregnant crew member	end of flying for pregnancy
6 mSv		medical exam
20 mSv		suspension for that year

There are 170 registered commercial airlines in Germany. Non-commercial airlines normally are not registered and thus are not controlled. In 2006 there were 19650 cabin and 8391 flight deck crew members from commercial operators and 48 cabin and 128 flight deck crew members from non-commercial operators, which operate jets and are thus registered at LBA, under radiation protection in Germany.

Of 663 German airplanes with take-off mass above 20t four are equipped with radiation measurement equipment. All the others of all classes (1026 in Germany, including the equipped) are not equipped. The equipment is not checked by the CAA.

German CAA confirmed the information from the RPA about dose action levels, calculation methods and so on.

Access to the dose database is given by order forms and FAQ.

There are no plans to change anything about the system. Luftfahrt-Bundesamt suggests introducing a European standardisation system to radiation protection of air crew as an improvement.

5.12.3.3 Operators

Of 12 contacted German operators only *Cirrus Airlines* kindly answered our questionnaire. *Cirrus Airline* operates 19 airplanes with masses from 5.7 to 20 t. None of them is equipped with dose measurement equipment. Radiation protection for air crew members is due to the Flight Safety Department. With date of 30.6.2007 there were 156 persons in flying duty for *Cirrus Airline*, 60 of them being male.

Dose assessment for *Cirrus Airlines* is done by IASON, Austria. The operator sends the flight plan data including geographic information and altitudes to the contractor for calculation. There have been no measurements to support the calculations.

At *Cirrus Airline*, pregnant staff member stop flying. For other personnel reaching the action level of 6 mSv/a leads to regular medical examinations and the optimisation of the flight roster to reduce future doses. The personal dose is recorded monthly for each crew member in a database kept by IASON in Austria. The data is kept for 30 years and only accessible for the Accountable Manager and the flight safety department. Data is quarterly reported to CAA.

Flight safety training for crew members at *Cirrus Airline* includes information about the health risks of radiation exposure. The medical check-up for personnel does not include radiation protection aspects, though.

Since implementation of radiation protection for air crews, the average and the maximum doses stayed the same for all crew members including pregnant ones. The work hours spent for radiation protection are about 15 hours a month. Additional costs, not including the above mentioned work hours, is about 5000 € per year.

5.13 Greece

5.13.1 Legislation

Radiation protection of air crew members in Greece is governed by the Radiation Protection Regulation as follows:

“1.2.5. Significant increase in exposure due to natural radiation sources

1.2.5.1. *The Greek Atomic Energy Commission shall be the competent authority for identifying, on the basis surveys or any appropriate method, the workplaces in which the presence of natural radiation sources (terrestrial or cosmic) lead to a significant increase in the exposure of workers, which cannot be disregarded from the radiation protection point of view:*

...

d) *work activities which concern aircraft and result in the exposure of workers to cosmic radiation.*

1.2.5.8. *The dose measurements and the dose monitoring of the activities defined in paragraph 1 shall be performed by the EEAE or by a natural or legal person duly authorised by the EEAE. The natural and legal persons authorised by the EEAE to perform these measurements must notify the results to the EEAE.*

1.2.5.9. *Airline companies must inform flight personnel, when they take up their duties for the first time, about exposure to cosmic radiation and the associated health hazards. Airline companies must be equipped with appropriate computer programmes, approved by the EEAE, for the measuring the doses received by flight personnel. The results of the dose measurements of flight personnel whose dose exceeds 1 mSv per year shall be communicated to the EEAE. Airline companies shall plan the routes of their flight personnel so as to reduce exposure of the most exposed personnel; exposure may not exceed 6 mSv per person in a year. Pregnant workers are entitled to require the airline company to relieve them of flight personnel duties.”*

5.13.2 Dose Register

The Greece national Dose Register (NDRIS) is kept and managed by the Greece Atomic Energy Commission (GAEC). The database contains all data from 1993 on [GAE 04]. The data on doses of the personnel are obtained from the CAA, which is also responsible for collection of the data on radiation exposure for aircrew.

5.13.3 National Practice

An airline is put under the scope of radiation protection if the doses to the personnel may exceed 1 mSv/a.

After the publication of the revised Radiation Protection Regulations in 2001, which transforms the EURATOM Basic Safety Standards into national legislation, the Greek Atomic Energy Commission invited all air companies' representatives and the Civil Aviation Authority and presented the requirements of the new legislation as well as the data needed to implement the dose calculation codes proposed. At the same time, a joint study was performed in collaboration with the Civil Aviation Authority, Olympic Airlines (the major air carrier in the country) and GAEC. Dosimetry codes were implemented in order to calculate air crew doses in the more indicative air routes, taking into account the frequency of the flights and the rotation of the personnel. It was shown that the probability for the individual doses to exceed the 6 mSv/a is minimal. According to the response to the questionnaire provided by GAEC, the contact between the above mentioned organizations is, however, not regular and the situation has not been settled yet.

5.14 Hungary

5.14.1 Legislation

The Atomic Energy Act and the decrees in the field of radiation protection in Hungary are mostly concerned with the use nuclear energy and the arising wastes as well as with medical use of radiation. There was no information about natural radiation found in those parts of legislation which are commented by NEA or found in English translations available.

The 96/29/Euratom is nationally implemented in the *Decree of the Minister of Health (16/2000)* [KER 04]. Supervision of radiation protection measurements is conducted by 7 Radiohygienic Centres. The defined dose limits are 50 mSv/a and 200 mSv for five consecutive years. For the eyes, the limit is 150 mSv/a, and for skin and extremities 500 mSv/a. In Hungary the categorisation for workers is implemented based on IAEA recommendations.

The Minister of Health is responsible for the radiation protection issues connected with the plants, materials and activities licensed by the Hungarian Atomic Energy Authority (HAEA, *Országos Atomenergia Hivatal*) [NEA 01].

The national institution for radiation protection is the National Research Institute for Radiobiology and Radiohygiene (NRIRR) in Budapest. Dosimetry is conducted by the National Dosimetry Service [KER 04] since 1960.

5.14.2 Dose Register

NRIRR keeps a national database for occupationally exposed workers.

5.14.3 National Practice

The questionnaire was answered by the civil aviation authority of Hungary, the Director General of Civil Aviation.

5.14.3.1 Civil Aviation Authority

The dose registration in Hungary is performed by the Radiation Dept. of the National Public Health and Medical Officer Service. The dose registration for aircrew is supervised by the CAA by visits to the airlines. Information on the doses to flight crew personnel is given on a regular basis. Preventive actions when reaching action levels are not implemented. Access to the database is restricted to authorised persons and protected.

5.15 Ireland

5.15.1 Legislation

In Ireland the Radiological Protection Institute of Ireland (RPII), established by the Radiation Protection Act, bundles most competencies regarding radiation protection. As given in the Radiological Protection Act [ISB 91]:

7.—(1) The Institute shall, in addition to any other functions assigned to it by or under this Act, have the following general functions:

...

(b) to monitor the exposure of individuals to activity or ionising radiation;

(c) to advise the Government, the Minister and other Ministers of the Government and the public, on measures for the protection of individuals in the State from radiological hazards;

...

(f) to advise the Government, the Minister and other Ministers in relation to international standards regarding ionising radiation, radioactive substances, nuclear devices, irradiating apparatus and radiological safety;

(g) where appropriate, to enter into arrangements with the Government, the Minister or other Ministers of the Government and such other persons or bodies as the Minister may direct to provide monitoring, advisory or consultancy services in relation to radiological safety;

...

The national implementation of European Council Directive 96/29/Euratom in Ireland is S.I. No. 125 of 2000 (*Ionising radiation Order*) [ISB 00]. The definitions in article 2 (Interpretation) include:

“ ...

“air crew” means the cabin and flight crew of an aircraft operated by an air operator or an undertaking in the State which operates an aircraft;

“air operator” means the holder of an Air Operator’s Certificate issued by the Irish Aviation Authority in accordance with the Irish Aviation Authority (Air Operators’ Certificate) Order, 1999 (S.I. No. 420 of 1999);

...

“natural radiation sources” means sources of ionising radiation from natural terrestrial or cosmic origin;

...

“workplace” includes any place, land or other location at, in, upon or near which, work is carried on whether occasionally or otherwise and, in particular, includes -

...

(d) a vehicle, vessel or aircraft.”

Thus radiation protection for flight crew members is clearly in the scope of [ISB 00], which is exactly defined in article 3, where paragraph 3 is dedicated to aviation:

“(3) Articles 7, 11, 33 and 42 of this Order apply to work activities involving the operation of aircraft pursuant to an Air Operator’s Certificate whereby any member of the air crew is liable to be subject to exposure to cosmic radiation in excess of 1 mSv in a period of 12 months.”

These are the articles mentioned in the above citation, which directly address radiation protection for air crews:

“Notification of Work Activities

7. (1) This Article applies to a work activity referred to in Article 3(2) or 3(3).

(2) The undertaking concerned shall notify the Institute forthwith after the date referred to in paragraph (3) of the work activity or as

provided for in Articles 30(4) or 32(3) and shall provide it with the information concerning the work activity referred to in Schedule 1.

(3) The date referred to in paragraph (2) is -

(a) in case the work activity commenced before the commencement of this Order, the commencement of this Order, and

(b) in case the work activity commenced after such commencement, the commencement of the work activity.

(4) Where, in the opinion of the Institute, the information supplied by an undertaking in accordance with paragraph (2) is insufficient or inadequate, the Institute may, by notice in writing, require that undertaking to furnish the Institute with such additional information as it specifies in the notice.

(5) Where an undertaking has notified the Institute of a work activity in accordance with paragraph (2) and subsequently makes a material change in that work activity which would affect the information so notified, the undertaking shall forthwith notify the Institute of that change.

...

Special Protection During Pregnancy and Breast Feeding

(1) As soon as may be after a pregnant woman worker informs the undertaking of her condition, the undertaking shall provide a level of protection for the child to be born which is comparable with that provided for members of the public.

(2) The undertaking shall ensure that the conditions for the pregnant woman in her employment after she has so informed it of that matter are such that the equivalent dose to the child to be born is as low as reasonably achievable and will be unlikely to exceed 1 mSv during the remainder of the pregnancy following the undertaking being informed of the pregnancy.

(3) On being informed by a woman that she is breast feeding, the undertaking shall not employ her in work involving a significant risk of bodily radioactive contamination.

...

Protection of Air Crew against exposure to cosmic radiation

33. (1) *Each air operator and each undertaking in the State which operates an aircraft shall evaluate the extent of the exposure of air crew from cosmic radiation in accordance with such guidelines as may be issued by the Institute for the purposes of the Order in this regard.*
- (2) *The air operator or undertaking referred to in paragraph (1) shall submit a written report in relation to the evaluation referred to in that paragraph to the Institute within -*
- (a) *in case it holds an air operator's certificate which was in force immediately before the commencement of this Order, 1 year from that commencement.*
- (b) *in case it holds an air operator's certificate which was granted on or after the commencement of this Order, 3 months from the making of the evaluation.*
- (3) *If the result of the evaluation referred to in paragraph (1) shows that air crew are liable to be subject to exposure to cosmic radiation in excess of 1 mSv in a period of 12 months, the air operator or undertaking referred to in paragraph (1) shall -*
- (a) *assess the exposures of that air crew by methods that have been approved of by the Institute prior to the assessment being carried out,*
- (b) *keep records relating to the assessment referred to in subparagraph (a) in a manner specified by the Institute,*
- (c) *at the request of any member of the air crew concerned make available to that member a copy of any dose record kept for the purposes of subparagraph (b) in relation to that member,*
- (d) *provide the Institute with summaries of all such current dose records relating to that year within 3 months of the end of each calendar year,*
- (e) *inform that air crew of the health risks involved in their work.*
- (4) *An air operator or an undertaking referred to in paragraph (1) shall organise the working schedules of air crew liable to receive an exposure to cosmic radiation in excess of 6 mSv in a period of 12 months with a view to reducing their exposures.*
- (5) *An air operator or an undertaking referred to in paragraph (1) whereby female air crew are liable to receive an exposure to cosmic radiation in excess of 1mSv in a period of 12 months shall*

apply the provisions of Article 11 relating to the obligations of an undertaking.”

The above cited legislation is in detail explained in [RPI 05] to facilitate implementation by operators.

5.15.2 Dose Register

The dosimetry service being part of RPII also acts as a dose data collection service. There is no additional central register in Ireland. Air crew personnel are not explicitly mentioned in dose data collection [CUR 04].

5.15.3 National Practice

5.15.3.1 Radiation Protection Authority

The Radiological Protection Institute of Ireland gets dose data directly from the operators. There are eight commercial airlines in Ireland. There is no distinction between flight deck and cabin crew members in Ireland, nor is there information about the gender included into the data collection. Thus, only the over all number of air crew is available. In 2006 there were 5692 exposed aviation personnel. 1500 of them did not even reach a dose of 1 mSv/a. The average dose of air crew members in 2005 was 2.0 mSv/a. None of the monitored persons received doses above 6 mSv/a in 2005.

Since the beginning of dose monitoring for air crew members doses increased due to more of flights, longer flight sector times and more personnel in flight activity. Due to [COL 06] the number of crew members receiving doses above 1 mSv grew 75 %.

Dose assessment is conducted by the air operators. Data is summarized and sent to the *Radiological Protection Institute* once a year. The dose data of air crew is collected in an own database separated from the data of other occupationally exposed workers. Doses are calculated using EPCARD or CARI6. Air crew members can request a copy of their dose record any time.

Each operator has to make a dose assessment for all crew members once and again each time there are changes in rosters or flight routes, which might lead to higher doses for crew members. The assessment shows if there are employees probably receiving doses above 1 mSv/a or even above 6 mSv/a. Any operator employing personnel liable to receive doses above 1 mSv/a falls under the scope of radiation protection legislation [RPI 05]. In [RPI 05] dose calculation is regulated as follows:

“How do I calculate a radiation dose?”

For the purpose of calculating air crew radiation doses a distinction is drawn between two categories of air crew. These are:

- *air crew liable to receive between 1 mSv and 6 mSv in a calendar year; and*

- *air crew liable to receive in excess of 6 mSv in any 12 month period or female air crew on declaration of pregnancy*

For air crew in the first category, the operator may opt to assess radiation doses using a simplified calculation based on annual averaged route doses and group roster data. For such assessments the annual average route dose should be calculated for the calendar year using the annual heliocentric potential, which is usually available towards the end of January of the following year. Exposures are then calculated for groups of air crew likely to receive similar exposure, rather than for individual crew members. The groups must be defined on the basis of similar work rosters. The operator must maintain a record of such groupings, which must be available to the air crew concerned and by an inspector of the RPII, on request.

Where the operator opts for group assessments, the calculation must be performed on the basis of the maximum dose to any individual member of the group and this figure must be recorded for each member of the group.

Where, on the basis of the annual calculation, it is shown that any individual or group receives in excess of 5 mSv, the operator should reassess the doses for the individuals concerned according to the procedures set out below for the second category of air crew.

For crew in the second category, the dose assessment must be based on monthly averaged route doses and individual roster data. Route doses must be calculated for each month using the heliocentric potential for that month. The monthly route doses are then combined with air crew roster data to derive the doses to individual air crew members. Each month the operator must derive the cumulative exposure over the previous 12-month period by summing the 12 monthly values. The assessment must be calculated individually for each crew member taking into account the actual flying record for that individual.

How are the doses to aircrew calculated?

For aircraft flying at altitudes above 8,000 m (~26,200 feet) and below 15,000 m (~50,000 feet) it is recommended that assessment of each individual air crew dose be determined by combining route dose with crew roster data. Route dose estimates can be calculated using computer programs specifically designed for that purpose. The computer programs EPCARD (European Package for the Calculation of Aviation Route Doses) and CAR13-6 have been approved by the European Commission⁴. The RPII recognises a dose assessment carried out using either of these two programs. For information

purposes, a comparison of route doses calculated by EPCARD and CARI-6 is given in Appendix-A.”

The duty of operators to inform their personnel about the health risks is clearly explained in [RPI 05]:

“What are air crew entitled to know?”

For air crew flying at altitudes over 8,000 m (~26,200 feet) the operator is required to provide each staff member with information about the risks associated with exposure to cosmic radiation. In addition, the operator is required to keep records relating to the dose assessment referred to above and shall, if requested by a member of the air crew concerned, make available to that staff member a copy and dose record kept in relation to him/her for the purpose of the Regulations.

The RPII may assess the adequacy of the information provided to air crew by operators. As a guideline, this information may include

- the nature of cosmic radiation;*
- the units of radiation dose;*
- the factors that influence cosmic radiation intensity (latitude, altitude, solar cycle);*
- the legal framework governing occupational exposure to radiation, in particular the requirements for the protection of air crew from cosmic radiation;*
- how cosmic radiation is measured;*
- the health risks associated with exposure to radiation;*
- the protection measures relevant to cosmic radiation; and*
- the protective measures necessary for pregnant air crew.”*

Dose records for crew members receiving less than 6 mSv a year have to be kept 5 years from the date to which the record refers. For those with doses above 6 mSv/a records have to be kept until the crew member attains or would have attained the age of 75 years or for a period of 30 years from the last year the person received a dose exceeding 6 mSv. The guidance notes include paper forms for reporting of summarized or individual doses [RPI 05].

5.16 Italy

5.16.1 Legislation

Occupational radiation protection in Italy is governed by *Legislative Decree No. 230 of 1995*. Additionally the protection of the public in general and workers in special is regulated in *Legislative Decree No. 241 of 2000*. Thus the scope of radiation protection in decree No. 230 is given as follows:

“Capo I – Campo Di Applicazione. Principi Generali Di Protezione Dalle Radiazioni Ionizzanti

Art. 1 Campo di applicazione

...

1-bis. Il presente decreto non si applica all'esposizione al radon nelle abitazioni o al fondo, naturale die radiazione, ossia non sie applica ne' ai radionuclidi contenuti nell'organismo umano, ne' alla radiazione cosmica presente al livello del suolo, ne' all'esposizione in superficie ai radionuclidi presenti nella crosta terrestre non perturbata. Dal campo die applicazione sono escluse le operazioni di aratura, die scavo o di riempimento effettuate nel corso di attivita' agricole o di costruzione, fuori dei casi in cui dette operazioni siano svolte nell'ambito die interventi per il recupero di suoli contaminati con materie radiattive.

..”

In Chapter III exposure to natural radiation is regulated as follows:

“Capo III-bis Esposizioni Da Attivita' Lavorative Con Particolari Sorgenti Naturali Di Radiazioni

Art. 10-bis Campo die applicazione

1. Le disposizioni del presente capo sie applicano alle attivita' lavorative nelle quali la presenza di sorgenti di radiazioni naturali conduce ad un significativo aumento dell'esposizione. Tali attivita' comprendono:

...

f) attivita' lavorative su aerei per quanto riguarda il personale navigante.

...

Art. 10-septies Sezione speciale della Commissione tecnica per le esposizioni a sorgenti naturali di radiazioni

1. *Nell'ambito della Commissione tecnica di cui all'articolo 9 e'istituita una sezione speciale per le esposizioni a sorgenti naturali di radiazioni con i seguenti compiti:*

...

g) formulare indicazioni per la sorveglianza e per gli interventi di radioprotezione ai fini dell'adozione di eventuali provvedimenti per il personale navigante."

Article 10 governs radiation protection for air crew members. The following citation regulates the duties of the employer to modify rosters to reduce exposure, to inform employees about the health risks of ionising radiation and to communicate the type of activity in relation to the definitions in article 10. Other duties, which are not specific to aviation but are due to all types of exposed occupations, are defined in chapter VIII, which has to be obeyed except for those given in paragraph 3:

"Art. 10-octies Attivita' di volo

1. *Le attivita' lavorative di cui all'articolo 10-bis, comma 1, lettera f), che possono comportare per il personale navigante significative esposizioni alle radiazioni ionizzanti sono individuate nell'allegato I-bis.*

2. *Nelle attivita' individuate ai sensi del comma 1, il datore di lavoro provvede a:*

a) programmare opportunamente i turni di lavoro, e ridurre l'esposizione dei lavoratori maggiormente esposti;

b) fornire al personale pilota istruzioni sulle modalita' di comportamento in caso di aumentate attivita' solare, al fine di ridurre, per quanto ragionevolmente ottenibile, la dose ai lavoratori; dette istruzioni sono informate agli orientamenti internazionali in materia;

c) trasmettere al Ministero della sanita' le comunicazioni in cui e' indicato il tipo di attivita' lavorativa e la relazione di cui all'articolo 10-ter, il Ministero, a richiesta, fornisce tali dati alle autorità di vigilanze e ai ministeri interessati.

3. *Alle attivita' di cui al comma 1 si applicano le disposizioni del capo VIII, ad eccezione di quelle di cui all'articolo 61, comma 3, lettere a) e g), all'articolo 62, all'articolo 63 all'articolo 79, comma 1 lettera b), numeri 1) e 2), e lettera c), e commi 2, 3, 4 e 7, all'articolo 80, comma 1, lettera a), e lettere d) ed e),*

limitatamente alla sorveglianza fisica della popolazione, nonche' all'articolo 81, comma 1, lettera a). La sorveglianza medica dei lavoratori di cui al comma 1, che non siano suscettibili di superare i 6 mSv/anno di dose efficace, e' assicurata con periodicit  almeno annuale, con le modalita' di cui al decreto del Presidente della Repubblica 18 novembre 1988, n. 566, al decreto del Ministro dei trasporti e della navigazione del 15 settembre 1995, pubblicato nel supplemento ordinario n. 128 alla Gazzetta Ufficiale n. 256 del 2 novembre 1995, ed alla legge 30 maggio 1995, n. 204, con oneri a carico del datore di lavoro.

4. *Nei casi di cui al comma 1, la valutazione delle dosi viene effettuata secondo le modalita' indicate nell'allegato I-bis.*

..."

5.16.2 Dose Register

Unfortunately there was no information about a National Dose Register in Italy found.

5.16.3 National Practice

5.16.3.1 Civil Aviation Authority

The Italian CAA, *Ente Nazionale per l'Aviazione Civile*, kindly answered our questionnaire. In Italy there are 48 registered commercial airlines, 44 non-commercial airlines for aerial work and 137 non-commercial from registered facilities in Italy. Seven of the commercial airlines are under radiation protection but none of the non-commercial. This is due to the criteria for the exclusion:

1. operators of helicopters
2. aircrafts flying beneath 8000 m

Thus, there are 9560 cabin crew and 6980 flight deck crew members in Italy under radiation protection. In none of the aircrafts registered in Italy is dose measurement equipment included.

The action level in Italy is for all crew members (pregnant included) 1 mSv/a.

The Italian legislation about radioprotection for aircrew is as follows:

- each crew member of airplanes that regularly fly over 8000 m is supposed to be allowed to reach or to exceed 1 mSv per year;
- for this reason each member of the crew that regularly flies over 8000 m is classified as exposed worker in category B;

- each crew member regularly flying over 8000 m has to be subject to periodical medical visit of idoneity as exposed worker in addition to the medical visit of idoneity to flight;
- doses to the crew are calculated with a program for the calculation of aviation route doses (generally CARI 6 or EPCARD) (until the year 2006 the program had to be controlled every year through measures done during some flights);
- the operating company has to rotate all crew members to avoid too big differences between the doses of different crew members;
- the operating company has to inform the pilots about what to do in case of solar storms.

For dose calculation CARI6 is used in Italy. Crew members have to be informed regularly about their doses.

Italian CAA is not involved into dose registration for air crew members. The compliance with regulations is checked by the Ministry of Health.

Flights for occupational transport are monitored, too. Frequent flyers and freelancers are not in the scope of radiation protection regulations.

5.16.3.2 Operators

Two Italian airlines, *Meridiana* and *Italfly*, kindly answered our questionnaire. At *Meridiana* all tasks relevant for radiation protection are fulfilled by the occupational safety department. At *Italfly*, the work is split between several departments.

Meridiana operates 22 aircrafts about 20 t take-off mass; none of those is equipped with dose measurement devices. *Italfly* works with one aircraft of 5.7 – 14 t maximum take-off mass, without measurement equipment. On the 21 December 2006, *Meridiana* employed 722 persons as flying personnel. *Italfly* has 5 cockpit crew members. *Italfly* staff is under dose monitoring, but none of *Meridiana*.

Dose calculation for *Italfly* is conducted by Flyrad using CARI6, which has been integrated into software provided by Flyrad. Dose calculation is normally based on the planned flight route, because it is usually the one leading to the higher dose. If this is not the case, calculation is done based on the real flight route. Periodically (at least twice a year) there are measurements on board the aircraft to support calculation. For measurement *Italfly* uses active and passive systems together. During climb every 1000 ft of altitude gain radiation is measured. In cruise altitude the measurements are conducted every 5 minutes. The integral value for the complete flight is afterwards calculated by integration. The calculated values are about 150 % to 200 % of the measured once. Measurement equipment is calibrated once a year.

Meridiana does dose calculation in-house with CARI6 based on planned flight routes. There are no supporting measurements at *Meridiana*. Doses are reported once a year to the authorities. Each year *Meridiana* staff is informed about cosmic radiation in general and about their personal dose.

Italfly operates with an internal action level of 3 mSv/a; reaching this level, work schedules are optimised for dose reduction. Flyrad gives alerts of solar events to allow additional protection. Dose data is stored to an internal database and at the contractors and kept for at least 10 years. Access is restricted to the authority, the accountable manager and the doctor in charge of medical surveillance. The data is reported yearly to the Ministry of Employment. Each record includes personal data, effective dose for the year and the total number of flight hours. Monitoring is extended to the occupational flights, too.

Both operators refresh information about health risks once a year. In case of *Italfly* training is conducted by instructors from Flyrad. Both airlines include special aspects of radiation protection into medical surveillance.

Since dose monitoring has been established, the average doses of the crews of both operators stayed the same. For *Meridiana* the maximum dose stayed, too. In case of *Italfly* maximum dose decreased.

The total cost for radiation protection for *Italfly* is 6500 € per year. There is no work time spent, because Flyrad provides complete service. In case of *Meridiana* exposure assessment takes about 100 hrs/month and costs of 3000 € per year. Additionally there are about 5 hours a month for dose minimisation and about 30 hours for the reporting duties.

5.17 Latvia

5.17.1 Legislation

Radiation Protection in Latvia is regulated by the *Act on Radiation Safety and Nuclear Safety, adopted on 26th October 2000* (unofficial translation provided by Latvian authorities):

“Section 5

Primary tasks of the Centre

The primary tasks of the Centre are as follows:

...

15) to establish and maintain a register of workers who conduct practices with ionising radiation sources or work in places with increased natural radiation;”

The detailed provisions for air crew radiation protection are found in the *Regulations for Protection against Ionising Radiation, adopted 9th April 2002*:

“Article 134

The employer in co-operation with the Centre shall control the dose of ionising radiation received by members of jet crews. If the received dose of ionising radiation is higher than 1 mSv but lower than 6 mSv per year, the employer shall ensure that for female air crew members the dose of ionising radiation which might be received by the foetus during pregnancy does not exceed 1 mSv.”

5.17.2 Dose Register

Since 2003 the dose data of occupationally exposed workers in Latvia is stored in an Access database [LVO 04].

5.17.3 National Practice

As there are answers from both authorities but none from the operators, the following information does not include the view of the airlines at all.

5.17.3.1 Radiation Protection Authority

The *Radiation Safety Centre (RSC)* in Latvia is not directly involved in the monitoring of air crew members. The centre receives the dose data from the CAA. If the calculations show need for support by direct measurement, RSC will provide TLD services.

In Latvia there are two airlines under radiation protection. The criterion for falling under radiation protection is, that calculated doses of air crew could exceed 1 mSv/a. The monitoring started in 2005. As doses for the flights calculated exceeded 1 mSv only in very rare cases, the full score of dose monitoring will start only in 2008. In the mean time there are preparations for TLD services, to start monitoring with initial measurements.

The national dose limits for are 6 mSv/a for general crew members and 1 mSv/a for pregnant women. Reaching 1 mSv/a personnel has to be warned of health risks and doses have to be measured directly. For pregnant women, reaching 1 mSv/a leads to a change of flight schedules if possible.

As soon as direct measurements are started, Latvia will establish a separate dose database only for air crew workers. Dose records will have to be kept until the person reaches the age of 75 years but in any case not less than 45 years after the termination of operations connected with exposure. After the mentioned time span, records are transferred to the archive. For dose calculation EPCARD and CARI6 are accredited in Latvia.

5.17.3.2 Civil Aviation Authority

The Latvian CAA supervises the compliance with JAR-OPS 1. In Latvia, occupational flights of crew members are monitored, but freelancer and frequent flyers are not, nor are people employed by several operators.

There are 19 commercial and 3 non-commercial airlines in Latvia. As none of them flies in heights above 27 000 ft, none of the airplanes registered in Latvia is equipped with dose measurement equipment. There are 347 cabin and 186 flight deck crew members under radiation protection in Latvia.

The action level in Latvia is 1 mSv/a for all air crew members, according to international law. Pregnant women, informing the operator about pregnancy, no longer work on aircrafts but on ground for the rest of pregnancy. Crew members have to be informed about their personal dose, if they reach the limit of 1 mSv/a.

EPCARD and CAR16 are accredited in Latvia for dose calculation. Dose records have to be stored until a person reaches the age of 75, provided the person was exposed to a dose of 6 mSv or more. Data is collected by the Radiation Safety Centre of Latvia.

The CAA spends about 16 hours per year for the management of the radiation protection of air crew members. This number will significantly increase in 2008 due to plans for personal dose measurements on board of aircrafts to compare the results with the calculated doses.

5.18 Lithuania

5.18.1 Legislation

Radiation protection legislation in Lithuania is constituted of the *Law on Radiation Protection* and some governmental decrees. By decree a national dose register has been established. The *Law on Radiation Protection* rules the monitoring of occupationally exposed workers in general. The details for practical implementation are found in the *Basic Standards for Radiation Protection*, in force since January 1998 and revised in 2001. These standards are the national implementation of EURATOM 96/29, EURATOM 97/43 and the International Basic Safety Standards. Monitoring and radiation protection for workers is ruled in *Hygiene Regulation HN 73-2001*. The special case of exposure to natural sources is ruled out by *Hygiene Regulation HN 85:1998* [ESO 03].

The regulatory body for radiation protection in Lithuania is the *Radiation Protection Centre* (RPC, established in 1997).

5.18.2 Dose Register

The RPC keeps the State Register of Sources of Ionising Radiation and Exposure of workers. RPC is also engaged in the evaluation of air crew doses.

The categorisation in A and B workers, as given in European Council Directive 29/96 EURATOM is valid in Lithuanian legislation. Class A workers are personally monitored. There is no named job category for flight personnel in the State Register.

5.18.3 National Practice

5.18.3.1 Civil Aviation Authority

As stated by the CAA of Lithuania, there is no operator with employees liable to receive doses above 1 mSv in Lithuania. Thus none of the 10 commercial airlines is in the scope of radiation protection.

5.19 Luxembourg

5.19.1 Legislation

Radiation protection in Luxembourg is governed by *règlement grand-ducal du 14 décembre 2000 concernant la protection de la population contre les dangers résultant des rayonnements ionisants*, the scope of which is given as follows :

“CHAPITRE 1 - Dispositions générales

Art. 1.1. - Champ d'application

1. Le présent règlement s'applique:

...

e) *aux activités professionnelles qui ne sont pas couvertes par les activités sous a) à d), mais qui impliquent la présence de sources naturelles de rayonnement et entraînent une augmentation notable de l'exposition des travailleurs ou du public, non négligeable du point de vue de la protection contre les rayonnements;*

2. *Le présent règlement ne s'applique ni à l'exposition au radon dans les habitations ni au niveau naturel de rayonnement, c'est-à-dire aux radionucléides contenus dans l'organisme humain, au rayonnement cosmique régnant au niveau du sol ou à l'exposition en surface aux radionucléides présents dans la croûte terrestre non perturbée. “*

... “

Chapter 5 gives dose limits for artificial (article 5.1) and natural sources of radiation. The general regulations and the part about natural radiation are given as follows:

“Art. 5.1.1. - Dispositions générales

1. *L'exposition des travailleurs aux rayonnements ionisants dans les cas d'expositions contrôlables doit être aussi faible que raisonnablement possible et le nombre de personnes et de*

travailleurs exposés à ces rayonnements doit être réduit aussi raisonnablement que possible.

2. Les mesures indispensables doivent être prises:

a) pour prévenir l'ingestion, l'inhalation ou toute pénétration incontrôlée de substances radioactives dans l'organisme ainsi que tout contact direct de l'organisme avec ces substances;

b) pour que les sources de rayonnements ionisants soient utilisées dans des conditions de sécurité aussi parfaites que raisonnablement possible.

3. Des mesures suffisantes sont prises pour faire en sorte que la contribution de chaque pratique à l'exposition de la population dans son ensemble soit maintenue au niveau le plus faible qu'il est raisonnablement possible d'atteindre, compte tenu des facteurs économiques et sociaux.

4. Les conditions auxquelles est soumise la femme enceinte dans le cadre de son emploi doivent être telles que la dose équivalente reçue par l'enfant à naître soit aussi faible que raisonnablement possible.

5. A l'exception des cas prévus à l'article 5.1.7., la somme des doses reçues du fait des différentes pratiques ne doit pas dépasser les limites de dose fixées au présent chapitre pour les travailleurs exposés, les apprentis, les étudiants, le public, l'enfant à naître et l'enfant allaité.

...

Art. 5.1.4. - Protection de l'enfant à naître et de l'enfant allaité

1. Les conditions auxquelles est soumise la femme enceinte dans le cadre de son emploi doivent être telles que la dose équivalente reçue par l'enfant à naître soit la plus faible qu'il est raisonnablement possible d'obtenir.

2. Dès la déclaration de la grossesse, il faut que la dose équivalente reçue par l'enfant à naître soit limitée à 1mSv pendant le reste de la grossesse.

3. Les femmes en période d'allaitement ne sont pas admises aux travaux qui comportent un risque de contamination élevé; le cas échéant, une surveillance particulière de la contamination radioactive de l'organisme sera assurée.

...

Art. 5.2. - Limites de dose pour les travailleurs exposés à des rayonnements ionisants d'origine naturelle.

Les limites prévues au présent chapitre s'appliquent aux activités professionnelles qui impliquent la présence de sources naturelles de rayonnement et entraînent une augmentation notable de l'exposition des travailleurs, non négligeable du point de vue de la protection contre les rayonnements.

Art. 5.2.1. - Dispositions générales

Les dispositions générales prévues à l'article 5.1.1., paragraphes 1 à 5 sont d'application.

...

Art. 5.2.3. - Exposition aux rayonnements gamma externe

1 Les limites de dose des travailleurs ou des personnes du public, qui au cours de leurs activités professionnelles sont soumis à des expositions aux rayonnements gamma externe d'origine naturelle sont celles prévues à l'article 5.1.3.

2. Dans le cadre le l'optimisation de l'exposition des travailleurs aux rayonnements gamma externe d'origine naturelle, les dispositions nécessaires sont prises par le chef d'établissement, à ce que les travailleurs exposés ne soient pas à ranger dans la catégorie A. “

Article 5.3 gives rules for dose evaluation and refers in this directly to Council Directive 96/29/EURATOM:

“Art. 5.3. - Méthodes d'évaluation de la dose efficace et de la dose équivalente en cas d'irradiation externe et en cas d'exposition interne

1. Les méthodes d'évaluation des doses suite à une irradiation externe contenues à l'annexe II de la directive 96/29 Euratom du Conseil CE du 13 mai 1996 fixant les normes de base relatives à la protection sanitaire de la population et des travailleurs contre les dangers résultant des rayonnements ionisants sont applicables.“

...”

Chapter 8 regulates the preventive action to be taken for occupationally exposed people. Paragraph 6 of article 8.2 restricts the before made regulations for air crews on points d, e, f, g, j and k. Preventive actions are conform with international regulations and include dose assessment, information of the worker about health risks and his

personal dose, reduction of dose, protection of the unborn child (article 5.1.4) and regular medical examinations, which are ruled by chapter 9 of the reglement:

“CHAPITRE 8 - Dispositions opérationnelles pour la radioprotection des travailleurs, apprentis et étudiants exposés aux rayonnements ionisants d’origine naturelle

...

Art. 8.2. - Dispositions opérationnelles

1. *Les dispositions opérationnelles qui régissent la radioprotection des travailleurs apprentis et étudiants subissant des expositions notables suite aux rayonnements ionisants d’origine naturelle sont dans les grands principes les mêmes que celles prévues aux chapitres 2, 5, 6, 7, 9, 10 et 11.*
2. *Pour des raisons pratiques, il n’y a pas lieu de distinguer dans les zones de travail entre des zones contrôlées et surveillées. Cependant, en fonction de la nature et de l’ampleur des risques radiologiques régnant dans les zones de travail, une surveillance radiologique du milieu de travail est organisée conformément à l’article 6.5.2. Des consignes de travail adaptées au risque radiologique tenant aux sources et aux opérations effectuées sont établies.*
3. *Pour les personnes, qui au cours de leurs activités professionnelles sont soumises à des expositions aux rayonnements cosmiques et qui sont susceptibles de recevoir une dose annuelle supérieure à 1/10, les prescriptions en matière de radioprotection contenues dans les règlements spécifiques internationaux doivent être observées.*
4. *Les personnes, qui au cours de leurs activités professionnelles sont soumises à des expositions aux rayonnements cosmiques et qui sont susceptibles de recevoir une dose annuelle inférieure à 1/10 des limites fixées à l’article 5.1.3. sont considérées comme des personnes du public.*
5. *Le chef d’établissement est responsables de l’évaluation et de l’application des dispositions visant à assurer la radioprotection des travailleurs exposés et notamment:*
 - a) *des mesures de radioprotection à prendre dans leur établissement et autour de celui-ci ainsi que des mesures d’optimisation de la radioprotection, quelles que soient les conditions de travail;*

- b) de l'évaluation préalable permettant d'identifier la nature et l'ampleur du risque radiologique encouru par les travailleurs ou par la population exposée;*
 - c) du contrôle strict des conditions de travail dans les zones susceptibles d'entraîner des expositions notables;*
 - d) d'appliquer l'article 5.1.4.;*
 - e) d'évaluer l'exposition du personnel concerné,*
 - f) de la mise à disposition des résultats de cette évaluation au personnel concerné;*
 - g) de la mise en oeuvre de la surveillance médicale du personnel exposé si elle s'impose;*
 - h) de réglementer l'accès aux différentes zones de travail susceptibles d'entraîner des expositions notables;*
 - i) de l'établissement de procédures et de consignes de travail adaptées au risque radiologique tenant aux sources et aux opérations effectuées ainsi que la mise à jour de ces procédures et consignes;*
 - j) d'informer le personnel exposé des risques que leur travail comporte pour leur santé;*
 - k) de tenir compte de l'exposition évaluée pour l'organisation des programmes de travail, en vue de réduire les doses du personnel fortement exposé;*
 - l) la mise en oeuvre d'actions correctives destinées à réduire l'exposition conformément à l'ensemble des dispositions du chapitre 11 ou à certaines d'entre elles.*
- 6. Pour le chef d'établissement qui se destine à l'exploitation d'aéronefs, seuls les points d, e, f, g, j, et k du paragraphe 5 sont d'application.*

CHAPITRE 9 - Surveillance médicale des travailleurs exposés

Art 9.1. Principes de la surveillance médicale

- 1. La surveillance médicale des travailleurs exposés et l'organisation de cette surveillance se fondent sur les principes qui régissent la médecine du travail.*

- 2. La surveillance médicale des travailleurs exposés aux rayonnements ionisants incombe aux médecins agréés des services de la médecine du travail.*

Art. 9.1.1. - Surveillance médicale

- 1. Chaque travailleur qui se destine à un travail sous rayonnements doit subir aux frais du chef d'établissement, un examen médical d'embauche par un médecin agréé pour déterminer son état de santé pour ce qui est de sa capacité à remplir les tâches qui lui sont assignées. Le médecin agréé déclare le travailleur apte, apte sous certaines conditions ou inapte au travail sous rayonnements ionisants.*
- 2. Chaque travailleur de la catégorie A doit subir aux frais du chef d'établissement des examens de santé annuels par un médecin agréé pour déterminer l'état de santé du travailleur pour ce qui est de sa capacité à remplir les tâches qui lui sont assignées. Le médecin agréé le déclare apte, apte sous certaines conditions ou inapte à continuer de travailler sous rayonnements ionisants.*
- 3. La nature de ces examens, auxquels il peut être procédé aussi souvent que le médecin agréé l'estime nécessaire, dépend du type de travail et de l'état de santé du travailleur concerné.*
- 4. Pour juger de l'aptitude d'un travailleur exposé à remplir les tâches qui lui sont assignées, le médecin agréé doit avoir accès à toute information pertinente qu'il estime nécessaire, y compris aux conditions ambiantes régnant sur les lieux de travail.*
- 5. Aucun travailleur n'est employé pendant une période quelconque à un poste spécifique en tant que travailleur de la catégorie A, ni classé dans cette catégorie si les examens médicaux concluent à l'inaptitude de ce travailleur à occuper ce poste spécifique.*
- 6. Une surveillance médicale doit intervenir chaque fois que l'une des limites de dose fixées au chapitre 5 a été dépassée.*
- 7. Les conditions ultérieures d'exposition sont subordonnées à l'accord du médecin agréé.*
- 8. La surveillance médicale prévue au présent article pour les travailleurs exposés est complétée par toute mesure en rapport avec la protection sanitaire de l'individu exposé que le médecin agréé estime nécessaire, et notamment des examens complémentaires, des opérations de décontamination ou un traitement curatif d'urgence.*

9. *Le médecin agréé indique éventuellement que la surveillance médicale doit se prolonger après la cessation du travail pendant le temps qu'il juge nécessaire pour sauvegarder la santé de l'intéressé.*

Art. 9.1.2. - Dossiers médicaux

1. *Le médecin agréé établit un dossier médical pour chaque travailleur de la catégorie A, pour les travailleurs ayant subi une exposition exceptionnelle concertée, pour les travailleurs ayant subi une exposition accidentelle ou une exposition d'urgence ainsi que pour tous les autres travailleurs ayant reçu une dose dépassant une des limites annuelles.*
2. *En ce qui concerne les travailleurs de la catégorie A, le dossier médical contient des renseignements concernant la nature de l'activité professionnelle, les résultats des examens médicaux préalables à l'embauche ou à la classification en tant que travailleur de la catégorie A, les résultats des examens de santé annuels ainsi que le relevé des doses visées par l'article 6.5.3. paragraphe 4.*
3. *Le dossier médical est tenu à jour aussi longtemps que l'intéressé reste dans cette catégorie. Il est ensuite conservé jusqu'au moment où l'intéressé a ou aurait atteint l'âge de 75 ans et, en tout cas, pendant une période d'au moins trente ans à compter de la fin de l'activité professionnelle comportant une exposition aux rayonnements ionisants. “*

5.19.2 Dose Register

No information about a national dose register in Luxembourg was found.

5.19.3 National Practice

5.19.3.1 Civil Aviation Authority

The Luxembourgian CAA *Direction de l'Aviation Civile (DAC)* is part of the system for dose registration. The obligations are managed by the coordinator civil aviation safety oversight. Supervision of dose registration, conducted by *DAC*, is done by visits to the airlines. Occupational transport of crew members and freelancers working for airlines are monitored. People with several jobs and frequent flyers are not included in radiation protection.

There is no training for air crew members regarding the health risks of radiation and there are no preventive actions.

CAA supervises the application of JAR-OPS; the supervision of radiation protection implementation according to règlement grand-ducal du 14 décembre 2000 is due to the Minister of Health. An estimation of the hours spent in CAA is not available.

In Luxembourg there are 6 commercial airlines of which one is not under radiation protection as this operators flies below 20.000 ft. Altogether there are 161 cabin crew and 620 flight deck crew members under radiation protection in Luxembourg. None of the Luxembourg aircrafts is equipped with dose measurement tools.

Breastfeeding women are not allowed to be occupationally exposed in Luxembourg nor are persons under the age of 18.

Dose calculation in Luxembourg is done using CARI6 or the software AIMS from Cargolux. The dose data is not yet stored in a database.

In future all operators will be checked on their compliance with JAR-OPS 1390(a).

5.19.3.2 Operators

Luxair kindly answered our questionnaire. The tasks to provide radiation protection for the crew members are split between the Operations Department and the Flight Safety Department. Dose calculation is done in-house using CARI6 based on planned route data and real flight times. Where are no measurements to support calculations. Doses are stored as part of personal data in-house.

As there are no freelancers employed by *Luxair* and their roster does not require occupational transport, both are not in the scope of dose calculation.

None of the 15 aircrafts operated by *Luxair* flies above 49 000 ft and none of the planes is equipped with dose measurement devices. There are 148 male (19 of them cabin crew) and 161 female (9 of them cockpit crew) flying crew members. Up to now no crew member ever reached doses above 3.5-4 mSv/a. Pregnant crew members are grounded as soon as pregnancy is reported.

For the reduction of doses, solar events are communicated via NOTRIS and flight altitudes are reduced as soon as there is a notification.

Information about health risks is provided in the operations manual. Since radiation protection started, both, maximum and average doses stayed the same for all personnel. The estimated time spent for this task is 3 hours a month.

5.20 Macedonia

5.20.1 Legislation

Macedonian legislation regarding radiation protection is governed by the *Law on Ionizing Radiation Protection and Safety of June 2002*. The dosimetry department of

the Radiation Protection Centre of Macedonia is engaged in occupational radiation protection for both artificial and natural exposures [NIK 07]:

“Definitions

Article 2

Definitions and technical terms used in this Law shall have the following meaning:

...

10. *“Natural radiation” means ionizing radiation including cosmic radiation and radiation of naturally occurring radionuclides.*

...

19. *“Worker working with source of ionizing radiation” –means any individual who during its working time is permanently or periodically exposed to ionizing radiation.*

...

II. COMPETENT AUTHORITY

Radiation Safety Directorate

Article 3

For carrying out managing and professional activities in the area of protection against ionizing radiation a Radiation Safety Directorate shall be established (hereinafter: Directorate).

The Directorate shall perform the following duties:

...

2. *To establish the intervention levels and radiation protection and safety requirements;*

...

6. *To maintain National Registry on sources of ionizing radiation and on workers exposed to ionizing radiation during work;*

...

Republic Institute of Public Health Protection

Article 6

The Republic Institute of Public Health Protection shall act as a Radiation Protection Centre.

At the request of and under conditions prescribed by the Directorate, the Republic Institute shall provide the following technical services to the Directorate:

- 1) prepare and propose expert grounds for preparation of sub-legal acts and standards in the area of radiation protection in accordance with the standards of the international organizations and the European Union;*
- 2) to submit to the Directorate reports on the improvement of radiation protection related to practices under regulatory control;*
- ...*
- 6) performs estimate of the degree of exposure to ionizing radiation at work;*
- 7) to conduct permanent medical surveillance of occupationally exposed individuals and keep records thereof;*
- ..."*

The law does not mention cosmic radiation or air crew radiation protection.

5.20.2 Dose Register

There was no information about a national dose register in Macedonia found.

5.20.3 National Practice

None of the authorities and airlines contacted answered to our questionnaire yet.

5.21 Malta

5.21.1 Legislation

Maltese legislation regarding radiation protection is governed by the *National Interest Enabling Powers Act, Cap. 365: Nuclear Safety and Radiation Protection Regulations of 2003*.

In Part 1 (General Provisions), Article 4, paragraph 3, the scope of this Law Act is extended to the exposure to natural radiation as found in aviation:

“ ...

- (3) *In accordance with Part 12 they shall also apply to work activities which are not covered by paragraph 1 but which involve the presence of natural radiation sources and may lead to a significant increase in the exposure of workers or members of the public which cannot be disregarded from the radiation protection point of view.*

..”

This separate statement is included as in paragraph one only natural radiation from processing of natural sources is mentioned.

In part 3, Article 9 the Radiation Protection Board is defined and the setup of a national dose registry is mentioned as one of its duties:

“9 (1) There shall be set up a Radiation Protection Board, hereinafter referred to as the Board, which shall act as the regulatory authority in the field of nuclear safety and radiation protection.

- (2) *The Board shall have such functions as may devolve on it under any other law or as may be assigned to it in writing by the Prime Minister or by the member agencies represented on the Board. In the case that other regulations are in force governing occupational, public, and medical exposures, or environmental protection and safety of sources, which in some way address the use of ionizing radiation, the Board shall, if it considers it necessary, make recommendations to the Prime Minister for the reallocation of the regulatory responsibility to the Board itself or to some other authority as the Board deems fit.*

- (3) *It shall be the function of the Board to:*

...

- (j) *gather the required data to enable an assessment of total exposure from all practices and work activities in Malta and including the distribution of the individual occupational and public exposures for each type of practice, and to enable the setting up of a National Register for Occupational Exposure to Ionising Radiation;*

...”

Part 12 of the same Act is overwritten **Significant Increase in Exposure due to Natural Radiation Sources**. Here special regulations regarding flight personnel are found:

“47. (1) It shall be the duty of the radiation employer to identify, by means of surveys or by any other appropriate means, work activities, not covered by regulation 4 (1), within which the presence of natural radiation sources leads to a significant increase in the exposure of workers or of members of the public which cannot be disregarded from the radiation protection point of view. Such work activities include, in particular:

...

(d) aircraft operation.

(2) In situations where the radiation employer has identified work activities pursuant to paragraph 1, wherein exposure to natural radiation sources needed attention and had to be subject to control, the radiation employer shall be required to set up appropriate means for monitoring exposure and as necessary:

(a) implement corrective measures to reduce exposure pursuant to all or part of Part 14;

(b) apply radiation protection measures pursuant to all or part of Parts 4, 5, 6, 7, 8, 9 and 11.

48. (1) Every radiation employer operating aircraft shall take account of exposure to cosmic radiation of air crew who are liable to be subject to exposure to more than 1 mSv per year. The radiation employer shall take appropriate measures, in particular:

(a) to assess the exposure of the crew concerned,

(b) to take into account the assessed exposure when organizing working schedules with a view to reducing the doses of highly exposed aircrew,

(c) to inform the workers concerned of the health risks their work involves,

(d) to apply Schedule 3, Part 3(2) and (3) to female air crew.”

Whereby in Schedule 3, Part 3(2) and (3) the following text is found:

“PART 3

Women of reproductive capacity

- (1) *Without prejudice to the above paragraphs, the limit on equivalent dose for the abdomen of a women of reproductive capacity who is at work, being the equivalent dose from external radiation resulting from exposure to ionising radiation averaged throughout the abdomen, shall be 13 mSv in any consecutive period of three months.*
- (2) *As soon as a pregnant woman informs the undertaking, in accordance with the Protection of Maternity at the Workplace Regulations, L.N. 98 of 2000, of her condition, the protection of the child to be born shall be comparable with that provided for members of the public. The conditions for the pregnant woman in the context of her employment shall therefore be such that the equivalent dose to the child to be born will be as low as reasonably achievable and that it will be unlikely that this dose will exceed 1 mSv during at least the remainder of the pregnancy.*
- (3) *As soon as a breastfeeding woman informs the undertaking in accordance with the Protection of Maternity at the Workplace Regulations, L.N. 98 of 2000, of her condition she shall be employed so that 1/20 of the Annual Limit Intake (ALI) shall not be exceeded.”*

5.21.2 Dose Register

No information regarding a Maltese national dose register has been found.

5.21.3 National Practice

None of the addressees did answer to our letter yet.

5.22 Netherlands

5.22.1 Legislation

In 2001 radiation protection in the Netherlands was newly ruled by *Besluit 397 of 16 July 2001*, published in the *Staatsblad van het Koninkrijk der Nederlanden*. The regulations explicitly exclude frequent flyers and air carriers in article 2 [NED 01]:

“ ...

- i. kosmische straling in een vliegtuig voor leden van de bevolking en voor werknemers, die niet behoren tot de vliegtuigbemanning;*

...”

Article 111 rules the occupational exposure of flight crews (implementation of § 42 of EURATOM 96/92):

“Artikel 111

1. *In afwijking van de artikelen 102 tot en met 110 zorgt de ondernemer ervoor dat met betrekking tot een werknemer die deel uitmaakt van een vliegtuigbemanning:*
 - a. *deze voor zijn aanstelling als zodanig wordt voorgelicht omtrent de risico's van kosmische straling;*
 - b. *de grootte van de door hem ontvangen effectieve dosis ten gevolge van kosmische straling wordt bepaald door middel van een door Onze Minister van Sociale Zaken en Werkgelegenheid vastgestelde methode;*
 - c. *indien een effectieve dosis van 6 mSv in een kalenderjaar kan worden overschreden, ter voldoening aan de in artikel 5 gestelde verplichting een aangepast werkrooster wordt vastgesteld en uitgevoerd en de desbetreffende werknemer wordt ingedeeld als A-werknemer;*
 - d. *de door hem ten gevolge van kosmische straling ontvangen effectieve dosis tezamen met de effectieve doses ten gevolge van handelingen die onder verantwoordelijkheid van de ondernemer worden verricht, 20 mSv in een kalenderjaar niet overschrijdt.*
2. *De artikelen 15, 16, 79, 80, 90, 91, 92, tweede lid, en 96 tot en met 100 zijn van overeenkomstige toepassing.*
3. *Dit artikel is niet van toepassing op vluchten die uitsluitend op een hoogte van minder dan acht kilometer plaatsvinden.*
4. *Onze Minister van Sociale Zaken en Werkgelegenheid kan nadere regels stellen met betrekking tot het bepaalde in dit artikel.”*

Thus, information of workers is ruled (1 a), flight crew members with effective doses above 6 mSv per year are part of category A workers and further regulations, including the methods for dose determination, are in responsibility of the Minister of Social Affairs and Employment. Flights beneath a height of 8 km are not affected by this legislation.

The annotations to *Besluit 397* include further explanations of article 111 in section 4.9:

“4.9 Vliegtuigbemanning

Geheel nieuw in richtlijn 96/29 en ook voor Nederland is de aandacht voor vliegtuigbemanningen, die worden blootgesteld aan ioniserende straling tijdens hun werk. Artikel 42 van richtlijn 96/29 draagt de lidstaten op speciale maatregelen terzake te nemen. In artikel 111 van dit besluit is daarom een verplichting voor de ondernemer opgenomen om bepaalde vliegtuigbemanningen in een stralingshygiënisch zorgsysteem onder te brengen. Dit impliceert in Nederland een grote toename van het aantal blootgestelde werknemers, naar schatting worden ca. 15 000 B-werknemers als zodanig aangewezen. De effectieve dosis van deze werknemers wordt bepaald met behulp van computerprogramma's die daarvoor zijn ontwikkeld. Dit op basis de van tevoren bepaalde dosis per vluchtroute. Daardoor hoeven deze werknemers niet allemaal van een persoonlijke dosismeter te worden voorzien.”

In the chapter about definitions and scope of the above mentioned regulations there is a further explanation regarding article 111:

“Artikel 111

Dit artikel bevat bepalingen met het oog op de bescherming van vliegtuigbemanningen tegen de blootstelling aan kosmische straling. De effectieve dosis mag in plaats van aan de hand van persoonlijke dosiscontrolemiddelen ook op andere wijze worden vastgesteld (art. 88). De Minister van Sociale Zaken en Werkgelegenheid wijst daartoe een computerprogramma aan (eerste lid onder b). Daarbij zal worden getracht om zoveel mogelijk aan te sluiten bij internationaal geaccepteerde programma's. Het tweede lid geeft aan welke artikelen uit de voorgaande hoofdstukken van toepassing zijn. Het betreft de indeling in de categorie werknemer of A- of B-werknemer, de vrijstelling van het dragen van persoonlijke dosiscontrolemiddelen, de dosisregistratie en het medische toezicht. In de praktijk zal de dosis voor vliegtuigbemanningen waarvan de vlieghoogte steeds beneden 8 km blijft lager zijn dan 1 mSv. Daarom zijn deze vluchten in het derde lid uitgezonderd en daarmee impliciet niet als werkzaamheden geïdentificeerd. Dit houdt in dat voor vluchten beneden de 8 km in het geheel geen dosisregistratie geëist wordt, en dat werknemers die steeds beneden de 8 km vliegen, niet als blootgestelde werknemer geclassificeerd behoeven te worden en voor hen derhalve ook geen persoonlijke dosisregistratie hoeft plaats te vinden.

De Raad van State beveelt in haar advies aan in de regelgeving aandacht te besteden aan andere personen dan vliegend personeel, die frequent en beroepsmatig in aanraking komen met kosmische straling. Hiertoe behoren met name de zogenoemde frequent flyers,

dit zijn werknemers, niet zijnde vliegtuigbemanningen, die uit hoofde van hun beroep regelmatig aan straling kunnen worden blootgesteld, met name op intercontinentale vluchten. Vanwege hun moeilijke traceerbaarheid en beheersbaarheid is voor deze groep het stralingshygiënische zorgsysteem, dat voor vliegend personeel geldt, moeilijker te realiseren. Ook aanbeveling 75 van ICRP stelt deze bijzondere groep buiten regelgeving te houden. Dit betekent dat de werkingssfeer van het besluit niet met deze groep wordt uitgebreid. Wel zal in een nog op te stellen ArboInformatieblad aandacht worden besteed aan deze groep.”

In Article 88 exceptions to the duty of personal dosimetry are formulated:

“Artikel 88

- 1. De regiodirecteur of, bij mijnbouw, de Inspecteur-Generaal der Mijnen, of, indien het de krijgsmacht betreft een door Onze Minister van Defensie aan te wijzen autoriteit, kan, indien het meten van blootstelling aan ioniserende straling aan de hand van persoonlijke controlemiddelen niet of niet goed mogelijk is, of als op andere wijze de effectieve of equivalente dosis wordt bepaald, ontheffing verlenen van het bepaalde in artikel 87.*
- 2. Aan de ontheffing, bedoeld in het eerste lid, worden voorschriften verbonden die inhouden dat de effectieve of equivalente dosis geschat wordt aan de hand van de individuele metingen bij andere blootgestelde werknemers, of aan de hand van de in artikel 86 bedoelde ruimtemonitoring, of in het geval van vliegtuigbemanningen op een wijze als bedoeld in artikel 111, eerste lid, onder b, of op andere wijze.”*

This allows estimating the effective or equivalent dose of air crew members to be estimated like given in article 111 as seen above, where the monitoring itself is regulated in *Regeling voorzieningen stralingsbescherming werknemers* [SZW 02]:

“§5. Vliegtuigbemanningen

Artikel 11. Methode bepaling dosis

- 1. De methode, bedoeld in artikel 111, eerste lid, onder b, van het besluit, voor de bepaling van de ontvangen effectieve dosis bestaat uit het bij elkaar brengen van de individuele relevante vluchtgegevens van de in dat artikel bedoelde werknemer en de op die werknemer betrekking hebbende dosisberekening met het in het derde lid genoemde computerprogramma.*
- 2. De individuele relevante vluchtgegevens worden volgens een schriftelijk vastgelegd protocol verzameld onder*

verantwoordelijkheid van de in het vijfde lid genoemde deskundige.

3. De dosisberekening wordt uitgevoerd met behulp van het computerprogramma CARI-6/6M, uitgegeven door de Federal Aviation Administration.
4. De bepaling van de blootstelling geschiedt zodanig dat op een later tijdstip de juistheid van de resultaten kan worden nagegaan.
5. De methode, bedoeld in het eerste lid, wordt beheerd door een deskundige met het diploma ioniserende straling niveau 5A, aangevuld met kennis over dosimetrie van vliegtuigbemanningen.”

In the Netherlands about 15 000 category B workers are expected from including aviation into dose monitoring. The doses are to be estimated using computer codes. In section 5.6 of the Annotations, the CARI program is explicitly mentioned:

“5.6 Vliegtuigbemanningen

De VNV heeft nota genomen van het feit dat vliegtuigbemanningen worden ingeschaald als B-werknemer. Voor wat betreft de medische keuring wordt verwezen naar de Arbowet. Daarnaast wijst de vereniging naar de specifieke methoden van persoonsdosimetrie en pleit in het bijzonder voor het reeds ontwikkelde CARI systeem.

Verder geeft de VNV specifiek commentaar met name op paragraaf 8.3. Er wordt op gewezen dat vliegtuigbemanningen thans voor de eerste maal onderwerp van specifieke stralingswetgeving zijn. Richtlijn 96/29 geeft de lidstaten de verplichting specifiek aandacht te besteden aan deze groep blootgestelde werknemers. Vanwege het specifieke karakter van het beroep van vliegend personeel, waarbij de reguliere stralingsbeschermingsmaatregelen maar gedeeltelijk bruikbaar zijn (afscherming en dosimetrie) is besloten dit type werknemers te beschouwen als B werknemers, waarbij blootstellingen plaats kunnen vinden van 1 t/m 6 mSv per jaar. Indien na evaluatie blijkt 1 Tien jaar Nationaal Dosisregistratie- en Informatiesysteem dat er hogere blootstellingen (meer dan 6 mSv per jaar) plaatsvinden, zal de indeling veranderen en ligt een indeling als A werknemer voor de hand. Voor medisch toezicht op B werknemers geldt het reguliere arbeidsgezondheidkundig regime van de Arbowet.

Voor wat betreft de te gebruiken methode van persoonsdosimetrie zal voornamelijk gebruik worden gemaakt van het CARI systeem. Dit systeem heeft als voordeel dat het in vele lidstaten al wordt gebruikt of gebruikt zal gaan worden. Bovendien is het systeem gevalideerd. Deze methode zal bij ministeriële regeling worden voorgeschreven.”

The cost of this dosimetry program for flight personnel is estimated to 450 000 € a year in the annotations to the regulations.

Employers have to send a dose statistic and the dose limit exceeding to the Ministry of Social Affairs and Employment once a year.

5.22.2 Dose Register

The *National Dose Registration and Information System (NDRIS)* is operated by the *Nuclear Research and Consultancy Group (NRG)* since 1989. All measured values are transferred monthly from the dosimetric services to the registry in electronic form after subtraction of the national average background dose of 2.16 μSv a day. Thus also negative values might be reported.

NDRIS processes the data and reports the data for each worker back to the ADS, thus combining information from different services concerning the same person.

Reported doses have to be kept by the employer until the employee reaches the age of 75 or at least 30 years after the last exposure. Approved dosimetric services (ADS) and NDRIS keep the data for the same period.

Due to Article 111 as seen above, the doses of all crew members of Dutch commercial airlines operating above 8 km are collected in NDRIS since 2002. NRG evaluates the doses from the flight plans. Aviation is one of the work categories grouped under the term of "Activities" [HON 03].

5.22.3 National Practice

5.22.3.1 Radiation Protection Authority

In Netherlands there are 3 commercial airlines under radiation protection. Companies are included into the radiation protection programme if they fly above 8 km and if their crews are liable to be subject to exposures above 1 mSv/a. In future, air force personnel will be included in the system, too.

At the end of December 2007 there were 1577 male and 6715 female cabin crew members under radiation protection in Netherlands. Besides there were 2718 male and 103 female flight deck crew members. The average dose for flight personnel in general was 1.73 mSv in 2007. In the same year 2258 of the persons monitored did not reach the dose of 1 mSv. The majority of 10 918 crew members were exposed to doses between 1 and 6 mSv. Nobody exceeded the limit of 6 mSv.

In total, average doses increased since monitoring started in 2002 with a dose of 1.34 mSv/a. The maximum values of dose increased about 8 or 9 % a year. Taking the 99-percentile the increase was about 6 % a year.

Dose limits for crew members are 20 mSv/a and for pregnant women 1 mSv/a. There is no special rule for women during breastfeeding. At reaching 6 mSv/a work schedules

have to be adapted to reduce doses. Air crew members exceeding the 6 mSv action level become category A workers.

Dose records for air crew members are stored in a database together with data of other occupationally exposed workers. All exposed workers might get their own information at any time. Employers have access to the data of their employees. Additionally the dosimetric service that did the calculations is allowed to access the data he compiled. Of the authorities the Ministry of Social Affairs, the Labour Inspectorate and the NDRIS operator have access to the data. Data has to be kept at least 30 years after the person stopped to be occupationally exposed or until he or she reaches the age of 75.

Dose data is collected by the airlines and reported to NRG, which manage the database, once a month.

5.22.3.2 Civil Aviation Authority

The Dutch CAA *Inspectie Verkeer en Waterstaat* kindly answered our questionnaire. In Netherlands occupational flights and flights of freelancers or personnel with multiple employments are monitored in case they operate above 8 km altitude. Frequent flyers are not included into radiation protection. Compliance with the radiation protection legislation is supervised by the Ministry of Social Affairs and Employment. Thus, the time spent by CAA staff in radiation protection is negligible.

As soon as a crew member exceeds 6 mSv/a he or she becomes category A worker. At this moment work plans have to be adjusted for minimising the personal dose. The dose limit is 20 mSv/a.

Crew members can get information about radiation safety from the CAA. Responsible personnel are flight operations inspector and air medical doctors.

There are 22 registered commercial airlines in the Netherlands. They are all under radiation protection, thus there are approximately 12 500 crew members under radiation protection. There is no dose measurement equipment on Dutch aircrafts.

5.23 Norway

5.23.1 Legislation

In Norway radiation protection is ruled by the *Act on Radiation Protection and Use of Radiation (No. 36 of 12 May 2000)*. The scope of the Act is given in Article 2:

“ ...

The Act also applies to human activity giving increased levels of naturally ionising radiation from the environment.

... ”

Section 10 Naturally ionising radiation

The ministry may lay down regulations that prescribe limitations, including dose limits, for work or periods spent in places where radiation levels from naturally ionising radiation are increased due to human activity.

...

Section 11 Internal control

The King may in further regulations lay down provisions concerning internal control and internal control systems to ensure compliance with requirements laid down in or pursuant to this Act.

Section 12 Regulations on satisfactory radiation protection and use of radiation etc.

In order to promote the purpose of this Act and to ensure proper radiation protection and use of radiation, the ministry may lay down regulations to supplement the provisions of this Act. Such regulations may inter alia lay down requirements with regard to:

- a) the organisation of radiation protection, including the designation of a responsible radiation protection officer, and requirements as regards the registration of information necessary for the purpose of internal control or supervision.*
- b) shielding measures in the form of design and adaptation of premises and workplaces, work procedures and use of personally fitted protective equipment. Requirements may also be laid down for the design and function of radiation-emitting equipment.*
- c) marking of radiation sources and information about the application, handling and storage of radiation sources. Requirements may also be laid down as to warning signs in premises or areas where radiation sources or radioactive waste are present which may entail a health risk. Requirements may also be laid down to inform involved persons and the general public about the use of radiation and radiation protection.*
- d) measurement of radiation levels, including personal dosimetry.*
- e) dose limits for relevant types of radiation.*
- f) transport of radiation sources, including radioactive waste and equipment containing such sources.*

g) follow up of protective measures in connection with the carrying out of repairs, maintenance or alteration of a radiation source or installation.

...”

In 2003 the new *regulation 1362 of 21st November 2003 on Radiation Protection and Use of Radiation* came into force and fills the above mentioned law with detailed rules for daily work. Regulation 1362 explicitly includes natural radiation:

“Section 2 Scope of the regulations

The regulations apply to any manufacture, import, export, transfer, possession, installation, use, handling and waste management of radiation sources. The regulations also apply to human activity giving increased levels of naturally ionising radiation from the environment.

...”

The comment to section 2 explicitly calls on flight crew exposure:

“...Examples of increased concentration of naturally occurring radioactive substances that are regulated by the regulations are: radon exposure at subterranean workplaces (mines), cosmic radiation to flight personnel and handling of scale (low radioactive deposits from the oil and gas sector)...”

The proper information of exposed personnel is addressed in Section 7 of regulation 1362 as follows:

“Section 7 Competence, instructions and procedures

Undertakings shall ensure that employees and other associated persons who install or work with radiation sources, or who may be exposed to radiation, shall have sufficient competence in the field of radiation protection and safe use of radiation sources and measuring and protective equipment.

The undertaking shall prepare instructions and work procedures in writing which ensure proper radiation protection and prevent persons from being exposed to levels which exceed limits stated in applicable standards or international guidelines.”

In section 20 (chapter IV) of the regulations, air planes are explicitly excluded from classification and marking of workplaces:

“...

This section does not regulate the transport of radioactive sources. The requirements as to marking of the workplace do not apply in the

case of elevated cosmic radiation to flight personnel or in the case of elevated radon exposure at subsurface workplaces....”

As in section 22 the duty for carrying of personal dosimeters is restricted to workers in controlled areas and at marked workplaces, flight crews do not have to be personally monitored in Norway.

In March 02 the Civil Aviation Authority of Norway published the official interpretation of JAR-OPS 1.390 and 1.680 in the Aeronautical Information Circular as follows:

”N 12 Nordiske strålevern- og luftfartsmyndigheters fortolkning av bestemmelser vedrørende kosmisk stråling

Reutstedelse av AIC – N 01/02

Vedlagt følger nordiske strålevern- og luftfartsmyndigheters fortolkning av bestemmelser vedrørende kosmisk stråling.

- Vedlegg -

Nordic Radiation Protection and Civil Aviation Authorities Working Party on Cosmic Radiation Control of the exposure to cosmic radiation of air crew in the Nordic countries. Dose rates from cosmic radiation vary strongly with altitude and also with latitude and with the phase of the solar cycle. The exposure of air crew to cosmic radiation can be significantly increased dependent on rostering.

The Nordic Radiation Protection and Civil Aviation Authorities have agreed on the following interpretation of requirements for the control of the exposure to cosmic radiation of air crew in the Nordic countries. The interpretation take due account of the requirements in JAR-OPS 1.390 and 1.680 regarding cosmic radiation (ref. 1), the revised European Basic Safety Standards Directive (ref. 2) and the guidance made by the European Commission in transposing the Directive into national legislation (ref. 3).

- 1. Operators of aircraft in commercial air transport registered in a Nordic country or operating on a Nordic AOC (Air Operator Certificate) shall take the exposure of air crew (both flight deck and cabin crew) to cosmic radiation into account in accordance with these recommendations if the annual effective dose to a crewmember can exceed 1 mSv¹.*
- 2. The operator (employer) shall inform the aircrew of the risks of occupational exposure to cosmic radiation. Female aircrew shall know of the need for early declaration of pregnancy in view of the risks of exposure for the child to be born.*

3. *Effective doses to air crew can be estimated by the operator by using route doses calculated with a suitable computer programme² taking generic or specific flying circumstances into account. Other means of estimating the exposure to air crew shall be approved by the National Radiation Protection Authority in co-operation with National Civil Aviation Authorities to ensure adherence to JAR-OPS 1. Operators, who before each traffic season can demonstrate annual average crew radiation exposure well below 6 mSv based on the average flying pattern and expected average number of flight duty hours, can use actual duty hours as a scaling factor for estimating individual effective doses. The average crew radiation exposure estimate must take into account the varying flying pattern of different groups of crew members, if applicable.*
4. *The operator shall after each calendar year estimate the effective dose to each individual crew member in accordance with paragraph 3 and inform the crew member of his/her effective dose.*
5. *Once a year before (date) the operator shall forward the following information regarding the previous calendar year to the national radiation protection authorities (name and address):*
 - (a) *A summary of the estimated yearly effective doses to the air crew (Number of crew members in each 1 mSv interval (< 1 mSv, 1-2 mSv, 2-3 mSv, 3-4 mSv, etc.)).*
 - (b) *A list of crew members with an estimated yearly effective dose equal to or above 6 mSv (Full name, national identification number and estimated dose in accordance with national legislation on personal registries).*
- 1) *For flights operating below 26.000 ft (~ 8 km) the annual effective dose to a crewmember will not exceed 1 mSv. Similar, the recommendations do not apply if the operator can demonstrate that due to the general operating practices of the company, it is very unlikely that the dose to the crew (or a well defined group of crew members) will exceed 1 mSv.*
- 2) *At present no approval procedure has been agreed upon. Examples of computer programs which have demonstrated an agreement with measured values available within acceptable uncertainty limits are CARI-6 (ref. 4), EPCARD-3.1 (ref. 5) and FREE-1.0 (ref. 6).*
6. *When organising working schedules the operator shall take into account the estimated effective doses with a view to reduce individual yearly doses at for those individuals whose yearly effective dose is estimated to be at or above 6mSv.*

7. *When a pregnant crew member informs the operator of her condition, the operator shall ensure that the working schedule for female crew members, once they have notified the operator that they are pregnant, keep the equivalent dose to the foetus as low as can reasonably be achieved and in any case ensure that the dose does not exceed 1mSv for the remainder of the pregnancy.”*

The Norwegian personal dosimetry program started in 1957 for occupationally exposed workers. There is no strict definition of occupationally exposed workers in the regulations. Norwegian Radiation Protection Authority (NRPA) published a list of relevant occupations and workplaces in their Guideline 8 [NRP 95].

Norwegian Airlines have rules to restrict the number of flight hours for pregnant women and the new rules by NRPA will cover occupational exposure to enhanced natural radiation like in aviation.

The NRPA recommends in their guidelines, which not have the power of law, to follow the dose limits of ICRP 60. The regulations are based on ICRP 26 and the European Council directive 96/92 EURATOM from 1996.

In regulation 1362 the dose limits are given in section 21 as follows:

“Section

21

Dose limits etc.

All radiation exposure shall be kept as low as reasonably achievable, and the following dose limits shall not be exceeded:

- a) The dose limit for workers over the age of 18 is 20 mSv per calendar year. The Norwegian Radiation Protection Authority may grant dispensation for individuals where the nature of the work makes it impracticable to set an annual limit of 20 mSv. In such cases permission may be given for a limit of 100 mSv over a continuous five-year period, on condition that the effective dose does not exceed 50 mSv in any single year.*
- b) The radiation dose to the lens of the eye shall not exceed 150 mSv per year.*
- c) The radiation dose to the skin, hands and feet shall not exceed 500 mSv per year.*
- d) For apprentices between the age of 16 and 18 years who use radiation sources as part of their training, doses of respectively 5, 50 and 150 mSv per year apply instead of the doses stated under a) to c).*

e) *For pregnant women the dose to the foetus shall not exceed 1 mSv for the remainder of the pregnancy, i.e. after pregnancy has been established.*

...

Where there is reason to believe that an employee has exceeded the dose limit, the employer shall immediately carry out an investigation to identify the causes, and take steps to avoid repeats.”

5.23.2 Dose Register

Since 1998 NRPA automatically stores dose data from workers in a database. This database only covers the monitoring conducted by NRPA, not the data collected by other dosimetry services. Aviation is not mentioned in the available list of occupations in this database. Air crew members might be covered by the expression “other work”, the category work facility would then consequently be “other use”.

In 2004 a reporting duty of dose data to NRPA was established and a central Dose Register was set up [SEK 04].

5.23.3 National Practice

5.23.3.1 Civil Aviation Authority

The Norwegian CAA *Luffartstilsynet* informed us, that in Norway there is no operator flying above 49 000 ft. Thus there were no answers to our questionnaire from Norway.

5.23.3.2 Operators

The only Norwegian operator who answered our letter is *widerøe*, who informed us that they do not exceed flight altitudes of 25000 ft and thus did not answer the questionnaire.

5.24 Poland

5.24.1 Legislation

Legislation regarding radiation protection in Poland is governed by the *Atomic Law Act (2000)*, which explicitly includes natural radiation (Article 1, par. 3):

“The Act shall also apply to the practices conducted in conditions of exposure to natural ionizing radiation enhanced by human activity.”

Regarding occupational exposure, Article 10 of Atomic Law Act states:

“1. A worker may be employed in exposure conditions after an appropriately qualified medical practitioner, hereinafter referred

to as an “authorized medical practitioner”, issues a certificate stating that there are no contraindications for such employment.

2. *Qualifications of authorized medical practitioner, procedures for issuing and preserving such certificates and the type and frequency of medical examinations for workers employed in exposure conditions, shall be established in the provisions of Labor Law, unless otherwise provided for in this Act.”*

The exposure of air crew members is mentioned in Article 23 of the Atomic Law Act as follows:

- “1. *Occupational activities involving the presence of natural radiation leading to an increase of the exposure of workers or the population, which is significant from radiological protection viewpoint, shall require an assessment of this exposure.*
2. *Exposure assessment shall be based on dosimetric measurements in the workplace.*
3. *The activities referred to in paragraph 1 shall include in particular the work performed in:*
 - 1) *mines, caves and other underground sites, and also in health resorts and spas;*
 - 2) *aviation, excluding the tasks performed by the ground personnel.*
4. *The Council of Ministers may establish by regulation:*
 - 1) *types of occupational activities involving the presence of natural radiation leading to the increase of the exposure of workers or population, which is significant from radiological protection viewpoint, other than those referred to in paragraph 3,*
 - 2) *methods of assessment of the exposure resulting from occupational activities referred to in paragraph 1, procedures for reducing this exposure and other measures aimed at radiological protection of exposed workers and of population,*

- taking into account the recommendations of the European Union, regulations issued under Art. 25(1), the characteristic features of the occupational activity and those of the exposed worker’s tasks.”

The supervision of radiation protection conditions is regulated in Article 63:

- “1. *Activities, which cause, or may cause, the exposure of humans and environment to ionizing radiation shall be subject to supervision and control from the viewpoint of nuclear safety and radiological protection.*
2. *Supervision and control referred to in paragraph 1 shall be executed by the:*
- 1) *nuclear regulatory bodies – in case of activities for which the licence is issued, or notification is received, by the Agency’s President,*
 - 2) *regional sanitary inspector, commander of military preventive medicine center or sanitary inspector for the Ministry for Home Affairs and Administration – in case of activities licensed by those bodies.*
- ...”

Dose limits are given in the *Regulation of the Council of Ministers of 18th January 2005 on ionizing radiation dose limits:*

“§ 2.

1. *Dose limit for workers expressed in terms of effective dose shall be equal to 20 mSv per calendar year, subject to § 3 (1).*
2. *Dose referred to in paragraph 1 may be exceeded in a given calendar year up to the value of 50 mSv, under the condition that its sum total value would not exceed 100 mSv in 5 consecutive calendar years.*
3. *Dose limit expressed in terms of equivalent dose per calendar year shall be equal to:*
 - 1) *150 mSv – for eye lens;*
 - 2) *500 mSv – for skin, as value averaged over any 1 cm² of skin exposed to radiation;*
 - 3) *500 mSv – for hands, forearms, feet and shins.*

§ 3.

1. *Female worker, from the moment when she notifies the head of organizational entity of her pregnancy, shall not be employed in conditions which would result in the effective dose for unborn child in excess of 1 mSv.*

2. *Breast-feeding female shall not be employed in conditions of exposure to internal and external contamination.*

§ 4.

1. *Dose limit values, established in § 2, shall apply for students, apprentices and trainees aged 18 and more years.*
2. *For students, apprentices and trainees aged from 16 to 18 years the dose limit expressed in terms of effective dose, subject to § 3, shall be equal to 6 mSv per calendar year, whereas the dose limit expressed in terms of equivalent dose per calendar year shall be equal to:*
 - 1) *50 mSv – for eye lens;*
 - 2) *150 mSv - for skin, as value averaged over any 1 cm² of skin exposed to radiation;*
 - 3) *150 mSv - for hands, forearms, feet and shins.*
3. *For students, apprentices and trainees under the age of 16 years the dose limit values established in § 5 shall be applied.*
4. *Individuals under the age of 18 years may be employed in exposure conditions exclusively for the purposes of education or vocational training.”*

Further regulations are made in the *Polish Aviation Act of 3 July 2002 (Polish O.J. of 17 May 2007, No. 100 item 696)* and the *Regulation of the Ministry of Infrastructure of 5 November 2004 on safety exploitation of aircrafts (Polish O.J. No 262 Item 2609)*. Of both documents no translation could be found. Collection of personal dose data by the employer is an obligation for workers of category A.

5.24.2 Dose Register

The national Dose Register in Poland is maintained by the *National Atomic Energy Agency* and covers only workers of category A. The register is legally governed by the *Atomic Law Act (2000)*, Art. 21 and the *Individual Doses Recording Decree of 2002*. Air crew doses might be introduced as “other” job characterisation.

5.24.3 National Practice

As from Poland both authorities and one airline answered to our questionnaire, there is a fairly good base of information to evaluate.

5.24.3.1 Radiation Protection Authority

The Polish National Atomic Energy Agency is not involved into radiation protection for air crew members. The legislation does not provide any dose limits but only dose constraints, given to 6 mSv for general and 1 mSv a year for pregnant staff. The dose assessment is in the responsibility of the operators and the data is not stored in the national dose register.

5.24.3.2 Civil Aviation Authority

In contrast to the answers from the National Atomic Energy Agency (NAEA), the Polish CAA stated that NAEA is responsible for radiation protection of air crew members. Dose registration though is supervised by the CAA by visits to the airline.

In future the inspectors of Flight Operation Department of CAA will get oversight of dose registration by an amendment of Polish Aviation Act. Registering of dose records will be one task of CAA in future.

Occupational transport of crew members, freelancers and persons with several jobs in different airlines are in the scope of radiation protection. Frequent flyers though are not under radiation protection.

When reaching action levels, personnel has to be informed about health risks of radiation and the working schedules have to help minimising personal doses.

There are 16 commercial and 19 non-commercial airlines registered in Poland. The non-commercial operators fly on lower altitudes with no risk of receiving doses of 1 mSv/a and thus are excluded from radiation protection. There are also 14 commercial airlines not reaching critical flight heights. In 2006 there were 1097 cabin and 622 flight deck crew members under radiation protection in Poland. None of the aircrafts registered in Poland is equipped with the means for dose measurement.

5.24.3.3 Operators

LOT airlines kindly answered our questionnaire. Dose calculation and record keeping at LOT is conducted by the Flight Operation Department whereas questions of crew members regarding radiation safety are answered by the medical unit, which also is responsible for regular information about this topic. Regulations regarding the protection measures are part of the LOT Operations Manual.

Doses are calculated in-house using CARI6 based on planned flight routes. There are no measurements to support dose assessment.

The total number of 40 aircrafts is not flying above 49 000 ft and thus are not equipped with dose measurement devices. In the middle of 2007 LOT airlines 560 male (119 of them cabin crew) and 657 female (9 of them flight deck) crew members. All of them were under radiation protection.

Pregnant personnel are grounded as soon as pregnancy becomes known. The average doses increased since monitoring started, the maximum dose however decreased.

LOT did not provide numbers regarding the over all cost of the implementations described above.

5.25 Portugal

5.25.1 Legislation

The responsible authority for radiation protection of occupationally exposed workers is the Direcção-Geral de Saúde (DGS) in the Ministry of Health. Radiation Protection is ruled based on EURATOM 80/836 and 84/467 in *Decreto Regulamentar No. 9/90*.

Radiation protection in general and for occupationally exposed workers is regulated in *inter alia*, No. 348/89 of 12 October 1989, as well as 2002 Decree Nos. 165/02, 167/02 and 174/02. No 165/02 is the national implementation of European Council directive 96/29/EURATOM laying down safety standards for radiation protection. Responsible for radiation protection in Portugal in general is the Minister for Health, who is advised by the *Comissão Nacional de Protecção contra Radiações* – CNPCR (National Radiation Protection Commission). Legislative power regarding radiation protection is given to the *Comissão para a Protecção Radiológica e Segurança Nuclear* (Commission for Radiological Protection and Nuclear Safety), consistent of representatives of the three involved Ministries (Urban Affairs, Territorial Planning and Environment; Health and Science and Higher Education).

Dose quantities used in Portuguese legislation are based on ICRP 26, dose limits are derived from EU Directive 80/836. Air crew members are not mentioned in Portuguese legislation. Since 1965 there is only one dosimetry service, which collects the data of occupational exposure.

The dose limit for occupationally exposed workers is 50 mSv, for 5 years in sequence the cumulative dose limit is 100 mSv.

There is no national implementation of Art. 42 of 96/229/EURATOM in Portugal, yet. But there is already a draft for a decree-law.

5.25.2 Dose Register

The national dose registry is driven by *Instituto Tecnológico e Nuclear (ITN)* under the responsibility of the Directorate General for Health of the Ministry of Health since 2004. Data since 1957 has been saved into the database. Data is collected for category A and B workers. The given list of professions does not include air crew. Air crew data might be collected using the profession Industry – others [ALV 04].

As soon as the draft decree-law cited in section 5.24.3.1 has entered power, the dose data of those crew members exceeding the limit of 1 mSv/a will be stored in the above mentioned central general national dose registry.

5.25.3 National Practice

From all Portuguese addressees asked for answering our questionnaires, only the RPA answered with a letter. The questionnaires have not been answered by any authority due to the fact that legislation regarding radiation protection of air crew is not in power in Portugal yet. After finishing the first draft of this final report, one answer by a Portuguese operator, TAPair, arrived.

5.25.3.1 Radiation Protection Authority

The *Independent Commission for Radiological Protection and Nuclear Safety* of Portugal kindly provided us with an unofficial translation of the draft law mentioned above:

“Article 16

Protection of flight crews and frequent passengers relating to exposure to cosmic radiation

- 1. Civil aviation undertakings must appraise, every 5 years, the levels of cosmic radiation received by flight crews on each of their routes.*
- 2. The results of the appraisal must be taken into account in the planning of the crews' flight scheduling, which must at keeping the exposure of the crew member below the annual limits for members of the public [1 mSv].*
- 3. The effectiveness of the flight scheduling for the protection of the health of the crew members must be demonstrated in a report, approved by the respective occupational health services, to be presented annually to the Directorate-General of Health.*
- 4. Whenever it is deemed that, despite the flight scheduling, the dosage limits for members of the public may be surpassed, the flight crews shall be subject to the provisions of Art. 15(1) of this Decree-Law [on occupational radiological protection].*
- 5. Flight crews and frequent passengers should be supplied with all information relating to the detrimental effects of exposure to cosmic radiation.*

6. *The provisions of Art. 7 of this Decree-Law [protection during pregnancy and breastfeeding] are applicable to the female members of flight crews.*

Article 7

Special protection during pregnancy and breastfeeding

1. *A professionally exposed woman has to declare her pregnancy to the owner of an installation in which she is working, in order to guarantee the protection of the child to be born.*
2. *Starting from the moment that a woman informed the installation about her pregnancy, the protection of the child to be born shall be comparable with that provided for members of the public, in order to guarantee that the equivalent dose of the child to be born hardly would exceed 1 mSv during the period of pregnancy.*
3. *Starting from the moment that a breastfeeding woman informed the installation about her situation, no function should be assigned to her that would include a significant risk of radioactive contamination of her organism.”*

As the cited regulations are not in power yet, the questionnaire has not been answered by the Portuguese RPA.

5.25.3.2 Operator

The Portuguese air operator TAPair kindly answered our questionnaire. At TAPair the department for crew management is responsible for all aspects of radiation protection, dose calculation, record keeping and the answering of personnel's questions regarding radiation protection.

TAPair operates 53 aircrafts all of which are above 20 t maximum take-off mass but none is equipped with measurement devices. All crew members of TAPair are monitored. On the 30th June of 2007 those were 742 cockpit crew members (18 of them female) and 1897 cabin crew members, of which are 1228 are female.

The operator conducts dose calculation himself using CARI6 based on planned flight routes not implementing solar flares. There are no measurements to support calculations.

The limits and constraints given by TAPair are 6 mSv/a as legally binding dose limit for general personnel, 5 mSv/a as action level for general personnel, 4 mSv/a as internally binding dose limit for this operator and 3 mSv/a as internally binding action level. Thus the internal constraints are always one mSv beneath the legal constraints and action levels one beneath the limit.

At reaching the action level, crew members will be grounded.

Regarding solar flares, TAPair uses safety limits which will start some sort of alert. There was no detailed information about how this alert system works.

TAPair collects sector times for all employees in an in-house database since 2002. The data is accessible by the Portuguese CAA.

There was no information included about the radiation protection for occupational transport or regarding freelancers. The comments regarding this topics were”-“, thus probably there is no radiation protection in these cases.

TAPair reports all personnel data once a year to the Portuguese CAA. Each crew member is given a report about his exposition once a year and any time asking for. The average and maximum dose rates of general personnel increased due to increasing annual flight hours. The doses for pregnant crew members stayed the same.

The costs for radiation protection are covered by the price for the crew management system COMPASS, which obviously covers the functionality. Dose reduction has not been needed yet, due to the fact that all doses are well below the limits.

5.26 Romania

5.26.1 Legislation

Radiation protection in Romania is ruled by the *Law on the Safe Conduct of Nuclear Activities No. 111/1996*. Natural radiation is not under the above mentioned law. The National Commission for the Control of Nuclear Activities (Comisia Nationala pentru Controlul Activitatilor Nucleare – CNCAN) is the regulatory body for the protection against ionizing radiation. Of the three directorates the third, for Radiation Protection, Radwaste, Transport and Radiological Emergency Protection is the one responsible for general radiation protection, including the protection of air crew against ionizing radiation.

The Romanian representation of IAEA Safety Series 115 and the European Council Directive 96/26/EURATOM is the *Radiological Safety Fundamental Norm (RSFN), Order 14/2000 of August 2000*. Additionally there is the *Norm on Individual Dosimetric Monitoring (Order 180/09.05.2002)*. Another institution involved in radiation protection for crew members is the State Inspectorate for Labour Protection from the Ministry of Labour and Social Protection.

Dose quantities used in Romania are based on ICRP 26. Dose limits for exposed workers are established to

- the sum of effective doses from the external exposure and the committed effective doses of internal exposure the value of 20 mSv per calendar year

- the equivalent dose in the lens of the eye the value of 150 mSv per calendar year,
- the average equivalent dose in any 1 cm² of skin the value of 500 mSv per calendar year,
- the equivalent dose in the hands from fingers up to the elbow and in the legs from soles up to ankles the value 500 mSv per calendar year.

The monitoring process includes three different reference levels:

- **Recording level** - the reference levels, at the excess of which, there is recorded the date in detail and kept.
- **Investigation level** - the reference levels, at the excess of which is the initiation to the follow-up investigation on causes and consequences of the ascertained variation of a monitored quantity of radiation protection.
- **Intervention level (Action level)** – value usually close to the annual limits. It has to be defined precisely what intervention is dealt with, and by which procedure is decided on it.

The personal monitoring of doses is obligatory for workers of category A and for workers of category B to ensure the correct classification. Workers exposed to natural radiation are not monitored in Romania [ROM 03].

5.26.2 Dose Register

Dosimetric services have to be approved by CNCAN and are ruled by norms. The reporting of doses to the national Dose Register, driven by CNCAN since 1.10.2002, is part of the duties of dosimetric services [PRE 04].

5.26.3 National Practice

5.26.3.1 Civil Aviation Authority

Due to the answers of Romanian CAA, there is no radiation protection for air crew members in Romania, yet. The national airline will implement a system for radiation measurements in aircrafts, though.

5.26.3.2 Operators

TAROM airlines answered to our questionnaire. Due to the flight routes they are operating on, none of the crew is liable to receive doses above 4.5 mSv/a. Thus there is no calculation and storage of doses established at TAROM, nor is there any aircraft equipped with dose measurement devices. The crew of totally 498 persons is not under monitoring. It is planned to include information about radiation risks in the operation manual in future.

5.27 Slovakia

5.27.1 Legislation

Radiation protection in Slovakia is regulated by *Act No. 272/1994 on the Protection of Human Health*, which came into force in January 1995. Amendments are to be found in *Amendment No. 470/2000* of the above mentioned Act. Responsible for the legislation in the field of Radiation Protection is the Ministry of Health.

The Public Health Authority of the Slovak Republic is responsible for licensing and controlling of dosimetry services. The dose quantities in Slovakian legislation are based on ICRP 60.

Dose limits both for occupationally exposed workers and for the public are given in an *Appendix to Regulation 12/2001 §5, article 1* and follow the recommendations of ICRP 60 and of the safety standards published by the IAEA.

Limitations to pregnant and breastfeeding women are formulated in relation to sealed sources and control areas and are thus not applicable to aircrew members.

Regulations on dosimetric practices are limited. There are some specifications found in *Regulation of Ministry of Health of the Slovak Republic No.12/2001 Coll.*, on Radiation Protection and in the licences for both, industry and dosimetry services.

The definition of occupationally exposed workers does not include aircrew personnel. Two of four existing dosimetry services in Slovakia are dedicated to the two NPPs. Thus dosimetry of aircrew might be provided either by Slovak Legal Metrology in Bratislava or by the Institute for Preventive and Clinical Medicine of the Slovak Health University in Bratislava.

5.27.2 Dose Register

Dosimetry data acquired by the four dosimetry services is reported to the Central Register of Occupational Doses (CROD) driven by the Public Health Authority. The dosimetry service is responsible for the information to the license holder and the supervisory authority about exceed of any limits.

5.27.3 National Practice

From Slovakia, the Nuclear Regulatory Authority informed us of not being competent for the topic of radiation protection of air crew members. The questionnaire has been forwarded to the Public Health Authority for answering. Unfortunately, no answer of this authority or from the CAA or any of the airlines did arrive yet.

5.28 Slovenia

5.28.1 Legislation

In Slovenia radiation protection is governed by the *Act on protection against Ionizing Radiation and Nuclear Safety (Off. Gaz. RS 102/04)*. Monitoring of work places, measurements of occupational personal dosimetry and education of workers is part of the work of the Institute Jožef Stefan (JSI).

The radiation protection of air crew in special is ruled by the following legislation:

“Ionising Radiation Protection and Nuclear Safety Act

(OJ RS, No.102/04 - reviewed)

3.4.6 *Exposure resulting from the presence of natural radiation sources*

Article 45 (systematic inspection of living and working environments)

The ministry responsible for health shall ensure protection against increased exposure of workers and members of the public to radiation resulting from natural radiation sources by systematic inspections of living and working environments.

The protection referred to in the previous paragraph shall be ensured:

where workers or members of the public are exposed to radon or thoron progeny, gamma radiation or any other exposure resulting from natural radiation sources in living and working environments, such as for example spas, caves, mines, underground locations and in certain areas on the surface,

where materials or waste, which are usually not considered radioactive but do contain naturally present radio-nuclides, accumulate or are stored or deposited,

during transport by air.

The government shall adopt a programme of systematic inspections of living and working environments relating to the areas referred to in the previous paragraph, and of awareness raising among the population on the importance of measures for the reduction of the presence of natural radiation sources.

Article 46 (measures to reduce the exposure of workers and members of the public)

If on the basis of the systematic inspections referred to in the previous Article it is established that the exposure of individuals resulting from natural radiation sources exceeds the values of dose limits for members of the public, the ministry responsible for health shall order the employer or manager of the facility and apparatus in question that measures be carried out aimed at reducing the exposure of workers and members of the public as well as measures for the protection of exposed workers within the scope of and in a way applying to persons carrying out practices involving radiation.

If workers or members of the public are exposed to radon, the measures described in the previous paragraph shall apply when the doses received exceed values specified by the minister responsible for health.

If aeroplane crews are exposed to cosmic radiation exceeding dose limits for members of the public, the ministry responsible for health shall order the air carrier:

to draw up an assessment of the exposure of workers,

to implement a work allocation which reduces as much as possible the doses received by the exposed crews,

to establish a method for the obligatory informing of workers on risks caused by exposure to cosmic radiation and

to enforce provisions relating to pregnant women as described in Article 20 of this Act.

When the doses referred to in the second paragraph of this Article are exceeded in childcare, cultural, health or educational facilities, the financial resources related to the carrying out of measures aimed at the reduction of exposure referred to in the first paragraph of this Article shall be ensured by the state.”

Dose quantities given in Slovenian legislation comply with ICRP 26. Dose limits for exposed workers are restricted to 50 mSv a year, the limits for the lens of the eye and for hematopoietic organs are 150 mSv and for any other organ 500 mSv per year.

For pregnant women it is forbidden to work with ionizing radiation sources or to be otherwise occupationally exposed, unless she insists to continue working as an exposed worker.

5.28.2 Dose Register

The national database for personal dosimetry records (CRPD) contains data since 1.1.2000. The data collection is ruled by the *Rules on the method of keeping records of personal doses due to exposure to ionizing radiation (OJ RS No. 33/04)* [JUG 05].

There are three approved dosimetric services in Slovenia. They have to provide regularly their data to the central Dose Register of occupational exposure which is driven by the Health Inspectorate of Republic Slovenia (HIRS). The profession groups are based on the expanded UNSCEAR questionnaire. The UNSCEAR grouping does not mention air crew.

5.28.3 National Practice

5.28.3.1 Radiation Protection Authority

Slovenian Radiation Protection Administration (SRPA) kindly answered our questionnaire. The radiation protection for air crew is not yet completely implemented in Slovenia. The operators report the dose data to *SRPA*. *SRPA* compiles the data for the operators.

The only airline in Slovenia is *Adria Airways*. They are only flying to maximum altitudes of about 11 300 m. As dosimetric monitoring is not yet fully established, there is data only from a preliminary study available. The studies results showed average crew doses of 1 to 3 mSv/a. For dose calculations during the preliminary study *CARI6* was used. There is no accreditation for calculation of air crew doses in Slovenia yet.

As soon as monitoring is established for air crew members, their data will be stored together with the data of other occupationally exposed workers. The records will be kept for not less than 30 years after the last exposure or until the worker reached 75 years of age. Data will be accessible by the employer, an approved medical practitioner and the worker's general practitioner.

Air crew members are going to be classified as category B workers in Slovenia. The dose constraint will then be 6 mSv/a. All crew members have to be informed about their doses, both due to exceeding of dose limits and regularly.

Pregnant air crew members have to work on ground in Slovenia.

5.29 Spain

5.29.1 Legislation

The Nuclear Safety Council (CSN) is the sole authority competent in the matters of nuclear safety and radiological protection in Spain. It was founded in 1980 as an administrative authority, independent of the central government, with special legal status. CSN is responsible for keeping the database on occupational exposure.

Directive 96/29/EURATOM is nationally implemented by the *Royal Decree 783/2001 dated 6th July*. Article 64 of this decree rules air crew radiation protection [ROY 01]:

“Artículo 64. Tripulación de aviones.

Las compañías aéreas tendrán que considerar un programa de protección radiológica cuando las exposiciones a la radiación cósmica del personal de tripulación de aviones puedan resultar en una dosis superior a 1 mSv por año oficial. Este programa contemplará, en particular:

Evaluación de la exposición del personal implicado.

Organización de los planes de trabajo a fin de reducir la exposición en el caso del personal de tripulación más expuesto.

Información a los trabajadores implicados sobre los riesgos radiológicos asociados a su trabajo.

Aplicación del artículo 10 al personal femenino de tripulación aérea”

5.29.2 Dose Register

Individual dose records must be kept by the employer and at termination of the employment a summary of the annual doses should be given to the worker. As CSN had foreseen possible problems with keeping the dose information in cases of frequent change of the employer or company insolvency, it started with the establishment of a centralized system of dose record keeping already in 1980. The official name of the Spanish National Dose Register is: *Banco Dosimétrico Nacional (BDN)*.

The main tasks of the register are:

- Centralized and safe keeping of individual dose records
- Identifying areas of potential problems
- Improvement of the surveillance and the control of exposed workers
- Statistical analysis of dose development and dose distributions for CSN, reports for the parliament, international organizations (UNSCEAR, OECD, EC).
- Support of epidemiological studies

The register is running under SOLARIS 8 operation system. ORACLE data base management system is used for the BDN as well as for the special register of the outside workers. Both registers are linked together. The staffs of the BDN and of the

department for radiological protection of exposed workers have on-line access to the data in the BDN via personal computers, which are connected to the main frame.

The main (master) tables of the database are: WORKERS, Facilities, Dosimetric Services, Employers, and MEASUREMENTS. The following information is kept:

- Personal information: The unique personal identification is assured by the use of National Identification Document Number, full name, first name, maiden name, date of birth, sex, type of work etc.
- Employer data: Company identification code, address, telephone, name of the radiation protection officer
- Facility: Name, address, main activity, specific activity
- Dose data: Monitoring period, deep dose (Hp (10)), shallow dose (Hp (0.07)), dose from internal exposure, extremity dose

Provisions for radiation protection of aircrew as contained in JAR-OPS and ACJ-OPS are applied [VIL 04].

5.29.3 National Practice

As none of the Spanish authorities answered our questionnaire, the evaluation of national practice is based only of the answers of one operator, *Spanair*.

5.29.3.1 Operators

At *Spanair* the dose calculation is done by the Flight Operations Division using EPCARD and the plan data for the flights. The same department is responsible for record keeping of personal doses. Information about the radiation risk is to be acquired from the Occupational Health & Safety Department. There is no support for calculations by measurement in aircrafts.

None of the 58 aircrafts in operation for *Spanair* is equipped with dose measurement devices. All flying crew members have been monitored in the middle of 2007, which means 546 male and 26 female cockpit crew members and 191 male and 886 female cabin crew members.

Spanair published a manual about radiation protection for crew members and included information about the health risks in the manual for Occupational Hazards. Information about radiation risks is also part of *Spanair* intranet. For crew members, who announce being pregnant, there is an internal rule to stop flying immediately.

Crew members of *Spanair* are category B workers as they are according to their flight routes not liable to receive doses above 6 mSv/a. Calculated doses are kept in an in-house database and can be accessed by crew members (only their own), workers representatives, Spanish CAA and other public authorities. Dose data is sent to the Spanish CAA and to the Council for Nuclear Security at the end of each calendar year.

Crew members can use an electronic form in intranet to ask for their dose information. Dose records are reported to personnel as soon as they leave the company.

Maximum and average dose rates of crew members stayed the same since dose monitoring started. *Spainair* did not provide any information about the cost of radiation protection for the operator.

5.30 Sweden

5.30.1 Legislation

Radiation protection in Sweden is governed by the *Swedish Radiation Protection Act of 1988*. Regarding exposure of employees to radiation, the following article is found in the above mentioned act:

“17 § If a particular type of work involves a special risk from the viewpoint of radiation protection for certain employees, the Government or the authority appointed by the Government may prescribe that special conditions shall apply to the performance of such work, or forbid the work to be carried out by certain employees.”

Limits for personal dose values in general are given based on Directive 96/29/EURATOM and are implemented in national Law in *SSI regulation SSI FS 1998:4*. For pregnant women the dose for the foetus is limited to 1 mSv.

As article 42 of 96/29/EURATOM is incorporated in JAR-OPS 1, which is in force in Sweden through the Sweden Civil Aviation Authority, according to [LIN 06] Nordic aviation and radio protection authorities agreed in a common not binding interpretation of this article. Thus airlines should report effective doses of air crew members once a year to the radiation protection authorities and crew work plans should be organised to keep personal doses below 6 mSv a year.

For crew members receiving doses over 6 mSv a year airlines have to get the same dose information as for other workers exposed to non natural radiation.

5.30.2 Dose Register

The national dose database driven by the Swedish Radio Protection Authority (Statens strålskyddsinstitut) provides data regarding workers of category A, the professions included are medical professions and workers at nuclear power plants. Air crew members are not part of the dose data base nor are exposure to radiation from natural sources governed by this part of legislation or by the SSI in general.

5.30.3 National Practice

The Swedish authorities kindly provided a copy of [LIN 06], including the following information: Calculated from work plans and flight data using CARI6, the average doses for Nordic SAS crew members slightly crew between 2002 and 2004 due to increasing work hours [LIN 06]. The majority of air crew personnel receive doses over 1 mSv but there is no dose over 6 mSv reported. The average annual effective dose of air crew members is comparable to this of nuclear industries staff.

5.30.3.1 Authorities

Swedish Radiation Protection (SSI) and Civil Aviation Authority answered the questionnaire jointly. The answers are thus documented jointly, too.

Dose data are kept by the airlines except for SAS who reports dose data yearly.

At the moment there are 10 commercial and 10 non-commercial airlines falling under the radiation protection legislation in Sweden. The criteria for the decision whether an airline has to respect radiation protection regulations are the altitude and latitude of flights operated by this airline and the types of aircrafts used. Swedish Authorities stated that neither personnel from commercial nor from non-commercial airlines are monitored (this probably meant, that none of them are subject to dose measurements).

The dose limits of occupational exposure in Sweden are 50 mSv/a or 100 mSv for 5 years in sequence. For pregnant women the limit is 1 mSv for the remaining time of pregnancy. Reaching the action level of 1 mSv/a the staff has to be informed about health effects of radiation, dose assessment has to take place and the dose records need to be kept. The data is not stored in a central register, though. For dose assessment a tool can freely be chosen by the operator. Crew members reaching more than 1 mSv/a have to be informed about their doses once a year and might ask for dose information at any time.

For SAS 20 % of the crew members do not reach the level of 1 mSv, the rest is exposed to doses between 1 and 6 mSv.

5.31 Switzerland

5.31.1 Legislation

Doses due to flight activities are mentioned in Art. 41 of the *Radiological Protection Ordinance in Switzerland (12. June 2005)*:

“1 *Personnel assigned to fly in jet aircraft shall be informed by the company owner at the time they first undertake such flying duties of the radiation exposure to which they will be subjected in the exercise of their profession.*

2 *Pregnant women shall have the right to insist on being relieved of flying duties.”*

In 2004 the expert group for dosimetry of the Commission for Radiation Protection and Supervision of Radioactivity (KSR) of Switzerland published *Guidance Material on Protection of Air Crew from Cosmic Radiation* [KSR 04].

Air couriers and exceptionally frequent flyers are not included in Swiss legal regulations. For regular air crew members, the calculation of potential exposures is recommended. For crew members liable for maximum doses over 6 mSv a year, personal dose monitoring has to be carried out. In Switzerland, records for these personnel should be kept 30 years after the last exposure exceeding this limit or until the person reaches the age of 75 years, whichever of those two rules provides the longer period of time. This is a recommendation from [KSR 04] not based on Swiss legislation but to comply with European regulations.

5.31.2 Dose Register

Data about personal doses of occupational exposed personnel is since 1988 collected in the national Dose Register of Switzerland at Federal Health Authority (Bundesamt für Gesundheit, BAG). Air crew are not occupationally exposed persons.

In 2002 the doses of air crew from Switzerland had all been estimated, there were no measurements. The average dose per year for air personnel is about 3 mSv [WER 02].

5.31.3 National Practice

5.31.3.1 Civil Aviation Authority

CAA in Switzerland is called *Bundesamt für Zivilluftfahrt BAZL* and is not included in radiation protection of crew members. Swiss operators are responsible for compliance with JAR-OPS regulations. Dose assessment is conducted for occupational transport, freelancers and for persons with several jobs at different airlines.

If the action level is reached for crew members, *BAZL* will require dose measurements.

In Switzerland crew members are informed about the health risks of radiation, *BAZL* supervises information of crew members. Tasks connected with air crew radiation protection cost about 15 man-hours at *BAZL*.

There are 33 commercial airlines in Switzerland. All crew members of those operators are under radiation protection. *BAZL* did not give exact numbers. *BAZL* spends 15 h a year in radiation protection for air crew members.

Swiss action limits are based on JAR-OPS 1 as preventive actions are. Dose assessment is not done by calculation of doses but by case by case studies. Dose records are stored by operators and not in a national database.

5.31.3.2 Operators

Swissair kindly provided answers to our questionnaire. There is no calculation of individual doses at *Swissair*, because they do not reach the dose limit of 6 mSv/a (JAR-OPS) respectively 20 mSv/a (Swiss legislation). There is the duty to inform about health risks, though. This is done by the medical services and publication of a cosmic radiation bulletin once a year. None of the 73 aircrafts is equipped with dose measurement devices. The proof for doses lying beneath dose limits is given by general calculations using EPCARD and flight plan data. If a crew member should ever reach action levels, he or she would have to change to ground duties at once. Since general dose assessment is conducted, the average and maximum doses of *Swissair* crews stayed the same. *Swissair* staff spends about 2 hours a month for the training of personnel and for communication with authorities regarding radiation protection.

5.32 Turkey

5.32.1 Legislation

The Turkish main authority regarding radiation protection is the Turkish Atomic Energy Authority (TAEA). The governing legislation is found in the Radiation Safety Decree (published in the Official Journal no. 18861 on the 7th September 1985) and the Radiation Safety Regulation (published in Official Journal No. 23999 on the 24th March 2000) [USL 00].

Radiation protection of flight personnel is addressed in Article 38 of chapter III, section III of the above mentioned Radiation Safety Regulation. Air crew members are informed about doses and health risks and control measures are taken [TUR 06].

5.32.2 Dose Register

Recording of dose data is regulated in article 69 (chapter III, section III, Radiation Safety Regulation). All institutions or organisations falling under the scope of radiation protection legislation have to keep records related to personnel for 30 years [TUR 06].

5.33 United Kingdom

5.33.1 Legislation

Legislation in regards to radiation protection is based on the *Health and Safety at Work etc. Act* of 1974 and the *Ionising Radiations Regulations 1999 (IRR99)*. The responsibility for radiation protection in the UK is given to the Health and Safety Commission (HSC) and the Health and Safety Executive (HSE).

The annual dose limits as set out in Schedule 4 to IRR99 are:

for the whole body

- for employees aged 18 years and over¹ 20 mSv
- for trainees (students or apprentices) aged 16-18 years 6 mSv
- for any other person 1 mSv

for individual organs and tissues

- for employees aged 18 years and over 500 mSv
- for trainees under 18 years 150 mSv
- for any other person 50 mSv

for the lens of the eye

- for employees aged 18 years and over 150 mSv
- for trainees under 18 years 50 mSv
- for any other person 15 mSv

for the abdomen of a woman with reproductive capacity - 13 mSv (in any consecutive three-months-interval)

For overexposed employees in the remaining part of the calendar year the employee shall not receive a dose greater than that proportion of any dose limit which is equal to the proportion that the remaining part of the year bears to the whole calendar year.

The monitoring of air crew members as given in the UK Esorex report is done by flight rosters and route doses, calculated using accepted models.

In UK the radiation protection for air crew members is regulated in *The Air Navigation (Cosmic Radiation) Order 2000 (Statutory Instrument 2000 No. 1104)*⁵ (ANO). The relevant parts are reproduced in the following:

“(...)

Protection of air crew from cosmic radiation

2. *The Air Navigation (No. 2) Order 1995[2] shall be amended as follows.*

3. *There shall be added to the heading to Part VI "and protection of air crew from cosmic radiation".*

⁵) <http://www.opsi.gov.uk/SI/si2000/20001104.htm>, Crown Copyright 2000.

4. After article 65 there shall be inserted –

Protection of air crew from cosmic radiation

" 65A. - (1) A relevant undertaking shall take appropriate measures to -

(a) assess the exposure to cosmic radiation when in flight of those air crew who are liable to be subject to cosmic radiation in excess of 1 Millisievert per year;

(b) take into account the assessed exposure when organising work schedules with a view to reducing the doses of highly exposed air crew; and

(c) inform the workers concerned of the health risks their work involves.

(2) A relevant undertaking shall ensure that in relation to a pregnant air crew member, the conditions of exposure to cosmic radiation when she is in flight are such that the equivalent dose to the foetus will be as low as reasonably achievable and is unlikely to exceed 1 Millisievert during the remainder of the pregnancy.

(3) Nothing in paragraph (2) shall require the undertaking concerned to take any action in relation to an air crew member until she has notified the undertaking in writing that she is pregnant.

(4) The definition in article 118 of "crew" shall not apply for the purposes of this article.

(5) In this article and in article 67 -

(a) "air crew" has the same meaning as in article 42 of Council Directive 96/29/Euratom of 13 May 1996[3]; and

(b) "undertaking" includes a natural or legal person and "relevant undertaking" means an undertaking established in the United Kingdom which operates aircraft.

(6) In this article -

(a) "highly exposed air crew" and "Millisievert" have the same respective meanings as in article 42 of Council Directive 96/29/Euratom of 13 May 1996; and

(b) "year" means any period of twelve months."

Keeping and production of records of exposure to cosmic radiation

5. - (1) *For article 67 there shall be substituted -*

" Keeping and production of records of exposure to cosmic radiation

67. - (1) *A relevant undertaking shall keep a record for the period and in the manner prescribed of the exposure to cosmic radiation of air crew assessed under article 65A and the names of the air crew concerned.*

(2) *A relevant undertaking shall, within a reasonable period after being requested to do so by an authorised person, cause to be produced to that person the record required to be kept under paragraph (1).*

(3) *A relevant undertaking shall, within a reasonable period after being requested to do so by a person in respect of whom a record is required to be kept under paragraph (1), supply a copy of that record to that person."*

(2) *In article 68(2), there shall be omitted sub-paragraph (i).*

Exemptions

6. *In article 116, after "(other than articles" insert "65A, 67,".*

Penalties

7. *In Part B of Schedule 12, in the column headed "Article of Order" there shall be inserted, after "64(1)", "65A" and "67" and in the column headed "Subject Matter" there shall be inserted, after "Crew's obligation not to fly in dangerous state of fatigue", "Protection of air crew from cosmic radiation" and "Keeping and production of records of exposure to cosmic radiation".*

Competent authority

8. *The Secretary of State shall be the competent authority under article 15 of Council Directive 96/29/Euratom of 13 May 1996 for the purposes of article 42 of the Directive.*

(...)"

In addition to the above mentioned *Air Navigation Order*, there is guidance material based on the expertise of NRPB, HSE, Civil Aviation Authority (CAA) and other sources to support operators in setting out the means of the directive [HSE 03].

Recommendations of how to implement the ANO regulations are reproduced in the following:

“9. Acceptable Means of Compliance

- 9.1 *Operators should ensure that studies are carried out so as to assess the likely magnitude of the exposure to cosmic radiation of air crew for whom they are responsible. These studies should cover all rostering arrangements.*
- 9.2 *For operators of turbo-prop aircraft, predictions of dose, the maintenance of records of route dose rates, and individual air crew records of predicted dose may not be required because, owing to the Protection of air crew from cosmic radiation: Guidance material normal flight characteristics of these aircraft, the annual doses of crew are likely to be low (less than 1mSv per year).*
- 9.3 *No controls are necessary for an individual member of air crew whose annual dose can be shown to be less than 1 mSv. Drawing on the measurements and evaluation of the EU research programme [4,5,6,7] , for flights at temperate latitudes at a typical altitude of 10.6 km (35,000 ft), and for average solar activity, the effective dose rate is about 5 to 6 microSv h⁻¹, and therefore a total time at altitude of about 200 hours is needed to accumulate 1 mSv. Near the equator at this altitude, the time needed is about 400 hours. At an altitude of 11.8 km (39,000 ft) these times are about 150 and 300 hours respectively, and at an altitude of 10 km (33,000 ft), about 250 and 500 hours respectively.*
- 9.4 *Airlines generally work in terms of 'block hours'. These start from when the aircraft is pushed back from its stand and finish when its engines are switched off after landing. Block hours may therefore be considerably greater than flying hours, and this must be recognised when estimating doses.*
- 9.5 *Operators whose air crew may receive an effective dose greater than 1 mSv, generally those operators whose aircraft operate above 8km (26 000ft), should carry out an assessment, by computer program prediction, of the maximum annual dose to which their air crew are liable. The detail of these assessments of exposure, expressed in millisieverts per year, must be recorded [8] . If the assessed annual dose is less than 6mSv per year, the Directive does not require any further action to be taken. However, it should be noted that the European Commission guidance on this issue recommends individual monitoring. This is also*

common practice for ground-based workers with annual doses between 1 and 6 mSv.

- 9.6 Individual monitoring is to be regarded as best practise but it is recognised that this can impose unjustifiable cost for some operators. In these circumstances an acceptable course of action would be to rely on an assessment of maximum doses where this shows that air crew will not be approaching annual doses of 6 mSv. A suitable cut off point would be where the assessment indicates a maximum annual dose of 4 mSv. Where air crew are liable to receive doses in excess of 4 mSv per annum, it is recommended that there should be monitoring of individual air crew member's exposure using computer program prediction. The purpose of such monitoring would be to ensure that annual doses did not exceed 6 mSv.*
- 9.7 Where an assessment of maximum doses indicates that air crew are liable to exceed 6 mSv per annum, individual monitoring must be carried out. In addition, operators should adjust an air crew member's roster to reduce exposure with the aim of preventing, where possible, doses in excess of 6 mSv per annum. Records for individuals exposed to more than 6 mSv per annum must be kept for a minimum of 30 years from the last annual exposure of more than 6 mSv (even if the individual concerned is deceased) or until the individual is 75 years of age, whichever is the longer period of time.*
- 9.8 Where the assessment of individual doses is necessary, this may be done by combining roster information with route doses. For example, a flight from northern Europe to the eastern seaboard of the USA will result in a value of effective dose of about 30 to 40 microSv. For a longer flight from northern Europe to Japan, the total effective dose is about 50 to 70 microSv. Transatlantic flights at the altitudes used by supersonic aircraft may give similar total effective doses as in subsonic aircraft, the higher dose rates being offset by the shorter flight times.*
- 9.9 Unusually high levels of cosmic radiation at altitudes relevant to civil aviation can result from solar particle events (SPEs). These are produced by sudden, sporadic releases of energy in the solar atmosphere (solar flares), and by coronal mass ejections (CMEs). Only a small fraction of SPEs, a few per year, cause an observable increased intensity of cosmic radiation fields at aviation altitudes. These can be detected by ground monitors and are referred to as ground level*

events (GLEs). The largest events often take place on either side of the period of maximum solar activity as measured by sunspot number. Any rise in dose rates associated with an event is quite rapid, usually taking place in minutes. The duration may be hours to several days. The prediction of which events will give rise to Protection of air crew from cosmic radiation: Guidance material significant increases in dose rates at aircraft altitudes is not currently possible. In the event of a rare SPE producing significantly elevated dose rates at aircraft altitudes it has been proposed that calculation of doses to crew on subsonic aircraft may be done retrospectively using computer calculations. However such a technique would require data from a large number of geomagnetically dispersed, ground-level neutron monitors, and such calculations would require validation against flight observations using active monitors. Very few such observations have been made to date as only Concorde has had a regulatory requirement to carry a monitor. Information that a GLE has occurred will be made available to airlines and a summary of assessments of doses made available.

10. Monitoring Compliance

10.1 The operator should have a system of record keeping which should be detailed in the Operations Manual and which should be available for inspection by the CAA. The style of record to be kept will be offered in due course and is likely to be similar to that being proposed for JAR-OPS.

10.2 To facilitate using flight time and duty rosters for the maintenance of radiation records, and to give a more accurate record of dose received, the ANO requirements relate to a rolling year. This defines the year of record as being the period of 12 months expiring at the end of the previous month and accords with one of the definitions in the ANO with regard to flight time limitation records.

10.3 Similarly, the radiation records should be kept for a 12 month period after the last complete 12 month period recorded, i.e. for two years. This accords with the requirement to keep flight time limitation records for one year after the flight referred to. However, individuals exposed to more than 6mSv in any 12 month period must have their records kept for 30 years (even if the person is deceased), or until the individual reaches 75 years, whichever is the longer period of time.

10.4 Individuals are entitled to have access to their records and to be able to obtain a copy to offer their new employer, should they change employment.”

5.33.2 Dose Register

There is a UK national dose registry (*Central Index of Dose Information, CIDI*), collecting dosimetry data for workers of category A (named classified persons in the UK), which are about 40.000 in UK. The register was started in 1987, based on data collected in 1986 and is operated by the National Radiation Protection Board (NRPB) for the Health & Safety Executive, being regulator and enforcer, on contract basis. There are about 20 approved dosimetry services (ADS) in the UK, between which the CIDI is coordinating information. The identifier for each person is the national insurance number. The system groups workers into seven sectors, which cover about 35 occupational categories. The best fit for air crew personal would be the sector “others”. Outside workers are included, if they are employed by an UK employer.

5.33.3 National Practice

Unfortunately, none of the authorities or airlines contacted answered to our questionnaire yet.

6 DATA EVALUATION

6.1 Basis for Data Evaluation

The following sections contain an evaluation of the questionnaires received from all three addressees, i.e. civil aviation authorities, airlines and radiation protection authorities. The basis for this evaluation is shown in Table 11. Out of 31 countries included in this study, there are 24 where a reply was received at least from one of the addressees, while 7 countries provided no (utilizable) reply altogether. In these cases, the legislation as described in section 5 needs to be used for evaluation purposes. In all other cases, the evaluation is based both on legislation and on replies received, and in four countries (Czech Republic, Finland, Germany, Poland) replies were received from all three addressees, making a cross-comparison possible.

Table 11: Overview of replies received to questionnaire and consistency check

Country	CAA	RPA	Airline	Remarks
Austria	-	-	-	No replies, evaluation based on legislation only
Belgium	-	X	-	No apparent inconsistencies with legislation or documents found
Bulgaria	-	(x)	-	
Croatia	(x)	(x)	-	No legislation exists, implementation is planned due to EU candidate status. No aircrafts flying above 49 000 ft
Cyprus	X	-	-	No inconsistencies
Czech Rep.	X	X	X	Different interpretation of "action level" at the two authorities. For RPA action level is 1 mSv/a, start of monitoring, for RPA it is 6 mSv, becoming category A worker
Denmark	X	X	-	No inconsistencies
Estonia	-	X	X	No inconsistencies
Finland	X	X	X	No inconsistencies
France	-	-	-	No replies, evaluation based on legislation only
Germany	X	X	X	Slight inconsistencies regarding regulation of non-commercial airlines
Greece	-	X	-	Late reply from Greek Atomic Energy Commission, evaluation mainly based on legislation only
Hungary	X	-	-	Late reply, evaluation mainly based on legislation
Ireland	-	X	-	No inconsistencies
Italy	X	-	X	No inconsistencies
Latvia	X	X	-	According to CAA, no airline is under radiological protection, but crew members. System not yet completely implemented, measurements are planned
Lithuania	(x)	-	-	Answer: No operators flying high enough for

Country	CAA	RPA	Airline	Remarks
				monitoring
Luxembourg	X	-	X	No inconsistencies
Macedonia	-	-	-	No replies, evaluation based on legislation only
Malta	-	-	-	No replies, evaluation based on legislation only
Netherlands	X	X	-	No inconsistencies
Norway	(x)	-	X	Answer to letter: matter not relevant, no answer to questionnaire
Poland	X	X	X	Inconsistency: Answer from CAA indicates RPA is responsible for radiation protection, answer from RPA: not involved
Portugal	-	(x)	-*	Evaluation based on legislation only
Romania	X	-	X	No inconsistencies
Slovak Rep.	-	-	-	No replies, evaluation based on legislation only
Slovenia	X	-	-	Answer: implementation not yet complete
Spain	-	-	X	
Sweden	X	X	-	CAA and RPA answered together. Inconsistency: no one monitored
Switzerland	-	X	X	No inconsistencies
Turkey	-	-	X	
UK	-	-	-	No replies, evaluation based on legislation only

*) Questionnaire received after evaluation was finished

6.2 Questions on Organisation and Dose Registration

The information provided on the way dose registration is performed has been compiled from questionnaires filled in by all three groups of addressees. As a supplement, the information from other sources, already given in section 5 is used, due to the missing answers. Details on the organisations that are responsible for registration of doses of aircrew members and for keeping dose databases have been presented in section 5 together with the general description of the situation in each country. Here, the approaches are described in a more general form.

- The answers received by CAAs indicated that there is generally no special department dealing with aircrew doses. Only Denmark and Cyprus indicated such a department, with Denmark indicating that 1 person in this department is involved in dose registration.
- The answers received by the CAAs to the questions on involvement in dose registration were non-uniform. About half of the replies (five out of eleven) indicated that CAAs are involved in dose registration. In all of those cases the CAA is part of the process of data transmission. The dose databases themselves are under the responsibility of RPA.

- The recording of doses for air crew members is either already in operation or the implementation process for putting up a dose register is still in progress (Belgium, Bulgaria, Croatia, Luxembourg, Portugal and Slovenia). Recording duties start in almost all cases with personal doses above 1 mSv/a. In most cases (about 16 of the countries in this overview) data is kept in a national database. In some cases data is kept exclusively at the operators (Switzerland, Sweden). Data for recording is mostly delivered to the RPA who operates the database. In France there is an online system for direct data input, as is in Germany, where the online system is operated by the CAA who reports data to the RPA for recording. No information was available about dose recording in Hungary, Italy, Macedonia, Malta and Slovakia. Estonia, Lithuania and Norway stated that there was no need of dose recording as nobody reaches the limit of 1 mSv/a. Information received from Poland regarding this topic was contradictory. An overview of this topic is given in Table 12.
- It was indicated in 8 of 14 answers that the CAAs exercise supervision of airlines having to send data on doses of their personnel. This is done by visits, by evaluation of databases or by copies of the dose records. In one case (Denmark) it was explained that the CAA does not supervise the database the airlines use to calculate the doses, but cooperates with the national protection authority that receives the annual reports and prepares dose statistics, which may be a mechanism also applied in other countries. Poland indicated that future amendments to the Polish Aviation Act and to the Internal Regulation of CAO will allow to perform oversight of dose registration by inspectors of Flight Operation Department, which means that some countries try to improve the situation.
- It has been indicated in 9 of 14 answers that dose registration for occupational transport of personnel is carried out. Switzerland indicates that such doses are only assessed. Poland pointed out that dose registering for occupational transport of aircrew is regulated by JAR-OPS 1.390 (implemented by Polish Aviation Act of 2 July 2002 and by regulation of the Ministry of Infrastructure 5 November 2003 concerning safety exploitation of aircrafts).
- All answers received indicated that frequent flyers are not comprised by dose registration.
- Freelancers are only covered in 5 out of 13 cases. The same applies to personnel with jobs in more than one airline air crew. Poland, answering yes in both cases, pointed out that both cases are regulated by JAR-OPS 1.390.
- The way in which information on personal dose values to the personnel is handled is non-uniform. 8 of 14 answers indicated that there is a certain person who is responsible for flight crew members with questions about radiation safety. As an example, Denmark indicated that such information is part of the normal inspection and meeting with the safety representatives in the airlines and that the CAA has also published a guideline on this matter. In addition, 6 of 14 answers indicated that training for aircrew members has been implemented. 4 of the CAAs having answered with yes perform checks of these trainings.

Table 12: Overview of national dose data recording

Nation	National Register	Operated by	Aircrew included	Path of information	Operated since	Source of information
Austria	yes	RPA	no information	no information	2005	Leg./Lit.
Belgium	yes	RPA	under development	airline – RPA		Quest. RPA
Bulgaria	under developm.	no information	under development	under development		Leg./Lit.
Croatia	yes	Health Inspectorate	no/planned	under development		Leg./Lit.
Cyprus	yes	RPA	no information	airline - CAA		Quest./Lit.
Czech Republic	yes	RPA	yes	airline – RPA	1997	Quest./Lit.
Denmark	no inform.	no information	no information	airline (database) – RPA (on paper) – CAA (copy)		Quest. CAA/RPA
Estonia	yes	no information	no information	no information	1999	Lit./Leg.
Finland	yes	RPA	yes	airline - RPA		Quest. RPA
France	yes	RPA	yes	airline – Database (online)	2005	Lit./Leg.
Germany	yes	RPA	yes	airline – CAA (online) – RPA	2003	Lit./Leg./Quest.
Greece	yes	RPA	yes	airline – RPA	1993	Lit./Leg.
Hungary	yes	RPA	no information	no information		Lit./Leg.
Ireland	yes	RPA	yes	airline – RPA (summarized data)		Quest.
Italy	yes	Ministry for Work	no information	no information		Lit./Leg.
Latvia	yes	RPA	under development	no information	2003	Lit./Leg.
Lithuania	yes	RPA	no	no reporting due to low doses		Lit./Leg.
Luxembourg	no information	no information	no information	no information		Lit./Leg./Quest.
Former Yugoslav Republic of Macedonia	no information	no information	no information	no information		Lit./Leg.
Malta	no information	no information	no information	no information		Lit./Leg.
Netherlands	yes	RPA	yes	airline – RPA	2002	Lit./Leg./Quest.
Norway	yes	RPA	no	no reporting due to low doses	1998	Lit./Leg./Quest.
Poland	yes	RPA	contradictory information	contradictory information		Lit./Leg./Quest.
Portugal	yes	RPA	under	under development	2004	Lit./Leg./Quest.

Nation	National Register	Operated by	Aircrew included	Path of information	Operated since	Source of information
			development			t.
Romania	yes	RPA	no	-	2002	Lit./Leg./Quest.
Slovakia	yes	RPA	no information	no information		Lit./Leg.
Slovenia	yes	RPA	in future	in future	2000	Lit./Leg./Quest.
Spain	yes	RPA	no information	no information	1980	Lit./Leg.
Sweden	yes	RPA	only SAS	SAS		Lit./Leg./Quest.
Switzerland	yes	RPA	no	no information	1988	Lit./Leg./Quest.
Turkey	yes	RPA	yes	no information		Lit./Leg.
United Kingdom	yes	RPA	no information	no information	1987	Lit./Leg.

6.3 Questions on Dose Limits / Action Levels

The questions on dose limits and action levels⁶ have provided a more or less uniform picture, with the exception that value of the dose limit is interpreted in different ways, which, however, has no consequences for practical applications.

- Answers to the legally binding dose limit received from CAAs and RPAs were 1 mSv/a, 6 mSv/a, 20 mSv/a or 50 mSv/a. In particular, the following answers were given:
 - 50 mSv/a is the value provided by Hungary and Sweden (with the additional constraint of 100 mSv in 5 consecutive years), in accordance with the implementation of the EURATOM Basic Safety Standards as outlined in section 5.14.
 - 20 mSv/a is the value provided by Germany and Ireland.
 - 6 mSv/a is the value provided by the CAAs of several countries (Czech Republic, Denmark, Luxembourg, Netherlands), while the RPAs of the Czech Republic, Denmark and The Netherlands state a value of 20 mSv/a.
 - 1 mSv/a is the value provided by all other countries. For Finland, there is a disagreement between the value 1 mSv/a stated by the CAA and 6 mSv/a stated by the RPA.

⁶) for the use of the terms “preventive action” / “action level” instead of “intervention” / “intervention level” in the present report, see footnote 1 on page 33.

- The national action level (i.e. a level that should not be reached in normal operation and above which preventive action will become effective) has been set to 1 mSv/a or 6 mSv/a.
 - 6 mSv/a is the value provided by Germany and The Netherlands.
 - 1 mSv/a is the value used by all other countries having provided an answer to this question.
- The action level for pregnant / breastfeeding flight crew members is 1 mSv/a for all countries except Hungary that have not set action values. However, preventive actions (see section 6.4) are taken far below these values.
 - A value of 6 mSv/a was provided by the CAA of Hungary.
 - Finland indicated a value of explicitly “less than 1 mSv/a”.
 - No such action levels have been set by Lithuania and Romania.
- An action level for persons of less than 18 years of age is of no practical relevance as most countries do not employ underage persons.
 - A value of 6 mSv/a was provided by Hungary.
 - Germany indicated that there is no special limit for this age group.
- Switzerland made reference to JAR-OPS 1 for all dose limits, action levels or dose constraints.

This picture is generally in line with answers received by the airlines:

- The legally binding dose limit for general flight personnel is given as
 - 20 mSv/a only by Czech Airline
 - 6 mSv/a is the value provided by Blue 1 and Finnair (both Finland) and LTU Lufttransport-Unternehmen GmbH (Germany), Italfly and Meridiana (both Italy), Luxair and Cargolux (Luxembourg) as well as Swiss.
 - 1 mSv/a is the value provided by Estonian Air, LOT (Poland) and S.C.Carpatair (Romania), and Pegasus Airlines (Turkey).
- The legally binding action levels as reported by the airlines are 1 mSv/a, 6 mSv/a and 10 mSv/a.
 - 10 mSv/a has only been answered by Cargolux (Luxembourg).
 - 6 mSv/a and 1 mSv/a are consistently stated with the CAA or RPA replies.

- 5 mSv/a reported by TAPair (Portugal), where the authorities stated that legislation is not yet concluded.
- The action levels for pregnant or breastfeeding personnel is generally given as 1 mSv/a with the following exceptions:
 - 6 mSv/a has been stated by S.C.Carpatair (Romania),
 - 0 mSv/a has been stated by LTU Lufttransport-Unternehmen GmbH (Germany), indicating that pregnant or breastfeeding personnel would not be exposed by suitable preventive actions.
- Internal action levels are in most cases reported to be the same as the legal ones. Exceptions are:
 - 4 mSv/a reported by TAPair (Portugal) and
 - 3 mSv/a given from Italfly (Italy).

6.4 Questions on Preventive Actions

There are various measures to reduce doses to personnel or to prevent personnel reaching a dose constraint (action level) or even a dose limit. There are various types of preventive actions. The following groups of answers were received concerning general flight personnel:

- Preventive actions for flight crew nearing their action level generally consist of alteration to the flight schedule. In particular, the following remarks were made:
 - Some countries (Italy, Poland) foresee provision of information about risks to the personnel, means to reduce exposure to the lowest possible level, and medical surveillance.
 - Germany prescribes medical checks if the action level (6 mSv/a) is exceeded. If a person would reach 20 mSv/a, he would be suspended from flights for the rest of that particular year.
 - Finland stated that when the effective dose reaches 1 mSv/a, the operator shall arrange follow-up dose and health monitoring with same principles as for radiation workers and take measures to ensure doses to be kept low and below 6 mSv/a.
 - Denmark states that the CAA contacts the airline and obliges it to change the flight pattern for crew members to get below 6 mSv/a in future schedule.
- In addition, some countries (Czech Republic, Lithuania, Cyprus and others) stated that this topic is not relevant as the personnel will usually not reach the action level.
- Romania stated that no measures are foreseen.

In addition, the following answers were provided concerning pregnant personnel:

- Preventive actions that have to be taken in cases the operator is informed of pregnancy consist of either the requirement to maintain the woman's dose to less than 1 mSv during pregnancy (by rearranging the schedule to flights so that the dose to the foetus would be appropriately limited to below 1 mSv) or the requirement to change her assignment to duties on the ground, either immediately or after the first three months of pregnancy (Cyprus).
- The preventive actions that are actually taken for pregnant women consist in all cases of changing their assignment to ground duties.

Solar events are regarded as practical to include in the scheme of preventive actions only for a small number of countries.

- Luxair (Luxembourg) stated that as soon as solar flares are communicated via NOTAMS, as per company regulations, the flight level will be reduced.
- Some countries like Italy require no action but recommend operators to set procedures in case of special solar events. Other countries like Poland plan to take appropriate procedures into their legislation.
- In a small number of countries, solar events are taken into account in dose data evaluation. If a solar event occurred, the doses are evaluated retrospectively and added to the database.
- All other countries either did not describe any measures or indicated that no procedures are foreseen. Some countries indicate that they regard any protection measures as impracticable.

6.5 Questions concerning Airlines, Aircrew, Airplanes

The information provided by the CAAs on airlines, aircrew members and airplanes is listed in Table 13, Table 14 and Table 16. This information allows the assessment of the relevance of the question of radiation protection for aircrew in each country.

Table 13: Information on airlines

Country	Commercial air transport operators		Non-commercial air transport organis.	
	# registered	# not under rad. prot.	# registered	# not under rad. prot.
Cyprus	3	none	none	n.a.
Czech Republic	17	all under scope of rad. prot., but only 5 fly above FL 250	n.a.	n.a.
Denmark	46	all under scope of rad. prot., private pilots only if employed by an airline; not required if < 26,000 feet	about 2,500 private pilots	all under scope of rad. prot., private pilots only if employed by an airline, not required if < 26,000 feet
Estonia	6	all (all operate below 15,000 m)	3	all (all operate below 15,000 m)
Finland	6 where > 1 mSv/a possible	all except the 6, as they operate at appropriately low altitudes	none where rad. prot. is applicable	

Country	Commercial air transport operators		Non-commercial air transport organis.	
	# registered	# not under rad. prot.	# registered	# not under rad. prot.
Germany	170	n.a.	16 with jets registration, all non-comm. oper. like VW, BMW, Bosch etc.; not registered by LBA	not under CAA (Luftfahrtbundesamt, LBA) registration
Italy	48	7 – Ital. law (DLGS 230/95): operators with aircraft < 25,000 ft. unlikely to be exposed > 1 mSv/a	44 “aerial work” 137 “registered facilities”	44 + 137 – exclusion of helicopter operators, aircraft < 25,000 ft.
Latvia	19	14, not flying > 27000 ft ACJ OPS 1.390(a)(1)	3	3, none flying > 27000 ft ACJ OPS 1.390(a)(1)
Lithuania	10	no airline reaching > 1 mSv/a	none	n.a.
Luxembourg	6	none	none	n.a.
Netherlands	22 total 14 fixed wing	all under scope of rad. prot.	~ 70	no answer
Poland	16 with AOC	19, aircraft below altitudes specified in ACJ JAR-OPS 1.390 (a)(1)	19	13 + 1, aircraft below altitudes specified in ACJ JAR-OPS 1.390 (a)(1)
Romania	no answer	none	no answer	no answer
Switzerland	33	none	none	n.a.

Table 14: Aircrew members under radiation protection in countries

Country	Commercial air transport operators		Non-commercial air transport organis.	
	# registered	# not under rad. prot.	# registered	# not under rad. prot.
Cyprus	3	none	none	n.a.
Czech Republic	17	all under scope of rad. prot., but only 5 fly above FL 250	n.a.	n.a.
Denmark	46	all under scope of rad. prot., private pilots only if employed by an airline; not required if < 26,000 feet	about 2,500 private pilots	all under scope of rad. prot., private pilots only if employed by an airline, not required if < 26,000 feet
Estonia	6	all (all operate below 15,000 m)	3	all (all operate below 15,000 m)
Finland	6 where > 1 mSv/a possible	all except the 6, as they operate at appropriately low altitudes	none where rad. prot. is applicable	
Germany	170	n.a.	16 with jets registration, all non-comm. oper. like VW, BMW, Bosch etc.; not registered by LBA	not under CAA (Luftfahrtbundesamt, LBA) registration

Country	Commercial air transport operators		Non-commercial air transport organis.	
	# registered	# not under rad. prot.	# registered	# not under rad. prot.
Italy	48	7 – Ital. law (DLGS 230/95): operators with aircraft < 25,000 ft. unlikely to be exposed > 1 mSv/a	44 “aerial work” 137 “registered facilities”	44 + 137 – exclusion of helicopter operators, aircraft < 25,000 ft.
Latvia	19	14, not flying > 27000 ft ACJ OPS 1.390(a)(1)	3	3, none flying > 27000 ft ACJ OPS 1.390(a)(1)
Lithuania	10	no airline reaching > 1 mSv/a	none	n.a.
Luxembourg	6	none	none	n.a.
Netherlands	22 total 14 fixed wing	all under scope of rad. prot.	~ 70	no answer
Poland	16 with AOC	19, aircraft below altitudes specified in ACJ JAR-OPS 1.390 (a)(1)	19	13 + 1, aircraft below altitudes specified in ACJ JAR-OPS 1.390 (a)(1)
Romania	no answer	none	no answer	no answer
Switzerland	33	none	none	n.a.

*) for Belgium: only personnel with doses > 1 mSv/a

Table 15: Aircrew members under radiation protection in airlines (total / monitored)

Airline	Cockpit crew		Cabin crew		Sky marshals	Freelancers, others
	male	female	male	female		
Blue1 (Finland)*	118 / 108	8 / 7	13 / 13	175 / 131	0	0
Cargolux (Luxembourg)	367 / 12	0	0	0		
S.C.Carpatair (Romania)	97 / 0	0	6 / 0	86 / 0	0	0
Ceske Aerolinie	510 / all	13 / all	164 / all	791 / all	0	0
Croatia Airlines	125	3	35	190		
Czech Airlines	510 / 510	13 / 13	164 / 164	791 / 791	0	0
Estonian Air	63 / 0	3 / 0	17 / 0	85 / 0	0	0
Finnair	79 / 79	5 / 5	2 / 2	64 / 64		
Italfly	4 / 4	1 / 1	0	0	0	
LOT (Poland)	441 / 441	9 / 9	119 / 119	648 / 648	0	0
LTU (Germany)	50 / 50	6 / 6	10 / 10	60 / 60		
Luxair	129 / 129	9 / 9	19 / 19	152 / 152	0	0
Meridiana (Italy)	222 / 0	4 / 0	187 / 0	309 / 0	0	0
Pegasus (Turkey)	546 / 546	26 / 26	191 / 191	886 / 886	0	0
Swiss	935	29	640	1739	0	male: 43 female 517
TAROM (Romania)	176 / 0	9 / 0	50 / 0	263 / 0	0	0

*) 11 Blue1 crew members are currently on leave, flying for other EU carrier

Table 16: Information on airplanes according to take-off mass – number of airplanes / number equipped with radiation protection measurement equipment

Country	> 20 t	14 – 20 t	5.7 – 14 t	2 – 5.7 t	< 2 t	CAA responsibility
Cyprus	18 / 0	1 / 0	2 / 0	4 / 0	60 / 0	-
Czech Republic	no numbers given; no measuring equipment, as no flights > FL490					n.a.
Denmark	no numbers given; no measuring equipment, as no flights > FL490; according to JAR-OPS 1.680					n.a.
Finland	82 / 0	8 / 0	11 / 0	29 / 0	484 / 0	no, STUK response.
Germany	663 / 4	56 / 0	181 / 0	102 / 0	224 / 0	no, no other organis. responsible
Hungary	65 / 0	5 / 0	15 / 0	263 / 0	429 / 0	none
Italy	269 / 0	57 / 0	70 / 0	165 / 0	1306 / 0	n.a.
Latvia*	40 / 0	0 / 0	10 / 0	12 / 0	40 / 0	no, Rad. Prot. Centre Latvia
Lithuania	15 / 0	5 / 0	12 / 0	41 / 0	197 / 0	n.a.
Luxembourg	50 / 0	8 / 0	11 / 0	30 / 0	49 / 0	no
Netherlands	~270 / not reg.	~10 / not reg.	~20 / not reg.	~60 / not reg.	~670 / 0 all < 8 km	no
Poland	61 / 0	11 / 0	28 / 0	342 / 0	700 / 0	no, resp. by National Atomic Energy Agency (Państwowa Agencja Atomistyki)
Romania	47 / 0	9 / 0	4 / 0	130 / 0	115 / 0	no
Switzerland	-	2019 / 0	1995 / 0	1932 / 0	1662 / 0	no

*) no aircraft in Latvia operating > FL490, JAR-OPS 1.390 (b)(1)

The answers to the questionnaire concerning airlines, number of aircrew and airplanes reveal the following points:

- Commercial airlines are generally under the scope of radiation protection, if they have aircraft capable of flying above 25,000 – 27,000 ft.
- Most non-commercial air transport organisations are generally not under the scope of radiation protection or are not regulated by the CAA.
- In most cases, actual measurement of the exposure by measurement equipment in airplanes is not carried out as the airplanes do not reach FL490. Only Germany indicated that a small number of airplanes > 20 t take-off weight are equipped with measurement devices.
- Aircrew of commercial airlines is generally appropriately registered and within the scope of radiation protection. Aircrew of non-commercial air transport organisations is often not registered by the CAA.

6.6 Questions on the Exposure Database

The answers provided in relation to the exposure database are summarised in Table 17 and Table 18.

Table 17: Exposure database and information to the personnel as provided by the authorities

Country	Software	Information to personnel	Period for data storage	Data loss and accession of data
Cyprus	CARI6	yes, when reaching action level	yearly	no, manual filing
Czech Rep.	CARI6	yes, generally yearly and when reaching action level	until worker > 75 a or > 40 a from end of exposure	protected against data loss, access regulated by SUJB (State Office f. Nucl. Safety)
Denmark	EPCARD, CARI6, FREE	yes, prescribed, in general intervals + when reaching action level	storage period not limited	database operated by nat. rad. prot. institute Airlines responsible for dose administration
Finland	EPCARD, CARI6	yes, prescribed, in general intervals	during employment plus 12 months afterwards	protected, access regulated by law for individual's inform.; allowed for competent authority
Germany	EPCARD, CARI6, PCAIRE	yes, prescribed, in general intervals + when reaching action level	<i>(question misinterpreted)</i> data transfer 2 times p.a., max. delay 6 months	protected, LBA Dept. information Technology and Federal Office for Rad. Protect.; access by order forms, regul. by LBA
Hungary	CARI6	yes, generally monthly / yearly	no	no; database handled by airline Malev
Italy	CARI6 accepted	yes, intervals not specified	until worker > 75 a or > 30 a from end of exposure	not applicable
Latvia	EPCARD, CARI6	yes, only when reaching interv. level	until worker > 75 a, in case exposure > 6 mSv	yes, access regulated by Cabinet of Ministers Regulation of public data protection
Lithuania	n.a.	n.a.	n.a.	n.a.
Luxembourg	CARI6 others: AIMS (Cargolux)	no	no	no regulations on access
Netherlands	CARI6	yes, frequency not specified; own request as provided by "Besluit stralingsbescherming"	until worker > 75 a or > 30 a from end of exposure	yes; National Dose control Information & Registration System, access for workers personally, their employers, Min. f. Soc. Affairs
Poland	none specified	yes, monthly/yearly and when reaching action level, JAR-OPS 1.390	yes, period not provided in answer	no; planned to carry out all issues concerning database of dose registering by Civil Aviation Office in coop. with air-operators

Country	Software	Information to personnel	Period for data storage	Data loss and accession of data
Romania	none	n.a.	n.a.	no database
Switzerland	not specified, others on case-by-case studies	yes, only when reaching action level	yes, period not provided in answer; according to JAR-OPS 1	no protection; database kept by companies

Table 18: Exposure database and information to the personnel as provided by the airlines

Airline	Software Database	Calc. based on	Calculation procedure
Blue1 (Finland)	CARI; in-house regulated by STUK	based on <u>planned</u> route (origin and destination) and <u>actual</u> work schedules	no measurement of doses
Cargolux (Luxembourg)	CARI6, AIMS, in-house	planned route, solar flares implemented	no measurement of doses
S.C.Carpatair (Romania)	no software, data based on CARI3, in-house	planned route	Calculation based on cosmic radiation dose using the JAR-OPS 1, Table 1 ACJ OPS 1.390 (a) (1) based on CARI-3,
Croatia Airlines	(no answer provided)	(no answer provided)	in the year 2000, an assessment study has been performed
Czeske Aerolinie	CARI6 in-house at Nucl. Physics Inst. of the Academy of Sciences	real flight routes, real heights, solar flares implemented	dose measurements based on real-time measurements, carried out 1999, 2003 and 2007 to evaluate calculated dose data; served for verification of calculations
Estonian Air	in-house database data stored 12 months after end of employment	calc. against annual sum of latitude 60° N no solar flares	JAR-OPS 1.390(B) Reference Table applies for basic calculations
Finnair	EPCARD, in-house	doses per flight leg	no measurement of doses
Italfly	both in-house (CARI6) and contractor FLYRAD (own software)	based on planned flight route (usually assumes higher FL → higher dose), otherwise on real route; solar flares implemented	supported by on-board measurements, according to national legislation; real-time active monitoring; 1 plane equipped with monitors. Validation performed at least 2 times/year. Calibration interval 1 year.
LOT (Poland)	CARI6, in-house	planned route, solar flares implemented	no measurement of doses
LTU (Germany)	contractor IASON (Austria)	based on each recorded flight (planned route) with geographic data and FL data. This data is sent in for calculation	no measurement of doses
Luxair	in-house database data stored without limitation		

Airline	Software Database	Calc. based on	Calculation procedure
Meridiana (Italy)	CARI6, in-house	based on planned flight route	
Swiss	EPCARD no database	planned route, once a year not supported by actual onboard measurements	General by JAR-OPS 1; no crewmember will exceed 6 mSv/a. Only information given to crewmembers about health risks
TAROM (Romania)	n. a.	preliminary assessment shows personnel is below 1 mSv/a	

The answers received on the subject of dose calculations reveal that the program CARI6 has been named most often, followed by EPCARD, PCAIRE and FREE. All countries having dose registration have the obligation of information on the doses to the aircrew. Access to the data is regulated in different ways, generally giving access to the individual himself on the basis of data / information protection regulations. The data are in most cases kept until the individual reaches 75 years of age or 30 or 40 years have passed since the last exposure has occurred.

Only Romania stated that no dose register for aircrew is available, but that this will be set up in the near future.

One answer concerning the actual execution of measurements has been received. Italfly states that measurements are performed in the following way: during climb, the actual level of radiation is recorded every 1.000 ft of altitude increment, during cruise every 5 minutes, during descent as per climb. From these data, the continuous value (integral function) from take off to landing is computed. The calculated dose is about 150 % to 200% of the measured dose, with an effort to the protection of air crew.

From several countries, actual data on the distribution of doses to the various groups and on average individual doses have been received in the questionnaires. The data are summarised in Table 19.

Table 19: Data on average individual doses and on dose distributions

Country	date of data	overall average dose [mSv/a]	number of persons with doses		
			< 1 mSv/a	1 – 6 mSv/a	> 6 mSv/a
Belgium	2007	1.85	316	603	0
Croatia	for all records (several years)	n.a.	5359	157	15
Czech Republic	for all records (several years)	2.2	1700 – 1800		0
Denmark	2006	2.2	939	3769	0
Finland	2007	2.1	737	2971	0
Germany	2006	2.2	5641	26725	57
Ireland	2005	~ 2.0 (2005)	1500	5692	0
Netherlands	2007	1.73	2258	10918	0
Slovenia*	preliminary study	average 1 – 3 mSv/a	~ 70	~ 100	0
Sweden		n.a.	typ. 20 %	typ. 80 %	0

*) For Slovenia: data based on studies

6.7 Questions on Communication with Radiation Protection Authorities

The answers provided by the CAAs on the communication with radiation protection authorities and the organisations responsible for collection of data on doses to aircrew have been provided in the country specific chapters in section 5.

6.8 Questions on Radiation Protection Organisation in Airlines

All operators responding to our questionnaire have implemented an information system for their air crew members. The responsibility is given to the medical (health) department or to the operation department. The information is part of initial trainings and recurrent trainings once a year, several operators included information in manuals and/or intranet. As the information is given in addition during trainings which have to be organised anyway, this one explanation for missing data about the cost of the system in the questionnaires. Probably the training of personnel regarding radiation protection does not introduce ongoing costs.

6.9 Miscellaneous, Changes, Improvements

The following suggestions for changes or improvements were received:

- Latvia plans to carry out on board measurements for flight personnel using personal dose measurement equipment in cooperation with Radiation Safety Centre until 2008. Afterwards a comparison with a software calculation will be done.
- Romania plans to implement a system for radiation monitoring at the National Airline.
- Poland plans amendments to the Polish Aviation Act and to the Internal Regulation of CAO that will allow to perform oversight of dose registration by inspectors of Flight Operation Department. Amendments to Internal Regulation of CAO will allow appointing a specialist responsible for radiation safety. Several legislative changes planned for full implementation of art. 42 of the Directive 96/29 EURATOM through the draft of national act concerning aspects of working time in civil aviation and through next amendments to the Polish Aviation Act. These planned changes in the field of civil aviation legislation will allow the Civil Aviation Office to undertake appropriate measures concerning radiation protection of air crew in Poland. For example, it is planned to enlarge existing checklists for radiation issues and to check the dose registering within Continued Surveillance.
- Latvia points out that as the majority of flights for both major companies are low altitude (many flights with Fokker 50, heights less 8 km) or short distance flights - up to few thousands km, dose estimates are low. As a consequence, full scope dose assessments and dose monitoring system has not yet been established, but arrangements for initial full scope screening started and information collection should be finished in 2008. After that time, TLD services agreements will be enforced for selected groups and companies.
- Germany suggests a European Standardisation System.
- Airlines from various countries comment that better information to flight crew has resulted in an earlier declaration of pregnancy and better awareness. However, it is also observed that very few crew members are interested in their cosmic radiation doses.
- A very detailed comment concerning improvements in the situation of contracting personnel has been received from Blue1 (Finland): *"Blue1 have used contracted flight crew, and calculated their doses. However, if Blue1's flight crew members are on a leave of absence, and work for other airlines, it is usually unlikely that their contracting airlines are able to give the cosmic radiation dose estimates. (Only certain EU states have implemented the regulation!) Blue1 cannot calculate the dose in such cases, because if Blue1's flight crew members are working for other companies, naturally their rosters are not recorded in Blue1's system. And even if they were, Blue1 could not make the calculations, because the used kind of flight profiles were not known (e.g. used altitude, climb and descent profiles). Another problem is that if flight crew member is contracted by an airline which operations do not exceed 1 mSv annual limit, they are not required to conduct any calculation. However, when the flight crew member returns back to his/her 'own' airline, the*

national authority may start asking for the dose estimations even for the contract period. There is an urgent need for EU-wide clarification regarding this matter!"

6.10 Evaluation of Overarching Questions

6.10.1 Degree of Implementation

The degree of implementation of the regulations of the EURATOM Basic Safety Standards [EUR 96] in national legislation can be seen as accomplished (with the minor exception of Romania claiming that some amendments are necessary for full implementation of radiation protection of aircrew). In addition, a number of countries apply dose constraints or action levels that are below the individual dose limits of 20 mSv/a or 100 mSv over 5 consecutive years, as prescribed in the Basic Safety Standards. Values of 6 mSv/a and 1 mSv/a are used in many countries, being treated like dose limits rather than dose constraints. This means that the level of protection is at least as high as foreseen in the regulations of Title VII of the EURATOM Basic Safety Standards.

6.10.2 Degree of Harmonisation

The question of how well the regulations in the various EU Member States and other countries included in this study have been harmonised cannot be answered in a straightforward way. The following observations can be made:

- All countries have implemented regulations that provide protection for aircrew. However, these exhibit differences in scope and level of detail.
- Doses for aircrew are generally recorded in a database if personnel may receive doses above 1 mSv/a. The way in which doses are calculated and which data are stored is, however, not uniform in the countries taken into consideration.
- The responsibilities of airlines, civil aviation authorities and radiation protection authorities with respect to dose calculation and registration show significant differences. This can be attributed to the fact that responsibilities have evolved over many decades and that traditionally the layout of ministries and departments is different in countries.
- Dose constraints and action levels for aircrew is an area where a greater harmonisation would be desirable. The fact that values from 1 mSv/a to 20 mSv/a or even 50 mSv/a are treated as something like a limit (see overview in section 0) indicates that clarification would be required (see section 7). Dose constraints for pregnant or breastfeeding women are, however, treated uniformly with few exceptions.
- Preventive actions also show a fairly high degree of harmonisation. If a person approaches the action level, the flight schedule is altered accordingly. If action levels are exceeded, additional medical surveillance is exercised.

- The way in which dose databases are kept is clearly another field where a higher degree of harmonisation could be achieved. The data being recorded and the way in which the results are presented vary between countries.

6.10.3 Quantification of dose reduction

The data that were received in the course of this project are not detailed enough to give a qualitative – let alone a quantitative – assessment of the evolution of doses as a consequence of the implementation of the EURATOM Basic Safety Standards or the regulations transferring these into national legislation. It can, however, be estimated that there has been some effect in reduction of doses exceeding action levels (e.g. 6 mSv/a), i.e. that the maximum individual doses have been decreased. This does, however, not mean that average individual doses have been reduced, as introduction of newer airplanes over time allowed higher and more economic flight levels.

6.10.4 Quantification of costs and efficiency

A more thorough investigation of costs and effort that has to be spent for performing dose assessments and an evaluation of such costs and effort in relation to dose reductions cannot be achieved, as the data that would be required for this was not supplied by neither the civil aviation and radiation protection authorities nor the airlines. This also means that a cost-benefit analysis of the implementation of the EURATOM Basic Safety Standards is not possible.

As the effort that was named by civil aviation authorities and airlines for dose calculations and record keeping was quantified in the range between a few person-days and nearly an entire year per calendar year, it becomes clear that this matter is more complex, requiring more information than has been provided in the answers to the questionnaires.

When considering the costs for dose assessment and recording, it should be kept in mind that the highest effort is usually associated with the implementation of the necessary infrastructure, including training, information etc. This is a phase that either has been completed recently or is still ongoing in the countries within the scope of this study. The routine operation of such a system is, however, associated with much lower annual costs. On the other hand, any additional measures for dose reduction, especially for the collective dose of aircrew within an airline, would be associated with much higher costs. Such reduction could be achieved in principle by lower flight altitudes, routes in lower geographical latitudes or reduction of the number of flights. However, none of these theoretical means is viable in practice. None of the airplanes providing response to the questionnaires indicated that the costs associated with dose assessment and record keeping were exceptionally high or were regarded as unjustified.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions on Country Specific Legislation

All countries within the scope of this study where aircrew might receive doses above 1 mSv/a have implemented appropriate legislation. However, as the evaluation in section 6 suggests, the treatment of dose limits and dose constraint (or action levels⁷) could be an area where clear guidance might be needed. As the discussion, especially the overview provided in section 0 reveals, there are some inconsistencies as to how these values are to be interpreted. The provision of Article 42 Basic Safety Standards:

“Each Member State shall make arrangements for undertakings operating aircraft to take account of exposure to cosmic radiation of air crew who are liable to be subject to exposure to more than 1 mSv per year. The undertakings shall take appropriate measures, in particular: to assess the exposure of the crew concerned, to take into account the assessed exposure when organizing working schedules with a view to reducing the doses of highly exposed aircrew ...”

which corresponds to the requirements of JAR-OPS 1.390 (section 3.4.2), clearly prescribe that 1 mSv/a is the dose value above which doses have to be assessed. This, however, does not automatically mean that these doses are entered into a national dose database, which, according to RP 88 [EUR 97], would be required only if 6 mSv/a are exceeded, while it recommends to require only individual dose estimates below this value. This is in line with the prescriptions of JAR-OPS 1.390, stating:

“... ensure that individual records are kept for those crew members who are liable to high exposure. These exposures are to be notified to the individual on an annual basis, and also upon leaving the operator.”

It can therefore be observed that the action to be taken when 1 mSv/a is exceeded is not uniform among countries. This might be an area where more specific recommendations by the European Commission could be helpful. A recommendation concerning this point is given in section 7.5.2.

It has, however, been established in this study that individual doses are recorded in all countries within the scope of this study, if they exceed or could exceed 1 mSv/a.

⁷) for the use of the terms “preventive action” / “action level” instead of “intervention” / “intervention level” in the present report, see footnote 1 on page 33.

7.2 Conclusions on Dose Measurements vs. Dose Calculations

A further area where improvement would be possible is the area of the determination of doses. In all cases, the doses to personnel are calculated, using various software packages, of which CARI6 and EPCARD have been named most frequently. A rare case is the use of pre-calculated tables for flight levels. Differences exist, however, in the use of the planned or the real flight route and in the inclusion of solar events for preparing a better estimate for the dose.

It has been stated several times that the calculated doses constitute an overestimation of the real dose that would be measured if the airplane were equipped with measurement equipment. This overestimation is, however, not severe, as it has been stated in various studies aiming at a comparison between real doses (i.e. those measured during flights) and doses calculated by various software programmes, as presented in section 3.3. These studies generally show satisfactory agreement between numerous measurements and computer software like PCAIRE, EPCARD and CARI6. Especially the very comprehensive study RP 140 [EUR 04] provides numerous details on such a comparison. This generally gives the impression that the effort for improving the accuracy of software tools for dose estimates for aircrew could be limited. The fact that solar flares are usually not very accurately represented in this software is also no fundamental problem, as the additional dose received during such very rare events can be assessed and recorded a posteriori.

The number of positive answers received to the question of airplanes equipped with on-board measurement equipment was small. Germany has stated that 4 airplanes out of a total of 663 with take-off mass above 20 t are fitted with measurement equipment. In addition, the airline Italfly has stated that 1 airplane out of a total of 5 is fitted with measurement equipment.

7.3 Conclusions on Harmonisation

Apart from the points raised in the previous sections on interpretation of dose constraints / dose limits and on dose calculations / dose measurements, the topic of the employment of freelancers or crew members working for other airlines has been mentioned in a small number of questionnaires. The Finnish airline *Blue 1* reported problems in employment of freelancers or crew members who work for other international airlines due to the fact that dose assessment is a European regulation and international airlines do not provide the data needed to correctly accumulate personal doses. Likewise, the German Luftfahrt-Bundesamt suggests introducing a European standardisation system to radiation protection of air crew as a possible improvement.

This might indicate the need to introduce an EU-wide reporting mechanism for doses for aircrew, as has been achieved with the radiation passport (EU Directive No. 90/641/EURATOM) for outside workers in the field of radiation protection in nuclear installations and other licensed practices. At least, guidance on how to handle doses of freelancers or crew members who work for airlines in other countries might be helpful.

7.4 Conclusions from the Concentration Process in Rulemaking through EASA

As addressed in section 3.5, the establishment of the European Aviation Safety Agency (EASA) leads to a gradual shift in responsibilities from the national civil aviation authorities towards this centralised European agency. As implementing and monitoring safety rules, including inspections in the Member States, as well as safety analysis and research are responsibilities of this agency, EASA could foster the harmonisation process.

In line with this process EASA adopted the JAR-OPS 1 regulation and published with the “Commission Regulation (EC) No 8/2008”, dated 11 December 2007, a binding document for all commercial airline operators being effective after 16 July 2008. Nevertheless, there is still the gap for non-commercial operators in consideration to the subjects assessed. Although the “Regulation (EC)No 216/2008”, dated 20 February 2008, has the objective for establishment and uniform application of common rules in the field of civil aviation which are applicable for all personnel and organisations involved in the operation of aircraft, there is no evidence given in respect to Cosmic Radiation for commercial or non-commercial operator.

Furthermore, there is no overall responsibility for the assessment of Cosmic Radiation throughout the EU. Up to now the responsibilities are left by the commercial airline operator, but the fact, that the airline business is a job market where employments throughout the world are common with fairly few restrictions resulting from flight crew licensing, has not yet been accounted for.

Keeping in mind, that the EASA is a fairly young organisation, which is growing by persons and tasks, it should be considered that the development and harmonisation of procedures in the field of Cosmic Radiation for commercial and non-commercial operators might be only a matter of time and could be supported by this study. Currently, however, tracking of doses for aircrew still lies with national bodies, and no final decision has yet been taken whether and how this matter should be transferred to the area of responsibility of EASA.

7.5 Recommendations to the European Commission for Improvements

7.5.1 Recommendation on Guidance for the Use of Dose Limits and Dose Constraints

The European Commission might consider issuing guidance or information material to national regulatory bodies, civil aviation authorities as well as to the aircraft operators on the proper use of dose limits and dose constraints, especially on the meaning of 1 mSv/a as a dose limit above which doses have to be recorded and on the role of

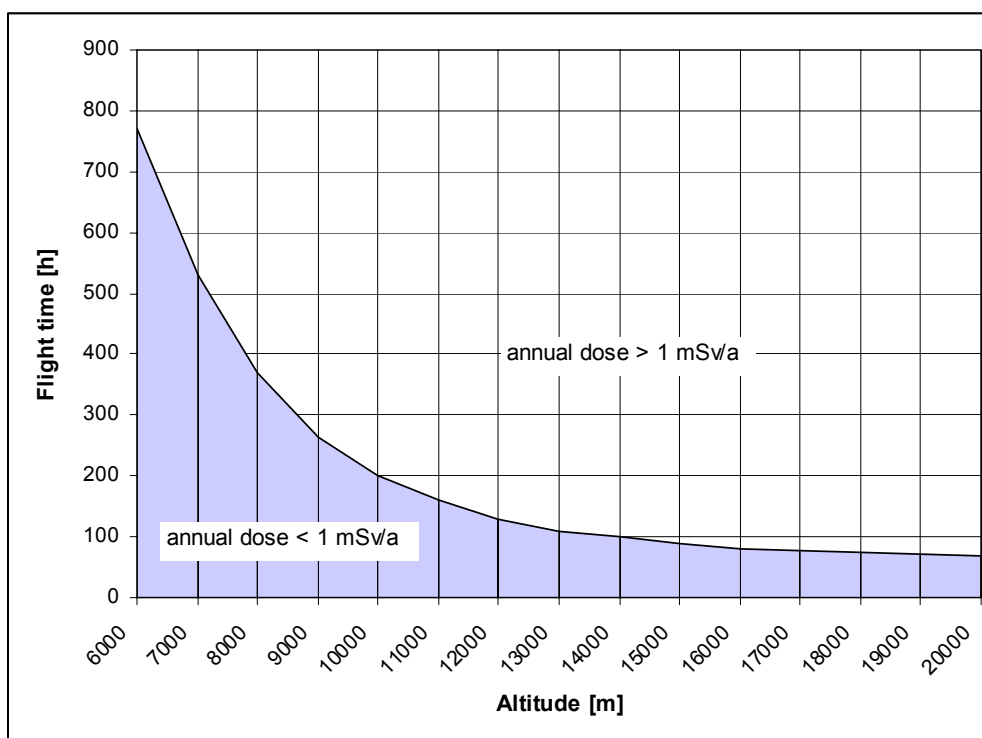
dose constraints that might be set internally (in a country or within an airline) to take actions to avoid reaching or even exceeding dose limits. For details, cf. section 0 and 7.1.

7.5.2 Recommendation on Procedures to Determine Compliance with the 1 mSv/a Dose Limit

As several answers have been received from countries and from airlines where some differences in the interpretation of ways to demonstrate compliance with the 1 mSv/a dose criterion became obvious (see sections 0 and 7.1), a procedure to determine compliance with the 1 mSv/a dose limit could be structured as follows ([SSK 03]).

1. The first criterion to demonstrate compliance with 1 mSv/a would be to use only aircraft with a maximum altitude of 6,000 m. In this case, a dose of 1 mSv/a will only be reached with more than 770 flight-h/a. Compliance can be demonstrated simply by specifying the type of aircraft that is used by the operator, e.g. helicopters.
2. A dose of 1 mSv/a will also not be exceeded on flights with maximum altitudes of 14,000 m with an annual flight time of less than 100 h/a. This figure is valid for any route. Compliance could be demonstrated by stating the annual number of flight hours.
3. The diagram in Figure 14 can be used to demonstrate compliance with the dose limit of 1 mSv/a by adding the annual flight times in each altitude for a specific crewmember.
4. The dose can be estimated on the basis of the flight schedule that will be expected for a specific crewmember in a particular year, using a licensed computer program for calculating doses to aircrew. The result of this estimation can be compared with the dose limit of 1 mSv/a.

Figure 14: Compliance with 1 mSv/a dose limit depending on flight altitude and annual flight time (diagram after [SSK 03])



This set of criteria has been proposed by the SSK in connection with the implementation of regulations for aircrew in the German Radiation Protection Ordinance. A similar set of criteria could also be incorporated in recommendations of the EU or even made part of the revised EURATOM BSS.

7.5.3 Recommendation on Reporting of Doses for Freelancers and Temporarily Deployed Personnel

As indicated in section 6.9 and addressed in more general form in section 7.3, the problem with reporting of doses for freelancers and personnel temporarily deployed to a different airline, also outside the EU, might need attention. Although the group of freelancers, i.e. those persons working for different airlines on a temporary basis, within Europe is small, presumably a few 100 persons, there is still the issue of how it can be assured that employees changing their employer (in the same country, between EU countries and between a EU and a non-EU country) will take all necessary information on the dose received up to that date with them. The same applies to employees who are deployed at a different airline on a temporary basis.

This might indicate the need to introduce an EU-wide reporting mechanism for doses for aircrew, as has been achieved with the radiation passport (EU Directive No. 90/641/EURATOM) for outside workers in the field of radiation protection in nuclear installations and other licensed practices. At least, guidance on how to handle doses of freelancers or crew members who work for airlines in other countries might be helpful.

It should be mentioned that no response received to the questionnaires has indicated that the current situation actually impedes change of employment or the free choice of job.

7.5.4 Recommendation on EU Legislation with Respect to Aircrew

The study has revealed that basically there is no area where the EU legislation would be incomplete or where regulations would clearly be missing. Room for improvement concerning easier ways to determine compliance with the 1 mSv/a dose limit (section 7.5.2) or transferring dose data between different employments (section 7.5.3) has already been mentioned. The requirements of Article 42 of the EURATOM Basic Safety Standards [EUR 96] and of Commission Regulation (EC) No 8/2008 of 11 December 2007 amending Council Regulation (EEC) No 3922/91 as regards common technical requirements and administrative procedures applicable to commercial transportation by aeroplane [EUR 07B] are comprehensive.

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