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BY

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INSTITUTE FOR ENERGY TECHNOLOGY
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Abstract

The work which is presented in this report is part of a Norwegian epidemiological project, carried out in cooperation between Institute for Energy Technology (IFE), the Norwegian Cancer Registry (NCR) and the Norwegian Radiation Protection Authority (NRPA). The project has been partially financed by the Norwegian Research Council. Originating from the Norwegian project, a number of similar projects have been started or are in the planning stage in a number of European countries. The present report lays the ground for estimation of individual exposure histories to cosmic radiation of pilots flying a great diversity of different aircraft. Aircraft that appear in the time-tables of the Scandinavian Airline System (SAS) have been treated in an earlier report (IFE/KR/E-96/008). The results presented in this report (radiation doserates for the different types of aircraft in the different years) will, in a later stage of the project, be utilized to estimate the individual radiation exposure histories. The major sources of information used as basis for the work in this report is information provided by several active pilots, members of the Pilots Associations, along with calculations performed using US Federal Avation Administration's computer code CARI-3N.

Key Words

Cosmic radiation, Cancer, Aviation

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Supplementary Data

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1 Introduction

The work which is presented in this report has been performed as part of a Norwegian epidemiological project entitled «Exposure to low level ionizing radiation and incidence of cancer in airline pilots and crew», carried out in cooperation between Institute for Energy Technology (IFE), the Norwegian Cancer Registry (NCR) and the Norwegian Radiation Protection Authority (NRPA). IFE was initiator of the project, and acts as project leader.

Originating from the Norwegian project, a number of similar projects have been started or are in the planning stage in a number of European countries. Interest has also been expressed from institutions in the USA and Canada. Attempts to form a European project combining all these efforts failed twice to obtain funding from the European Union. Other means of financing the project work and meetings, in order to obtain a satisfactory level of coordination and cooperation between the national projects are presently being sought.

The present report lays the ground for estimation of individual exposure histories to cosmic radiation of pilots not employed by the Scandinavian Airline System (SAS). Calculation of the exposure histories of pilots who are employed by SAS have been reported in detail in (TV96). The results presented in this report (radiation doserates for the different types of aircraft in the different years) will, in a later stage of the project, be utilized to estimate the individual radiation exposure histories.

The work presented here has to a large extent been performed on a voluntary basis by members of the Norwegian Pilots Association.

2 The epidemiological project

The present project is based upon a concept conceived in 1981 by the author of the present report in cooperation with Georg Petersen, then MD of the Oslo Health Council, presently United Nations Expert stationed in Cambodia. The concept was further developed in 1982, and subsequently submitted as a project proposal to the Norwegian Research Council. Although the proposed project won the approval of the Civil Aviation Administration and was granted the necessary permissions from the Cancer Register and the Data Inspectorate, adequate funding was not obtained, and the project was dormant until 1992, when a renewed and extended project proposal was submitted to the Commission of the European Communities' Radiation Protection Programme (RPP). In addition to the institutions mentioned in Chapter 1, the planned project participants were the German Cancer Research Center, Heidelberg and the Wageningen University, Department of Epidemiology and Public Health, Netherlands. The project was subsequently approved by the RPP. A feasibility study was funded, which should include airline pilots and, if feasible, cabin crew licensed in Norway, and was carried out by the Norwegian participants in the project proposal.

The Norwegian cohort has now been established by NCR, and extensive quality control and evaluation of the completeness of the cohort has been carried out. The cohort consists of all pilots and cabin crew in the registers of the Norwegian Aviation Administration since 1. January 1946 for the pilots and from 1. January 1950 for cabin crew and up till 18. February 1994. There are about 3,800 pilots and 3,700 cabin crew in the cohort.

3 Aircraft types and codes in the Aviation Administration register

The files based on the license renewal registers of the Norwegian Aviation Administration contained a very large number of aircraft types or codes; more than 400. Closer examination showed many of these to just be different names for the same airplane, misspellings or just minor differences (which nevertheless are confusing for a computer) like B747, B 747 and B-747.

After these obvious things had been harmonized, there were still around 100 different types of airplanes in the data base, and the next task was to determine what are typical cruise altitudes for all these. A number of different pilots from SAS, Braathens SAFE and/or the Pilots Associations have contributed. There was initially some confusion, as some of the altitudes given for some of the airplanes was maximum altitudes at which it could fly, rather than typical altitudes, but this has, through several iterations, been corrected. Although there are still a few "mysteries", aircraft type codes that no-one has been able to identify; practically all the different types of airplanes now have assigned to them typical cruising altitudes, and the altitudes and aircraft type codes that are currently in the data base are given in Table 1. In many cases the same airplane can be called several different things. In such cases it is attempted to keep to the names that are in most frequent use among professional pilots. None of these "rules-of-thumb" have been used rigidly, however. The ruling purpose of choice of names or renaming of aircraft types has been to assign some typical cruise altitude to every type of aircraft or aircraft type code that appears in the data base.

Lists of synonyms and the rules used at different stages of this work for renaming aircraft types/codes in the data base are given in *Appendix A*. They may prove useful for others attempting to perform a similar task in the future.

For many of the cruise altitude one particular aircraft type has been chosen to represent the whole group. The aircraft type chosen is indicated by underlining.

Some of the names or codes in the table, like M\RKE, are confusions caused by the computer not understanding the Norwegian letter Ø. (MØRKE means darkness, so in any case, it is not an aircraft type). This is, however, what is in the data base, and one has either to find out if the register of the Aviation Administration really contains this "information" or if it is simply a mistake done when typing information into the data base. In most such cases the "information" appears only once, and attempting to correct it by going back to the registers at the Aviation Administration is not worth the effort involved. Accordingly, it is just assigned to a reasonable altitude group, based on other information on the same pilot, when available.

Table 1 Aircraft types/codes and typical cruise altitudes

Typical cruise altitude (feet)	Aircraft types or codes for aircraft in this cruise altitude group			
1,500 (All aircraft types in this group are helicopters)	280C HELI AS 355 BK117 PUMA SA330 SH-7	AS 332 AS-350B BO 105C R 22 UH-12	AS 332 l2 AS-365 BV-234 SE 3130 WS51	AS 350 BH-412 HEL SE ALOUETTE WS55
3,000	SEABEE			
4,000	1 M LAND	1 M SJØ		
5,000	AU AUSTER JT-4A PIPER SUPER CUB T S2A PITTS	SINGLE OTTER JT4-9 R-2000 TSC-1A2	FINNMARK FLYBÅT PIONEER R-2800	JT-4 PIPER COLT R-3350
6,000	FAIRCHILD CORNELL	NORSEMAN SJØFLY		
7,000	CATALINA	CONSOLIDATED PBY		
8,000	5B DO228 OXFORD WIDGEON	ALBATROSS HERON RP RC-3 SEA	C-119 JU52 VERTOL44	DC3 LA4 WALRUS SJØFLY
10,000	2M LAND BRISTOL 171 B C406 GRUMMAN LOCKHEED L449A SAAB 90A SHORT-SEALAND	3A C-177 DC4 L749A PIPER AZTEC SAAB 90A2 SM333	AC-50 C208TP FH-1100 LOADSTAR PIPER CHEROKEE SCANDIA590 SR- TEAL	BEECHCRAFT-2 C402 FLER-M LAND LOCKHEED 12 PIPER NAVAJO SH-7 SUNDE RLAND
13,000	SANDRINGHAM	DASH		
15,000	SUPER BROUSSARD	CARVAIR ATL-98		
18,000	SC-7	SAAB-340		
20,000	ATR 42 EMB-110/120 MU 2	B26 F-5 NORD260	BE100 FA SA226 VICKERS-VISCOUNT	CONSTELLATION JETSTR. 31
22,000	PILATUS-TURBO			
23,000	FOKK28	HERCULES	YS-11	
25,000	BA31 BE1900	BAC-1-11 COMET 4	BE90 HAWKER SIDDELEY 748	BE200
29,000	BE99	C-441	INVADOR B-26	NA-265
31,000	B707 CF-104	B720 CL-600	B727 VC-9	BE300
33,000	LOCKHEED1011	VC-10		
35,000	JET FALCON	HS-125	LEAR-JET	MU-300
37,000	CITATION	GULFSTREAM		

4 Flight profiles used in the calculations

The computer program CARI-3N, developed at the USA Federal Aviation Administration (FR91) has been used to calculate the doses and doserates along specific flights. The flight legs must, of course, be defined to make a dose calculation possible, since the radiation intensity is a function both of altitude and geographical latitude. The required definition is in the form of a so-called flight profile, which describes the "history" of the flight concerning altitude vs. time, in conjunction with the geographical coordinates of the departure and arrival airports. These coordinates, for a very large number of airports all over the world, are in a datafile which is part of the CARI-3N program package.

A flight profile consists of numerical values of the following quantities:

(Duration of ascent from lift-off to first cruise level) (T_{ascent}),
(Altitude of 1st cruise level) (H_1), (Duration of cruising at 1st cruise level) (T_1),
(Altitude of 2nd cruise level) (H_2), (Duration of cruising at 2nd cruise level) (T_2),
(etc. if more cruise levels),
(Duration of descent from last cruise level to touch-down) ($T_{descent}$).
All durations are in minutes, and the altitudes are in feet. In addition the taxing times at the departure (T_{taxi1}) and arrival (T_{taxi2}) airports are specified, although these quantities are not used by the CARI-3N program. The taxing times are, however, included in the time duration of the flight as it is specified in the time tables, since flight duration is routinely reckoned from departure from the gate at the departure airport until docking at the gate of the arrival airport. The flight-hours per year, as reported by the pilots to the Aviation Administration, are also reckoned from gate to gate in the same manner.

Representative flight profiles as well as departure and arrival airports have been chosen for each of the typical cruise altitude groups in *Table 1*. These are shown in *Table 2*. These flight profiles and airports have kindly been specified, based upon experience, by co-pilot Stein Gilhuus from SAS. In each case the route as well as flight profile has been chosen to be representative, as far as possible, of use in Norway of the particular aircraft which is most important in the altitude group (underlined in the table), or alternatively representative of the group of aircrafts as a whole, when it was difficult to pick one particular aircraft. In the 10,000 feet altitude group, both C402 and C406 are underlined, since their flight characteristics will be very similar.

Table 2 Representative flight profiles and departure and arrival airports for the cruise altitude groups

Typical cruise altitude (feet)	Representative route/ flight time	T_{taxi1}	T_{ascent}	H_1	T_1	H_2	T_2	$T_{descent}$	T_{taxi2}
1,500	Bodø-Evenes 1h 0m	5m	3m	1,500	44m			3m	5m
3,000	FBU-Kr.sand 1h 0m	5m	6m	3,000	40m			6m	3m
4,000	FBU-Kr.sand 1h 30m	5m	8m	4,000	40m			6m	3m
5,000	Brønnøys.-Bodø 55m	5m	10m	5,000	27m			10m	3m
6,000	Brønnøys.-Bodø 55m	5m	10m	6,000	27m			10m	3m
7,000	Bodø-Trondheim 3h 0m	5m	17m	7,000	2:25			10m	3m
8,000	FBU-Trondheim 2h 0m	5m	15m	8,000	1:27			10m	3m
10,000	FBU-Trondheim 1h 30m	5m	10m	10,000	1:02			10m	3m
13,000	Bodø-Evenes 40m	5m	9m	13,000	15m			8m	3m
15,000	Bodø-Evenes 40m	5m	9m	15,000	15m			8m	3m
18,000	Bergen-Trondh. 1h 30m	5m	15m	18,000	57m			10m	3m
20,000	Torp-Trondheim 1h 15m	5m	12m	20,000	45m			10m	3m
22,000	FBU-Trondheim 1h 0m	5m	12m	22,000	32m			10m	3m
23,000	FBU-Trondheim 1h 0m	5m	12m	23,000	32m			10m	3m
25,000	FBU-Bodø 2h 15m	5m	15m	25,000	1:41			11m	3m
29,000	Tromsø-FBU 2h 30m	5m	20m	29,000	1:47			15m	3m
31,000	Oslo-LasPalmas 5h 0m	5m	25m	31,000	4:12			15m	3m
33,000	London-JFK 7h 10m	15m	23m	31,000	3:30	33,000	2:27	25m	10m
35,000	Tromsø-FBU 1h 50m	7m	25m	35,000	50m			25m	3m
37,000	FBU-Tromsø 2h 5m	5m	20m	37,000	1:17			20m	3m

5 Calculation of the radiation dose and doserate along specific flight legs, using the CARI-3N computer program

As already mentioned, the radiation dose calculations have been performed with the computer program CARI-3N.

The radiation doses have been calculated for one particular route for each altitude group. It has also been calculated for several different years. The difference between the years is caused by the variations from year to year (actually from month to month) of the radiation from the sun, which deflects the cosmic radiation to a larger or lesser degree. The intensity of the radiation from the sun is characterized by a quantity called the heliocentric potential. A low heliocentric potential gives somewhat higher cosmic radiation at cruise altitudes than a high heliocentric potential.

The results of the CARI-3N calculations for all the flight legs calculated are shown in *Tables 3 to 12*, for the different time periods covered by this study, and these values will be used in the concluding phase of the study to calculate the individual radiation exposures of the pilots summed over their professional careers. *Tables 13 and 14* will not be used in the study, but are included here to give a feeling of the maximum range of variation of the radiation intensity, as they present results from calculations using the very highest and lowest of heliocentric potentials for one specific month in the library of heliocentric potentials in the CARI-3N computer program. (It should be mentioned here that this library of heliocentric potentials was changed after the present calculations had been completed, as new and more reliable information had become available. At this stage, however, it was not possible to do all the calculations over again, especially as the impact on the results would have been minor.)

Table 3 Doses and doserates, years 1946 - 1949 (heliocentric potential 740 MV)

Typical cruise altitude (feet)	Representative route/ flight time	Total dose on this flight (microSv)	Dose per flighthour (microSv/h)
1,500	Bodø-Evenes 1h 0m	0.03	0.03
3,000	FBU-Kr.sand 1h 0m	0.04	0.04
4,000	FBU-Kr.sand 1h 30m	0.04	0.03
5,000	Brønnøys.-Bodø 55m	0.04	0.04
6,000	Brønnøys.-Bodø 55m	0.05	0.04
7,000	Bodø-Trondheim 3h 0m	0.21	0.07
8,000	FBU-Trondheim 2h 0m	0.15	0.08
10,000	FBU-Trondheim 1h 30m	0.15	0.10
13,000	Bodø-Evenes 40m	0.08	0.12
15,000	Bodø-Evenes 40m	0.11	0.17
18,000	Bergen-Trondh. 1h 30m	0.53	0.35
20,000	Torp-Trondheim 1h 15m	0.57	0.46
22,000	FBU-Trondheim 1h 0m	0.57	0.57
23,000	FBU-Trondheim 1h 0m	0.65	0.65
25,000	FBU-Bodø 2h 15m	2.5	1.1
29,000	Tromsø-FBU 2h 30m	4.4	1.8
31,000	Oslo-LasPalmas 5h 0m	9.8	2.0
33,000	London-JFK 7h 10m	18.5	2.6
35,000	Tromsø-FBU 1h 50m	4.3	2.3
37,000	FBU-Tromsø 2h 5m	7.1	3.4

Table 4 Doses and doserates, years 1950 - 1954 (heliocentric potential 555 MV)

Typical cruise altitude (feet)	Representative route/ flight time	Total dose on this flight (microSv)	Dose per flighthour (microSv/h)
1,500	Bodø-Evenes 1h 0m	0.03	0.03
3,000	FBU-Kr.sand 1h 0m	0.04	0.04
4,000	FBU-Kr.sand 1h 30m	0.04	0.03
5,000	Brønnøys.-Bodø 55m	0.04	0.04
6,000	Brønnøys.-Bodø 55m	0.05	0.05
7,000	Bodø-Trondheim 3h 0m	0.22	0.07
8,000	FBU-Trondheim 2h 0m	0.16	0.08
10,000	FBU-Trondheim 1h 30m	0.16	0.11
13,000	Bodø-Evenes 40m	0.08	0.12
15,000	Bodø-Evenes 40m	0.11	0.17
18,000	Bergen-Trondh. 1h 30m	0.57	0.38
20,000	Torp-Trondheim 1h 15m	0.61	0.49
22,000	FBU-Trondheim 1h 0m	0.61	0.61
23,000	FBU-Trondheim 1h 0m	0.71	0.71
25,000	FBU-Bodø 2h 15m	2.7	1.2
29,000	Tromsø-FBU 2h 30m	4.7	1,9
31,000	Oslo-LasPalmas 5h 0m	10.3	2.1
33,000	London-JFK 7h 10m	20.0	2.8
35,000	Tromsø-FBU 1h 50m	4.7	2.6
37,000	FBU-Tromsø 2h 5m	7.8	3.7

Table 5 Doses and doserates, years 1955 - 1959 (heliocentric potential 872 MV)

Typical cruise altitude (feet)	Representative route/ flight time	Total dose on this flight (microSv)	Dose per flighthour (microSv/h)
1,500	Bodø-Evenes 1h 0m	0.03	0.03
3,000	FBU-Kr.sand 1h 0m	0.04	0.04
4,000	FBU-Kr.sand 1h 30m	0.04	0.03
5,000	Brønnøys.-Bodø 55m	0.04	0.04
6,000	Brønnøys.-Bodø 55m	0.04	0.04
7,000	Bodø-Trondheim 3h 0m	0.20	0.07
8,000	FBU-Trondheim 2h 0m	0.15	0.08
10,000	FBU-Trondheim 1h 30m	0.15	0.10
13,000	Bodø-Evenes 40m	0.08	0.12
15,000	Bodø-Evenes 40m	0.10	0.15
18,000	Bergen-Trondh. 1h 30m	0.51	0.34
20,000	Torp-Trondheim 1h 15m	0.55	0.44
22,000	FBU-Trondheim 1h 0m	0.54	0.54
23,000	FBU-Trondheim 1h 0m	0.62	0.62
25,000	FBU-Bodø 2h 15m	2.3	1.0
29,000	Tromsø-FBU 2h 30m	4.1	1,6
31,000	Oslo-LasPalmas 5h 0m	9.5	1.9
33,000	London-JFK 7h 10m	17.6	2.4
35,000	Tromsø-FBU 1h 50m	4.1	2.2
37,000	FBU-Tromsø 2h 5m	6.7	3.2

Table 6 Doses and doserates, years 1960 - 1965 (heliocentric potential 614 MV)

Typical cruise altitude (feet)	Representative route/ flight time	Total dose on this flight (microSv)	Dose per flighthour (microSv/h)
1,500	Bodø-Evenes 1h 0m	0.03	0.03
3,000	FBU-Kr.sand 1h 0m	0.04	0.04
4,000	FBU-Kr.sand 1h 30m	0.04	0.03
5,000	Brønnøys.-Bodø 55m	0.04	0.04
6,000	Brønnøys.-Bodø 55m	0.05	0.05
7,000	Bodø-Trondheim 3h 0m	0.22	0.07
8,000	FBU-Trondheim 2h 0m	0.16	0.08
10,000	FBU-Trondheim 1h 30m	0.16	0.11
13,000	Bodø-Evenes 40m	0.08	0.12
15,000	Bodø-Evenes 40m	0.11	0.17
18,000	Bergen-Trondh. 1h 30m	0.56	0.37
20,000	Torp-Trondheim 1h 15m	0.60	0.48
22,000	FBU-Trondheim 1h 0m	0.59	0.59
23,000	FBU-Trondheim 1h 0m	0.69	0.69
25,000	FBU-Bodø 2h 15m	2.6	1.2
29,000	Tromsø-FBU 2h 30m	4.6	1.8
31,000	Oslo-LasPalmas 5h 0m	10.1	2.0
33,000	London-JFK 7h 10m	19.5	2.7
35,000	Tromsø-FBU 1h 50m	4.6	2.5
37,000	FBU-Tromsø 2h 5m	7.5	3.6

Table 7 Doses and doserates, years 1965 - 1969 (heliocentric potential 523 MV)

Typical cruise altitude (feet)	Representative route/ flight time	Total dose on this flight (microSv)	Dose per flighthour (microSv/h)
1,500	Bodø-Evenes 1h 0m	0.03	0.03
3,000	FBU-Kr.sand 1h 0m	0.04	0.04
4,000	FBU-Kr.sand 1h 30m	0.04	0.03
5,000	Brønnøys.-Bodø 55m	0.04	0.04
6,000	Brønnøys.-Bodø 55m	0.05	0.05
7,000	Bodø-Trondheim 3h 0m	0.22	0.07
8,000	FBU-Trondheim 2h 0m	0.16	0.08
10,000	FBU-Trondheim 1h 30m	0.16	0.11
13,000	Bodø-Evenes 40m	0.08	0.12
15,000	Bodø-Evenes 40m	0.11	0.17
18,000	Bergen-Trondh. 1h 30m	0.58	0.39
20,000	Torp-Trondheim 1h 15m	0.62	0.50
22,000	FBU-Trondheim 1h 0m	0.62	0.62
23,000	FBU-Trondheim 1h 0m	0.72	0.72
25,000	FBU-Bodø 2h 15m	2.7	1.2
29,000	Tromsø-FBU 2h 30m	4.8	1.9
31,000	Oslo-LasPalmas 5h 0m	10.4	2.1
33,000	London-JFK 7h 10m	20.4	2.8
35,000	Tromsø-FBU 1h 50m	4.8	2.6
37,000	FBU-Tromsø 2h 5m	8.0	3.8

Table 8 Doses and doserates, years 1970 - 1974 (heliocentric potential 496 MV)

Typical cruise altitude (feet)	Representative route/ flight time	Total dose on this flight (microSv)	Dose per flighthour (microSv/h)
1,500	Bodø-Evenes 1h 0m	0.03	0.03
3,000	FBU-Kr.sand 1h 0m	0.04	0.04
4,000	FBU-Kr.sand 1h 30m	0.04	0.03
5,000	Brønnøys.-Bodø 55m	0.04	0.04
6,000	Brønnøys.-Bodø 55m	0.05	0.05
7,000	Bodø-Trondheim 3h 0m	0.22	0.07
8,000	FBU-Trondheim 2h 0m	0.16	0.08
10,000	FBU-Trondheim 1h 30m	0.16	0.11
13,000	Bodø-Evenes 40m	0.08	0.12
15,000	Bodø-Evenes 40m	0.11	0.17
18,000	Bergen-Trondh. 1h 30m	0.58	0.39
20,000	Torp-Trondheim 1h 15m	0.63	0.50
22,000	FBU-Trondheim 1h 0m	0.63	0.63
23,000	FBU-Trondheim 1h 0m	0.72	0.72
25,000	FBU-Bodø 2h 15m	2.7	1.2
29,000	Tromsø-FBU 2h 30m	4.9	2.0
31,000	Oslo-LasPalmas 5h 0m	10.4	2.1
33,000	London-JFK 7h 10m	20.6	2.9
35,000	Tromsø-FBU 1h 50m	4.9	2.7
37,000	FBU-Tromsø 2h 5m	8.1	3.9

Table 9 Doses and doserates, years 1975 - 1979 (heliocentric potential 453 MV)

Typical cruise altitude (feet)	Representative route/ flight time	Total dose on this flight (microSv)	Dose per flighthour (microSv/h)
1,500	Bodø-Evenes 1h 0m	0.03	0.03
3,000	FBU-Kr.sand 1h 0m	0.04	0.04
4,000	FBU-Kr.sand 1h 30m	0.04	0.03
5,000	Brønnøys.-Bodø 55m	0.04	0.04
6,000	Brønnøys.-Bodø 55m	0.05	0.05
7,000	Bodø-Trondheim 3h 0m	0.23	0.08
8,000	FBU-Trondheim 2h 0m	0.16	0.08
10,000	FBU-Trondheim 1h 30m	0.16	0.11
13,000	Bodø-Evenes 40m	0.08	0.12
15,000	Bodø-Evenes 40m	0.12	0.20
18,000	Bergen-Trondh. 1h 30m	0.59	0.39
20,000	Torp-Trondheim 1h 15m	0.64	0.51
22,000	FBU-Trondheim 1h 0m	0.64	0.64
23,000	FBU-Trondheim 1h 0m	0.74	0.74
25,000	FBU-Bodø 2h 15m	2.8	1.2
29,000	Tromsø-FBU 2h 30m	5.0	2.0
31,000	Oslo-LasPalmas 5h 0m	10.6	2.1
33,000	London-JFK 7h 10m	21.1	2.9
35,000	Tromsø-FBU 1h 50m	5.0	2.7
37,000	FBU-Tromsø 2h 5m	8.3	4.0

Table 10 Doses and doserates, years 1980 - 1984 (heliocentric potential 763 MV)

Typical cruise altitude (feet)	Representative route/ flight time	Total dose on this flight (microSv)	Dose per flighthour (microSv/h)
1,500	Bodø-Evenes 1h 0m	0.03	0.03
3,000	FBU-Kr.sand 1h 0m	0.04	0.04
4,000	FBU-Kr.sand 1h 30m	0.04	0.03
5,000	Brønnøys.-Bodø 55m	0.04	0.04
6,000	Brønnøys.-Bodø 55m	0.05	0.04
7,000	Bodø-Trondheim 3h 0m	0.21	0.07
8,000	FBU-Trondheim 2h 0m	0.15	0.08
10,000	FBU-Trondheim 1h 30m	0.15	0.10
13,000	Bodø-Evenes 40m	0.08	0.12
15,000	Bodø-Evenes 40m	0.10	0.15
18,000	Bergen-Trondh. 1h 30m	0.53	0.35
20,000	Torp-Trondheim 1h 15m	0.57	0.46
22,000	FBU-Trondheim 1h 0m	0.56	0.56
23,000	FBU-Trondheim 1h 0m	0.65	0.65
25,000	FBU-Bodø 2h 15m	2.4	1.1
29,000	Tromsø-FBU 2h 30m	4.3	1.7
31,000	Oslo-LasPalmas 5h 0m	9.7	1.9
33,000	London-JFK 7h 10m	18.3	2.6
35,000	Tromsø-FBU 1h 50m	4.3	2.3
37,000	FBU-Tromsø 2h 5m	7.0	3.4

Table 11 Doses and doserates, years 1985 - 1989 (heliocentric potential 553 MV)

Typical cruise altitude (feet)	Representative route/ flight time	Total dose on this flight (microSv)	Dose per flighthour (microSv/h)
1,500	Bodø-Evenes 1h 0m	0.03	0.03
3,000	FBU-Kr.sand 1h 0m	0.04	0.04
4,000	FBU-Kr.sand 1h 30m	0.04	0.03
5,000	Brønnøys.-Bodø 55m	0.04	0.04
6,000	Brønnøys.-Bodø 55m	0.05	0.05
7,000	Bodø-Trondheim 3h 0m	0.22	0.07
8,000	FBU-Trondheim 2h 0m	0.16	0.08
10,000	FBU-Trondheim 1h 30m	0.16	0.11
13,000	Bodø-Evenes 40m	0.08	0.12
15,000	Bodø-Evenes 40m	0.11	0.17
18,000	Bergen-Trondh. 1h 30m	0.57	0.38
20,000	Torp-Trondheim 1h 15m	0.61	0.49
22,000	FBU-Trondheim 1h 0m	0.61	0.61
23,000	FBU-Trondheim 1h 0m	0.71	0.71
25,000	FBU-Bodø 2h 15m	2.7	1.2
29,000	Tromsø-FBU 2h 30m	4.7	1.9
31,000	Oslo-LasPalmas 5h 0m	10.3	2.1
33,000	London-JFK 7h 10m	20.1	2.8
35,000	Tromsø-FBU 1h 50m	4.7	2.6
37,000	FBU-Tromsø 2h 5m	7.8	3.7

Table 12 Doses and doserates, years 1990 - 1994 (heliocentric potential 730 MV)

Typical cruise altitude (feet)	Representative route/ flight time	Total dose on this flight (microSv)	Dose per flighthour (microSv/h)
1,500	Bodø-Evenes 1h 0m	0.03	0.03
3,000	FBU-Kr.sand 1h 0m	0.04	0.04
4,000	FBU-Kr.sand 1h 30m	0.04	0.03
5,000	Brønnøys.-Bodø 55m	0.04	0.04
6,000	Brønnøys.-Bodø 55m	0.05	0.05
7,000	Bodø-Trondheim 3h 0m	0.21	0.07
8,000	FBU-Trondheim 2h 0m	0.15	0.08
10,000	FBU-Trondheim 1h 30m	0.15	0.10
13,000	Bodø-Evenes 40m	0.08	0.12
15,000	Bodø-Evenes 40m	0.11	0.17
18,000	Bergen-Trondh. 1h 30m	0.53	0.35
20,000	Torp-Trondheim 1h 15m	0.57	0.46
22,000	FBU-Trondheim 1h 0m	0.57	0.57
23,000	FBU-Trondheim 1h 0m	0.66	0.66
25,000	FBU-Bodø 2h 15m	2.5	1.1
29,000	Tromsø-FBU 2h 30m	4.4	1.8
31,000	Oslo-LasPalmas 5h 0m	9.8	2.0
33,000	London-JFK 7h 10m	18.6	2.6
35,000	Tromsø-FBU 1h 50m	4.3	2.3
37,000	FBU-Tromsø 2h 5m	7.1	3.4

Table 13 Doses and doserates, heliocentric potential 1429 MV (June 1991) (the highest heliocentric in the time period covered by the CARI data file)

Typical cruise altitude (feet)	Representative route/ flight time	Total dose on this flight (microSv)	Dose per flighthour (microSv/h)
1,500	Bodø-Evenes 1h 0m	0.03	0.03
3,000	FBU-Kr.sand 1h 0m	0.03	0.03
4,000	FBU-Kr.sand 1h 30m	0.04	0.03
5,000	Brønnøys.-Bodø 55m	0.04	0.04
6,000	Brønnøys.-Bodø 55m	0.04	0.04
7,000	Bodø-Trondheim 3h 0m	0.19	0.06
8,000	FBU-Trondheim 2h 0m	0.13	0.07
10,000	FBU-Trondheim 1h 30m	0.13	0.09
13,000	Bodø-Evenes 40m	0.07	0.11
15,000	Bodø-Evenes 40m	0.09	0.14
18,000	Bergen-Trondh. 1h 30m	0.44	0.29
20,000	Torp-Trondheim 1h 15m	0.47	0.38
22,000	FBU-Trondheim 1h 0m	0.46	0.46
23,000	FBU-Trondheim 1h 0m	0.53	0.53
25,000	FBU-Bodø 2h 15m	2.0	0.89
29,000	Tromsø-FBU 2h 30m	3.5	1.4
31,000	Oslo-LasPalmas 5h 0m	8.4	1.7
33,000	London-JFK 7h 10m	14.8	2.1
35,000	Tromsø-FBU 1h 50m	3.4	1.9
37,000	FBU-Tromsø 2h 5m	5.5	2.6

Table 14 Doses and doserates, heliocentric potential 352 MV (February 1995) (the highest heliocentric in the time period covered by the CARI data file)

Typical cruise altitude (feet)	Representative route/ flight time	Total dose on this flight (microSv)	Dose per flighthour (microSv/h)
1,500	Bodø-Evenes 1h 0m	0.03	0.03
3,000	FBU-Kr.sand 1h 0m	0.04	0.04
4,000	FBU-Kr.sand 1h 30m	0.05	0.03
5,000	Brønnøys.-Bodø 55m	0.04	0.04
6,000	Brønnøys.-Bodø 55m	0.05	0.05
7,000	Bodø-Trondheim 3h 0m	0.23	0.08
8,000	FBU-Trondheim 2h 0m	0.17	0.09
10,000	FBU-Trondheim 1h 30m	0.17	0.11
13,000	Bodø-Evenes 40m	0.09	0.14
15,000	Bodø-Evenes 40m	0.12	0.18
18,000	Bergen-Trondh. 1h 30m	0.62	0.41
20,000	Torp-Trondheim 1h 15m	0.67	0.54
22,000	FBU-Trondheim 1h 0m	0.67	0.67
23,000	FBU-Trondheim 1h 0m	0.78	0.78
25,000	FBU-Bodø 2h 15m	3.0	1.3
29,000	Tromsø-FBU 2h 30m	5.3	2.1
31,000	Oslo-LasPalmas 5h 0m	10.9	2.2
33,000	London-JFK 7h 10m	22.3	3.1
35,000	Tromsø-FBU 1h 50m	5.3	2.9
37,000	FBU-Tromsø 2h 5m	8.9	4.3

6 References

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TV96 U. Tveten: Cosmic radiation and airline pilots. Exposure patterns of Norwegian SAS-pilots 1960 to 1994. IFE/KR/E-96/008. ISSN 0333-2039. ISBN 82-7017-160-3. Institute for Energy Technology, Kjeller, Norway. February 1997.

APPENDIX A

AIRCRAFT TYPES AND CODES IN THE DATA BASE

The data base is based on information from the Norwegian Aviation Administration. In its first completed form near the end of December 1994 (some data have been added later), a computer search came up with 427 different aircraft types or codes. Many of these were really the same, just in different combinations or slightly different spelling, or the only difference might even be with/without a space somewhere in the name.

For completeness the whole list is nevertheless given in *Table A.1*.

Table A.1 List of aircraft types or codes contained in the data base, by 27 December 1994 (three pages)

Klasse
1, 2A
1-ENG
1-M LAND
1-M LAND 1, 2A
1-M LAND 1, 2A, 3A
1-M LAND 1, 2A, 3A, 4A
1-M LAND 1,2A,3A
1-M LAND 2A
1-M LAND 2A 3A 4A
1-M LAND 2A, 3A
1-M LAND 2A, 3A, 4A
1-M LAND 2A, 3A, 4A, 5A
1-M LAND 2A, 3A, 4A, 5A, 5B
1-M LAND 2A, 4A
1-M LAND 2A, 5B
1-M LAND 2A,3A
1-M LAND 2A. 3A, 4A, 5A
1-M LAND 2B, 3B, 4B, 5B
1-M LAND 3A
1-M LAND 4B
1-M LAND 5B
1-M LAND INNTIL 5700 KG
1-M LAND1,2A
1-M LAND2A
1-M LAND2A, 3A, 4A
1-M SJ\
1-M SJØ
1-M SJØ 1, 2A
1-M SJØ 1, 2A, 3A, 4A
1-M SJØ 1, 2A,3A
1-M SJØ 1,2A
1-M SJØ 2A
1-M SJØ 2A, 3A
1-M SJØ 2A, 3A, 4A
1-M SJØ 2A,3A
1-M SJØ 2B 3B 4B 5B
1-M SJØ 2B, 3B, 4B, 5B
1-M SJØ 3A
1-M SJØ 4A, 5B
1-M SJØ 5B
1-MOT LAND
1-MOT SJØ
2-ENG

Klasse
2-M LAND
2-M LAND MAKS 5700 KG
2A
2A-21
2M LAND
3A
4A
5 A FINNMARK FLYBÅT
5A FINNMARK FLYBÅT
5B
A 300
A-300
A-BELL 206A
AB 205
AB 206 JET RANGER
AC-6-T
ALOUETTE
ALOUETTE 2
ALOUETTE 3
ALOUETTE 3-315
AMFIBIUM CESSNA
AMPHIBIUM (EN MOTORS)
ATR 42
AU AUSTER
AUGUSTA BELL 204 B
B 720/707
B 736
B 737
B 747
B 767
B-26
B-707
B-707/720
B-720
B-727
B-737
B-747
B-767
BA 31
BA-31
BAC-1-11
BE 100
BE 200

Klasse
BE 90
BE 99
BE-10
BE-1900
BE-20
BE-200
BE-300
BE-90
BE-99
BEECH 200
BEECHCRAFT-2
BEKK 204
BELL
BELL 204
BELL 204 A/B
BELL 204 B
BELL 204B
BELL 205
BELL 206
BELL 206A
BELL 212
BELL 212 CPO
BELL 214
BELL 214 ST
BELL 47
BELL 47 G
BELL-47
BELL204
BELL212
BELL214
BO-105
BOING 727
BOING 737
BOING 747
C 208TP
C 337
C 406
C 46
C 500
C 501
C 551
C 650
C-130

Klasse
C-185 AMF
C-206 AMF.
C-208
C-240
C-440
C-441
C-46
C-46 R
C-46C
C-46R
C-47
C-500
C-501
C-54
C-550
C-551
C-560
C.46 R
CARVAIR ATL-98
CATALINA
CATALINA 28-5ACF
CATALINA AMFIBIUM
CATALINA PB Y-5A
CE 550
CE-337
CE-550
CESSNA
CESSNA 172
CESSNA 206
CESSNA 206 AFIBIUM
CESSNA 337
CESSNA 402
CESSNA 404
CESSNA CITATION
CESSNA F-406
CESSNA U-206
CESSNA-337
CL-600
COMET 4
COMMERCIAL AIR TRANSPORTATION
CONSOLIDATED PBY
CONSTELLATION
CONVAIR

Klasse
CONVAIR 240
CONVAIR 440
CONVAIR-240
CONVAIR-990
CV-14
CV-240
CV-340
CV-340/440
CV-440
CV-46
CV-580
CV-990
D H HERON
D-8
DA 20
DA-20
DC 4
DC 6
DC 8
DC 9
DC-10
DC-3
DC-4
DC-6
DC-6 6B
DC-6 AB
DC-6 B
DC-6-6B
DC-6/6B
DC-6/B
DC-6A
DC-6AB
DC-6B
DC-7
DC-7B
DC-7C
DC-8
DC-8C
DC-9
DC-B26
DC3
DH 114
DH 114 HERON

Klasse
DH OTTER, AMPHIBIUM
DH TWIN OTTER
DH-100
DH-114
DH-114 HERON
DH-114-1B
DH-OTR- AMF.
DHC 6
DHC 7
DHC 8
DHC-2
DHC-2 AMF.
DHC-3
DHC-3 AMF.
DHC-3 OTTER SEAPLAN
DHC-6
DHC-7
DHC-8
DO 228
DO-228
DO-228-101/201
DO-228-201
DO-228-202
DO-228/101
DO-228/201
E EMB-120
EMB-110
EMB-120
F 27
F-27
F-27-50
F-28
F-50
F28
FA SA226
FAIRCHILD CORNELL
FAN JET FALCON DA-20
FH 227
FH-227
FH-227B
FINNMARK AMFIBIER
FINNMARK FLYBÅT
FK 27

Klasse
FK 28
FK 50
FLER-M LAND
FLER-M LAND: DH-104 HERON
FLER-M SJ\
FLER-M SJØ
FOKKER 50
FOKKER F-27
G-1159
GRUMMAN
GRUMMAN GOOSE
GRUMMAN WIDG.AMF
GRUMMAN WIDGEON
GRUMMAN WIDGEON AMF.
GRUMMAN WIDGEON AMFIBIUM
HAWKER SIDDELEY 748
HERON
HERON 114
HERON D H 114
HERON D. H. 114
HERON DH 114
HILLER 12
HILLER 360
HS 748
HS-114
HS-125
HS-748
HU-16B
HU-16B ALBATROSS
HUGHES 269
HUGHES 269/300
HUGHES 300
HUGHES 300C
HUGHES 500
INVADER B-26
JETSTR. 31
JT 4A
JT4-9
JU 52
JU-52
JU52
L 188
L-1011

Klasse
L-188
L-188 EKECTRA
L-188 ELECTRA
L-382
LA 4
LA-4
LEAR JET
LIAR JET 23/24
LOCHEED 382B HERCULES
LOCKHEED 12
LOCKHEED L749A
LOCKHEED LODESTAR
LODESTAR
M\RKE
MERLIN IIIB
MH 260
MH-260
MU 2
MU-300
NA-265
NORD 260
NORD-260
NORSEMAN SJØFLY
OTTER AMFIBIEFLY
OTTER AMFIBIUM
OXFORD
OXFORD ANSON
P & W R-2800
P-T-PORTER
PA-23-250
PA-31-350
PC-6
PILATUS TURBO PORTER
PIPER AZTEC
R 2000
R-2000
R-2800
R-3350
RP RC-3 SEA*
S 235
S 90
S RALLYE
S-210

Klasse
S-210 B
S-55
S-58
S-58 T
S-58-T
S-58T
S-61
S-61 N
S-61N
S-62
S-90
SA 2
SA 315
SA 315B LAMA
SA 321
SA 330 G
SA 330 PUMA
SA-2
SA-20
SA-226
SA-227
SA-2A
SA-330
SA2
SANDRINGHAM
SB SF340
SC-7
SCANDIA
SCANDIA 590
SCANDIA S-90
SE 3130
SE-210
SE-210 CPO
SE-210-10 B
SE-210-10B
SEA KING
SEABEE
SEABEE AMF.
SEABEE AMFIBIUM
SEABEE GOOSE
SF 34
SF-340
SH 33

Klasse
SH 36
SH-7
SHORT SEALAND
SHORT SEALAND AMFIBIER
SHORT SEALAND AMFIBIUM
SIKORSKY 55
SIKORSKY S-55
SIKORSKY S-61
SM 333
SR TEAL AMF*
SR TEAL AMP*
SUNDERLAND
SUPER BROUSSARD
SW 51
SAAB 90A-2
T S2A PITTS
TEAL AMF.
TSC 1A2
TWIN OTTER
TWIN PIONEER
TWIN PIONER
TWIN-PIONEER
V.VISCOUNT
VC-10
VC-9
VERTOL 44
VICKERS VISCOUNT
VICKERS VISCOUT
VICOUNT
VISCOUNT
W S 51
W.S. 55
W.S.51
WALRUS SJØFLY
WIDGEON
WIDGEON
WS 51
WS 55
WS-55
YS-11

A list of synonyms was then prepared, and the names in the data base were changed accordingly. The list of synonyms is in *Table A.2*. Not all of these names appear in the final list of names (*Table 1*), and in some cases the names have been changed at later stages. However, it is believed that the below list can be of considerable help to others trying to identify aircraft codes in the future, which is the reason why it is included here in full.

Table A.2 "Synonym list"

Name used in the modified data base	Names found in the raw data base
1M LAND	1, 2A[2] 1-ENG 1-MOT LAND (A large number of codes starting with 1-M LAND)
1M SJØ	1M SJ\ 1-MOT SJØ AMFIBIUM (EN MOTORS) (A large number of codes starting with 1-M SJØ)
AB300	A 300 A-300 AIRBUS
B26	B-26
B720	B 720/707 B-707/720 B-720
B707	B-707
B727	B-727 BOING 727
B736	B 736
B737	B 737 B-737 BOING 737
B747	B 747 B-747 BOING 747
B767	B 767 B-767
BE10	BE-10
BE20	BE-20
BE90	BE 90 BE-90
BE99	BE99 BE-99
BE100	BE 100
BE200	BE 200 BE-200 BEECH 200
BE300	BE-300
BE1900	BE-1900
CARAVELLE	SE-210 SE-210 CPO SE-210-10 B SE-210-10B
CATALINA	CATALINA 28-5ACF CATALINA AMFIBIUM CATALINA PB Y-5A
CESS	C 500 C 501 C 551 C 650 C-185 AMF CESSNA C-206 AMF. C-208 C-240 C-46 C-46 R C-46C C-46R C-47 CESSNA 172 CESSNA 206 CESSNA 206 AFIBIUM CESSNA 402 CESSNA 404 CESSNA U-206
CESSNA CITATION	C-500
CESSNA-337	CESSNA 337 CESSNA-337

Name used in the modified data base	Names found in the raw data base
CONVAIR	CONVAIR 240 CONVAIR 440 CONVAIR-240 CONVAIR-990 CV-14 CV-240 CV-340 CV-340/440 CV-440 CV-46 CV-580 CV-990
CORON	
CURT	
DASH	DHC 7 DHC 8 DHC-7 DHC-8
DC3	DC-3
DC4	DC 4 DC-4
DC6	DC 6 DC-6 DC6 6B DC-6/6B DC-6/B DC-6A DC-6AB DC-6 AB DC-6 B DC-6 6B DC-6B
DC7	DC-7 DC-7B DC-7C
DC8	DC 8 DC-8 DC-8C
DC9	DC 9 DC-9
DC10	DC-10
DO228	DO 228 DO-228 DO-228-101/201 DO-228-201 DO-228-202 DO-228/201 DO-228/101
ELECTRA	L-188 L-188 EKECTRA L-188 ELECTRA
EMB-110/120	EMB-110 EMB-120 E EMB-120
FH227	FH 227 FH-227 FH-227B
FINNMARK FLYBÅT	5 A FINNMARK FLYBÅT 5A FINNMARK FLYB. FINNMARK AMFIBIER
FLER-M-SJØ	FLER-M SJ\ FLER-M SJØ
FOKK27	F 27 F-27 F-27-50 FK 27 FOKKER F 27
FOKK28	F-28 F28 FK 28
FOKK50	F-50 F 50 FOKKER 50
GRUMMAN	(A large number of codes beginning with GRUMMAN)
HEL	A-BELL 206A AB 205 AB 206 JET RANGER A-C-6-7 ALOUETTE ALOUETTE 2 ALOUETTE 3 ALOUETTE 3-315 AUGUSTA BELL 204 B BEKK 204 (A large number of codes starting with BELL) BO-105 (A large number of codes beginning with HUGHES) S 235 S 90 S-210 S-210B S-55 (A large number of codes beginning with S- and SA and SA-) S RALLYE SEA KING SH 33 SH 36 SIKORSKI 55 SIKORSKI S-55 SIKORSKI S-61
HERON	D H HERON DH 114 DH 114 HERON DH-114 HERON DH-114 DH-114-1B HERON 114 FLER-M LAND: DH-104 HERON HERON D H 114 HERON D. H. 114 HERON DH 114
HU16B	HU-16B HU-16B ALBATROSS
JET FALCON	DA 20 DA-20
JU52	JU 52 JU-52
LA4	LA 4 LA-4

Name used in the modified data base	Names found in the raw data base
LEAR-JET	LEAR JET LIAR JET 23/24
HERCULES	LOCHEED 382B HERCULES C-130 L-382
LOADSTAR	LOCKHEED LODESTAR
MD80	
MET	
MH260	MH 260 MH-260
NORD260	NORD 260 NORD-260
OTTER[1]	DHC-3 DHC-3 AMF. DHC-3-SEAPLAN DHC-6 DHC 6 OTTER AMFIBIEFLY OTTER AMFIBIUM TWIN OTTER DH OTTER AMPHIBIUM DH TWIN OTTER DH-OTR-AMF.
OXFORD	OXFORD ANSON
PILATUS-TURBO	P & W R-2800 P-T-PORTER PA-23-250 PA-31-350 PC-6 PILATUS TURBO PORTER
PIONEER	TWIN PIONEER TWIN PIONER TWIN-PIONEER
SCANDIA590	SCANDIA SCANDIA 590 SCANDIA S-90
SEABEE	SEABEE SEABEE AMF. SEABEE AMFIBIUM SEABEE GOOSE
SHORT-SEALAND	SHORT SEALAND SHORT SEALAND AMFIBIER SHORT SEALAND AMFIBIUM
SR-TEAL	SR TEAL AMF SR TEAL AMP TEAL AMF.
TRISTAR	L-1011
VICKERS-VISCOUNT	V.VISCOUNT VICKERS VISCOUNT VICKERS VISCOUT VICOUNT VISCOUNT
WIDGEON	WIDEGEON
WS51	W S 51 W.S.51 WS 51
WS55	W.S. 55 WS 55 WS-55

[1] At this time we were not aware of the difference between single-Otter (DHC-2 and DHC-3) and twin-Otter (DHC-6). For this reason some of these corrections had to be done over again at a later stage in the project.

[2] 2A should really have been in the class 2M LAND, which did not exist at that time. It would be time-consuming to search for the original 2A- cases, and not worth the cost, considering the infinitesimal impact a correction would have on the results of the study.

By replacing the many names in the right-hand column of *Table A.2* with the corresponding single name in the left-hand column, the number of codes in the data base was gradually, over the course of almost one year, reduced to 185.

In the meantime additional data had been entered into the data base. Based upon the status 1st March 1997, synonyms and/or typical cruise altitudes have been assigned. The list of additional synonyms is reproduced in *Table A.3*.

Table A.3 Additional "synonyms", March 1997

Name used in the final data base	Names found in the raw data base
2M LAND	2A 4A BN-2A LIGHT TWINS
CESSNA	C-150 C-172
CF-104	F-104 F-104/105
CITATION	C-550
FOKK 50	FK-50 FOKK 27-50
HERCULES	C-130
PIPER AZTEC	PIPER PA-23
PIPER CHEROKEE	CHEROKEE PA-28 PA-28/180
R-3350	R-3350-34
SAAB-340	SB-SF340
PIPER NAVAJO	NAVAJO PA-31

For many of the codes in the data base it was not clear what aircraft they referred to; even though the data had been taken from the registers of the Aviation Authority. In some cases the names/codes were simply misspelt, in other cases a number of very different names/codes were used for the same aircraft. And most of the names/codes are not known to the general public, or to any person not engaged in or particularly interested in aviation.

The next step was once more to enlist the assistance of experienced airline pilots, who assigned cruise altitudes to the different aircraft. Basis for this work was a list of aircraft types and codes from the data base as it looked on the 18 December 1995. *Table A.4* contains the codes as they appear on this list, along with clarifying information from the pilots, new code name adopted, and typical cruise altitudes. Some additional information has been added in March 1997.

The typical cruise altitudes were assigned by a number of different air pilots. Unfortunately, not knowing sufficiently well the purpose of the project, some of the altitudes specified were maximum altitudes for the aircraft rather than typical cruise altitudes. One more round through the material corrected this misunderstanding. This new round of evaluation, coordinated by copilot Peter Bull of Braathens SAFE and copilot Stein Gilhuus of SAS, assigned typical cruise altitudes to all aircraft types except some very few, that could not be identified. For these unidentified ones it was in some cases possible to choose an altitude group based upon other information on the same pilot; or the best possible guess was adopted. The resulting classification is given in *Table 1* of the main text, but also here, in *Table A.4*, in a somewhat different form.

Table A.4 Additional explanations/information, suggestion for new name/code, and suggested typical cruise altitude (not always the ones finally adopted).

Code	Explanation/information	New name/code	Altitude (feet), sometimes typical, sometimes maximum
1M LAND	A general code, meaning a small one-engine land airplane	1M LAND	4,000
1M SJØ	A general code, meaning a small one-engine sea airplane	1M SJØ	4,000
280C HELI	Helikopter	HEL	
2M LAND	A general code, meaning a small two-engine land airplane	2M LAND	10,000
3A	A general code, meaning a small three-engine airplane	3A	
4A	A general code, meaning a small four-engine land airplane	4A	
5B		5B	10,000
AB300		AB300	37,000
AC-50	FALCON-50	FALCON-50	
ALBATROSS	Military	ALBATROSS	8,000
AS 332	Helikopter	HEL	
AS 332 L2	"	HEL	
AS 355	"	HEL	
AS-350B	"	HEL	
AS-355	"	HEL	
AS-365	"	HEL	
ATR 42	(Avion de Transport Regional)	AIR42	20,000
AU AUSTER	Small sportsplane	AU AUSTER	10,000
B26	INVADER B-26	INVADER B-26	30,000
B707	Boeing	B707	39,000
B720	"	B720	39,000
B727	" (very similar to B737)	B727	
B736	This is wrong	B737	
B737	Boeing	B737	33,000
B747	" (Jumbo)	B747	37,000
B767	"	B767	42,000

Code	Explanation/information	New name/code	Altitude (feet), sometimes typical, sometimes maximum
BA31	British Aerospace 31 Jetstream	JETSTREAM	
BAC-1-11		BAC-1-11	30,000
BE10	BEECHCRAFT, error; is BE100	BE100	25,000
BE20	" , error; is BE200	BE200	30,000
BE90	"	BE90	30,000
BE99	"	BE99	25,000
BE100	"	BE100	25,000
BE200	"	BE200	30,000
BE300	"	BE300	
BE1900	"	BE1900	25,000
BEECH 200	"	BE200	30,000
BEECHCRAFT-2	"	BEECHCRAFT-2	
BH-412		BH-412	
BK117	Helikopter	HEL	
BO 105C	"	HEL	
BOING VERTOL 234	" (Shall be Boeing, of course) (VERTOL means vertical takeoff and landing)	HEL	
BRISTOL 171 B		BRISTOL 171 B	
BV-234	Helikopter (Same as Boeing Vertol 234)	HEL	
C 208TP		CESSNA	
C 337		CESSNA	
C 406		CESSNA	
C 46		CURTISS	10,000
C-119	Military	C-119	8,000
C-177		CESSNA	
C-402		CESSNA	
C-440		CESSNA	
C-441		CESSNA	33,000
C-501		CESSNA	

Code	Explanation/information	New name/code	Altitude (feet), sometimes typical, sometimes maximum
C-54		CESSNA	
C-550	Cessna Citation	CITATION	
C-551		CESSNA	
C-560		CESSNA	
C.46 R		CURTISS	
CARAVELLE		CARAVELLE	33,000
CARVAIR ATL-98		-	
CATALINA		CATALINA	10,000
CATALINA 28-5ACF		CATALINA	10,000
CE-337		CESSNA	
CE-550	Cessna Citation	CITATION	
CESS		CESSNA	20,000
CESSNA CITATION		CITATION	40,000
CESSNA F-406		CESSNA	
CESSNA337		CESSNA	20,000
CF-104	Starfighter fighterplane	CF-104	30,000
CL-600	Canadair Challenger	CF-104	35,000
COMET 4		COMET 4	35,000
CONSOLIDATED PBY		CONSOLIDATED PBY	10,000
CONSTELLATION		CONSTELLATION	25,000
CONVAIR-14, CONVAIR-46, CONVAIR-240, CONVAIR-340,	As Metropolitan	METROPOLITAN	
CONVAIR-440	Metropolitan	METROPOLITAN	
CONVAIR-580		CONVAIR-580	20,000
CONVAIR-990	Coronado	CORONADO	30,000
D-8		DASH	20,000
DASH		DASH	20,000
DC10		DC10	40,000
DC3		DC3	10,000
DC4		DC4	10,000

Code	Explanation/information	New name/code	Altitude (feet), sometimes typical, sometimes maximum
DC6		DC6	25,000
DC7		DC7	25,000
DC8		DC8	35,000
DC9		DC9	37,000
DH-100	Private fighter VAMPIRE, used for shows only	Removed from the data base	-
DHC-2	DHC Canada Turbo-Beaver Used in agriculture	DHC-2	10,000
DHC-2 AMF.	DHC Canada Turbo-Beaver	DHC-2	10,000
DO228		DO228	10,000
ELECTRA		ELECTRA	
EMB-110/120	Embraer Bandeirante (110) and Araguaia (120)	EMB-110/120	24,000
ENSTRØM 280	Helikopter	HEL	
F-5	Military	F-5	20,000
F-28 ENSTR.	"	HEL	
F-28 HELI	"	HEL	
FA SA226	Swearinger Metro	FA SA226	22,000
FAIRCHILD CORNELL		FAIRCHILD CORNELL	8,000
FAN JET FALCON DA-20		JET FALCON	
FH-1100		FH-1100	
FH227	Fokker 27 (Friendship)	FOKK27	
FINNMARK FLYBÅT		FINNMARK FLYBÅT	10,000
FK 50	Fokker 50	FOKK50	
FLER-M LAND	Group notation for three or more engines land-plane	FLER-M LAND	
FLER-M SJØ	Group notation for three or more engines sea-plane	FLER-M SJØ	
FOKK27	Fokker 27	FOKK27	25,000
FOKK28	Fokker 28	FOKK28	28,000
FOKK50	Fokker 50	FOKK50	
G-1159	Gulfstream	G-1159	40,000
GRUMMAN	Many different military airplanes	GRUMMAN	10,000

Code	Explanation/information	New name/code	Altitude (feet), sometimes typical, sometimes maximum
HAWKER SIDDELEY 748		HAWKER SIDDELEY 748	33,000
HEL		HEL	
HERCULES		HERCULES	25,000
HERON		HERON	10,000
HERON DH 114		HERON	10,000
HILLER 12	Helikopter	HEL	
HILLER 12C	"	HEL	
HILLER 360	"	HEL	
HILLER 360UH 12	"	HEL	
HS 748	Hawker Siddeley	HAWKER SIDDELEY 748	25,000
HS-114	Hawker Siddeley	HERON	
HS-125	Hawker Siddeley	HS-125	41,000
HS-748	Hawker Siddeley	HAWKER SIDDELEY 748	25,000
HU16B	Grumman Albatross	GRUMMAN	10,000
INVADER B-26		INVADER B-26	30,000
JET FALCON		JET FALCON	33,000
JETSTR.31		JETSTREAM	20,000
JT-4	JT means Jet Trainer	JT-4	
JT-4A	"	JT-4A	
JT4-9	"	JT4-9	
JU52	Junkers	JU52	10,000
LA4	Lake LA-4 Buccaneer	LA4	10,000
LEAR-JET		LEAR-JET	40,000
LOCKHEED 12		LOCKHEED 12	40,000
LOCKHEED L749A	Constellation	LOCKHEED L749A	
LODESTAR	Mis-spelt	LOADSTAR	
MRKE	An error	Is removed from the data file	
MBB BK-117	Helikopter	HEL	
MD 520N	Helikopter	HEL	
MERLIN IIIB		MERLIN IIIB	25,000

Code	Explanation/information	New name/code	Altitude (feet), sometimes typical, sometimes maximum
MH260		MH260	
MU 2	Mitsubishi	MU2	20,000
MU-300	Mitsubishi	MU-300	41,000
NA-265	Sabreliner	NA-265	
NORD260	(French transport aircraft)	NORD260	25,000
NORSEMAN SJØFLY	Sea airplane	NORSEMAN SJØFLY	10,000
OTTER	This grouping was wrong. The group has been subdivided	SINGLE OTTER TWIN OTTER	
OXFORD		OXFORD	10,000
PILATUS-TURBO		PILATUS-TURBO	10,000
PIONEER		PIONEER	
PIPER AZTEC		PIPER AZTEC	10,000
PIPER CHEROKEE		PIPER CHEROKEE	10,000
PIPER NAVAJO		PIPER NAVAJO	10,000
PUMA SA-330	Helikopter	HEL	
R 2000		R 2000	
R 22		R 22	
R-2000	Robin sportsplane	R-2000	
R-2800	Robin sportsplane?	R-2800	
R-3350	Robin sportsplane?	R-3350	
RP RC-3 SEA	Sea airplane	RPRC-3 SEA	
SB SF340	Saab-340	SAAB-340	20,000
SC-7		SC-7	20,000
SCANDIA590	(Swedish)	SCANDIA590	
SE 3130	Helikopter	HEL	
SE ALOUETTE	Helikopter	HEL	
SEABEE		SEABEE	6,000
SF 34	(SF stands for Saab-Fairchild, a cooperation product)	SAAB-340	20,000
SF-340		SAAB-340	20,000
SH-7	Shorts Skyland	SH-7	

Code	Explanation/information	New name/code	Altitude (feet), sometimes typical, sometimes maximum
SHORT-SEALAND	A group name	SHORT-SEALAND	10,000
SM 333		SM 333	
SR-TEAL		SR-TEAL	10,000
SUNDERLAND		SUNDERLAND	10,000
SUPER BROUSSARD		SUPER BROUSSARD	
SW 51		SW 51	
SAAB 90A-2		SAAB 90A-2	
T S2A PITTS		T S2A PITTS	5,000
TRISTAR		TRISTAR	35,000
TSC 1A2	Teal II Schweitzer	TSC 1A2	
UH-12	Helikopter (Hiller)	UH-12	
VC-10		VC-10	35,000
VC-9	We have not been able to identify this aircraft. A misspelling?	VC-10	
VERTOL 44	Vertical take-off and landing	VERTOL 44	10,000
VICKERS-VISCOUNT		VICKERS-VISCOUNT	25,000
W.S.551/?		WS55	
WALRUS SJØFLY	Sea airplane	WALRUS SJØFLY	10,000
WIDGEON		WIDGEON	10,000
WS51		WS51	
WS55		WS55	
YS-11		YS-11	

EKSPERIMENTANALYSE
Data Production and Evaluation
EKSPERIMENTSYSTEMER
Test Rig Design and Production
EKSPERIMENTTEKNIKK
Experiment Engineering
ENERGISYSTEMER
Energy Systems
FYSIKK
Physics
ISOTOPLABORATORIENE
Isotope Laboratories
KONTROLLROMSSYSTEMER
Control Room Systems

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MILJØ- OG STRÅLEVERN
Health and Safety
PROSESSIMULERING
Process Simulation
REAKTORDRIFT
Reactor operation
RESERVOAR- OG LETETEKNOLOGI
Reservoir and Exploration Technology
SIMULERING OG SYSTEMUTVIKLING
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The Institute`s annual turnover is approx. NOK 390 million.

The total number of employees is approx. 580 (1997). In addition 12-15 foreign scientists attached to the Halden project.

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