Section 3 - Mass and balance

Chapter 1 – Motor-powered aircraft

AMC1 CAT.POL.MAB.100(b)   Mass and balance, loading

WEIGHING OF AN AIRCRAFT

(a)   New aircraft that have been weighed at the factory may be placed into operation without reweighing if the mass and balance records have been adjusted for alterations or modifications to the aircraft. Aircraft transferred from one EU operator to another EU operator do not have to be weighed prior to use by the receiving operator, unless more than 4 years have elapsed since the last weighing.

(b)   The mass and centre of gravity (CG) position of an aircraft should be revised whenever the cumulative changes to the dry operating mass exceed ±0.5 % of the maximum landing mass or for aeroplanes the cumulative change in CG position exceeds 0.5 % of the mean aerodynamic chord. This may be done by weighing the aircraft or by calculation.

(c)   When weighing an aircraft, normal precautions should be taken consistent with good practices such as:

   (1)   checking for completeness of the aircraft and equipment;

   (2)   determining that fluids are properly accounted for;

   (3)   ensuring that the aircraft is clean; and

   (4)   ensuring that weighing is accomplished in an enclosed building.

(d)   Any equipment used for weighing should be properly calibrated, zeroed, and used in accordance with the manufacturer's instructions. Each scale should be calibrated either by the manufacturer, by a civil department of weights and measures or by an appropriately authorized organisation within two years or within a time period defined by the manufacturer of the weighing equipment, whichever is less. The equipment should enable the mass of the aircraft to be established accurately. One single accuracy criterion for weighing equipment cannot be given. However, the weighing accuracy is considered satisfactory if the accuracy criteria in Table1 are met by the individual scales/cells of the weighing equipment used:

Table 1: Accuracy criteria for weighing equipment

For a scale/cell load	An accuracy of
below 2 000 kg	±1 %
from 2 000 kg to 20 000 kg	±20 kg
from 2 000 kg to 20 000 kg	±0·1 %

AMC2 CAT.POL.MAB.100(b)   Mass and balance, loading

FLEET MASS AND CG POSITION – AEROPLANES

(a) For a group of aeroplanes of the same model and configuration, an average dry operating mass and CG position may be used as the fleet mass and CG position, provided that:

  (1) the dry operating mass of an individual aeroplane does not differ by more than ±0.5 % of the maximum structural landing mass from the established dry operating fleet mass; or

  (2) the CG position of an individual aeroplane does not differ by more than ±0.5 % of the mean aerodynamic chord from the established fleet CG.

(b) The operator should verify that, after an equipment or configuration change or after weighing, the aeroplane falls within the tolerances above.

(c) To add an aeroplane to a fleet operated with fleet values, the operator should verify by weighing or calculation that its actual values fall within the tolerances specified in (a)(1) and (2).

(d) To obtain fleet values, the operator should weigh, in the period between two fleet mass evaluations, a certain number of aeroplanes as specified in Table 1, where 'n' is the number of aeroplanes in the fleet using fleet values. Those aeroplanes in the fleet that have not been weighed for the longest time should be selected first.

Table 1: Minimum number of weighings to obtain fleet values

Number of aeroplanes in the fleet	Minimum number of weighings
2 or 3	n
4 to 9	(n + 3)/2
10 or more	(n + 51)/10

(e) The interval between two fleet mass evaluations should not exceed 48 months.

(f) The fleet values should be updated at least at the end of each fleet mass evaluation.

(g) Aeroplanes that have not been weighed since the last fleet mass evaluation may be kept in a fleet operated with fleet values, provided that the individual values are revised by calculation and stay within the tolerances above. If these individual values no longer fall within the tolerances, the operator should determine new fleet values or operate aeroplanes not falling within the limits with their individual values.

(h) If an individual aeroplane mass is within the dry operating fleet mass tolerance but its CG position exceeds the tolerance, the aeroplane may be operated under the applicable dry operating fleet mass but with an individual CG position.

(i) Aeroplanes for which no mean aerodynamic chord has been published should be operated with their individual mass and CG position values. They may be operated under the dry operating fleet mass and CG position, provided that a risk assessment has been completed.

AMC3 CAT.POL.MAB.100(b)   Mass and balance, loading

CENTRE OF GRAVITY LIMITS – OPERATIONAL CG ENVELOPE AND IN-FLIGHT CG

In the Certificate Limitations section of the AFM, forward and aft CG limits are specified. These limits ensure that the certification stability and control criteria are met throughout the whole flight and allow the proper trim setting for take-off. The operator should ensure that these limits are respected by:

(a)   Defining and applying operational margins to the certified CG envelope in order to compensate for the following deviations and errors:

(1)   Deviations of actual CG at empty or operating mass from published values due, for example, to weighing errors, unaccounted modifications and/or equipment variations.

(2)   Deviations in fuel distribution in tanks from the applicable schedule.

(3)   Deviations in the distribution of baggage and cargo in the various compartments as compared with the assumed load distribution as well as inaccuracies in the actual mass of baggage and cargo.

(4)   Deviations in actual passenger seating from the seating distribution assumed when preparing the mass and balance documentation. Large CG errors may occur when 'free seating', i.e. freedom of passengers to select any seat when entering the aircraft, is permitted. Although in most cases reasonably even longitudinal passenger seating can be expected, there is a risk of an extreme forward or aft seat selection causing very large and unacceptable CG errors, assuming that the balance calculation is done on the basis of an assumed even distribution. The largest errors may occur at a load factor of approximately 50% if all passengers are seated in either the forward or aft half of the cabin. Statistical analysis indicates that the risk of such extreme seating adversely affecting the CG is greatest on small aircraft.

(5)   Deviations of the actual CG of cargo and passenger load within individual cargo compartments or cabin sections from the normally assumed mid position.

(6)   Deviations of the CG caused by gear and flap positions and by application of the prescribed fuel usage procedure, unless already covered by the certified limits.

(7)   Deviations caused by in-flight movement of cabin crew, galley equipment and passengers.

(8)   On small aeroplanes, deviations caused by the difference between actual passenger masses and standard passenger masses when such masses are used.

(b)   Defining and applying operational procedures in order to:

(1)   ensure an even distribution of passengers in the cabin;

(2)   take into account any significant CG travel during flight caused by passenger/crew movement; and

(3)   take into account any significant CG travel during flight caused by fuel consumption/transfer.

AMC1 CAT.POL.MAB.100(d)   Mass and balance, loading

DRY OPERATING MASS

The dry operating mass includes:

(a)   crew and crew baggage;

(b)   catering and removable passenger service equipment; and

(c)   tank water and lavatory chemicals.

AMC2 CAT.POL.MAB.100(d)   Mass and balance, loading

MASS VALUES FOR CREW MEMBERS

(a)   The operator should use the following mass values for crew to determine the dry operating mass:

   (1)   actual masses including any crew baggage; or

   (2)   standard masses, including hand baggage, of 85 kg for flight crew/technical crew members and 75 kg for cabin crew members.

(b)   The operator should correct the dry operating mass to account for any additional baggage. The position of this additional baggage should be accounted for when establishing the centre of gravity of the aeroplane.

AMC1 CAT.POL.MAB.100(e)   Mass and balance, loading

MASS VALUES FOR PASSENGERS AND BAGGAGE

(a)   When the number of passenger seats available is:

   (1)   less than 10 for aeroplanes; or

   (2)   less than 6 for helicopters,

   passenger mass may be calculated on the basis of a statement by, or on behalf of, each passenger, adding to it a predetermined mass to account for hand baggage and clothing.

   The predetermined mass for hand baggage and clothing should be established by the operator on the basis of studies relevant to his particular operation. In any case, it should not be less than:

   (1)   4 kg for clothing; and

   (2)   6 kg for hand baggage.

   The passengers' stated mass and the mass of passengers' clothing and hand baggage should be checked prior to boarding and adjusted, if necessary. The operator should establish a procedure in the operations manual when to select actual or standard masses and the procedure to be followed when using verbal statements.

(b)   When determining the actual mass by weighing, passengers' personal belongings and hand baggage should be included. Such weighing should be conducted immediately prior to boarding the aircraft.

(c)   When determining the mass of passengers by using standard mass values, the standard mass values in Tables 1 and 2 below should be used. The standard masses

include hand baggage and the mass of any infant carried by an adult on one passenger seat. Infants occupying separate passenger seats should be considered as children for the purpose of this AMC. When the total number of passenger seats available on an aircraft is 20 or more, the standard masses for males and females in Table 1 should be used. As an alternative, in cases where the total number of passenger seats available is 30 or more, the 'All Adult' mass values in Table 1 may be used.

Table 1: Standard masses for passengers – aircraft with a total number of passenger seats of 20 or more

Passenger seats:	20 and more		30 and more
	Male	Female	All adult
All flights except holiday charters	88 kg	70 kg	84 kg
Holiday charters*	83 kg	69 kg	76 kg
Children	35 kg	35 kg	35 kg

* Holiday charter means a charter flight that is part of a holiday travel package. On such flights the entire passenger capacity is hired by one or more charterer(s) for the carriage of passengers who are travelling, all or in part by air, on a round- or circle-trip basis for holiday purposes. The holiday charter mass values apply provided that not more than 5 % of passenger seats installed in the aircraft are used for the non-revenue carriage of certain categories of passengers. Categories of passengers such as company personnel, tour operators' staff, representatives of the press, authority officials etc. can be included within the 5% without negating the use of holiday charter mass values.

Table 2: Standard masses for passengers – aircraft with a total number of passenger seats of 19 or less

Passenger seats:	1 - 5	6 - 9	10 - 19
Male	104 kg	96 kg	92 kg
Female	86 kg	78 kg	74 kg
Children	35 kg	35 kg	35 kg

(1) On aeroplane flights with 19 passenger seats or less and all helicopter flights where no hand baggage is carried in the cabin or where hand baggage is accounted for separately, 6 kg may be deducted from male and female masses in Table 2. Articles such as an overcoat, an umbrella, a small handbag or purse, reading material or a small camera are not considered as hand baggage.

(2) For helicopter operations in which a survival suit is provided to passengers, 3 kg should be added to the passenger mass value.

(d) Mass values for baggage

(1) Aeroplanes. When the total number of passenger seats available on the aeroplane is 20 or more, the standard mass values for checked baggage of Table 3 should be used.

(2) Helicopters. When the total number of passenger seats available on the helicopters is 20 or more, the standard mass value for checked baggage should be 13 kg.

(3) For aircraft with 19 passenger seats or less, the actual mass of checked baggage should be determined by weighing.

Table 3: Standard masses for baggage – aeroplanes with a total number of passenger seats of 20 or more

Type of flight	Baggage standard mass
Domestic	11 kg
Within the European region	13 kg
Intercontinental	15 kg
All other	13 kg

(4) For the purpose of Table 3:

  (i) domestic flight means a flight with origin and destination within the borders of one State;

  (ii) flights within the European region mean flights, other than domestic flights, whose origin and destination are within the area specified in (d)(5); and

  (iii) intercontinental flight means flights beyond the European region with origin and destination in different continents.

(5) Flights within the European region are flights conducted within the following area:

  – N7200 E04500

  – N4000 E04500

  – N3500 E03700

  – N3000 E03700

  – N3000 W00600

  – N2700 W00900

  – N2700 W03000

  – N6700 W03000

  – N7200 W01000

  – N7200 E04500

  as depicted in Figure 1.

Figure 1: The European region
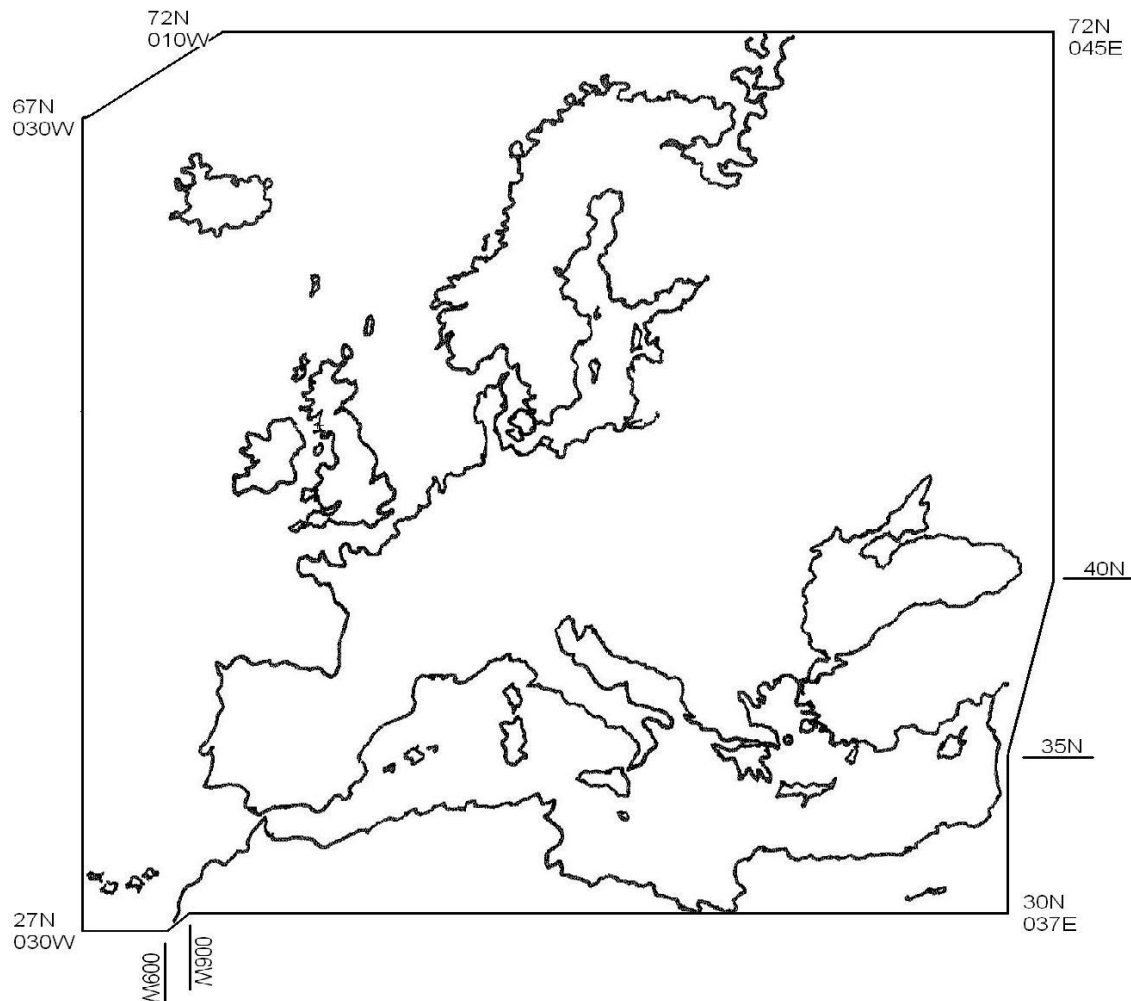
(f) Other standard masses may be used provided they are calculated on the basis of a detailed weighing survey plan and a reliable statistical analysis method is applied. The operator should advise the competent authority about the intent of the passenger weighing survey and explain the survey plan in general terms. The revised standard mass values should only be used in circumstances comparable with those under which the survey was conducted. Where the revised standard masses exceed those in Tables 1, 2 and 3 of, then such higher values should be used.

(g) On any flight identified as carrying a significant number of passengers whose masses, including hand baggage, are expected to significantly deviate from the standard passenger mass, the operator should determine the actual mass of such passengers by weighing or by adding an adequate mass increment.

(h) If standard mass values for checked baggage are used and a significant number of passengers checked baggage is expected to significantly deviate from the standard baggage mass, the operator should determine the actual mass of such baggage by weighing or by adding an adequate mass increment.

AMC2 CAT.POL.MAB.100(e)   Mass and balance, loading

PROCEDURE FOR ESTABLISHING REVISED STANDARD MASS VALUES FOR PASSENGERS AND BAGGAGE

(a)   Passengers

(1)   Weight sampling method. The average mass of passengers and their hand baggage should be determined by weighing, taking random samples. The selection of random samples should by nature and extent be representative of the passenger volume, considering the type of operation, the frequency of flights on various routes, in/outbound flights, applicable season and seat capacity of the aircraft.

(2)   Sample size. The survey plan should cover the weighing of at least the greatest of:

(i)   a number of passengers calculated from a pilot sample, using normal statistical procedures and based on a relative confidence range (accuracy) of 1 % for all adult and 2 % for separate male and female average masses; and

(ii)   for aircraft:

(A)   with a passenger seating capacity of 40 or more, a total of 2 000 passengers; or

(B)   with a passenger seating capacity of less than 40, a total number of 50 multiplied by the passenger seating capacity.

(3)   Passenger masses. Passenger masses should include the mass of the passengers' belongings that are carried when entering the aircraft. When taking random samples of passenger masses, infants should be weighted together with the accompanying adult.

(4)   Weighing location. The location for the weighing of passengers should be selected as close as possible to the aircraft, at a point where a change in the passenger mass by disposing of or by acquiring more personal belongings is unlikely to occur before the passengers board the aircraft.

(5)   Weighing machine. The weighing machine used for passenger weighing should have a capacity of at least 150 kg. The mass should be displayed at minimum graduations of 500 g. The weighing machine should have an accuracy of at least 0.5 % or 200 g, whichever is greater.

(6)   Recording of mass values. For each flight included in the survey the mass of the passengers, the corresponding passenger category (i.e. male / female / children) and the flight number should be recorded.

(b)   Checked baggage. The statistical procedure for determining revised standard baggage mass values based on average baggage masses of the minimum required sample size should comply with (a)(1) and (a)(2). For baggage, the relative confidence range (accuracy) should amount to 1 %. A minimum of 2 000 pieces of checked baggage should be weighed.

(c)   Determination of revised standard mass values for passengers and checked baggage.

(1)   To ensure that, in preference to the use of actual masses determined by weighing, the use of revised standard mass values for passengers and checked baggage does not adversely affect operational safety, a statistical analysis should be carried out. Such an analysis should generate average mass values for passengers and baggage as well as other data.

(2)   On aircraft with 20 or more passenger seats, these averages apply as revised standard male and female mass values.

(3)   On aircraft with 19 passenger seats or less, the increments in Table 1 should be added to the average passenger mass to obtain the revised standard mass values:

Table 1: Increments for revised standard masses values

Number of passenger seats	Required mass increment
1 – 5 incl.	16 kg
6 – 9 incl.	8 kg
10 – 19 incl.	4 kg

Alternatively, all adult revised standard (average) mass values may be applied on aircraft with 30 or more passenger seats. Revised standard (average) checked baggage mass values are applicable to aircraft with 20 or more passenger seats.

(4) The revised standard masses should be reviewed at intervals not exceeding 5 years.

(5) All adult revised standard mass values should be based on a male/female ratio of 80/20 in respect of all flights except holiday charters that are 50/50. A different ratio on specific routes or flights may be used, provided supporting data shows that the alternative male/female ratio is conservative and covers at least 84 % of the actual male/female ratios on a sample of at least 100 representative flights.

(6) The resulting average mass values should be rounded to the nearest whole number in kg. Checked baggage mass values should be rounded to the nearest 0.5 kg figure, as appropriate.

(7) When operating on similar routes or networks, operators may pool their weighing surveys provided that in addition to the joint weighing survey results, results from individual operators participating in the joint survey are separately indicated in order to validate the joint survey results.

GM1 CAT.POL.MAB.100(e)   Mass and balance, loading

ADJUSTMENT OF STANDARD MASSES

When standard mass values are used, AMC1 CAT.POL.MAB.100(d) item (g) states that the operator should identify and adjust the passenger and checked baggage masses in cases where significant numbers of passengers or quantities of baggage are suspected of significantly deviating from the standard values. Therefore the operations manual should contain instructions to ensure that:

(a) check-in, operations and cabin staff and loading personnel report or take appropriate action when a flight is identified as carrying a significant number of passengers whose masses, including hand baggage, are expected to significantly deviate from the standard passenger mass, and/or groups of passengers carrying exceptionally heavy baggage (e.g. military personnel or sports teams); and

(b) on small aircraft, where the risks of overload and/or CG errors are the greatest, pilots pay special attention to the load and its distribution and make proper adjustments.

GM2 CAT.POL.MAB.100(e)   Mass and Balance, Loading

STATISTICAL EVALUATION OF PASSENGERS AND BAGGAGE DATA

(a)   Sample size.

    (1)   For calculating the required sample size it is necessary to make an estimate of the standard deviation on the basis of standard deviations calculated for similar populations or for preliminary surveys. The precision of a sample estimate is calculated for 95 % reliability or 'significance', i.e. there is a 95 % probability that the true value falls within the specified confidence interval around the estimated value. This standard deviation value is also used for calculating the standard passenger mass.

    (2)   As a consequence, for the parameters of mass distribution, i.e. mean and standard deviation, three cases have to be distinguished:

        (i) μ, σ = the true values of the average passenger mass and standard deviation, which are unknown and which are to be estimated by weighing passenger samples.

        (ii) μ', σ' = the 'a priori' estimates of the average passenger mass and the standard deviation, i.e. values resulting from an earlier survey, which are needed to determine the current sample size.

        (iii) $\bar{x}$, s = the estimates for the current true values of m and s, calculated from the sample.

        The sample size can then be calculated using the following formula:

$$n \geq \frac{(1.96 * \sigma' * 100)^2}{(e'_r * \mu')^2}$$

        where:

        n = number of passengers to be weighed (sample size)

        e'_r = allowed relative confidence range (accuracy) for the estimate of μ by $\bar{x}$ (see also equation in (c)). The allowed relative confidence range specifies the accuracy to be achieved when estimating the true mean. For example, if it is proposed to estimate the true mean to within ± 1 %, then e'_r will be 1 in the above formula.

        1.96 = value from the Gaussian distribution for 95 % significance level of the resulting confidence interval.

(b)   Calculation of average mass and standard deviation. If the sample of passengers weighed is drawn at random, then the arithmetic mean of the sample ($\bar{x}$) is an unbiased estimate of the true average mass (μ) of the population.

    (1)   Arithmetic mean of sample where:

$$\bar{x} = \frac{\sum_{j=1}^{n} x_j}{n}$$

        x_j = mass values of individual passengers (sampling units).

(2)   Standard deviation where:

$$s = \sqrt{\dfrac{\sum\limits_{j=1}^{n}(x_j - \bar{x})^2}{n-1}}$$

  x_j- = =deviation of the individual value from the sample mean.

(c) Checking the accuracy of the sample mean. The accuracy (confidence range) which can be ascribed to the sample mean as an indicator of the true mean is a function of the standard deviation of the sample which has to be checked after the sample has been evaluated. This is done using the formula:

$$e_r = \dfrac{1 \cdot 96 * s * 100}{\sqrt{n} * \bar{x}} \, (\%)$$

whereby e_r should not exceed 1 % for an all adult average mass and 2 % for an average male and/or female mass. The result of this calculation gives the relative accuracy of the estimate of µ at the 95 % significance level. This means that with 95 % probability, the true average mass µ lies within the interval:

$$\bar{x} \pm \dfrac{1 \cdot 96 * s}{\sqrt{n}}$$

(d) Example of determination of the required sample size and average passenger mass

 (1) Introduction. Standard passenger mass values for mass and balance purposes require passenger weighing programs be carried out. The following example shows the various steps required for establishing the sample size and evaluating the sample data. It is provided primarily for those who are not well versed in statistical computations. All mass figures used throughout the example are entirely fictitious.

 (2) Determination of required sample size. For calculating the required sample size, estimates of the standard (average) passenger mass and the standard deviation are needed. The 'a priori' estimates from an earlier survey may be used for this purpose. If such estimates are not available, a small representative sample of about 100 passengers should be weighed so that the required values can be calculated. The latter has been assumed for the example.

   Step 1: Estimated average passenger mass.

n	x_j (kg)
1	79.9
2	68.1
3	77.9
4	74.5
5	54.1
6	$\bar{x}$ 62.2
7	89.3
8	108.7
.	.

85	63.2
86	75.4
$\displaystyle\sum_{j=1}^{86}$	6 071.6

$$\mu' \;=\; \bar{x} = \frac{\sum x_j}{n} \;=\; \frac{6071.6}{86}$$

$$= 70.6 \text{ kg}$$

Step 2:   Estimated standard deviation.

n	x_j	$(x_j - x)$	$(x_j - x)^2$
1	79.9	+9.3	86.49
2	68.1	−2.5	6.25
3	77.9	+7.3	53.29
4	74.5	+3.9	15.21
5	54.1	−16.5	272.25
6	62.2	−8.4	70.56
7	89.3	+18.7	349.69
8	108.7	+38.1	1 451.61
.	.	.	.
85	63.2	−7.4	54.76
86	75.4	−4.8	23.04
$\sum_{j=1}^{86}$	6071.6		34 683.40

$$\sigma' = \sqrt{\frac{\sum (x_j - \bar{x})^2}{n-1}}$$

$$\sigma' = \sqrt{\frac{34\ 683.40}{86-1}}$$

$$\sigma' = 20.20 \text{ kg}$$

Step 3:   Required sample size.

The required number of passengers to be weighed should be such that the confidence range, e'_r, does not exceed 1 % as specified in (c).

$$n \geq \frac{(1.96 * \sigma' * 100)^2}{(e'_r * \mu')^2}$$

$$n \geq \frac{(1.96 * 20.20 * 100)^2}{(1 * 70.6)^2}$$

$$n \geq 3145$$

The result shows that at least 3 145 passengers should be weighed to achieve the required accuracy. If e'_r is chosen as 2 % the result would be n ≥786.

Step 4:   After having established the required sample size a plan for weighing the passengers is to be worked out.

(3)   Determination of the passenger average mass

Step 1:   Having collected the required number of passenger mass values, the average passenger mass can be calculated. For the purpose of this example it has been assumed that 3 180 passengers were weighed. The sum of the individual masses amounts to 231 186.2 kg.

$$n = 3\,180$$

$$\sum_{j-1}^{3180} X_j = 231\,186 \cdot 2 \quad kg$$

$$\bar{x} = \frac{\sum X_j}{n} = \frac{231186 \cdot 2}{3180} \quad kg$$

$$\bar{x} = 72 \cdot 7 \quad kg$$

Step 2:   Calculation of the standard deviation.

For calculating the standard deviation the method shown in paragraph (2) step 2 should be applied.

$$\sum (x_j - \bar{x})^2 = 745\,145 \cdot 20$$

$$s = \sqrt{\frac{\sum (x_j - \bar{x})^2}{n-1}}$$

$$s = \sqrt{\frac{745\,145 \cdot 20}{3180 - 1}}$$

$$s = 15.31 \quad kg$$

Step 3:   Calculation of the accuracy of the sample mean.

$$e_r = \frac{1.96 * s * 100}{\sqrt{n} * \bar{x}} \%$$

$$e_r = \frac{1.96 * 15.31 * 100}{\sqrt{3180} * 72.7} \%$$

$e_r = 0.73 \%$

Step 4:   Calculation of the confidence range of the sample mean.

$$\bar{x} \pm \frac{1.96 * s}{\sqrt{n}}$$

$$\bar{x} \pm \frac{1.96 * 15.31}{\sqrt{3180}} \ kg$$

72.7 ± 0.5 kg

The result of this calculation shows that there is a 95 % probability of the actual mean for all passengers lying within the range 72.2 kg to 73.2 kg.

GM3 CAT.POL.MAB.100(e)   Mass and balance, loading

GUIDANCE ON PASSENGER WEIGHING SURVEYS

(a)   Detailed survey plan.

(1)   The operator should establish and submit to the competent authority a detailed weighing survey plan that is fully representative of the operation, i.e. the network or route under consideration and the survey should involve the weighing of an adequate number of passengers.

(2)   A representative survey plan means a weighing plan specified in terms of weighing locations, dates and flight numbers giving a reasonable reflection of the operator's timetable and/or area of operation.

(3)   The minimum number of passengers to be weighed is the highest of the following:

(i)   The number that follows from the means of compliance that the sample should be representative of the total operation to which the results will be applied; this will often prove to be the overriding requirement.

(ii)   The number that follows from the statistical requirement specifying the accuracy of the resulting mean values, which should be at least 2 % for male and female standard masses and 1 % for all adult standard masses, where applicable. The required sample size can be estimated on the basis of a pilot sample (at least 100 passengers) or from a previous survey. If analysis of the results of the survey indicates that the requirements on the accuracy of the mean values for male or female standard masses or all adult standard masses, as applicable, are not met, an additional number of representative passengers should be weighed in order to satisfy the statistical requirements.

(4)   To avoid unrealistically small samples a minimum sample size of 2 000 passengers (males + females) is also required, except for small aircraft where in view of the burden of the large number of flights to be weighed to cover 2 000 passengers, a lesser number is considered acceptable.

(b)   Execution of weighing programme.

(1)   At the beginning of the weighing programme it is important to note, and to account for, the data requirements of the weighing survey report (see (e)).

(2)   As far as is practicable, the weighing programme should be conducted in accordance with the specified survey plan.

(3)   Passengers and all their personal belongings should be weighed as close as possible to the boarding point and the mass, as well as the associated passenger category (male/female/child), should be recorded.

(c)   Analysis of results of weighing survey. The data of the weighing survey should be analysed as explained in this GM. To obtain an insight to variations per flight, per route etc. this analysis should be carried out in several stages, i.e. by flight, by route, by area, inbound/outbound, etc. Significant deviations from the weighing survey plan should be explained as well as their possible effect(s) on the results.

(d)   Results of the weighing survey

(1)   The results of the weighing survey should be summarised. Conclusions and any proposed deviations from published standard mass values should be justified. The results of a passenger weighing survey are average masses for passengers, including hand baggage, which may lead to proposals to adjust the standard mass values given in AMC1 CAT.POL.MAB.100(e) Tables 1 and 2. These averages, rounded to the nearest whole number may, in principle, be applied as standard mass values for males and females on aircraft with 20 or more passenger seats. Because of variations in actual passenger masses, the total passenger load also varies and statistical analysis indicates that the risk of a significant overload becomes unacceptable for aircraft with less than 20 seats. This is the reason for passenger mass increments on small aircraft.

(2)   The average masses of males and females differ by some 15 kg or more. Because of uncertainties in the male/female ratio the variation of the total passenger load is greater if all adult standard masses are used than when using separate male and female standard masses. Statistical analysis indicates that the use of all adult standard mass values should be limited to aircraft with 30 passenger seats or more.

(3)   Standard mass values for all adults must be based on the averages for males and females found in the sample, taking into account a reference male/female

ratio of 80/20 for all flights except holiday charters where a ratio of 50/50 applies. The operator may, based on the data from his weighing programme, or by proving a different male/female ratio, apply for approval of a different ratio on specific routes or flights.

(e) Weighing survey report:

The weighing survey report, reflecting the content of (d)(1) - (3), should be prepared in a standard format as follows:

WEIGHING SURVEY REPORT

1   Introduction

Objective and brief description of the weighing survey.

2   Weighing survey plan

Discussion of the selected flight number, airports, dates, etc.

Determination of the minimum number of passengers to be weighed.

Survey plan.

3   Analysis and discussion of weighing survey results

Significant deviations from survey plan (if any).

Variations in means and standard deviations in the network.

Discussion of the (summary of) results.

4   Summary of results and conclusions

Main results and conclusions.

Proposed deviations from published standard mass values.

Attachment 1

Applicable summer and/or winter timetables or flight programmes.

Attachment 2

Weighing results per flight (showing individual passenger masses and sex); means and standard deviations per flight, per route, per area and for the total network.

GM1 CAT.POL.MAB.100(g)   Mass and balance, loading

FUEL DENSITY

(a)   If the actual fuel density is not known, the operator may use standard fuel density values for determining the mass of the fuel load. Such standard values should be based on current fuel density measurements for the airports or areas concerned.

(b)   Typical fuel density values are:

(1)	Gasoline (piston engine fuel)	–	0.71
(2)	JET A1 (Jet fuel JP 1)	–	0.79
(3)	JET B (Jet fuel JP 4)	–	0.76
(4)	Oil	–	0.88

GM1 CAT.POL.MAB.100(i)   Mass and balance, loading

IN-FLIGHT CHANGES IN LOADING - HELICOPTERS

In-flight changes in loading may occur in hoist operations.

AMC1 CAT.POL.MAB.105(a)   Mass and balance data and documentation

CONTENTS

The mass and balance documentation should include advice to the commander whenever a non-standard method has been used for determining the mass of the load.

AMC1 CAT.POL.MAB.105(b)   Mass and balance data and documentation

INTEGRITY

The operator should verify the integrity of mass and balance data and documentation generated by a computerised mass and balance system, at intervals not exceeding 6 months. The operator should establish a system to check that amendments of its input data are incorporated properly in the system and that the system is operating correctly on a continuous basis.

AMC1 CAT.POL.MAB.105(c)   Mass and balance data and documentation

SIGNATURE OR EQUIVALENT

Where a signature by hand is impracticable or it is desirable to arrange the equivalent verification by electronic means, the following conditions should be applied in order to make an electronic signature the equivalent of a conventional hand-written signature:

(a)   electronic 'signing' by entering a personal identification number (PIN) code with appropriate security etc.;

(b)   entering the PIN code generates a print-out of the individual's name and professional capacity on the relevant document(s) in such a way that it is evident, to anyone having a need for that information, who has signed the document;

(c)   the computer system logs information to indicate when and where each PIN code has been entered;

(d)   the use of the PIN code is, from a legal and responsibility point of view, considered to be fully equivalent to signature by hand;

(e)   the requirements for record keeping remain unchanged; and.

(f)   all personnel concerned are made aware of the conditions associated with electronic signature and this is documented.

AMC2 CAT.POL.MAB.105(c)   Mass and balance data and documentation

MASS AND BALANCE DOCUMENTATION SENT VIA DATA LINK

Whenever the mass and balance documentation is sent to the aircraft via data link, a copy of the final mass and balance documentation as accepted by the commander should be available on the ground.

GM1 CAT.POL.MAB.105(e)   Mass and balance data and documentation

ON-BOARD INTEGRATED MASS AND BALANCE COMPUTER SYSTEM.

An on-board integrated mass and balance computer system may be an aircraft installed system capable of receiving input data either from other aircraft systems or from a mass and balance system on ground, in order to generate mass and balance data as an output.

GM2 CAT.POL.MAB.105(e)   Mass and balance data and documentation

STAND-ALONE COMPUTERISED MASS AND BALANCE SYSTEM

A stand-alone computerised mass and balance system may be a computer, either as a part of an electronic flight bag (EFB) system or solely dedicated to mass and balance purposes, requiring input from the user, in order to generate mass and balance data as an output.