SOUTH AFRICAN CIVIL AVIATION AUTHORITY

TECHNICAL GUIDANCE MATERIAL for Aircraft Mass and Balance Control

SUBJECT: **AIRCRAFT MASS AND BALANCE CONTROL**

EFFECTIVE DATE: 17 February 2023

APPLICABILITY

Issuance of a special flight permit under Part 91, 121, 127, 135

PURPOSE

This guidance document provides one means, but not the only means, for obtaining approval for a mass and balance data control system.

REQUIREMENTS

South African Civil Aviation Regulations (SACARs) for aircraft under Part 91, 127, 121, 135

1. REFERENCE:

i. South African Civil Aviation Regulations, 2011 as amended (SACARs)
ii. South African Civil Aviation Technical Standards (SACATS)

2. TERMS AND ABBREVIATIONS:

TERM	DEFINITION
Centre of gravity	A point from which the weight of a body or system may be considered to act. In uniform gravity, it is the same as the centre of mass.

ABBREVIATION	DESCRIPTION
AOC	Air Operating Certificate
SACARs	South African Civil Aviation Regulations
SACATS	South African Civil Aviation Technical Standards
CG	
SACAA	South African Civil Aviation Authority

3. GENERAL

3.1 FOCUS

3.1.1 This document provides guidance to Air Operator Certificate (AOC) holders that are required to have an approved mass and balance data control program in terms of CAR 91.07.11.

Note 1: When reference is made to a specific Regulation or Technical Standard (i.e.,121.06.4) it will equally apply to parts 135 and 127.

Note 2: To the extent that a certificate holder adopts the suggestions contained in this document the certificate holder must ensure that when appropriate, discretionary language such as "should" and "may" is replaced with mandatory language in the operations specifications and in relevant manuals.

3.2 DISCUSSION.

3.2.1 An operator may submit, for inclusion into its operations specifications, any method and procedure that shows that an aircraft will be properly loaded and will not exceed approved mass and balance limitations during operation.

3.2.2 The approval of such a mass and balance control system is based on an evaluation of the program presented for a particular aircraft and of a particular operator's ability to implement that program.

3.2.3 Whatever method is used, the program should account for all probable loading conditions that may be experienced in service and show that the loading schedule developed will ensure satisfactory aircraft loading within the approved limits during ground operations and throughout each flight.

3.3 CONTENTS.

3.3.1 Mass and balance control systems encompass the following:

a. Methods for establishing, monitoring, and adjusting individual aircraft or fleet empty mass and centre of gravity (CG) in conjunction with the initial and periodic re-weighing of aircraft.

b. A loading schedule composed of graphs, tables, and computations and/or computer programs, etc., whereby the various mass and balance conditions of an aircraft may be established based on pertinent data for use in loading that particular aircraft in a satisfactory manner.

c. Procedures for using the loading schedule to establish that the loaded condition of the aircraft is within approved mass and CG limits.

d. A load manifest to document loading information by personnel responsible for mass and balance control and procedures for its preparation.

e. Procedures for all applicable personnel concerned with aircraft loading and operations, giving complete details regarding distribution of passengers, fuel, cargo, and necessary restrictions to passenger movement on the ground and during flight.

f. Operational performance factors such as takeoff and landing mass accountability; extension and retraction of landing gear, flaps, slats, and thrust reversers; and en route and taxi fuel bumoff, should be provided for in the program.

3.4 TERMS, DESCRIPTIONS, AND GENERAL STANDARDS.

3.4.1 Empty Mass. The mass of the airframe, engines, propellers, rotors, and fixed equipment. Empty mass excludes the mass of the crew and payload but includes the mass of all fixed ballast, unusable fuel, undrainable oil, and total quantity of hydraulic fluid. The empty mass of an aircraft is the maximum certificated mass less the following:

3.4.2 All drainable fuel and oil, except system fuel and oil. System fuel and oil are the amounts required to fill both systems and the tanks, where applicable, up to the outlets to the engines. When oil is used for propeller feathering, such oil is included as system oil.

3.4.3 Other drainable fluids, including potable water and lavatory servicing fluid, thrust augmentation, and de-icing fluids.

a. Crew and crew baggage.
b. Passengers and cargo (revenue and nonrevenue).
c. Removable passenger service equipment, food, magazines, etc., including service carts, dishes, trays, and beverages.
d. Removable emergency equipment.
e. Other equipment variable for flights.
f. Spare parts.

3.4.4 Operating Mass. The basic operating mass established by the operator for a particular model aircraft should include the following standard items in addition to the empty mass of the aircraft or as otherwise specified by the operator.

a. Normal oil quantity.
b. Lavatory servicing fluid, potable water, etc.
c. Drainable unusable fuel.
d. Crew and crew baggage.
e. Passenger service equipment, including service carts, food, dishes, beverages, magazines, etc.
f. Spare parts normally carried on-board and not accounted for as cargo.
g. Required emergency equipment for all flights.
h. All other items of equipment considered standard by the operator.

3.4.5 A detailed listing of the items comprising empty mass and operating mass should be included in the operator's program**.**

3.4.6 Structural Limits. Mass and CG limits are established at the time of aircraft certification. They are specified in, or referenced by, the applicable type certificate data sheet or aircraft specification. The operator's mass and balance program should provide for maintaining these limits and should stress the point that the aircraft must be operated at or below its maximum certificated operating mass. The following are general definitions of structural mass limits normally considered in mass and balance programs.

a. Maximum Zero Fuel Mass. The maximum zero fuel mass means the maximum permissible mass of an aircraft with no disposable fuel and oil.
b. Maximum Landing Mass. This landing mass limit is the maximum mass at which the aircraft may normally be landed. Some aircraft are equipped to jettison fuel to reduce aircraft mass down to the landing limit in an emergency situation.
c. Maximum Takeoff Mass. This is the maximum allowable, total loaded aircraft mass at the start of the takeoff run.
d. Maximum Ramp Mass. This is the maximum allowable, total loaded aircraft mass for taxi**.**

3.5 AIRCRA FT MASS ESTABLISHMENT.

3.5.1 Aircraft mass and balance control systems normally contain provisions for determining aircraft mass in accordance with the following procedures:

a. Individual Aircraft Mass and Changes.
b. The loading schedule may utilise the individual mass of the aircraft in computing pertinent maximum certificated mass and balance.
c. The individual mass and CG position of each aircraft should be confirmed at the specified reweighing periods.
d. In addition, it should be re-established by computing or reweighing whenever the cumulative change to the operating mass exceeds plus or minus one-half of 1 percent of the maximum landing mass or the cumulative change in the CG position exceeds one-half of 1 percent of the mean aerodynamic chord (MAC). In the case of helicopters, whenever the cumulative change in the CG position exceeds one-half of 1 percent of the total CG range, the mass and balance should be re-established.

3.5.2 Fleet Mass, Establishment, and Changes. For a fleet group of aircraft of the same model and configuration, an average operating fleet mass may be utilised if the operating mass and CG position are within the limits established herein. The fleet mass should be calculated on the following basis:

3.5.3 An operator's empty fleet mass is usually determined by weighing aircraft according to the following table: for a fleet of 1 to 3, weigh all aircraft; for a fleet of 4 to 9, weigh 3 aircraft plus at least 50 percent of the number over 3; for fleets over 9, weigh 6 aircraft plus at least 10 percent of the number over 9.

3.5.4 In choosing the aircraft to be weighed, the aircraft in the fleet having the highest time since last weighing should be selected.

3.5.5 When the average empty mass and CG position have been determined for aircraft weighed and the fleet operating mass established necessary data should be computed for aircraft not weighed but which are considered eligible under such fleet mass.

3.5.6 If the operating mass of any aircraft weighed or the calculated operating mass of any of the remaining aircraft in the fleet varies by an amount exceeding plus or minus one-half of 1 percent of the maximum landing mass from the established operating fleet mass or the CG position varies more than plus or minus one-half of 1 percent of the length of the MAC from the fleet mass CG, the aircraft shall be omitted from that group and operated on its actual or calculated operating mass and CG position.

3.5.7 The South African Civil Aviation Authority (SACAA) will consider submissions by an operator that it is safe to go beyond the limits described in the preceding sentence without having to take that aircraft out of the fleet mass. If it falls within the limits of another fleet or group, it may become part of that fleet.

3.5.8 For those cases in which the aircraft is within the operating fleet mass tolerance but the CG position varies in excess of the tolerance allowed, the SACAA would accept an operator using the aircraft under the applicable operating fleet mass and with an individual CG position**.**

3.5.9 Re-establishment of the operator's empty fleet mass or operating fleet mass and corresponding CG positions may be accomplished between weighing periods by calculation based on the current empty mass of the aircraft previously weighed for fleet mass purposes.

3.5.10 Weighing for re-establishment of fleet mass is normally conducted on a 3- year basis unless changes in aircraft configuration make it necessary to reweigh and/or recalculate CG sooner.

3.5.11 Establishing Initial Mass. Prior to being placed into service, each aircraft should be weighed, and the empty mass and CG location established CAR 91.07.11 (2). New aircraft are normally weighed at the factory and are eligible to be placed into operation without re-weighing if the mass and balance records have been adjusted for alterations or modifications to the aircraft.

3.5.12 Periodic Weighing - Aircraft Using Individual Mass. Aircraft operated under a loading schedule utilising individual aircraft mass in computing the maximum certificated mass are normally weighed at intervals of 60 calendar months.

3.5.13 Periodic Weighing - Aircraft Using Fleet Mass. Aircraft operating under fleet mass should be weighed in accordance with procedures outlined for the establishment of fleet mass.

3.5.14 Since each fleet is normally re-established every 5 years and a specified number of aircraft weighed at such periods, no additional weighing is considered necessary.

3.5.15 A rotation program should, however, be incorporated so all aircraft in the fleet will be weighed periodically.

3.5.16 Weighing Procedure. Normal precautions, consistent with good practices, should be taken such as checking to insure the aircraft has the required items of installed equipment, determining that the fluids are properly accounted for, that the aircraft is clean, and that weighing is accomplished in an enclosed building.

3.5.17 Any acceptable scales may be used for weighing provided they are properly calibrated, zeroed, and used in accordance with the manufacturer' s instructions.

3.5.18 Each scale should be calibrated, either by the manufacturer or by a recognised facility such as a civil department of mass and measures, periodically as recommended in the manufacturer's calibration schedule.

3.5.19 If a calibration schedule is not available from the manufacturer, the SACAA would find it acceptable to use the scale to weigh the aircraft within one year after the calibration of the scale.

3.5.20 The SACAA will consider any evidence that would justify a safety determination for accepting a longer period between calibrations.

3.6 LOADING SCHEDULE.

3.6.1 Loading schedules should be simple and orderly, based on sound principles, thus reducing the elements of human error.

3.6.2 Loading schedules may be applied to individual aircraft or to a complete fleet. When an operator utilises several types or models of aircraft, a loading schedule, which may be index- type, tabular-type, or a computer, should be identified with the type or model of aircraft for which it is designed.

3.7 LOADING PROVISIONS.

3.7.1 All seats, compartments, and other loading stations should be properly marked and the identification used should correspond with the instructions established for computing mass and balance of the aircraft.

3.7.2 When the loading schedule provides for blocking off seats or compartments in order to remain within the CG limits, effective means should be provided to ensure that such seats or compartments are not occupied during operations specified.

3.7.3 In such cases, instructions should be prepared for crewmembers, load agents, cargo handlers, and other personnel concerned, giving complete information regarding distribution of passengers, cargo, fuel, and other items. Information relative to maximum capacities and other pertinent limitations affecting the mass or balance of the aircraft should be included in these instructions.

3.7.4 When it is possible by adverse distribution of passengers and/or cargo to exceed the approved CG limits of the aircraft, special instructions should be issued to the pilot in command and appropriate personnel so that the load distribution can be maintained within the approved limitation.

3.7.5 A suitable commercially available scale should be available for use when passenger, baggage, and cargo mass are otherwise undeterminable.

3.8 STANDARD PASSENGER MASS.

3.8.1 Actual mass, or when appropriate, average passenger mass are used to compute passenger loads over any segment of a certificate holder's operations.

3.8.2 Actual mass is used for operations with aircraft having nine or less passenger seats and aircraft carrying non-standard passenger loads as described in paragraph 11.

3.8.3 The loading system should readily accommodate non-standard mass groups, and the manifest should indicate whether average or actual masses, or a combination thereof, were used in the computation.

Note: The intent of this document is to provide methods and procedures for developing mass and balance control systems, not to address the entire spectrum of all possible mass configurations. Therefore, the operator should consider providing the SACAA with a reliable survey to establish an average passenger mass for its specific operation**.**

3.8.4 Average Passenger Mass. Special average mass or special ratios may be established for particular operations based on surveys that: (1) indicate that those mass consistently provide for loading within prescribed mass and balance limits; and (2) meet the criteria for surveys and statistical analysis outlined in appendix 1.

3.8.5 The appropriate standard masses are documented in SACATS 91.07.11.

3.8.6 The requirements regarding the number and weights of carry-on baggage are documented in SACATS 121.07.18.

3.8.7 For those operators that do not have an approved carry-on bag program described in their operations specifications, all baggage must be accounted for at actual mass.

3.8.8 The carry-on bags permitted by an operator's program should be included in the standard average passenger mass. Any movement of these carry-on bags from the cabin to the baggage compartment may not require any mass recalculations but the operator must ensure that CG calculations are not adversely effected.

3.8.9 Average Mass for Children. The mass of children less than 2 years old has been factored into the adult mass.

3.9 NON-STANDARD PASSENGER MASS.

3.9.1 Actual Passenger Mass. Actual passenger mass are used for non-standard mass groups, unless average mass has been established for those groups.

3.9.2 This includes athletic squads and other groups that are larger or smaller than the average.

3.9.3 When such groups form only a part of the total passenger load, actual mass, or established average mass for the non--standard group, may be used for such exception groups and average mass used for the balance of the passenger load.

3.9.4 In such instances, a notation should be made in the load manifest indicating the number of persons in the special group and identifying the group; i.e., football squad, etc.

3.9.5 Determination of Actual Passenger Mass. Actual passenger mass may be determined by:

a. Scale weighing of each passenger prior to boarding the aircraft, including handbags carried on board by the passenger; or
b. Asking each passenger his/her mass and adding to it a predetermined constant to provide for handbags and clothing. This constant may be approved for an operator on the basis of studies by the operator that considers particular routes and seasonal variations, when applicable. Personnel listing passengers on this basis should receive instruction for estimating passenger mass to reasonably confirm their accuracy.

3.9.6 Non-standard Average Passenger Mass - Military Groups. In lieu of actual mass (preferred}, the following average mass may be used for military groups, unless the passengers or their carry-on baggage appreciably differ from these standard masses:

Note: This represents the standard combat soldier as would be seen on contract flights involving large movements. This includes 88 kg as shown above, 9 kg for additional hand- carried mobility pack, and an additional 4.5 kg for hand-carried weapons.

3.10 CREW MASS.

For crewmembers, the appropriate standard masses for flight crew are documented in SACATS 91.07.1 1.

3.11 PASSENGER AND CREW BAGGAGE AND MAIL.

3.11.1 Procedures should be provided so that all baggage, including that, carried aboard by the passengers, and mail is properly accounted for.

3.11.2 If desired by the operator, a standard crew baggage mass may be used.

3.11.3 Mailbags and checked baggage average mass may be used as described below.

3.11.4 Actual mass should be used for aircraft of nine or less passenger seats.

3.11.5 Actual mass is used when it is noticeable that the checked baggage or the mailbags exceed the average mass.

3.11.6 Average Mass or Actual Mass. An operator may establish average passenger baggage mass predicated on a study of actual baggage mass for the operations or routes involved that consider seasonal and other variables; or it may use the following average mass for each piece of checked baggage.

3.11.7 Domestic and International Operations. The standard mass values for baggage are documented in SACATS 91.07.11.

Note: Use of average passenger baggage mass is not advisable in computing the mass and balance of charter flights and other special services involving the carriage of special groups.

3.11.8 Normal Operations. All mailbag manifested mass should be used in determining the mass of mailbag shipments.

3.11.9 Should it be necessary to separate (break bulk) a manifested shipment or should manifested mass not be available, the SACAA would accept the use of average individual bag mass, in circumstances where the average has been determined and substantiated by recent surveys that follow the survey and statistical models suggested in appendix 1.

3.12 MOVEMENT OF PASSENGERS AND CREWMEMBERS DURING FLIGHT.

3.12.1 The operator should show that the procedures fully account for the extreme variation in CG travel during flight caused by all or any combination of the following variables:

3.12.2 Human Movement. The operator should compute the movement of passengers and cabin attendants from their normal position in the aircraft cabin to other areas such as the galley or lavatory.

3.12.3 If the capacity of such compartment is one, the movement of either one passenger or one cabin attendant, whichever most adversely affects the CG condition, should be considered.

3.12.4 When the capacity of the lavatory or galley is two or more, the movement of that number of passengers or cabin attendants from positions evenly distributed throughout the aircraft may be used.

3.12.5 Where seats are blocked off and the movement of passengers and/or cabin attendants is evenly distributed throughout, only the actual loaded section of the aircraft should be used.

3.12.6 The extreme movements of the cabin attendants carrying out their assigned duties within the cabin should be considered.

3.12.7 The various conditions should be combined in such a manner that the most adverse effect on the CG will be obtained and accounted for in the development of the loading schedule to assure the aircraft is loaded within the approved limits at all times during the ground and flight operations.

3.12.8 Landing Gear, Flaps, Slats and Thrust Reverser Extension and Retraction. Possible change in CG position due to the extension or retraction of landing gear, flaps, slats, thrust reverser or other translating equipment, as provided by the manufacturer, should be investigated. The results of such an investigation should be taken into consideration.

3.12.9 Fuel. The effect of the CG travel within the aircraft during flight, due to fuel used down to the required reserve fuel or to an acceptable minimum reserve fuel established by the operator, should be taken into consideration.

3.13 RECORD.

3.13.1 The mass and balance system should include methods by which the operator will maintain a complete, current, and continuous record of the mass and CG of each aircraft.

3.13.2 Such records should reflect all alterations and changes affecting either the mass or balance of the aircraft and will include a current equipment list.

3.13.3 Operators should have the facility to update the equipment list as may be required for transfer or sublease of the aircraft. When fleet mass is used, pertinent computations should also be available in individual aircraft files.

3.14 MASS OF FLUIDS.

The mass of all fluids used in the aircraft may be established on the basis of actual mass, a standard volume conversion, or volume conversion utilising appropriate temperature correction factors to accurately determine the mass by computation of the quantity of fluid aboard.

3.15 CONTENT OF OPERATIONS SPECIFICATIONS PROCEDURES FOR AIRCRAFT MASS AND BALANCE CONTROL.

3.15.1 The operations specifications should contain the procedures (or refer to the operator's approved mass and balance control program document) used to maintain control of mass and balance of all aircraft operated under the terms of the operating certificate which assures that the aircraft, under all operating conditions, is loaded within mass and CG limitations.

3.15.2 This description should include a reference to the procedures used for determining mass of passengers/crew, mass of baggage, periodic aircraft weighing, type of loading devices, and identification of the aircraft concerned.

4. DOCUMENT AUTHORISATION

DEVELOPED BY:		
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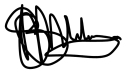	**Siphamandla Mhlanga (Acting)**	**17 February 2023**
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Note: All weight calculations in this appendix are in pounds.

1. FOCUS.

The methodology presented can be used to determine standard average mass for passengers, checked baggage, carry-on baggage, mail, other normal averaged items and male/female ratios in lieu of using those standard average values suggested in the guidance document.

2. DETERMINATION OF STANDARD AVERAGE MASS VALUES FOR PASSENGERS, BAGGAGE,AND CARGO/MAIL.

It is critical that operators determine that average mass used for passengers, baggage, and cargo/mail do not adversely affect operational safety. In lieu of using the standard average mass values contained in the CAR, average mass may be generated by use of a suitable statistical analysis.

a. This appendix contains an acceptable methodology for conducting a statistical analysis and establishing suitable average mass.

b. Average mass values for adults should be based on a male/female ratio of 60/40. Use of a different ratio should be based on acceptable survey data. An acceptable methodology is shown in this appendix.

c. For practical reasons passenger mass values may be rounded to the nearest whole number in pounds, and the checked bag mass may be rounded to the nearest 0.5 pounds.

3. SAMPLING METHOD.

Averages should be determined by a random sample, i.e., every member of the group must have a chance of selection. The process may be determined by ticket selection with random selected numbers, flight selections, and aerodrome selections with consideration given to check point or gate/flights within those aerodromes. The process used is dependent on the diversity of the carrier's operation. In addition, the random sample must be of a conventional airline population and should consider the type of operation, the market, and the frequency of flights on various routes. Significant variations in the mass should be taken into consideration. A survey plan should cover the weighing of at least 1500 of the items being sampled or as specified in paragraph 6a(1) of this appendix, whichever is larger.

a. Passenger Mass.

(1)Adults and Children. Adults may be defined as persons of an age of 13 or more years. They may be further classified as male or female. No differentiation of sex shall be made for children, who are defined as persons less than age 13.
(2)Survey participants should be given the assurance that all data taken will remain confidential and that under no circumstance are they obligated to participate, although participation should be encouraged. All displays of mass figures shall be arranged so that they are only visible to authorised survey people.

(3)Surveys should be conducted inside an aerodrome location and at a site that will not inconvenience participants or other airline passengers.
(4)Carry-on baggage should be accounted for as part of the total mass of the passenger. If desired, carry-on baggage may be weighed separately and added to the passenger mass.
(5)Survey data should include, but not be limited to: sex, adult or child categorisation, survey location, mass with carry-on, mass without carry-on, date conducted, and child carried.

b. Checked Baggage.

(1)The total of checked baggage and/or mail shall be determined by either the sum total of the actual mass of all the pieces or the actual total mass of the contents of the baggage containers they are in.
(2)As an alternative, an approved standard average bag mass, specific to the individual carrier's operation, multiplied by the total count of the number of pieces, may be used. That average mass may be determined as specified in this document.
(3)A form should be designed to include boarding point, destination, mass of bags or any other information pertinent to the final results. Consideration should be given to size and differences in items being sampled.

c. Mail.

(1)Survey data should include boarding point, destination, mass of bags or any other information pertinent to the final results. Consideration should be given to size and differences in items being sampled.

4. SCALES.

The weighing scales to be used for conducting mass surveys shall have a capacity of at least 400 pounds. All mass should be displayed at a minimum interval of 1 pound and should be accurate to within ± .2 kilograms. The tolerance shall not exceed ± 0.1 kilograms for every 91 kilograms of mass.

5. MASS DATA.

The recording of mass data may be done manually or automatically. All data should be retained for permanent records and as substantiation of data results.

6. EVALUATION OF DATA.

The methodology described in the following subparagraph a. should be used if the survey is being conducted to determine average mass. If the survey is being conducted to determine only male/female percentages, use the methodology in subparagraph f.

a. Calculation of Passenger Average Mass.

(1} Sample size. For calculating the required sample size it is necessary to estimate the standard deviation based on standard deviations calculated for similar populations. It is common practice to compute the precision of a sample estimate for some specified degree of reliability. A reliability of 95 percent is commonly used, i.e., there is a 95 percent probability that the true value will fall within the specified confidence interval, around the estimated value. In order to keep the sample size at an economical level and to achieve an acceptable degree of accuracy, it is necessary to use this value for calculating the standard passenger average.
(2} Consequently, for the parameters of mass distribution three cases of mean and standard deviation have to be distinguished:

m, s = The true value of the average passenger mass and standard deviation which are unknown and which are to be estimated by weighing passenger samples.
m1, s1 = The initial estimates of the average passenger mass and standard deviation (values obtained from earlier survey samples}.
x, s = The estimates for the current true values of and calculated from the sample.

b. Formulas. The following formulas will be necessary in determining the correct results: (1} FORMULA - CALCULATION OF THE SAMPLE SIZE:

$$n = \max\left[1500, \frac{(1.96 * s1 * 100)^2}{(e1 * m1)^2}\right]$$

where:
n = No. of passengers to be weighed (sample size},
e1 = Allowed relative confidence range (accuracy} for the estimate of m by x.

Note: The allowed relative confidence range specifies the accuracy to be achieved when estimating the true mean. For example, to estimate the true mean to within ± 1 percent, e1 will be 1 in the above formula.

1.96 = Value from the Gaussian distribution for 95 percent significance level of the resulting confidence interval.

(1) FORMULA - CALCULATION OF THE ARITHMETIC MEAN:

If the sample of passengers weighed is random, the arithmetic mean of the sample, x, is an unbiased estimate of the true average mass m of the population.

(2) FORMULA - CALCULATION OF THE STANDARD DEVIATION:

where (xj - x) is the deviation of the individual value from the sample mean.

(3) FORMULA - CALCULATION OF 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 is why this had to be estimated initially by m1 and s1). It has to be checked after the sample has been evaluated and can be done using the following formula: e should not exceed:

1 percent for an adult average mass;
2 percent for an average male or female mass; or
4 percent for checked baggage and mail mass.

(4) FORMULA - CALCULATION OF THE CONFIDENCE RANGE OF THE SAMPLE MEAN: This means that with 95 percent probability, the true average mass m lies within the interval:

c.Example - Adult Average Mass. The following example may be applied to any sample item. It shows the various steps required for establishing the sample size and evaluating the sample data. It is provided primarily as a guide for statistical computations. All mass figures used throughout the example are entirely fictitious.

d.Calculation Of The Required Sample Size. For calculating the required sample size, estimates of the standard (average) passenger mass and the standard deviation are needed. The initial 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. However, the representative small sample cannot serve to be the total sample requirement. The following example assumes an 86-passenger sample. n
= 86

Step 1: Estimated average
passenger mass

Step 2: Estimated standard deviation

Step 3: The required number of passengers to be weighed should be such that the confidence range, e1, does not exceed 1 percent.

$$n = \max\left[1500, \frac{(1.96 * s1 * 100)\,2}{(e1 * m1)2}\right]$$

$$= \max\left[1500, \frac{(1.96 * 44.53 * 100)\,2}{(1 * 155.616)\,2}\right]$$

= max (1500, 3146)
n = 3146
Result: At least 3,146 passengers have to be weighed to achieve the required accuracy. A plan for weighing this sample size of passengers should then be worked out.

e.Determination Of Passenger Average Mass.

Step 1: After 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 mass amounts to 231183 kilograms.

Step 2: Calculation Of The Standard Deviation.

Step 3: Calculation Of The Accuracy Of The Sample Mean.

Step 4: Calculation Of The Confidence Range Of The Sample Mean.

The result of this calculation shows that there is a 95 percent probability of the actual mean for all passengers lying within the range of 72 to 73 kilograms.

f.Calculation Of Male/Female Ratio. The methodology described in this section should be used only if the purpose of the survey is to determine the percentage mix of male/females. Once determined, use the male and female mass from paragraph 10 of the guidance document and the percentages found in the survey to calculate the standard average adult mass.

Let:

km = number of males in the sample kf = number of females in the sample k = km + kf = total sample size
p = percentage of males
q = percentage of females p + q = 100
sp = sq = standard deviation of percentage xa = standard average adult mass
xm = standard average male mass from paragraph of the guidance document

xf = standard average female mass from paragraph 10 of the guidance document sm = standard deviation of male mass
sf = standard deviation of female mass
sxa = standard error of average adult mass

(1) Formulas. The following formulas should be used in determining the correct results:

(i) FORMULA - Calculation of the percentage of male and female passengers and the standard deviation.

(ii} FORMULA - Calculation of 95 percent confidence range for both male and female percentages.

$p \pm 1.96 * sp$

(iii) FORMULA - Calculation of standard average adult mass using male and female mass from paragraph 10 of the guidance document.

(iv} FORMULA - Calculation of the standard deviation of the standard average adult mass.

(v} FORMULA - Calculation of the accuracy of the standard average adult mass.

$$e = \frac{1.96 * sxa}{xa} * 100 (\%)$$

(vi} FORMULA - Calculation of the 95 percent confidence range of the standard average adult mass.

$xa \pm 1.96 * sxa$

(vii) FORMULA - Calculation of the sample size.

Note: Data from the surveys yielding the averages in paragraph 1Oa of the guidance document may be used to derive the sample size needed for update surveys. These values apply: nm = 1039; nf == 640; xm = 195; xf = 155; p =.619; q = .381; x = 180; sm = 35.1 and sf = 34.8.

Thus, for male/female averages, e = .02,
This sample size can be used until the average mass in the guidance document is updated with later survey data.

Example - Male/Female Average. The following example may be applied to any sample. It shows the various steps required for evaluating the sample data. It is provided primarily as a guide for statistical computations. All mass figures used throughout the example are entirely fictitious.

Given: Sample of 1,500 passengers, 910 male and 590 female. Step 1. Calculating the percentage of males and females.
km

p = -- * 100
k

910
= ---- * 100 1500

L;A AUL;-AL;-f-U-003

= 60.7 %

q = 100.0 - 60.7 = 39.3%.

Step 2. Calculation Of the Standard Deviation. Note that the standard deviations for the percentage of men and women are equal.
Step 3. Calculating the confidence range. pm ± 1.96 Sp =
60.7 ± 1.96 * 1.26 =
60.7 % ± 2.47 %

This indicates that there is a 95 percent probability that the actual percentage of men is between 58.2 percent and 63.2 percent, and that the percentage of women is between 36.8 percent and 41.8 percent, i.e., 58.2/41.8 and 63.2/36.8 .

Step 4. Calculation Of the Standard Average Adult Mass. Use the standard average male and female mass shown in paragraph 10a of the guidance document (assume summer mass for this example) and the percentages of men and women found in the survey. When doing this calculation, divide pm and qf by 100 to express them in decimal form.

Step 5. Calculation Of The Standard Deviation Of The Average Adult Mass. When doing this calculation, divide p, q, and sp by 100 to express them in decimal form.

From the survey supporting the guidance document averages:

sm = 35.1; nm = 1039; sf = 34.8; nf = 640; xm = 195; and xf = 155. Thus, Step 6. Calculation Of The Accuracy Of The Standard Average Adult Mass.
1.96 * sxa
e = ----- * 100
xa

1.96 * .99
= ---- * 100 179

= 1.1%
Step 7. Calculation Of The Confidence Range Of The Standard Average Adult Mass. xa ± 1.96 * sxa =
179 ± 1.96 * .99 =
179 ± 1.9 lbs.

This indicates that there is a 95 percent probability that the actual standard average adult mass is between 80 and 82 kilograms