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TECHNICAL CIRCULAR

AIRCRAFT MASS AND BALANCE

1. Authority

This advisory circular is issued by the Executive Chairman of the Institute of Civil Aviation de Mozambique (IACM) in pursuance of powers vested in him under Article 31 of Law 21/2009 of 21 September and Article 12 of Resolution 19/2011 of 30 November.

2. Purpose

This Technical Circular (TC) provides one means, but not the only means, for obtaining approval of a mass and balance data control system.

3. Objective

This document provides guidance to air operator certificate (AOC) holders that are required to have an approved mass and balance data control program by Parts 121, 127 and 135 of the Civil Aviation Regulations (MOZCARS).

4. Discussion

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

5. Contents

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 burnoff, should be provided for in the program.

6. Terms, Descriptions, and General Standards

A. **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:

(1) 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.
(2) Other drainable fluids, including potable water and lavatory servicing fluid, thrust augmentation, and de-icing fluids.
(3) Crew and crew baggage.
(4) Passengers and cargo (revenue and nonrevenue).
(5) Removable passenger service equipment, food, magazines, etc., including service carts, dishes, trays, and beverages.
(6) Removable emergency equipment.
(7) Other equipment variable for flights.

(8) Spare parts.

B. **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.

(1) Normal oil quantity.
(2) Lavatory servicing fluid, potable water, etc.
(3) Drainable unusable fuel.
(4) Crew and crew baggage.
(5) Passenger service equipment, including service carts, food, dishes, beverages, magazines, etc.
(6) Spare parts normally carried on-board and not accounted for as cargo.
(7) Required emergency equipment for all flights.
(8) All other items of equipment considered standard by the operator.

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

D. **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.

(1) **Maximum Zero Fuel Mass**. The maximum zero fuel mass means the maximum permissible mass of an aircraft with no disposable fuel and oil.
(2) **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.
(3) **Maximum Takeoff Mass**. This is the maximum allowable, total loaded aircraft mass at the start of the takeoff run.
(4) **Maximum Ramp Mass**. This is the maximum allowable, total loaded aircraft mass for taxi.

7. Aircraft Mass Establishment

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**. The loading schedule may utilise the individual mass of the aircraft in computing pertinent maximum certificated mass and balance. The individual mass and CG position of each aircraft should be confirmed at the specified reweighing periods. 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.

B. **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:

(1) 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.

(2) In choosing the aircraft to be weighed, the aircraft in the fleet having the highest time since last weighing should be selected. 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. 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. The Civil Aviation Authority (IACM) 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. 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 IACM would accept an operator using the aircraft under the applicable operating fleet mass and with an individual CG position.

(3) 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. 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.

C. **Establishing Initial Mass**. Prior to being placed into service, each aircraft should be weighed and the empty mass and CG location established. 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. Aircraft transferred from one operator that has an approved mass and balance program, to another operator with an approved program need not be weighed prior to use by the receiving operator unless more than 36 calendar months have elapsed since last weighing. Aircraft transferred, purchased or leased from an operator without an approved mass and balance

program can be placed into service without being reweighed if the last weighing was accomplished by an acceptable method and was accomplished within the last 12 calendar months.

D. **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 36 calendar months. An operator may, however, extend this weighing period for a particular model aircraft when pertinent records of actual routine weighing during the preceding period of operation show that mass and balance records maintained are sufficiently accurate to indicate aircraft mass and CG positions are within the cumulative limits specified in paragraph 7a. Such applications should be substantiated in each instance with at least two aircraft weighed. An increase should not be granted which would permit any aircraft to exceed 48 calendar months since the last weighing. In the case of helicopters, increases should not exceed a time that is equivalent to the aircraft overhaul period.

E. **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. Since each fleet is normally re-established every 3 years and a specified number of aircraft weighed at such periods, no additional weighing is considered necessary. A rotation program should, however, be incorporated so all aircraft in the fleet will be weighed periodically.

F. **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. Any acceptable scales may be used for weighing provided they are properly calibrated, zeroed, and used in accordance with the manufacturer's instructions. 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. If a calibration schedule is not available from the manufacturer, the IACM would find it acceptable to use the scale to weigh the aircraft within one year after the calibration of the scale. The IACM will consider any evidence that would justify a safety determination for accepting a longer period between calibrations.

8. Loading Schedule

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

9. Loading Provisions

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

10. Standard Passenger Mass

Actual mass, or when appropriate, average passenger mass are used to compute passenger loads over any segment of a certificate holder's operations. 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. The loading system should readily accommodate non-standard mass groups, and the manifest should indicate whether average or actual mass, or a combination thereof, were used in the computation.

***Note**: The intent of this TC 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 IACM with a reliable survey to establish an average passenger mass for its specific operation.*

A. **Average Passenger Mass**. The standard average passenger mass listed in the following table was developed for conventional airline passenger groups. They cannot be arbitrarily adopted for operations with passenger groups that appreciably differ from the basis or where the mix of male and female passengers is known to be different than a 60 percent male/40 percent female operation. 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.

STANDARD AVERAGE PASSENGER MASS (Includes 20 pounds carry-on baggage for adult passengers)	
Adult Passenger (60%/40% male/female mix)	80 Kg
Male	90 Kg
Female	70 Kg
Children (Applicable between ages 2 and 12 years)	35 Kg

(1) The table above is for certificate holders authorised to use an approved carry-on baggage program with a specified 2-bag limit as described in the operations manual.

(2) For certificate holders authorised to use an approved carry-on baggage program with a specified bag limit of other than 2 bags, the standard average passenger mass will be different.

(3) For those operators that do not have an approved carry-on bag program described in their operations specifications, all baggage may be either accounted for at actual mass, or in accordance with paragraphs 13b and 13c.

(4) 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.

B. **Average Mass for Children**. The average mass of children aged 2-12 years normally is used only when needed to accommodate available payload. Otherwise, as passengers, they are considered the same as adult passengers. The mass of children less than 2 years old has been factored into the adult mass.

11. Non-Standard Passenger Mass

A. **Actual Passenger Mass**. Actual passenger mass are used for non-standard mass groups, unless average mass have been established for those groups. This includes athletic squads and other groups that are larger or smaller than the average. 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. 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.

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

(1) Scale weighing of each passenger prior to boarding the aircraft, including handbags carried on board by the passenger; or
(2) 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.

C. **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:

Non-combat-Equipped Military Personnel *Note: This mass includes 10 Kg of hand-carried baggage*	90 Kg
Combat-Equipped Military Personnel	100 Kg

Note: This represents the standard combat soldier as would be seen on contract flights involving large movements. This includes 90 Kg as shown above, 10 Kg for additional hand-carried mobility pack, and an additional 5 Kg for hand-carried weapons.

12. Crew Mass

For crewmembers, the following approved average mass may be used:

A. Male cabin attendants 80 Kg; female cabin attendants 60 Kg; or 65 Kg average for all flight attendants.

B. Male flight crewmembers 80 Kg; female flight crewmembers 60 Kg.

13. Passenger And Crew Baggage And Mail

A. Procedures should be provided so that all baggage, including that carried aboard by the passengers, and mail is properly accounted for. If desired by the operator, a standard crew baggage mass may be used. Mailbags and checked baggage actual mass shall be used.

B. 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.

14. Movement Of Passengers And Crewmembers During Flight

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:

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

B. **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.

C. **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.

15. Record

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

16. 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.

17. Content Of Operations Specifications Procedures For Aircraft Mass And Balance Control (Not Applicable With The New MOZ CAR 121/127/135 Ops Specs Format)

The operations specifications should contain the procedures (or make reference 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. 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.

18. Adoption Of This Guidance

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

INSTITUTE OF CIVIL AVIATION OF MOZAMBIQUE

THE CHAIRMAN OF THE BOARD AND CEO

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