Federal Aviation Administration
Aviation Rulemaking Advisory Committee

Air Carrier/General Aviation Maintenance Issue Area
Weight and Balance Working Group

Task 1 – Weights for passengers, carry-on baggage and checked baggage

Task Assignment

Aviation Rulemaking Advisory Committee; Air Carrier/General Aviation Maintenance Subcommittee; Weight and Balance Working Group

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of establishment of Weight and Balance Working Group.

SUMMARY: Notice is given of the establishment of a Weight and Balance Working Group by the Air Carrier/General Aviation Maintenance Subcommittee of the Aviation Rulemaking Advisory Committee. This notice informs the public of the activities of the Air Carrier/General Aviation Maintenance Subcommittee of the Aviation Advisory Committee.

FOR FURTHER INFORMATION CONTACT: Mr. William J. White, Executive Director, Air Carrier/General Aviation Maintenance Subcommittee, Flight Standards Service (AFS-2), 800 Independence Avenue SW., Washington, DC 20591, Telephone: (202) 267-8237; FAX: (202) 267-5230.

SUPPLEMENTARY INFORMATION: The Federal Aviation Administration (FAA) established an Aviation Rulemaking Advisory Committee (56 FR 2190, January 22, 1991) which held its first meeting on May 23, 1991 (56 FR 20492, May 3, 1991). The Air Carrier/General Aviation Maintenance Subcommittee was established at that meeting to provide advice and recommendations to the Director, Flight Standards Service, regarding mechanic certification and approved training schools outlined in parts 65 and 147 and the maintenance standards for parts 23, 25, 27, 29, 31, 33, and 35 aircraft, engines, propellers, and their component parts and parallel provisions in parts 21, 43, 91, 121, 125, 127, 129, 133, 135, and 137 of the Federal Aviation Regulations (FAR). At its first meeting on May 24, 1991 (56 FR 20492, May 3, 1991), the subcommittee established the Weight and Balance Working Group.

Specifically, the working group's task is the following:

Review the existing methods of establishing current standard weights for passengers, carry-on baggage, and checked baggage to determine the need to revise Advisory Circular (AC) 120-27B, Aircraft Weight and Balance Control.

The Weight and Balance Working Group will be comprised of experts from those organizations having an interest in the task assigned to it. A working group member need not necessarily be a representative of one of the organizations of the parent Air Carrier/General Aviation Maintenance Subcommittee or of the full Aviation Rulemaking Advisory Committee. An individual who has expertise in the subject matter and wishes to become a member of the working group should write the person listed under the caption **"FOR FURTHER INFORMATION CONTACT"** expressing that desire and describing his or her interest in the task and the expertise he or she would bring to the working group. The request will be reviewed with the subcommittee chair and working group leader, and the individual advised whether or not the request can be accommodated.

The Secretary of Transportation has determined that the formation and use of the Aviation Rulemaking Advisory Committee and its subcommittees are necessary in the public interest in connection with the performance of duties imposed on the FAA by law. Meetings of the full committee and any subcommittees will be open to the public except as authorized by section 10(d) of the Federal Advisory Committee Act. Meetings of the Weight and Balance Working Group will not be open to the public, except to the extent that individuals with an interest and expertise are selected to participate. No public announcement of working group meetings will be made.

Issued in Washington, DC on August 20, 1991.

William J. White,

Executive Director, Air Carrier/General Aviation Maintenance Subcommittee, Aviation Rulemaking Advisory Committee.

[FR Doc. 91-20492 Filed 8-26-91; 8:45 am]

BILLING CODE 4910-13-M

Recommendation Letter

Air Transport Association

October 30, 1992

Mr. Anthony J. Broderick
Associate Administrator for Regulation & Certification, AVR-1
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

Subject: Aircraft Weight and Balance Control, Revision of Advisory Circular No. 120-27 Drafted by ARAC Air Carrier/General Aviation Maintenance Subcommittee

Dear Mr. Broderick:

On May 24, 1991, the Air Carrier/General Aviation Maintenance Subcommittee of the Aviation Rulemaking Advisory Committee created a working group to resolve issues with aircraft weight and balance advisory materials. The Weight and Balance Working Group was specifically charged to review the existing methods of establishing methods of establishing current standard weights for passengers, carry-on baggage and checked baggage to determine the need to revise Advisory Circular AC No. 120-27B, AIRCRAFT WEIGHT AND BALANCE CONTROL.

The Weight and Balance Working Group performed the assigned review and proposed a revision to AC 120-27B. This revision was reviewed and approved by the Air Carrier/General Aviation Maintenance Subcommittee at its regularly scheduled meeting on September 28, 1992.

Draft AC 120-27C is hereby transmitted in accordance with the procedures delineated for ARAC Subcommittees for FAA public notice and comment procedures leading to the issue of the proposed amendment. The Weight and Balance Working Group and the Subcommittee will stand by to respond to public comments as required.

Sincerely,

Joseph D. Vreeman, Chairman
Air Carrier/General Aviation Maintenance Subcommittee

cc: Fred Leonelli, AFS-300, DFO
Joe Manno, AFS 330 (w/disc)
Working Group Members

Air Transport Association of America
1301 Pennsylvania Ave., NW – Suite 1100 Washington, DC 20004-1707
(202) 626-4000

92-0435

U.S. Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave.. S.W.
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NOV 23 1992

Mr. Joseph D. Vreeman, Chairman
Air Carrier/General Aviation
Maintenance Subcommittee
Air Transport Association of America
Washington, DC 20004-1707

Dear Mr. Vreeman:

This letter acknowledges receipt of your October 30 letter in which you transmitted draft Advisory Circular No. 120-27, Aircraft Weight and Balance Control.

We will move as quickly as possible to complete the internal review and coordination process. We will then advise you of the date that a notice of availability for public comment appears in the Federal Register.

I would like to thank your subcommittee, and particularly the Weight and Balance Working Group, for its prompt action and efforts in completing the task assigned by the Federal Aviation Administration.

Sincerely,

Anthony J. Broderick
Associate Administrator
for Regulation and Certification

U.S. Department
of Transportation
**Federal Aviation
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800 Independence Ave., S.W.
Washington, D.C. 20591

JAN 3 1994

Mr. Steve R. Erickson, Assistant Chair
Aviation Rulemaking Advisory Committee
Air Transport Association of America
1301 Pennsylvania Avenue, NW.
Washington, DC 20004-1707

Dear Mr. Erickson:

On behalf of the Federal Aviation Administration (FAA), I wish to thank you and the Weight and Balance Control Working Group for your work and efforts in revising Advisory Circular (AC) No. 120-27B, Aircraft Weight and Balance Control.

The different disciplines within the FAA have reviewed ARAC's recommendation and have asked the following questions:

- What is the average passenger weight used in the proposed AC?
- What are the standard carry-on baggage weights for aircraft operating under Parts 121 and 135?
- What data do you have to support the passenger and carry-on baggage weights?

Before the FAA publishes the AC, we would like ARAC and the Weight and Balance Working Group to have the opportunity to review and address the above questions. We are, therefore, returning this project to ARAC and request a response within 90 days.

If you need additional information concerning this matter, please contact the FAA representative, Howard J. Vaughn, at (703) 661-0333, extension 5009.

Sincerely,

Anthony J. Broderick
Associate Administrator for
Regulation and Certification

Air Transport Association

March 25, 1994

Mr. Anthony J. Broderick
Associate Administrator for Regulation & Certification, AVR-1
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

Subject: Substantiation of Weight Values for Proposed AC 120-27C, Aircraft Weight and Balance

Ref: (1) January 3, 1994 Letter from Anthony Broderick, FAA, to Steve Erickson, Aviation Rulemaking Advisory Committee, re Passenger and Carry-on Baggage Weight Questions on Proposed AC 120-27C

(2) February 15, 1994 Meeting of the Weight and Balance Working Group (FAA Representatives Francis Heil, Ben Burton and Howard Vaughn in Attendance)

Dear Mr. Broderick:

A meeting of the Weight and Balance Working Group was held on February 15 (Ref. (2)) to adddress the questions you raised about standard average passenger and bag weights proposed for AC 120-27C (Ref (1)). In response to your letter, the following answers are provided.

Standard Average Weights for Passenger and Carry-On Bags. (1) What is the average passenger weight used in the proposed AC; and (2) what are the standard carry-on baggage weights for aircraft operating under Parts 121 and 135? There are no discrete values for these items separately. The proposed values in AC 120-27C are combined values for passengers and carry-on baggage. The values are 180 pounds for Summer periods and 185 pounds for Winter periods, both based on an average male/female passenger mix ratio of 60/40. To see how these values compare to other weights in current use, please examine Exhibit A.

Passenger weight has been combined with the carry-on baggage weight for several reasons:

1. To facilitate the collection of weight survey data and promote consistency of results: By weighing passengers with their carry-on baggage, the need to make arbitrary distinctions between items that are worn (coats, purses) and those that are carried (briefcases, umbrellas) is avoided. (It also avoids the

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inconvenience to passengers when separating them from their belongings for the survey.)

Since airlines performing these surveys use their own definitions of "worn" and "carried" items, previous comparisons between airlines have generated inconsistencies. By combining the two numbers, that inconsistency is eliminated.

2. To harmonize with European operators: JAA has issued a draft JAR-OPS regulation with weight-and-balance guidance based on combined passenger and carry-on weight values. AC 120-27C will put U.S. and European operators on equal footing, taking advantage of harmonization benefits and making comparisons more meaningful.

3. To simplify usage: By having only one weight value to account for both passenger and carry-on-baggage weights, numerical manipulations made for the dispatch sheet are reduced by half. This not only saves labor, but also reduces the opportunities for errors in calculation.

Supporting Data. You also asked what data the Working Group has to support the passenger and carry-on baggage weights. The Working Group, in deriving the proposed standard values, used the most statistically correct and latest survey data available. Data from recent surveys conducted by American, Delta and United airlines, as well as several international carriers, were used to reach the proposed values. The WG values for adult males and females match the corresponding values used by JAA.

Authoritative polls for the U.S. airline industry confirm the surveys of U.S. airlines indicating that the proportion of females travelling in the U.S. is higher than in Europe and other countries. While JAA established an average adult weight based on a male/female ratio of 80/20, the valid ratio for U.S. air travel is 60/40. Thus the average adult weight for U.S. operations is less than the average adult weight for JAA operations.

Exhibit A contains a comparison of the JAA proposal and the ARAC WG proposal. The WG is confident of the validity of these data, and urges FAA to proceed promptly with a public comment period on the draft AC.

Sincerely,

Steven R. Erickson

Steven R. Erickson
Assistant ARAC Chair
Air Carrier/GA Maintenance Issues

Copy: WAB WG

EXHIBIT A

STANDARD AVERAGE WEIGHTS IN VARIOUS DOCUMENTS

	SEASONAL WEIGHTS, LBS SUMMER	WINTER
1980 AC 120-27A		
STD AVG ADULT	160	165
CARRY-ON PER PAX	5	5
ADULT W/CARRY-ON	165	170
1990 AC 120-27B		
STD AVG ADULT	170	175
CARRY-ON PER PAX	10	10
ADULT W/CARRY-ON	180	185
JAA PROPOSAL *		
STD AVG M W/CARRY-ON	194	194
STD AVG F W/CARRY-ON	154	154
STD AVG ADULT W/C-O @ 80/20 M/F	185	185
ARAC WG DRAFT AC 120-27C *		
STD AVG M W/C-O	195	200
STD AVG F W/C-O	155	160
STD AVG ADULT W/C-O @ 60/40 M/F	180	185

* CARRIER MAY OPT TO CONDUCT SURVEY IN LIEU OF USING THESE AVERAGES

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APR 18 1994

Mr. Steve R. Erickson
Assistant Chair, Aviation Rulemaking
Advisory Committee
Air Transport Association of America
1301 Pennsylvania Avenue, NW.
Washington, DC 20004-1707

Dear Mr. Erickson:

Thank you for your March 25 letter on behalf of the Weight and Balance Working Group concerning the rationale the group used to arrive at weight values for proposed Advisory Circular (AC) 120-27C. The additional information submitted will be reviewed and evaluated by the Federal Aviation Administration (FAA) before final action is taken.

Again, I wish to thank you and the working group for your work and efforts in revising the AC. You will be notified of the outcome of the FAA evaluation when it has been completed.

Sincerely,

Anthony J. Broderick
Associate Administrator for
Regulation and Certification

U.S. Department
of Transportation

**Federal Aviation
Administration**

800 Independence Ave. S.W.
Washington, D.C. 20591

AUG 1 1994

Mr. Steve R. Erickson
Aviation Rulemaking Advisory Committee
Air Transport Association of America
1301 Pennsylvania Avenue, NW.
Washington, DC 20004-1707

Dear Mr. Erickson:

We are enclosing the Advisory Circular (AC) developed by the Weight and Balance Control Working Group and submitted to the Federal Aviation Administration as a recommendation. The AC has been reviewed by the agency and revised to include what we believe to be necessary agency safety requirements.

Please review the revised AC and let us know of any concerns that you might have. We would like to have your comments within 60 days.

If you need additional information concerning this matter, please contact the Executive Director, Frederick J. Leonelli, at (202) 267-3546.

Again, many thanks for all your work and efforts in revising the Aircraft Weight and Balance Control AC.

Sincerely,

Anthony J. Broderick
Associate Administrator for
Regulation and Certification

Enclosure

Control # 1566-94

Air Transport Association

to ARM-1 reply 9/14

September 12, 1994

Mr. Anthony J. Broderick
Associate Administrator for Regulation & Certification (AVR-1)
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

Dear Mr. Broderick:

This is in response to your letter, dated August 1, 1994, concerning a proposed revision for AC 120-27C, Aircraft Weight & Balance.

ARAC's Weight & Balance Working Group met on August 17, 1994, to review the changes which had been proposed by the FAA to the working group's revised draft AC. A list of individuals who attended that meeting is attached. Each of the FAA proposed changes was reviewed and discussed in detail, and agreement was reached among all parties in attendance on the precise wording that would be recommended to be published in the final revised advisory circular.

A copy of the draft AC is attached, reflecting the agreed changes as editorial mars in the margins. The revised draft reflects total agreement from both the working group and the FAA attendees.

On August 19, 1994, ARAC held a meeting to discuss Air Carrier/General Aviation Maintenance Issues; copies of the minutes of that meeting are available from the FAA's Office of Rulemaking. During that meeting, ARAC members reviewed the draft AC 120-27C and compared the revised draft to the version that was originally recommended by ARAC for FAA acceptance. ARAC unanimously accepted the marked-up revision, and agreed that the resulting draft is substantively unchanged from the version that was originally recommended to the FAA. Because there is no substantive difference between the original and marked-up versions, ARAC recommended that the Agency proceed immediately with the publication process; further public review and comment of the ARAC product is unnecessary.

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Thank you for the opportunity to review this draft with the Agency, and to establish effective and efficient guidance on aircraft weight and balance.

Sincerely,

Steven R. Erickson

Steven R. Erickson
Assistant ARAC Chair
Air Carrier/General Aviation
Maintenance Issues

Attachments

cc: Fred Leonelli, FAA (AFS-300)
Barbara Herber, FAA (ARM-205)
Don Collier, ATA
Jim Casey, ATA
ARAC Weight & Balance Working Group
ATA Aircraft Performance Network
ATA Airworthiness Engineering Committee

Acknowledgement Letter

U.S. Department
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**Federal Aviation
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SEP 30 1994

Mr. Steven R. Erickson
Assistant Chair, Aviation Rulemaking
Advisory Committee
Air Transport Association of America
Washington, DC 20004-1707

Dear Mr. Erickson:

This letter acknowledges receipt of your September 12 letter with which you transmitted the Aviation Rulemaking Advisory Committee's (ARAC) final version of the Weight and Balance Control Advisory Circular (AC).

I would like to thank you and the Weight and Balance Working Group for such prompt action in reviewing the revised AC. I am particularly pleased that the joint ARAC/Federal Aviation Administration (FAA) meeting to resolve outstanding issues was so successful.

I am advised, however, that after a thorough review of the revised version of the AC, several minor revisions may be required. Mr. Frederick Leonelli will be contacting you soon to explain the necessity for these revisions. I am confident that the final product will represent the best efforts of both ARAC and the FAA and will include necessary safety requirements.

We will make every effort to move as quickly as possible to finalize the Weight and Balance Control AC. As you may already know, it is not necessary to publish the AC in the Federal Register for public comment.

Again, many thanks for all your work and efforts in the development of the Aircraft Weight and Balance Control AC.

Sincerely,

Anthony J. Broderick
Associate Administrator for
Regulation and Certification

Recommendation

U.S. DEPARTMENT

OF TRANSPORTATION

Federal Aviation Administration

Advisory Circular

Subject: AIRCRAFT WEIGHT AND BALANCE CONTROL

Date: ____ [10/25/90] AC No: 120-27C[B]

Initiated by: AFS-330 Change:

1. PURPOSE. This advisory circular (AC) provides a method and procedures for developing a weight *and* balance control system.

2. FOCUS. This document provides guidance to certificate holders that are required to have an approved weight and balance program by Federal Aviation Regulations (FAR) Part 121 or elect to have an approved program under FAR Part 135.

3. CANCELLATION. AC 120-27B[A], Aircraft Weight and Balance Control, dated [May 14, 1980] *October 25, 1990.*

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 weight and balance limitations during operation. The approval of such a weight 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 which 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. Weight and balance control systems encompass the following:

a. Methods for establishing, monitoring, and adjusting individual aircraft or fleet empty weight and center of gravity (CG) in conjunction with the initial and periodic[al] reweighing of aircraft.

b. A loading schedule composed of graphs, tables, and computations, ***and/or computer programs,*** etc., whereby the various weight 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 weight and CG limits.

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

e. Procedures for *all applicable* [crewmembers, cargo handlers, and other] 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. The program should provide for operational performance factors such as takeoff and landing *weight* [away] accountability*; extension and retraction of landing gear, flaps, slats and thrust reversers;* and en route and taxi fuel burnoff.

6. TERMS, DESCRIPTIONS, AND GENERAL STANDARDS.

a. Empty Weight. The weight of the airframe, engines, propellers, rotors, and fixed equipment. Empty weight excludes the weight of the crew and payload but includes the weight of all fixed ballast, unusable fuel [supply], undrainable oil, [total quantity of engine coolant,] and total quantity of hydraulic fluid [(see FAR Section 135.2(e)(2))]. The empty weight of an aircraft is the gross weight 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*[3]) *Other drainable fluids, including potable water and lavatory service water,* [Drainable antidetonant injection,] *thrust* augmentation, and deicing fluids.

(*3*[2]) Crew and crew baggage.

(4) Passengers and cargo (revenue and nonrevenue).

(5) Removable passenger service equipment, food, magazines, etc., including *service carts, dishes and beverages* [drainable washing and potable water].

(6) *Removable e*[E]mergency equipment [(overwater, tropical, and frigid)].

(7) Other equipment variable for flights.

(8) *Spare parts.* [Flight spares (spark plugs, wheel, cylinder, etc.)]

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

(1) Normal oil quantity.

(2) *Lavatory servicing fluid, potable water, etc.* [Antidetonant injection, augmentation, and deicing fluids.]

(3) ***Drainable unuseable fuel.*** [Crew and crew baggage.]

(4) ***Crew and crew baggage.*** [Passenger service equipment, including washing and potable water, magazines, etc.]

(5) ***Passenger service equipment, including service carts, food, trays, dishes, beverages, magazines, etc.*** [All other items of equipment considered standard by the operator concerned.]

(6) ***Spare parts normally carried on-board and not accounted for as cargo.*** [Emergency equipment, if required, for all flights.]

(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 weight and operating weight should be included in the operator's program.

d. Structural Limits. Weight and CG limits are established at the time of aircraft certification. They are specifi***ed***[cally] in, or referenced by, the applicable type certificate data sheet or aircraft specification. The operator's weight and balance program should provide for maintaining these limits ***and*** [. The operator's program] should stress the point ***that*** the aircraft must be operated at or below its maximum certificated operating weight. Following are general definitions of structural weight limits normally considered in weight and balance programs.

(1) Maximum Zero Fuel Weight. The maximum zero fuel weight means the maximum permissible weight of an aircraft with no disposable fuel or oil (see FAR Sections 121.198(b) and 135.2(e)(3)).

(2) Maximum Landing Weight. The landing weight limit is the maximum weight at which the aircraft may normally be landed. Some aircraft are equipped to jettison fuel as an abnormal measure to reduce aircraft weight down to the landing limit.

(3) Maximum Takeoff Weight. This is the maximum allowable, total loaded aircraft weight at the start of the takeoff run.

(4) Maximum Ramp Weight. This is the maximum allowable, total loaded aircraft weight for taxi.

7. AIRCRAFT WEIGHT ESTABLISHMENT. Aircraft weight and balance control systems normally contain provisions for determining aircraft weight in accordance with the following procedures:

a. Individual Aircraft Weight and Changes. The loading schedule may utilize the individual weight of the aircraft in computing pertinent gross weight and balance. The individual weight and CG position of each aircraft should be confirmed at the specified reweighing periods. In addition, it should be reestablished by ***computing or*** reweighing whenever the cumulative change to the operating weight exceeds plus or minus one-half of 1 percent of the maximum landing weight 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 weight and balance should be reestablished.

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

(1) An operator's empty fleet weight 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 of 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 weight and CG position have been determined for aircraft weighed and the fleet operating weight established, necessary data should be computed for aircraft not weighed but which are considered eligible under such fleet weight. If the operating weight of any aircraft weighed or the calculated operating weight 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 weight from the established operating fleet weight or the CG position varies more than plus or minus one-half of 1 percent of the ***length of the*** MAC from the fleet ***weight*** CG, the aircraft should be omitted from that group and operated on its actual ***or calculated*** operating weight and CG position. If it falls within the limits of another fleet or group, it may [then] become part of ***that*** [the] fleet. In cases where the aircraft is within the operating fleet weight tolerance but the CG position varies in excess of the tolerance allowed, the aircraft may still be utilized under the applicable operating fleet weight but with an individual CG position.

(3) Reestablishment of the operator's empty fleet weight or operating fleet weight and corresponding CG positions may be accomplished between weighing periods by calculation based on the current empty weight of the aircraft previously weighed for fleet weight purposes. Weighing for reestablishment of fleet weights is normally conducted on a 3-year basis unless a shorter period is desired by the operator.

c. Establishing Initial Weight. Prior to being placed into service, each aircraft should be weighed and the empty weight and CG location established. New aircraft are normally weighed at the factory and are eligible to be placed into operation without reweighing if the weight and balance records have been adjusted for alterations or modifications to the aircraft. Aircraft transferred from one operator within an approved weight 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 weight 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 Weights. Aircraft operated under a loading schedule utilizing individual aircraft weights in computing the gross weight are normally weighed at intervals of 36 calendar months. An operator may, however, extend this weigh*ing*[t] period for a particular model aircraft when pertinent records of actual routine weighing during the preceding period of operation show that weight and balance records maintained are sufficiently accurate to indicate aircraft weights and CG positions are within the cumulative limits specified in paragraph 7a. Such applications should be limited to increases in increments of 12 months and should be substantiated in each instance with at least two aircraft weighed. Increases 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 which is equivalent to the aircraft overhaul period.

e. Periodic Weighing - Aircraft Using Fleet Weights. Aircraft operating under fleet weights should be weighed in accordance with procedures outlined for the establishment of fleet weights. Since each fleet is normally reestablished 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* [the aircraft equipment list to ensure the aircraft has the items of installed equipment contained in the list], 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 have been calibrated, either by the manufacturer or by a *recognized facility such as a* civil department of weights and measures, within 1 year, *or as recommended by the manufacturer,* prior to weighing any aircraft for this purpose unless the operator has evidence which warrants 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 utilizes several types of models of aircraft, a loading schedule, which may be index-type, tabular-type, or a computer, should be identified with the type of model or 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 weight 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 weight 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*** [crewmembers] so that the load distribution can be maintained within the approved limitation. A suitable commercial***ly available*** scale should be available for use when passenger, baggage, and cargo weights are otherwise undeterminable.

10. ***STANDARD*** PASSENGER WEIGHTS. Actual or average passenger weights may be used to compute passenger loads over any segment of a certificate holder's operations. However, actual weight should be used for operations with [reciprocating powered] aircraft ***having*** [of] nine or less ***passenger*** seats [and for all operations involving nonstandard weight passenger groups. Both methods may be used interchangeably provided only one method is used for any flight from originating to terminating point, except as indicated in subparagraph b].

The loading system should readily accommodate nonstandard weight groups, and the manifest should indicate whether average or actual weights, or a combination thereof, were used in the computation.

a. Average Passenger Weights. The standard average passenger weights listed in the following table were ***developed for*** [derived from an extensive survey of] conventional airline passenger groups. They should not 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% male/40% female operation.*** Special average weights ***or special ratios*** may be established for particular operations based on surveys ***(a)*** indicating those weights consistently provide for loading within prescribed weight and balance limits ***and (b) meeting the criteria for surveys and statistical analysis outlined in Appendix A of this document.*** Predominantly male passenger groups usually warrant higher averages.

STANDARD AVERAGE PASSENGER WEIGHTS
(Includes carry-on baggage)

Summer - for the period of May 1 through October 31:
Adult Passenger *(60%/40% male/female mix)*.....*180*[170] pounds
Male.....*195 pounds*
Female.....*155 pounds*

Winter - for the period of November 1 through April 30:
Adult Passenger *(60%/40% male/female mix)*.....*185*[175] pounds
Male.....***200 pounds***
Female.....***160 pounds***

Summer/Winter
Children.....80 pounds
(Applicable between ages 2 and 12)

b. Aircraft Typically Operated by Regional Carriers. Aircraft with limited cabin baggage stowage capability, where the operator's approved carry-on baggage program limits each passenger to a maximum of one carry-on bag in the cabin, may use the following standard average weights for passengers and carry-on bags:

Summer - for the period of May 1 through October 31:

Adult Passenger (60%/40% male/female mix).....170 pounds
Male.....185 pounds
Female.....145 pounds

Winter - for the period of November 1 through April 30:

Adult Passenger (60%/40% male/female mix).....175 pounds
Male.....190 pounds
Female.....150 pounds

Summer/Winter

Children.....80 pounds
(Applicable between ages 2 and 12)

Carry-on bags which cannot be stowed in the passenger cabin, and which are instead taken from passengers during the boarding process and stowed in a baggage compartment, shall be accounted for at an additional weight of 10 pounds per bag located at the compartment's center of gravity.

c. The average weight for children normally is used only when needed to accommodate available payload. Otherwise, as ticketed passengers, they are considered the same as adult passengers. Children less than 2 years old are considered babes-in-arms, and their weight is considered negligible.

Note: The intention of this AC is to provide methods and procedures for developing weight and balance control systems, not to address the entire spectrum of all possible weight configurations. Therefore, the operator should consider providing the Federal Aviation Administration with a reliable survey to establish an average passenger weight for its specific operation.

11. NONSTANDARD PASSENGER WEIGHTS

a. Actual Passenger Weights. Actual passenger weights are used on flights reserved wholly by nonstandard weight groups, ***unless average weight have been established for those groups.*** This includes athletic squads and other groups which are larger or smaller than the U.S. average; for compliance purposes, actual weights can be verbally solicited and 10 pounds per passenger added to allow for hand baggage, clothing variables, etc.

[NONSTANDARD PASSENGER WEIGHTS--MILITARY GROUPS

Noncombat-Equipped Military Personnel .....195 pounds

Note: This weight includes 20 pounds of hand-carried baggage.

Combat-Equipped Military Personnel.....225 pounds

Note: This represents the standard combat soldier as would be seen on contract flights involving large movements. This includes 195 pounds as shown above, 20 pounds for additional hand-carried mobility pack, and additional 10 pounds for hand-carried weapons.

b. Actual Passenger Weights. Actual passenger weights should be used in the case of flights carrying large groups of passengers whose average weight obviously does not conform to the normal standard weight, such as athletic squads or other groups which are smaller or larger than the U.S. average.]

Where [When] such groups form only a part of the total passenger load, actual weights, ***or established average weights for the nonstandard group,*** may be used for such exception groups and average weights 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. [Actual weights should be used for aircraft with small passenger capacities in which deviations from average weights could result in exceeding weight and balance limits. For example, there are numerous commuter type aircraft with a nine or less seating configuration that cannot carry full fuel and passenger loads simultaneously. These aircraft should use actual weights for their passengers and baggage.]

b[c]. *Determination of Actual Passenger Weight. Actual passenger weights may* [Actual passenger weight may] be determined by:

(1) Scale weighing of each passenger prior to boarding the aircraft, including ***hand bags*** [minor articles] carried ***on*** [a]board by the passenger***; or***[.]

(2) Asking each passenger his/her weight and adding to it a predetermined constant to provide for hand ***baggage*** [-carried articles] and [also to cover possible seasonal effect upon passenger weight due to variance in] clothing[weight]. This constant may be approved for an operator on the basis of studies by the operator that consider particular routes and seasonal variations, when applicable. Personnel listing passengers on this basis should receive instruction for estimating passenger weights to reasonably confirm their accuracy.

c. Nonstandard Average Passenger Weights - Military Groups. In lieu of actual weights (preferred), the following average weights may be used for military groups:

Noncombat-Equipped Military Personnel.....195 pounds

Note: This weight includes 20 pounds of hand-carried baggage.

Combat-Equipped Military Personnel.....225 pounds

Note: This represents the standard combat soldier as would be seen on contract flights involving large movements. This includes 195 pounds as shown above, 20 pounds for additional hand-carried mobility pack, and additional 10 pounds for hand-carried weapons.

12[11]. CREW WEIGHT. For crewmembers, the following approved average weights may be used:

a. Male cabin attendants *180* [150] pounds; female cabin attendants 130 pounds***; or 140 pounds average for all flight attendants.***

b. Male flight crewmembers *180* [170] pounds; female flight crewmembers 130.

13[12]. PASSENGER AND CREW BAGGAGE *AND MAIL*. 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*** weight may be used. ***Mail bag and checked baggage average weights may be used as described below.*** [The use of a]*A*ctual weights ***should be used for*** [is critical and required for FAR Part 135 reciprocating engine-powered] aircraft of nine or less passenger ***seat***s. [The following average passenger baggage weights may be approved for use in turbine-powered aircraft:]

a. [For FAR Part 135 operations with turbine-powered aircraft and/or aircraft type certificated for 10 or more passenger seats, a]*A*n operator may establish average passenger baggage weights predicated on a study of actual baggage weights for the operations or routes involved that consider seasonal and other variables*; or it may use the following average weights for each piece of checked baggage.*

b. For [FAR Part 121] domestic operations:

(1) [For each piece of checked baggage, a]*A*n average of not less than *25*[23.5] pounds; and

[(2) For each passenger boarding the aircraft, an average of not less than 10 pounds is added for hand baggage whether or not such baggage is carried by the passenger.]

c. For *International (transoceanic)* [FAR Part 121] flag and supplemental operations:

(1) [For each piece of checked baggage, a]*A*n average of not less than *30*[26.5] pounds.

[(2) For each passenger boarding the aircraft, not less than 10 pounds is added for hand baggage whether or not such baggage is carried by the passenger.]

Note: Average passenger baggage weights should not be used in computing the weight and balance of charter flights and other special services involving the carriage of special groups.

d. For normal operations, all mail bag manifested weight should be used in determining the weights of mail bag shipments. Should it be necessary to separate (break bulk) a manifested shipment or should manifested weights not be available, average individual bag weights may be used provided the average has been determined and substantiated by recent surveys that comply with the survey and statistical requirements in Appendix A of this document.

14[13]. *MOVEMENT OF PASSENGERS AND CREWMEMBERS* [TRAVEL] 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. 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*** [lounge] 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***[lounge] 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,*** [retraction] should be investigated and results accounted for.

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 accounted for.

15[14]. RECORD. The weight and balance system should include methods by which the operator will maintain a complete, current, and continuous record of the weight and CG of each aircraft. Such records should reflect all alterations and changes affecting either the weight or balance of the aircraft and will include a [complete and] 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 weights are used, pertinent computations should also be available in individual aircraft files.

16[15]. WEIGHT OF FLUIDS. The weight of all fluids used in the aircraft may be established on the basis of actual weight, a standard volume conversion, or a volume conversion utilizing appropriate temperature correction factors to accurately determine the weight by computation of the quantity of fluid aboard.

17[16]. CONTENT OF OPERATIONS SPECIFICATIONS PROCEDURES FOR AIRCRAFT WEIGHT AND BALANCE CONTROL. The operations specifications should contain the procedures (or make reference to the operator's approved weight and balance control program document) used to maintain control of weight 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 weight and CG limitations. This description should include a reference to the procedures used for determining weight of passengers/crew, weight of baggage, periodic aircraft weighing, type of loading devices, and identification of the aircraft concerned.

Thomas C. Accardi
Acting Director, Flight Standards Service

APPENDIX A. PROCEDURES FOR CONDUCTING SURVEYS AND ESTABLISHING AVERAGE WEIGHTS

1. FOCUS

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

1.0. DETERMINATION OF STANDARD AVERAGE WEIGHT VALUES FOR PASSENGERS, BAGGAGE, AND CARGO/MAIL

Operators must ensure that average weights used for passengers, baggage, and cargo/mail do not adversely affect operational safety. In lieu of using the standard average weight values contained in this Advisory Circular, average weights may be generated by use of a suitable statistical analysis.

Appendix A contains an acceptable methodology for conducting a statistical analysis and establishing suitable average weights.

Average weight 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 Appendix A.

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

1.1 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, airport selections with consideration given to check point or gate/flights within those airports. 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 weights 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 1.4, subparagraph A.1 of this document, whichever is larger.

A. Passenger Weights

1. Adults and Children. Adults may be defined as persons of an age of 12 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 between the ages of 2 and 12.

2. Infants are defined as persons less than 2 years of age and usually represent a very small portion of the survey. Survey samples should include infant weights together with the accompanying adult.

3. 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 weight figures shall be arranged so that they are only visible to authorized survey people.

4. Surveys should be conducted inside an airport location and at a site that will not inconvenience participants or other airline passengers.

5. Carry-on baggage should be accounted for as part of the total weight of the passenger. If desired, carry-on baggage may be weighed separately and added to the passenger weight.

6. Survey data should include, but not be limited to: sex, adult or child categorization, survey location, weight with carry-on, weight 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 weights of all the pieces or the actual total weights of the contents of the baggage containers they are in.

2. As an alternative, an approved standard average bag weight, specific to the individual carrier's operation, multiplied by the total count of the number of pieces, may be used. Those average weights may be determined as specified in this document.

3. Checked baggage averages specified in the Advisory Circular may be used in lieu of determining specific averages.

4. A form should be designed to include boarding point, destination, weight 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. Mail weights may be as specified in the Advisory Circular, item 13, paragraph d.

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

1.2 SCALES

The weighing scales to be used for conducting weight surveys shall have a capacity of at least 400 lb. All weights should be displayed at a minimum interval of 1 lb and should be accurate to within ± ½ lb. The tolerance shall not exceed ± 1 lb for every 200 lbs of weight.

1.3 RECORDING OF WEIGHT VALUES

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

1.4 EVALUATION OF DATA

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

A. Calculation of Adult Average Weight

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% is commonly used, i.e., there is a 95% 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.

Consequently, for the parameters of weight distribution three cases of mean and standard deviation have to be distinguished:

μ,σ = The true value of the average passenger weight and standard deviation which are unknown and which are to be estimated by weighing passenger samples.

μ^1,σ^1 = The initial estimates of the average passenger weight and standard deviation (values obtained from earlier survey samples).

$\bar{x},s$ = The estimates for the current true values of μ and σ calculated from the sample.

2. Formulas. The following formulas will be necessary in determining the correct results:

(a) FORMULA - Calculation of the sample size:

$$n \geq \frac{(1.96*\sigma^1*100)^2}{(e^1*\mu^1)^2}$$

where:

n = No. of passengers to be weighed (sample size),

e^1 = Allowed relative confidence range (accuracy) for the estimate of μ 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%, e^1 will be 1 in the above formula.

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

(b) FORMULA - Calculation of the arithmetic mean:

If the sample of passengers weighed is random, the arithmetic mean of the sample, $\bar{x}$, is an unbiased estimate of the true average weight μ of the population.

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

(c) FORMULA - Calculation of the standard deviation:

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

where $(x_j - \bar{x})$ is the deviation of the individual value from the sample mean.

(d) 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 μ^1 and σ^1). It has to be checked after the sample has been evaluated and can be done using the following formula:

$$e = \frac{1.96 * s * 100}{\sqrt{n} * x} \quad (\%).$$

e should not exceed:
1% for an adult average weight;
2% for an average male or female weight; or
4% for checked baggage and mail weights.

(e) FORMULA - Calculation of the confidence range of the sample mean:

This means that with 95% probability, the true average weight μ lies within the interval:

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

3. Example.

Adult Average Weight

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 weight figures used throughout the example are entirely fictitious.

a. Calculation of the required sample size

For calculating the required sample size, estimates of the standard (average) passenger weight 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 a 86-passenger sample.

n = 86.

Step 1: Estimated average passenger weight

j	x_j (lb)
1	176.1
2	150.1
3	171.1
4	164.2
5	119.2
6	137.2
7	196.8
8	239.6
.	.
.	.
.	.
.	.
85	139.3
86	166.2
Σ 86	13,385.4

$$\mu = \bar{x} = \frac{\Sigma x_j}{n} = \frac{13385.4}{86} = 155.616 \text{ lb.}$$

Step 2: Estimated standard deviation

$(x_j - \bar{x})$	$(x_j - \bar{x})^2$
+20.5	420.2
- 5.5	30.2
+16.1	259.2
+ 8.6	73.9
-36.4	1324.9
-18.5	342.2
+41.2	1697.4
+84.0	7056.0
.	.
.	.
.	.
.	.
-16.3	265.6
+10.6	112.4
	168559.3

$$\sigma^1 = \frac{\sqrt{\sum_{j=1}^{n}(x_j-\bar{x})^2}}{\sqrt{n-1}} = \frac{\sqrt{168,559.3}}{\sqrt{85}} = 44.53 \text{ lb.}$$

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

$$n \geq \frac{(1.96*\sigma^1*100)^2}{(e^1*\mu^1)^2} = \frac{(1.96*44.53*100)^2}{(1*155.616)^2} = 3146$$

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.

b. Determination of passenger average weight

Step 1: After having collected the required number of passenger weight values, the average passenger weight can be calculated. For the purpose of this example, it has been assumed that 3,180 passengers were weighed. The sum of the individual weights amounts to 509,673.0 lbs.

$n = 3180.$

$\Sigma x_j = 509,673.0$ lbs.

$$\bar{x} = \frac{509,673.0}{3180} = 160.27 \text{ lbs.}$$

Step 2: Calculation of the standard deviation.

$\Sigma(x_j-\bar{x})^2 = 3,621,079.6$ (given)

$$s = \frac{\sqrt{\sum_{j=1}^{n}(x_j-\bar{x})^2}}{\sqrt{n-1}} = \frac{\sqrt{3,621,079.6}}{\sqrt{3179}} = 33.75 \text{ lb.}$$

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

$$e = \frac{1.96*s*100}{\sqrt{n} * \bar{x}}(\%) = \frac{1.96*33.75*100}{\sqrt{3180}*160.27} = 0.73\%.$$

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

$$\bar{x} \pm \frac{1.96*s}{\sqrt{n}} = \bar{x} \pm \frac{1.96*33.75}{\sqrt{3180}} = 160.27 \pm 1.2$$

The result of this calculation shows that there is a 95% probability of the actual mean for all passengers lying within the range of 159.07 to 161.47 lbs.

B. 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 weights from paragraph 10 of the Advisory Circular and the percentages found in the survey to calculate the standard average adult weight.

Let:

n_m = number of males in the sample

n_f = number of females in the sample

$n = n_m + n_f$ = total sample size

p_m = percentage of males

q_f = percentage of females

$p_m + q_f = 100$

$s_p = s_q$ = standard deviation of percentage

$\bar{x}_a$ = standard average adult weight

$\bar{x}_m$ = standard average male weight from para 10 of A/C

$\bar{x}_f$ = standard average female weight from para 10 of A/C

s_m = standard deviation of male weight

s_f = standard deviation of female weight

$s_{\bar{x}a}$ = standard error of average adult weight

1. FORMULAS - The following formulas should be used in determining the correct results:

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

$$p_m = \frac{n_m}{n} * 100 \ (\%)$$

$$q_f = \frac{n_f}{n} * 100 \ (\%)$$

$$s_p = \frac{\sqrt{p_m * q_f}}{\sqrt{n-1}}$$

(b) FORMULA - Calculation of 95% confidence range for both male and female percentages.

$$p_m \pm 1.96 * s_p \ .$$

(c) FORMULA - Calculation of standard average adult weight using male and female weights from paragraph 10 in the Advisory Circular.

$$\bar{x}_a = \frac{\bar{x}_m * p_m}{100} + \frac{\bar{x}_f * p_f}{100} \ .$$

(d) FORMULA - Calculation of the standard deviation of the standard average adult weight.

$$s_{\bar{x}a} = \sqrt{(p_m^2 * \frac{s_m^2}{n_m}) + (q_f^2 * \frac{s_f^2}{n_f}) + (\bar{x}_m^2 * s_p^2) + (\bar{x}_f^2 * s_p^2)}$$

(e) FORMULA - Calculation of the accuracy of the standard average adult weight.

$$e = \frac{1.96 * s_{\bar{x}a}}{\bar{x}_a} * 100 \ (\%)$$

(f) FORMULA - Calculation of the 95% confidence range of the standard average adult weight.

$$\bar{x}_a \pm 1.96 * s_{\bar{x}a}$$

(g) FORMULA - Calculation of the sample size.

$$n = \frac{(\bar{x}_m^2 + \bar{x}_f^2) * p_m * q_f}{(\frac{e * \bar{x}_a}{1.96})^2 - (\frac{p_m^2 * s_m^2}{n_m} + \frac{q_f^2 * s_f^2}{n_f})}$$

Note: Data from the surveys yielding the averages in paragraph 10a of the Advisory Circular may be used to derive the sample size needed for update surveys. These values apply: $n_m = 1039$; $n_f = 640$; $\bar{x}_m = 195$; $\bar{x}_f = 155$;

p_m =.612; q_f = .388; $\bar{x}_a$ = 180; s_m = 35.1 and s_f = 34.8.

Thus, for male/female averages, e = .02, and

$$n = \frac{((195)^2+(155)^2)*.612*.388}{(\frac{.02*180}{1.96})^2 - (\frac{(.612)^2*(35.1)^2}{1039}) - (\frac{(.388)^2*(34.8)^2}{640})}$$

$$= 5571.$$

This sample size can be used until the average weights in the Advisory Circular are updated with later survey data.

2. 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 weight figures used throughout the example are entirely fictitious.

Given: Sample of 5,600 passengers, 3400 male and 2200 female.

Step 1. Calculating the percentage of males and females.

$$p_m = \frac{n_m}{n} * 100\ (\%) = \frac{3400}{5600} * 100 = 60.7\%$$

$$q_f = 100.0 - 60.7 = 39.3\%.$$

Step 2. Calculation of the standard deviation. Note that the standard deviations for the percentage of men and women are equal.

$$s_p = \frac{\sqrt{p_m*q_f}}{\sqrt{n-1}} = \frac{\sqrt{60.7*39.3}}{\sqrt{5599}} = 0.65\%.$$

Step 3. Calculating the confidence range.

$$p_m \pm 1.96*s_p = 60.7 \pm 1.96*0.65 = 60.7\% \pm 1.28\%$$

This indicates that there is a 95% probability that the actual percentage of men is between 59.4% and 62.0%, and that the percentage of women is between 38.0% and 40.6%, i.e., 59.4/40.6 and 62.0/38.0.

Step 4. Calculation of the standard average adult weight. Use the standard average male and female weights shown in paragraph 10a of the Advisory Circular (assume Summer weights for this

EXHIBIT A

STANDARD AVERAGE WEIGHTS IN VARIOUS DOCUMENTS

	SEASONAL WEIGHTS, LBS SUMMER	WINTER
1980 AC 120-27A		
STD AVG ADULT	160	165
CARRY-ON PER PAX	5	5
ADULT W/CARRY-ON	165	170
1990 AC 120-27B		
STD AVG ADULT	170	175
CARRY-ON PER PAX	10	10
ADULT W/CARRY-ON	180	185
JAA PROPOSAL *		
STD AVG M W/CARRY-ON	194	194
STD AVG F W/CARRY-ON	154	154
STD AVG ADULT W/C-O @ 80/20 M/F	185	185
ARAC WG DRAFT AC 120-27C *		
STD AVG M W/C-O	195	200
STD AVG F W/C-O	155	160
STD AVG ADULT W/C-O @ 60/40 M/F	180	185

* CARRIER MAY OPT TO CONDUCT SURVEY IN LIEU OF USING THESE AVERAGES

example) and the percentages of men and women found in the survey. When doing this calculation, divide p_m and q_f by 100 to express them in decimal form.

$$\bar{x}_a = \frac{\bar{x}_m * p_m}{100} + \frac{\bar{x}_f * p_f}{100} = \frac{195*60.7}{100} + \frac{155*39.3}{100}$$

$$= 179 \text{ lbs.}$$

Step 5. Calculation of the standard deviation of the average adult weight. When doing this calculation, divide p_m, q_f and s_p by 100 to express them in decimal form.

$$s_{\bar{x}a} = \sqrt{(p_m^2 * \frac{s_m^2}{n_m}) + (q_f^2 * \frac{s_f^2}{n_f}) + (\bar{x}_{m2} * s_p^2) + (\bar{x}_{f2} * s_p^2)}$$

From the survey supporting the Advisory Circular averages: s_m = 35.1; n_m = 1039; s_f = 34.8; n_f = 640; $\bar{x}_m$ = 195; and $\bar{x}_f$ = 155. Thus,

$$s_{\bar{x}a} = \sqrt{((.607)^2 * \frac{(35.1)^2}{1039}) + ((.393)^2 * \frac{(34.8)^2}{640}) + (195*.0065)^2 + (155*.0065)^2}$$

$$= 1.83.$$

Step 6. Calculation of the accuracy of the standard average adult weight.

$$e = \frac{1.96 * s_{\bar{x}a}}{\bar{x}_a} * 100\ (\%) = \frac{1.96*1.83}{179} * 100\% = 2.0\%.$$

Step 7. Calculation of the confidence range of the standard average adult weight.

$$\bar{x}_a \pm 1.96 * s_{\bar{x}a} = 179 \pm 1.96*1.83 = 179 \pm 3.6 \text{ lbs.}$$

This indicates that there is a 95% probability that the actual standard average adult weight is between 175 and 183 lbs.

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject:	Aircraft Weight and Balance Control	**Date:**	**AC No:** 120-27C
		Initiated by: AFS-330	**Change:**

1. PURPOSE. This advisory circular (AC) provides one means, but not the only means, for obtaining approval of a weight and balance control system.

2. FOCUS. This document provides guidance to certificate holders that are required to have an approved weight and balance program by Federal Aviation Regulations (FAR) Part 121 or choose to have an approved program under FAR Part 135.

3. CANCELLATION. AC 120-27B, Aircraft Weight and Balance Control, dated October 25, 1990, is cancelled.

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 weight and balance limitations during operation. The approval of such a weight 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 which 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. Weight and balance control systems encompass the following:

a. Methods for establishing, monitoring, and adjusting individual aircraft or fleet empty weight and center of gravity (CG) in conjunction with the initial and periodic reweighing of aircraft.

b. A loading schedule composed of graphs, tables, and computations and/or computer programs, etc., whereby the various weight 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 weight and CG limits.

d. A load manifest to document loading information by personnel responsible for weight 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 weight 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 Weight. The weight of the airframe, engines, propellers, rotors, and fixed equipment. Empty weight excludes the weight of the crew and payload but includes the weight of all fixed ballast, unusable fuel, undrainable oil, and total quantity of hydraulic fluid. The empty weight of an aircraft is the maximum certificated weight 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 service water, thrust augmentation, and deicing 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 Weight. The basic operating weight established by the operator for a particular model aircraft should include the following standard items in addition to the empty weight 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 weight and operating weight should be included in the operator's program.

d. Structural Limits. Weight 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 weight 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 weight. The following are general definitions of structural weight limits normally considered in weight and balance programs.

(1) Maximum Zero Fuel Weight. The maximum zero fuel weight means the maximum permissible weight of an aircraft with no disposable fuel and oil (see FAR Sections 121.198(b) and 135.2(e)(3)).

(2) Maximum Landing Weight. This landing weight limit is the maximum weight at which the aircraft may normally be landed. Some aircraft are equipped to jettison fuel to reduce aircraft weight down to the landing limit in an emergency situation.

(3) Maximum Takeoff Weight. This is the maximum allowable, total loaded aircraft weight at the start of the takeoff run.

(4) Maximum Ramp Weight. This is the maximum allowable, total loaded aircraft weight for taxi.

7. AIRCRAFT WEIGHT ESTABLISHMENT. Aircraft weight and balance control systems normally contain provisions for determining aircraft weight in accordance with the following procedures:

a. Individual Aircraft Weight and Changes. The loading schedule may utilize the individual weight of the aircraft in computing pertinent maximum certificated weight and balance. The individual weight and CG position of each aircraft should be confirmed at the specified reweighing periods. In addition, it should be reestablished by computing or reweighing whenever the cumulative change to the operating weight exceeds plus or minus one-half of 1 percent of the maximum landing weight 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 weight and balance should be reestablished.

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

(1) An operator's empty fleet weight 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 of 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 weight and CG position have been determined for aircraft weighed and the fleet operating weight established, necessary data should be computed for aircraft not weighed but which are considered eligible under such fleet weight. If the operating weight of any aircraft weighed or the calculated operating weight 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 weight from the established operating fleet weight or the CG position varies more than plus or minus one-half of 1 percent of the length of the MAC from the

fleet weight CG, the aircraft shall be omitted from that group and operated on its actual or calculated operating weight and CG position. The FAA 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 weight. 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 weight tolerance but the CG position varies in excess of the tolerance allowed, the FAA would accept an operator using the aircraft under the applicable operating fleet weight and with an individual CG position.

(3) Reestablishment of the operator's empty fleet weight or operating fleet weight and corresponding CG positions may be accomplished between weighing periods by calculation based on the current empty weight of the aircraft previously weighed for fleet weight purposes. Weighing for reestablishment of fleet weights 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 Weight. Prior to being placed into service, each aircraft should be weighed and the empty weight and CG location established. New aircraft are normally weighed at the factory and are eligible to be placed into operation without reweighing if the weight and balance records have been adjusted for alterations or modifications to the aircraft. Aircraft transferred from one operator, that has an approved weight 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 weight 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 Weights. Aircraft operated under a loading schedule utilizing individual aircraft weights in computing the maximum certificated weight 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 weight and balance records maintained are sufficiently accurate to indicate aircraft weights and CG positions are within the cumulative limits specified in paragraph 7a. Such applications should be limited to increases in increments of 12 months and should be substantiated in each instance with at least two aircraft weighed. Increases 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 which is equivalent to the aircraft overhaul period.

e. Periodic Weighing - Aircraft Using Fleet Weights. Aircraft operating under fleet weights should be weighed in accordance with procedures outlined for the establishment of fleet weights. Since each fleet is normally reestablished 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 recognized facility such as a civil department of weights and measures, periodically as recommended in the manufacturer's calibration schedule. If a calibration schedule is not available from the manufacturer, the FAA would find it acceptable to use the scale to weigh the aircraft within one year after the calibration of the scale. The FAA 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 utilizes 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 weight 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 weight 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 weights are otherwise undeterminable.

10. STANDARD PASSENGER WEIGHTS. Actual weights, or when appropriate, average passenger weights are used to compute passenger loads over any segment of a certificate holder's operations. Actual weights are used for operations with aircraft having nine or less passenger seats and aircraft carrying nonstandard passenger loads as described by paragraph 11. The loading system should readily accommodate nonstandard weight groups, and the manifest should indicate whether average or actual weights, or a combination thereof, were used in the computation.

> Note: The intention of this AC is to provide methods and procedures for developing weight and balance control systems, not to address the entire spectrum of all possible weight configurations. Therefore, the operator should consider providing the Federal Aviation Administration with a reliable survey to establish an average passenger weight for its specific operation.

a. Average Passenger Weights. The standard average passenger weights listed in the following table were 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% male/40% female operation. Special average weights or special ratios may be established for particular operations based on surveys: (a) indicating those weights consistently provide for loading within prescribed weight and balance limits; and (b) meeting the criteria for surveys and statistical analysis outlined in appendix 1 of this document.

STANDARD AVERAGE PASSENGER WEIGHTS

(Includes 20 pounds carry-on baggage for adult passengers)

Summer - for the period of May 1 through October 31:

Adult Passenger (60%/40% male/female mix).....180 pounds

Male.....195 pounds

Female.....155 pounds

Winter - for the period of November 1 through April 30:

Adult Passenger (60%/40% male/female mix).....185 pounds

Male.....200 pounds

Female.....160 pounds

Summer/Winter

Children.....80 pounds
(Applicable between ages 2 and 12)

b. Average Passenger Weights for Aircraft with Limited Cabin Storage. Aircraft with limited cabin baggage stowage capability, where the operator's approved carry-on baggage program limits each passenger to a maximum of one carry-on bag in the cabin, may use the following average weights for passengers and carry-on bags. 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% male/40% female operation.

AVERAGE PASSENGER WEIGHTS - LIMITED CABIN STOWAGE
(Includes 10 pounds carry-on baggage for adult passengers)

Summer - for the period of May 1 through October 31:	
Adult Passenger (60%/40% male/female mix)	170 pounds
Male	185 pounds
Female	145 pounds
Winter - for the period of November 1 through April 30:	
Adult Passenger (60%/40% male/female mix)	175 pounds
Male	190 pounds
Female	150 pounds
Summer/Winter	
Children (Applicable between ages 2 and 12)	80 pounds

With data submitted by the certificate holder to the FAA for a review of its statistical validity, the following provision may be approved by the FAA:

The single carry-on bag permitted in the cabin by this paragraph (b) (and as described in the certificate holder's weight and balance program) is included in the average passenger weight. Moving this bag from the cabin to the baggage compartment does not require any weight recalculations. This may not be true of CG calculations.

All other bags (i.e., bags other than the single carry-on bag permitted in the cabin by paragraph (b) and as described in the certificate holder's weight and balance program) use actual weights or, if and as appropriate, the average weights for checked baggage described in paragraphs 13(b) or 13(c).

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

11. NONSTANDARD PASSENGER WEIGHTS

a. Actual Passenger Weights. Actual passenger weights are used for nonstandard weight groups, unless average weights have been established for those groups. This includes athletic squads and other groups which are larger or smaller than the U.S. average.

When such groups form only a part of the total passenger load, actual weights, or established average weights for the nonstandard group, may be used for such exception groups and average weights 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 Weight. Actual passenger weights may be determined by:

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

(2) Asking each passenger his/her weight and adding to it a predetermined constant to provide for hand baggage and clothing. This constant may be approved for an operator on the basis of studies by the operator that consider particular routes and seasonal variations, when applicable. Personnel listing passengers on this basis should receive instruction for estimating passenger weights to reasonably confirm their accuracy.

c. Nonstandard Average Passenger Weights - Military Groups. In lieu of actual weights (preferred), the following average weights may be used for military groups, unless the passengers or their carry-on baggage appreciably differ from these standard weights:

Noncombat-Equipped Military Personnel.....195 pounds

Note: This weight includes 20 pounds of hand-carried baggage.

Combat-Equipped Military Personnel.....225 pounds

Note: This represents the standard combat soldier as would be seen on contract flights involving large movements. This includes 195 pounds as shown above, 20 pounds for additional hand-carried mobility pack, and an additional 10 pounds for hand-carried weapons.

12. CREW WEIGHT. For crewmembers, the following approved average weights may be used:

a. Male cabin attendants 180 pounds; female cabin attendants 130 pounds; or 140 pounds average for all flight attendants.

b. Male flight crewmembers 180 pounds; female flight crewmembers 130.

13. PASSENGER AND CREW BAGGAGE AND MAIL. 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 weight may be used. Mail bags and checked baggage average weights may be used as described below. Actual weights should be used for aircraft of nine or less passenger seats. Actual weights are used when it is noticeable that the checked baggage or the mail bags exceed the average weights.

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

b. Domestic Operations. Not less than an average of 25 pounds should be used.

c. International Flag and Supplemental Operations. Not less than an average of 30 pounds should be used.

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

d. Normal Operations. All mail bag manifested weight should be used in determining the weights of mail bag shipments. Should it be necessary to separate (break bulk) a manifested shipment or should manifested weights not be available, the FAA would accept the use of average individual bag weights, in circumstances where the average has been determined and substantiated by recent surveys that follow the survey and statistical models suggested in appendix 1 of this document.

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

Such records should reflect all alterations and changes affecting either the weight 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 weights are used, pertinent computations should also be available in individual aircraft files.

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

17. CONTENT OF OPERATIONS SPECIFICATIONS PROCEDURES FOR AIRCRAFT WEIGHT AND BALANCE CONTROL. The operations specifications should contain the procedures (or make reference to the operator's approved weight and balance control program document) used to maintain control of weight 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 weight and CG limitations. This description should include a reference to the procedures used for determining weight of passengers/crew, weight of baggage, periodic aircraft weighing, type of loading devices, and identification of the aircraft concerned.

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

APPENDIX 1. PROCEDURES FOR CONDUCTING SURVEYS AND ESTABLISHING AVERAGE WEIGHTS

1. FOCUS. The methodology presented can be used to determine standard average weights 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 Advisory Circular.

2. DETERMINATION OF STANDARD AVERAGE WEIGHT VALUES FOR PASSENGERS, BAGGAGE, AND CARGO/MAIL. It is critical that operators determine that average weights used for passengers, baggage, and cargo/mail do not adversely affect operational safety. In lieu of using the standard average weight values contained in this Advisory Circular, average weights may be generated by use of a suitable statistical analysis.

Appendix 1 contains an acceptable methodology for conducting a statistical analysis and establishing suitable average weights.

Average weight 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 appendix 1.

For practical reasons passenger weight values may be rounded to the nearest whole number in pounds, and the checked bag weight 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, airport selections with consideration given to check point or gate/flights within those airports. 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 weights 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 document, whichever is larger.

a. Passenger Weights.

(1) Adults and Children. For purposes of this AC only, 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 weight figures shall be arranged so that they are only visible to authorized survey people.

(3) Surveys should be conducted inside an airport 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 weight of the passenger. If desired, carry-on baggage may be weighed separately and added to the passenger weight.

(5) Survey data should include, but not be limited to: sex, adult or child categorization, survey location, weight with carry-on, weight 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 weights of all the pieces or the actual total weights of the contents of the baggage containers they are in.

(2) As an alternative, an approved standard average bag weight, specific to the individual carrier's operation, multiplied by the total count of the number of pieces, may be used. Those average weights may be determined as specified in this document.

(3) Checked baggage averages specified in the Advisory Circular may be used in lieu of determining specific averages.

(4) A form should be designed to include boarding point, destination, weight 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) Mail weights may be as specified in the Advisory Circular, item 13, paragraph d.

(2) Survey data should include boarding point, destination, weight 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 weight surveys shall have a capacity of at least 400 lbs. All weights should be displayed at a minimum interval of 1 lb. and should be accurate to within ± ½ lb. The tolerance shall not exceed ± 1 lb. for every 200 lbs. of weight.

5. WEIGHT DATA. The recording of weight 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 weights. If the survey is being conducted to determine only male/female percentages, use the methodology in subparagraph f.

a. Calculation of Passenger Average Weight.

(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% is commonly used, i.e., there is a 95% 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 weight distribution three cases of mean and standard deviation have to be distinguished:

μ, σ = The true value of the average passenger weight and standard deviation which are unknown and which are to be estimated by weighing passenger samples.

μ^1, σ^1 = The initial estimates of the average passenger weight and standard deviation (values obtained from earlier survey samples).

$\bar{x}, s$ = The estimates for the current true values of μ and σ calculated from the sample.

b. Formulas. The following formulas will be necessary in determining the correct results:

(1) FORMULA - Calculation of the sample size:

$$n \geq \frac{(1.96 * \sigma^1 * 100)^2}{(e^1 * \mu^1)^2}$$

where:

n = No. of passengers to be weighed (sample size),

e^1 = Allowed relative confidence range (accuracy) for the estimate of μ 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%, e^1 will be 1 in the above formula.

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

(2) 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 weight μ of the population.

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

(3) FORMULA - Calculation of the standard deviation:

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

where $(x_j - \bar{x})$ is the deviation of the individual value from the sample mean.

(4) 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 μ^1 and σ^1). It has to be checked after the sample has been evaluated and can be done using the following formula:

$$e = \frac{1.96 * s * 100}{\sqrt{n} * x} \ (\%).$$

e should not exceed:
1% for an adult average weight;
2% for an average male or female weight; or
4% for checked baggage and mail weights.

(5) FORMULA - Calculation of the confidence range of the sample mean:

This means that with 95% probability, the true average weight μ lies within the interval:

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

c. Example - Adult Average Weight. 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 weight 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 weight 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 weight

Step 2: Estimated standard deviation

j	x_j (lb)		$(x_j - \bar{x})$	$(x_j - \bar{x})^2$
1	176.1	$\mu = \bar{x}$	+20.5	420.2
2	150.1		- 5.5	30.2
3	171.1		+16.1	259.2
4	164.2		+ 8.6	73.9
5	119.2	$= \frac{\Sigma x_j}{n}$	-36.4	1324.9
6	137.2		-18.5	342.2
7	196.8		+41.2	1697.4
8	239.6		+84.0	7056.0
.	.	$= \frac{13385.4}{86}$	.	.
.	.		.	.
.	.		.	.
.	.		.	.
85	139.3	= 155.616 lb.	-16.3	265.6
86	166.2		+10.6	112.4
Σ 86	13,385.4			168,559.3

$$\sigma^1 = \frac{\sqrt{\sum_{j=1}^{n} (x_j - \bar{x})^2}}{\sqrt{n-1}} = \frac{\sqrt{168,559.3}}{\sqrt{85}} = 44.53 lb.$$

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

$$n \geq \frac{(1.96*\sigma^1*100)^2}{(e^1*\mu^1)^2} = \frac{(1.96*44.53*100)^2}{(1*155.616)^2} = 3146$$

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 Weight.

Step 1: After having collected the required number of passenger weight values, the average passenger weight can be calculated. For the purpose of this example, it has been assumed that 3,180 passengers were weighed. The sum of the individual weights amounts to 509,673.0 lbs.

n = 3,180.

$$\Sigma x_j = 509,673.0 \text{ lbs.}$$

$$\bar{x} = \frac{509,673.0}{3180} = 160.27 \text{ lbs.}$$

Step 2: Calculation of the standard deviation.

$$\Sigma (x_j - \bar{x})^2 = 3,621,079.6 \text{ (given)}$$

$$s = \frac{\sqrt{\sum_{j=1}^{n} (x_j - \bar{x})^2}}{\sqrt{n-1}} = \frac{\sqrt{3,621,079.6}}{\sqrt{3179}} = 33.75 \text{ lb.}$$

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

$$e = \frac{1.96*s*100}{\sqrt{n*\bar{x}}}(\%) = \frac{1.96*33.75*100}{\sqrt{3180*160.27}} = 0.73\%$$

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

$$\bar{x} \pm \frac{1.96*s}{\sqrt{n}} = \bar{x} \pm \frac{1.96*33.75}{\sqrt{3180}} = 160.27 \pm 1.2$$

The result of this calculation shows that there is a 95% probability of the actual mean for all passengers lying within the range of 159.07 to 161.47 lbs.

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 weights from paragraph 10 of the Advisory Circular and the percentages found in the survey to calculate the standard average adult weight.

Let:

n_m = number of males in the sample

n_f = number of females in the sample

$n = n_m + n_f$ = total sample size

p_m = percentage of males

q_f = percentage of females

$p_m + q_f = 100$

$s_p = s_q$ = standard deviation of percentage

$\bar{x}_a$ = standard average adult weight

$\bar{x}_m$ = standard average male weight from paragraph 10 of the AC

$\bar{x}_f$ = standard average female weight from paragraph 10 of the AC

s_m = standard deviation of male weight

s_f = standard deviation of female weight

$s_{\bar{x}a}$ = standard error of average adult weight

(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.

$$p_m = \frac{n_m}{n} * 100 \ (\%)$$

$$q_f = \frac{n_f}{n} * 100 \ (\%)$$

$$s_p = \frac{\sqrt{p_m * q_f}}{\sqrt{n-1}}$$

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

$$p_m \pm 1.96 * s_p$$

(iii) FORMULA - Calculation of standard average adult weight using male and female weights from paragraph 10 in the Advisory Circular.

$$\overline{x_a} = \frac{\overline{x_m} * p_m}{100} + \frac{\overline{x_f} * p_f}{100}$$

(iv) FORMULA - Calculation of the standard deviation of the standard average adult weight.

$$s_{\overline{x_a}} = \sqrt{\left(p_m^2 * \frac{s_m^2}{n_m}\right) + \left(q_f^2 * \frac{s_f^2}{n_f}\right) + (x_m^2 * s_p^2) + (x_f^2 * s_p^2)}$$

(v) FORMULA - Calculation of the accuracy of the standard average adult weight.

$$e = \frac{1.96 * s_{\overline{x_a}}}{x_a} * 100(\%)$$

(vi) FORMULA - Calculation of the 95% confidence range of the standard average adult weight.

$$\overline{x_a} \pm 1.96 * s_{\overline{x_a}}$$

(vii) FORMULA - Calculation of the sample size.

$$n = \frac{(x_m^2 + x_f^2) * p_m * q_f}{\left(e * \frac{x_a}{1.96}\right)^2 - \left(\frac{p_m^2 * s_m^2}{n_m} + \frac{q_f^2 * s_f^2}{n_f}\right)}$$

Note: Data from the surveys yielding the averages in paragraph 10a of the Advisory Circular may be used to derive the sample size needed for update-surveys. - These values apply: n_m = 1039; n_f = 640; x_m = 195; x_f = 155; p_m =.612; q_f = .388; x_a = 180; s_m = 35.1 and s_f = 34.8.

Thus, for male/female averages, e = .02, and

$$n = \frac{((195)^2+(155)^2)*.612*.388}{\left(\frac{.02*180}{1.96}\right)^2 - \left(\frac{(.612)^2*(35.1)^2}{1039}\right) - \left(\frac{(.388)^2*(34.8)^2}{640}\right)} = 5571.$$

This sample size can be used until the average weights in the Advisory Circular are updated with later survey data.

g. 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 weight figures used throughout the example are entirely fictitious.

Given: Sample of 5,600 passengers, 3,400 male and 2,200 female.

Step 1. Calculating the percentage of males and females.

$$p_m = \frac{n_m}{n} * 100\ (\%) = \frac{3400}{5600} * 100 = 60.7\%$$

$$q_f = 100.0 - 60.7 = 39.3\%.$$

Step 2. Calculation of the standard deviation. Note that the standard deviations for the percentage of men and women are equal.

$$s_p = \frac{\sqrt{p_m * q_f}}{\sqrt{n-1}} = \frac{\sqrt{60.7*39.3}}{\sqrt{5599}} = 0.65\%$$

Step 3. Calculating the confidence range.

$$p_m \pm 1.96*s_p = 60.7 \pm 1.96*0.65 = 60.7\% \pm 1.28\%$$

This indicates that there is a 95% probability that the actual percentage of men is between 59.4% and 62.0%, and that the percentage of women is between 38.0% and 40.6%, i.e., 59.4/40.6 and 62.0/38.0.

Step 4. Calculation of the standard average adult weight. Use the standard average male and female weights

shown in paragraph 10a of the Advisory Circular (assume Summer weights for this example) and the percentages of men and women found in the survey. When doing this calculation, divide p_m and q_f by 100 to express them in decimal form.

$$x_a = \frac{\overline{x_m} * p_m}{100} + \frac{\overline{x_f} * p_f}{100} = \frac{195 * 60.7}{100} + \frac{155 * 39.3}{100} = 179 \ lbs.$$

Step 5. Calculation of the standard deviation of the average adult weight. When doing this calculation, divide p_m, q_f, and s_p by 100 to express them in decimal form.

$$s_{\overline{x_a}} = \sqrt{\left(p_m^2 * \frac{s_m^2}{n_m}\right) + \left(q_f^2 * \frac{s_f^2}{n_f}\right) + (x_m^2 * s_p^2) + (x_f^2 * s_p^2)}$$

From the survey supporting the Advisory Circular averages: s_m = 35.1; n_m = 1039; s_f = 34.8; n_f = 640; $\bar{x}_m$ = 195; and $\bar{x}_f$ = 155. Thus,

$$s_{\overline{x_a}} = \sqrt{\left((.607)^2 * \frac{(35.1)^2}{1039}\right) + \left((.393)^2 * \frac{(34.8)^2}{640}\right) + (195^2 * .0065^2) + (155^2 * .006}$$

Step 6. Calculation of the accuracy of the standard average adult weight.

$$e = \frac{1.96 * s_{\overline{x_a}}}{x_a} * 100\ (\%) = \frac{1.96 * 1.83}{179} * 100(\%) = 2.0\%.$$

Step 7. Calculation of the confidence range of the standard average adult weight.

$$\overline{x_a} \pm 1.96 * s_{\overline{x_a}} = 179 \pm 1.96 * 1.83 = 179 \pm 3.6 \ lbs.$$

This indicates that there is a 95% probability that the actual standard average adult weight is between 175 and 183 lbs.

Federal Aviation Administration

[AC 120-27C]

Proposed Revision to Advisory Circular—Aircraft Weight and Balance Control

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of availability of proposed advisory circular (AC), and request for comments.

SUMMARY: This notice announces the availability of proposed AC 120-27C, Aircraft Weight and Balance Control, for review and public comments. The proposed AC 120-27C provides guidance on acceptable means, but not the only means, for certain certificate holders to obtain approval of a weight and balance control system.

DATES: Comments must be received on or before February 27, 1995.

ADDRESSES: Copies of proposed AC 120-27C can be obtained from and comments may be returned to: Federal Aviation Administrtion, Flight Standards National Field Office, P.O. Box 20034, Washington, DC 20041; telephone (703) 661-0333, extension 5009.

FOR FURTHER INFORMATION CONTACT: Mr. Benjamin J. Burton, Jr., Federal Aviation Administration, Aircraft Maintenance Division, AFS-300, 800 Independence Avenue, SW., Washington, DC 20591; telephone (202) 267-3797.

SUPPLEMENTARY INFORMATION:

Comments Invited

Interested persons are invited to comment on the proposed AC 120-27C by submitting such written data, views, or arguments as they desire to the address specified above. Commenters must identify the title of the proposed AC and submit comments, in duplicate, to the address specified above. All communications received on or before the closing date for comments will be considered by the Flight Standards National Field Office before issuing the final AC.

Comments received on the proposed AC 120-27C may be examined before and after the comment closing date at the Federal Aviation Administration, Flight Standards National Field Office, Gateway Building, suite 131, Washington Dulles International Airport, Washington, DC 20041; weekdays between 8 a.m. and 4 p.m., except on Federal holidays.

Background

On October 25, 1990, the FAA issued AC 120-27B, Aircraft Weight and Balance Control, which canceled AC 120-27A, Aircraft Weight and Balance Control, dated May 14, 1980. The FAA requested that the Aviation Rulemaking Advisory Committee (ARAC) review the existing methods by which standard weights for passengers, carry-on baggage, and checked baggage are established and recommend any necessary revisions to AC 120-27B. The ARAC was chartered in February 1991, to provide recommendations to the FAA on issues related to aviation safety.

Discussion

Based on the ARAC's recommendations, the FAA proposes to revise AC 120-27B as AC 120-27C. Proposed AC 120-27C recommends standard average passenger weights for conventional airline adult passenger groups (60 percent male/40 percent female mix), male passenger groups, and female passenger groups. The recommended adult passenger group averages provide for two types of operations: (1) Aircraft used by airlines that permit carry-on baggage; and (2) Aircraft with limited cabin stowage capability (i.e., aircraft used by regional airlines) where approved carry-on baggage programs limit each passenger to one carry-on bag. Please note that the weight table recommended by ARAC for aircraft with limited cabin stowage did not contain the three explanatory paragraphs included in the FAA proposal. The FAA has determined that these paragraphs are necessary to fully explain the requirements that must be met in order to use this table.

Proposed AC 120-27C also recommends new standard average weights for crewmembers, baggage loaded on domestic flights, baggage loaded on international flights, and baggage loaded on flights by supplemental operators.

Appendix 1 of the proposed AC 120-27C provides guidance on acceptable methods for an operator to conduct surveys and to establish male/female ratios of passenger groups or standard average weights of passengers, checked baggage, carry-on baggage, mail, or other normal items in that operator's approved weight and balance control system.

Issued in Washington, DC, on December 20, 1994.

William J. White,

Acting Director, Flight Standards Service.

[FR Doc. 94-31912 Filed 12-27-94; 8:45 am]

BILLING CODE 4910-13-M

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject:	Aircraft Weight and Balance Control	**Date:**	**AC No:** 120-27C
		Initiated by: AFS-330	**Change:**

1. PURPOSE. This advisory circular (AC) provides one means, but not the only means, for obtaining approval of a weight and balance control system.

2. FOCUS. This document provides guidance to certificate holders that are required to have an approved weight and balance program by Federal Aviation Regulations (FAR) Part 121 or choose to have an approved program under FAR Part 135.

3. CANCELLATION. AC 120-27B, Aircraft Weight and Balance Control, dated October 25, 1990, is cancelled.

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 weight and balance limitations during operation. The approval of such a weight 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 which 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. Weight and balance control systems encompass the following:

a. Methods for establishing, monitoring, and adjusting individual aircraft or fleet empty weight and center of gravity (CG) in conjunction with the initial and periodic reweighing of aircraft.

b. A loading schedule composed of graphs, tables, and computations and/or computer programs, etc., whereby the various weight 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 weight and CG limits.

d. A load manifest to document loading information by personnel responsible for weight 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 weight 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 Weight. The weight of the airframe, engines, propellers, rotors, and fixed equipment. Empty weight excludes the weight of the crew and payload but includes the weight of all fixed ballast, unusable fuel, undrainable oil, and total quantity of hydraulic fluid. The empty weight of an aircraft is the maximum certificated weight 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 service water, thrust augmentation, and deicing 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 Weight. The basic operating weight established by the operator for a particular model aircraft should include the following standard items in addition to the empty weight 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 weight and operating weight should be included in the operator's program.

d. Structural Limits. Weight 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 weight 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 weight. The following are general definitions of structural weight limits normally considered in weight and balance programs.

(1) Maximum Zero Fuel Weight. The maximum zero fuel weight means the maximum permissible weight of an aircraft with no disposable fuel and oil (see FAR Sections 121.198(b) and 135.2(e)(3)).

(2) Maximum Landing Weight. This landing weight limit is the maximum weight at which the aircraft may normally be landed. Some aircraft are equipped to jettison fuel to reduce aircraft weight down to the landing limit in an emergency situation.

(3) Maximum Takeoff Weight. This is the maximum allowable, total loaded aircraft weight at the start of the takeoff run.

(4) Maximum Ramp Weight. This is the maximum allowable, total loaded aircraft weight for taxi.

7. AIRCRAFT WEIGHT ESTABLISHMENT. Aircraft weight and balance control systems normally contain provisions for determining aircraft weight in accordance with the following procedures:

a. Individual Aircraft Weight and Changes. The loading schedule may utilize the individual weight of the aircraft in computing pertinent maximum certificated weight and balance. The individual weight and CG position of each aircraft should be confirmed at the specified reweighing periods. In addition, it should be reestablished by computing or reweighing whenever the cumulative change to the operating weight exceeds plus or minus one-half of 1 percent of the maximum landing weight 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 weight and balance should be reestablished.

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

(1) An operator's empty fleet weight 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 of 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 weight and CG position have been determined for aircraft weighed and the fleet operating weight established, necessary data should be computed for aircraft not weighed but which are considered eligible under such fleet weight. If the operating weight of any aircraft weighed or the calculated operating weight 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 weight from the established operating fleet weight or the CG position varies more than plus or minus one-half of 1 percent of the length of the MAC from the

fleet weight CG, the aircraft shall be omitted from that group and operated on its actual or calculated operating weight and CG position. The FAA 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 weight. 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 weight tolerance but the CG position varies in excess of the tolerance allowed, the FAA would accept an operator using the aircraft under the applicable operating fleet weight and with an individual CG position.

(3) Reestablishment of the operator's empty fleet weight or operating fleet weight and corresponding CG positions may be accomplished between weighing periods by calculation based on the current empty weight of the aircraft previously weighed for fleet weight purposes. Weighing for reestablishment of fleet weights 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 Weight. Prior to being placed into service, each aircraft should be weighed and the empty weight and CG location established. New aircraft are normally weighed at the factory and are eligible to be placed into operation without reweighing if the weight and balance records have been adjusted for alterations or modifications to the aircraft. Aircraft transferred from one operator, that has an approved weight 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 weight 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 Weights. Aircraft operated under a loading schedule utilizing individual aircraft weights in computing the maximum certificated weight 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 weight and balance records maintained are sufficiently accurate to indicate aircraft weights and CG positions are within the cumulative limits specified in paragraph 7a. Such applications should be limited to increases in increments of 12 months and should be substantiated in each instance with at least two aircraft weighed. Increases 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 which is equivalent to the aircraft overhaul period.

e. Periodic Weighing - Aircraft Using Fleet Weights. Aircraft operating under fleet weights should be weighed in accordance with procedures outlined for the establishment of fleet weights. Since each fleet is normally reestablished 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 recognized facility such as a civil department of weights and measures, periodically as recommended in the manufacturer's calibration schedule. If a calibration schedule is not available from the manufacturer, the FAA would find it acceptable to use the scale to weigh the aircraft within one year after the calibration of the scale. The FAA 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 utilizes 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 weight 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 weight 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 weights are otherwise undeterminable.

10. STANDARD PASSENGER WEIGHTS. Actual weights, or when appropriate, average passenger weights are used to compute passenger loads over any segment of a certificate holder's operations. Actual weights are used for operations with aircraft having nine or less passenger seats and aircraft carrying nonstandard passenger loads as described by paragraph 11. The loading system should readily accommodate nonstandard weight groups, and the manifest should indicate whether average or actual weights, or a combination thereof, were used in the computation.

> Note: The intention of this AC is to provide methods and procedures for developing weight and balance control systems, not to address the entire spectrum of all possible weight configurations. Therefore, the operator should consider providing the Federal Aviation Administration with a reliable survey to establish an average passenger weight for its specific operation.

a. Average Passenger Weights. The standard average passenger weights listed in the following table were 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% male/40% female operation. Special average weights or special ratios may be established for particular operations based on surveys: (a) indicating those weights consistently provide for loading within prescribed weight and balance limits; and (b) meeting the criteria for surveys and statistical analysis outlined in appendix 1 of this document.

STANDARD AVERAGE PASSENGER WEIGHTS

(Includes 20 pounds carry-on baggage for adult passengers)

Summer - for the period of May 1 through October 31:

Adult Passenger (60%/40% male/female mix)	180 pounds
Male	195 pounds
Female	155 pounds

Winter - for the period of November 1 through April 30:

Adult Passenger (60%/40% male/female mix)	185 pounds
Male	200 pounds
Female	160 pounds

Summer/Winter

Children (Applicable between ages 2 and 12)	80 pounds

b. Average Passenger Weights for Aircraft with Limited Cabin Storage. Aircraft with limited cabin baggage stowage capability, where the operator's approved carry-on baggage program limits each passenger to a maximum of one carry-on bag in the cabin, may use the following average weights for passengers and carry-on bags. 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% male/40% female operation.

AVERAGE PASSENGER WEIGHTS - LIMITED CABIN STOWAGE
(Includes 10 pounds carry-on baggage for adult passengers)

Summer - for the period of May 1 through October 31:	
Adult Passenger (60%/40% male/female mix)	170 pounds
Male	185 pounds
Female	145 pounds
Winter - for the period of November 1 through April 30:	
Adult Passenger (60%/40% male/female mix)	175 pounds
Male	190 pounds
Female	150 pounds
Summer/Winter	
Children (Applicable between ages 2 and 12)	80 pounds

With data submitted by the certificate holder to the FAA for a review of its statistical validity, the following provision may be approved by the FAA:

The single carry-on bag permitted in the cabin by this paragraph (b) (and as described in the certificate holder's weight and balance program) is included in the average passenger weight. Moving this bag from the cabin to the baggage compartment does not require any weight recalculations. This may not be true of CG calculations.

All other bags (i.e., bags other than the single carry-on bag permitted in the cabin by paragraph (b) and as described in the certificate holder's weight and balance program) use actual weights or, if and as appropriate, the average weights for checked baggage described in paragraphs 13(b) or 13(c).

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

11. NONSTANDARD PASSENGER WEIGHTS

a. Actual Passenger Weights. Actual passenger weights are used for nonstandard weight groups, unless average weights have been established for those groups. This includes athletic squads and other groups which are larger or smaller than the U.S. average.

When such groups form only a part of the total passenger load, actual weights, or established average weights for the nonstandard group, may be used for such exception groups and average weights 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 Weight. Actual passenger weights may be determined by:

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

(2) Asking each passenger his/her weight and adding to it a predetermined constant to provide for hand baggage and clothing. This constant may be approved for an operator on the basis of studies by the operator that consider particular routes and seasonal variations, when applicable. Personnel listing passengers on this basis should receive instruction for estimating passenger weights to reasonably confirm their accuracy.

c. Nonstandard Average Passenger Weights - Military Groups. In lieu of actual weights (preferred), the following average weights may be used for military groups, unless the passengers or their carry-on baggage appreciably differ from these standard weights:

Noncombat-Equipped Military Personnel.....195 pounds

Note: This weight includes 20 pounds of hand-carried baggage.

Combat-Equipped Military Personnel.....225 pounds

Note: This represents the standard combat soldier as would be seen on contract flights involving large movements. This includes 195 pounds as shown above, 20 pounds for additional hand-carried mobility pack, and an additional 10 pounds for hand-carried weapons.

12. CREW WEIGHT. For crewmembers, the following approved average weights may be used:

a. Male cabin attendants 180 pounds; female cabin attendants 130 pounds; or 140 pounds average for all flight attendants.

b. Male flight crewmembers 180 pounds; female flight crewmembers 130.

13. PASSENGER AND CREW BAGGAGE AND MAIL. 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 weight may be used. Mail bags and checked baggage average weights may be used as described below. Actual weights should be used for aircraft of nine or less passenger seats. Actual weights are used when it is noticeable that the checked baggage or the mail bags exceed the average weights.

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

b. Domestic Operations. Not less than an average of 25 pounds should be used.

c. International Flag and Supplemental Operations. Not less than an average of 30 pounds should be used.

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

d. Normal Operations. All mail bag manifested weight should be used in determining the weights of mail bag shipments. Should it be necessary to separate (break bulk) a manifested shipment or should manifested weights not be available, the FAA would accept the use of average individual bag weights, in circumstances where the average has been determined and substantiated by recent surveys that follow the survey and statistical models suggested in appendix 1 of this document.

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

Such records should reflect all alterations and changes affecting either the weight 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 weights are used, pertinent computations should also be available in individual aircraft files.

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

17. CONTENT OF OPERATIONS SPECIFICATIONS PROCEDURES FOR AIRCRAFT WEIGHT AND BALANCE CONTROL. The operations specifications should contain the procedures (or make reference to the operator's approved weight and balance control program document) used to maintain control of weight 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 weight and CG limitations. This description should include a reference to the procedures used for determining weight of passengers/crew, weight of baggage, periodic aircraft weighing, type of loading devices, and identification of the aircraft concerned.

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

APPENDIX 1. PROCEDURES FOR CONDUCTING SURVEYS AND ESTABLISHING AVERAGE WEIGHTS

1. FOCUS. The methodology presented can be used to determine standard average weights 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 Advisory Circular.

2. DETERMINATION OF STANDARD AVERAGE WEIGHT VALUES FOR PASSENGERS, BAGGAGE, AND CARGO/MAIL. It is critical that operators determine that average weights used for passengers, baggage, and cargo/mail do not adversely affect operational safety. In lieu of using the standard average weight values contained in this Advisory Circular, average weights may be generated by use of a suitable statistical analysis.

Appendix 1 contains an acceptable methodology for conducting a statistical analysis and establishing suitable average weights.

Average weight 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 appendix 1.

For practical reasons passenger weight values may be rounded to the nearest whole number in pounds, and the checked bag weight 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, airport selections with consideration given to check point or gate/flights within those airports. 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 weights 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 document, whichever is larger.

a. Passenger Weights.

(1) Adults and Children. For purposes of this AC only, 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 weight figures shall be arranged so that they are only visible to authorized survey people.

(3) Surveys should be conducted inside an airport 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 weight of the passenger. If desired, carry-on baggage may be weighed separately and added to the passenger weight.

(5) Survey data should include, but not be limited to: sex, adult or child categorization, survey location, weight with carry-on, weight 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 weights of all the pieces or the actual total weights of the contents of the baggage containers they are in.

(2) As an alternative, an approved standard average bag weight, specific to the individual carrier's operation, multiplied by the total count of the number of pieces, may be used. Those average weights may be determined as specified in this document.

(3) Checked baggage averages specified in the Advisory Circular may be used in lieu of determining specific averages.

(4) A form should be designed to include boarding point, destination, weight 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) Mail weights may be as specified in the Advisory Circular, item 13, paragraph d.

(2) Survey data should include boarding point, destination, weight 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 weight surveys shall have a capacity of at least 400 lbs. All weights should be displayed at a minimum interval of 1 lb. and should be accurate to within ± ½ lb. The tolerance shall not exceed ± 1 lb. for every 200 lbs. of weight.

5. WEIGHT DATA. The recording of weight 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 weights. If the survey is being conducted to determine only male/female percentages, use the methodology in subparagraph f.

a. Calculation of Passenger Average Weight.

(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% is commonly used, i.e., there is a 95% 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 weight distribution three cases of mean and standard deviation have to be distinguished:

μ, σ = The true value of the average passenger weight and standard deviation which are unknown and which are to be estimated by weighing passenger samples.

μ^1, σ^1 = The initial estimates of the average passenger weight and standard deviation (values obtained from earlier survey samples).

$\bar{x}, s$ = The estimates for the current true values of μ and σ calculated from the sample.

b. Formulas. The following formulas will be necessary in determining the correct results:

(1) FORMULA - Calculation of the sample size:

$$n \geq \frac{(1.96 * \sigma^1 * 100)^2}{(e^1 * \mu^1)^2}$$

where:

n = No. of passengers to be weighed (sample size),

e^1 = Allowed relative confidence range (accuracy) for the estimate of μ 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%, e^1 will be 1 in the above formula.

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

(2) 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 weight μ of the population.

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

(3) FORMULA - Calculation of the standard deviation:

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

where $(x_j - \bar{x})$ is the deviation of the individual value from the sample mean.

(4) 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 μ^1 and σ^1). It has to be checked after the sample has been evaluated and can be done using the following formula:

$$e = \frac{1.96 * s * 100}{\sqrt{n} * x} \quad (\%).$$

e should not exceed:
1% for an adult average weight;
2% for an average male or female weight; or
4% for checked baggage and mail weights.

(5) FORMULA - Calculation of the confidence range of the sample mean:

This means that with 95% probability, the true average weight μ lies within the interval:

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

c. Example - Adult Average Weight. 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 weight 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 weight 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 weight

j	x_j (lb)
1	176.1
2	150.1
3	171.1
4	164.2
5	119.2
6	137.2
7	196.8
8	239.6
.	.
.	.
.	.
.	.
85	139.3
86	166.2
Σ 86	13,385.4

$$\mu = \bar{x} = \frac{\Sigma x_j}{n} = \frac{13385.4}{86} = 155.616 \text{ lb.}$$

Step 2: Estimated standard deviation

$(x_j-\bar{x})$	$(x_j-\bar{x})^2$
+20.5	420.2
- 5.5	30.2
+16.1	259.2
+ 8.6	73.9
-36.4	1324.9
-18.5	342.2
+41.2	1697.4
+84.0	7056.0
.	.
.	.
.	.
.	.
-16.3	265.6
+10.6	112.4
	168,559.3

$$\sigma^1 = \frac{\sqrt{\sum_{j=1}^{n} (x_j-\bar{x})^2}}{\sqrt{n-1}} = \frac{\sqrt{168,559.3}}{\sqrt{85}} = 44.53 lb.$$

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

$$n \geq \frac{(1.96*\sigma^1*100)^2}{(e^1*\mu^1)^2} = \frac{(1.96*44.53*100)^2}{(1*155.616)^2} = 3146$$

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 Weight.

Step 1: After having collected the required number of passenger weight values, the average passenger weight can be calculated. For the purpose of this example, it has been assumed that 3,180 passengers were weighed. The sum of the individual weights amounts to 509,673.0 lbs.

$n = 3,180.$

$$\Sigma x_j = 509,673.0 \text{ lbs.}$$

$$\bar{x} = \frac{509,673.0}{3180} = 160.27 \text{ lbs.}$$

Step 2: Calculation of the standard deviation.

$$\Sigma (x_j - \bar{x})^2 = 3,621,079.6 \text{ (given)}$$

$$s = \frac{\sqrt{\sum_{j=1}^{n} (x_j - \bar{x})^2}}{\sqrt{n-1}} = \frac{\sqrt{3,621,079.6}}{\sqrt{3179}} = 33.75 \text{ lb.}$$

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

$$e = \frac{1.96*s*100}{\sqrt{n*\bar{x}}}(\%) = \frac{1.96*33.75*100}{\sqrt{3180*160.27}} = 0.73\%$$

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

$$\bar{x} \pm \frac{1.96*s}{\sqrt{n}} = \bar{x} \pm \frac{1.96*33.75}{\sqrt{3180}} = 160.27 \pm 1.2$$

The result of this calculation shows that there is a 95% probability of the actual mean for all passengers lying within the range of 159.07 to 161.47 lbs.

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 weights from paragraph 10 of the Advisory Circular and the percentages found in the survey to calculate the standard average adult weight.

Let:

n_m = number of males in the sample

n_f = number of females in the sample

$n = n_m + n_f$ = total sample size

p_m = percentage of males

q_f = percentage of females

$p_m + q_f = 100$

$s_p = s_q$ = standard deviation of percentage

$\bar{x}_a$ = standard average adult weight

$\bar{x}_m$ = standard average male weight from paragraph 10 of the AC

$\bar{x}_f$ = standard average female weight from paragraph 10 of the AC

s_m = standard deviation of male weight

s_f = standard deviation of female weight

$s_{\bar{x}a}$ = standard error of average adult weight

(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.

$$p_m = \frac{n_m}{n} * 100\ (\%)$$

$$q_f = \frac{n_f}{n} * 100\ (\%)$$

$$s_p = \frac{\sqrt{p_m * q_f}}{\sqrt{n-1}}$$

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

$$p_m \pm 1.96 * s_p$$

(iii) FORMULA - Calculation of standard average adult weight using male and female weights from paragraph 10 in the Advisory Circular.

$$\bar{x}_a = \frac{\bar{x}_m * p_m}{100} + \frac{\bar{x}_f * p_f}{100}$$

(iv) FORMULA - Calculation of the standard deviation of the standard average adult weight.

$$s_{\overline{x_a}} = \sqrt{\left(p_m^2 * \frac{s_m^2}{n_m}\right) + \left(q_f^2 * \frac{s_f^2}{n_f}\right) + (x_m^2 * s_p^2) + (x_f^2 * s_p^2)}$$

(v) FORMULA - Calculation of the accuracy of the standard average adult weight.

$$e = \frac{1.96 * s_{\overline{x_a}}}{x_a} * 100(\%)$$

(vi) FORMULA - Calculation of the 95% confidence range of the standard average adult weight.

$$\overline{x_a} \pm 1.96 * s_{\overline{x_a}}$$

(vii) FORMULA - Calculation of the sample size.

$$n = \frac{(x_m^2 + x_f^2) * p_m * q_f}{\left(e * \frac{x_a}{1.96}\right)^2 - \left(\frac{p_m^2 * s_m^2}{n_m} + \frac{q_f^2 * s_f^2}{n_f}\right)}$$

Note: Data from the surveys yielding the averages in paragraph 10a of the Advisory Circular may be used to derive the sample size needed for update-surveys. These values apply: $n_m = 1039$; $n_f = 640$; $x_m = 195$; $x_f = 155$; $p_m = .612$; $q_f = .388$; $x_a = 180$; $s_m = 35.1$ and $s_f = 34.8$.

Thus, for male/female averages, e = .02, and

$$n = \frac{((195)^2+(155)^2)*.612*.388}{\left(\frac{.02*180}{1.96}\right)^2 - \left(\frac{(.612)^2*(35.1)^2}{1039}\right) - \left(\frac{(.388)^2*(34.8)^2}{640}\right)} = 5571.$$

This sample size can be used until the average weights in the Advisory Circular are updated with later survey data.

g. 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 weight figures used throughout the example are entirely fictitious.

Given: Sample of 5,600 passengers, 3,400 male and 2,200 female.

Step 1. Calculating the percentage of males and females.

$$p_m = \frac{n_m}{n} * 100\ (\%) = \frac{3400}{5600} * 100 = 60.7\%$$

$$q_f = 100.0 - 60.7 = 39.3\%.$$

Step 2. Calculation of the standard deviation. Note that the standard deviations for the percentage of men and women are equal.

$$s_p = \frac{\sqrt{p_m*q_f}}{\sqrt{n-1}} = \frac{\sqrt{60.7*39.3}}{\sqrt{5599}} = 0.65\%$$

Step 3. Calculating the confidence range.

$$p_m \pm 1.96*s_p = 60.7 \pm 1.96*0.65 = 60.7\% \pm 1.28\%$$

This indicates that there is a 95% probability that the actual percentage of men is between 59.4% and 62.0%, and that the percentage of women is between 38.0% and 40.6%, i.e., 59.4/40.6 and 62.0/38.0.

Step 4. Calculation of the standard average adult weight. Use the standard average male and female weights

shown in paragraph 10a of the Advisory Circular (assume Summer weights for this example) and the percentages of men and women found in the survey. When doing this calculation, divide p_m and q_f by 100 to express them in decimal form.

$$x_a = \frac{\overline{x_m} * p_m}{100} + \frac{\overline{x_f} * p_f}{100} = \frac{195 * 60.7}{100} + \frac{155 * 39.3}{100} = 179 \ lbs.$$

Step 5. Calculation of the standard deviation of the average adult weight. When doing this calculation, divide p_m, q_f, and s_p by 100 to express them in decimal form.

$$s_{\overline{x_a}} = \sqrt{\left(p_m^2 * \frac{s_m^2}{n_m}\right) + \left(q_f^2 * \frac{s_f^2}{n_f}\right) + (x_m^2 * s_p^2) + (x_f^2 * s_p^2)}$$

From the survey supporting the Advisory Circular averages: s_m = 35.1; n_m = 1039; s_f = 34.8; n_f = 640; $\bar{x}_m$ = 195; and $\bar{x}_f$ = 155. Thus,

$$s_{\overline{x_a}} = \sqrt{\left((.607)^2 * \frac{(35.1)^2}{1039}\right) + \left((.393)^2 * \frac{(34.8)^2}{640}\right) + (195^2 * .0065^2) + (155^2 * .006}$$

Step 6. Calculation of the accuracy of the standard average adult weight.

$$e = \frac{1.96 * s_{\overline{x_a}}}{x_a} * 100\ (\%) = \frac{1.96 * 1.83}{179} * 100\ (\%) = 2.0\%.$$

Step 7. Calculation of the confidence range of the standard average adult weight.

$$\overline{x_a} \pm 1.96 * s_{\overline{x_a}} = 179 \pm 1.96 * 1.83 = 179 \pm 3.6 \ lbs.$$

This indicates that there is a 95% probability that the actual standard average adult weight is between 175 and 183 lbs.

February 23, 1995

FEDERAL AVIATION ADMINISTRATION
Flight Standards National Field Office
P. O. Box 20034
Washington, D.C. 20041

Subject: Comments on Proposed Advisory Circular 120-27C - AIRCRAFT WEIGHT AND BALANCE CONTROL

On behalf of its member airlines, the Regional Airline Association (RAA) desires to comment on proposed Advisory Circular (AC) 120-27C. As proposed, this AC is not acceptable to RAA and should be revised as recommended below.

STATEMENT OF PROBLEM

The proposed AC is for the most part consistent with the recommendation of the Aviation Rulemaking Advisory Committee (ARAC) which was submitted in 1992. However, FAA has made a substantial change to Paragraph 10b, pertaining to average weights of carry-on bags for aircraft with limited cabin stowage, which significantly and adversely affects the intent of the original ARAC recommendation. RAA objects to this change, and recommends that the original intent be restored.

As originally proposed by ARAC, an explanatory subparagraph below a table in Paragraph 10b, titled "Average Passenger Weights - Limited Cabin Stowage", read:

> **"Carry-on bags which cannot be stowed in the passenger cabin, and which are instead taken from passengers during the boarding process and stowed in a baggage compartment, should be accounted for at an additional weight of 10 pounds per bag located at the compartment's center of gravity."**

FAA has removed this subparagraph and replaced it with the following three new subparagraphs:

> **"With data submitted by the certificate holder to the FAA for a review of its statistical validity, the following provision may be approved by the FAA:**
>
> **"The <u>single</u> carry-on bag permitted in the cabin by this paragraph (b) (and as described in the certificate holder's weight and balance program) is included in the average passenger weight. Moving this bag from the cabin to the baggage compartment does not require any weight recalculations. This may not be true of CG calculations.**

> **"All other bags (i. e., bags other than the single carry-on bag permitted in the cabin by paragraph (b) and as described in the certificate holder's weight and balance program) use actual weights or, if and as appropriate, the average weights for checked baggage described in paragraphs 13(b) or 13(c)."**

RAA submits that the first subparagraph above is contrary to the general purpose of the advisory circular, and Paragraph 10 in particular. This advisory circular is intended to provide guidance for acceptable use of average weights for passengers and carry-on bags under standard (normal) airline operating conditions, without further need for data submittal or specific FAA approval. This subparagraph should be deleted in its entirety.

The second of the above three subparagraphs seems superfluous, but is generally consistent with the intent of the ARAC proposal and therefore is acceptable to RAA. However, RAA suggests a minor editorial change to clarify the last sentence.

The third of these three subparagraphs changes the intent of paragraph 10b as recommended by ARAC, and **is not acceptable to RAA**. It would raise the average weight of additional carry-on bags to an unrealistic value, resulting in a severe and adverse penalty to the economic viability of smaller aircraft and with no commensurate increase in safety. This subparagraph should be revised as recommended below.

RECOMMENDATION

RAA recommends, therefore, that the three explanatory subparagraphs following the table in Paragraph 10b be replaced by the following two new subparagraphs:

> **"The single carry-on bag permitted in the cabin by this paragraph (b), and as described in the certificate holder's weight and balance program, is included in the average passenger weight. Moving this bag from the cabin to the baggage compartment does not require any weight recalculations, but will require accountability for any change in CG.**
>
> **"All other carry-on bags (i.e., bags which meet carry-on bag criteria but cannot be stowed in the passenger cabin, and which are instead taken from passengers during the boarding process and stowed in a baggage compartment) should be accounted for at an additional weight of 10 pounds per bag located at the compartment's center of gravity."**

DISCUSSION

RAA was informed by FAA in November, 1994 - more than two years after ARAC submitted its

proposal - that FAA intended to revise Paragraph 10b of the AC because FAA believed that the ARAC proposal was not supported by valid survey data. This allegation is vigorously disputed by RAA.

An ARAC Working Group (WG) spent more than a year analyzing data from airline surveys and from other sources, with the assistance of an FAA statistician, to develop appropriate values for average weights of passengers, carry-on bags, and checked baggage to be used as guidance under normal airline operating conditions. The results, contained in Paragraph 10 of the AC, were agreed to by consensus of all members of the ARAC WG.

A search of RAA files disclosed some of the survey data relating to carry-on bag weights which was considered by the ARAC, and some additional data received more recently. It is summarized in the attached table (Attachment I). Clearly, this data - which is consistent with and supports the ARAC proposal - shows that the average weight of carry-on bags, both per bag and per passenger, is very much closer to 10 pounds each than to the 25 pound figure used for average weight of checked bags.

ARAC recognized that many passengers transfer, during the course of their trip, between large transport airplanes (which allow two carry-on bags in the cabin) and smaller commuter airplanes. ARAC intended that any carry-on bags in addition to the one bag allowed in the cabin, which are taken from a passenger during the boarding process and placed in the baggage compartment, would **also be accounted for at 10 pounds each** - based on data from airline surveys which supported the use of 10 pounds as the average weight of carry-on bags.

It is this intent which the FAA proposes to change. FAA would account for all additional carry-on bags, beyond the one allowed in the cabin, **as checked bags at 25 pounds per bag.**

This would mean that two carry-on bags carried by a passenger on board a large transport would be accounted for at 20 pounds - but those same two bags on a 19-passenger commuter airplane with limited cabin stowage would have to be accounted for at 35 pounds. This requirement would adversely and unfairly penalize payload and/or range capability of smaller aircraft.

Safety would not be increased because the requirement could, on some occasions, remove the option of an operator to add fuel in excess of the requirements. **Public interest could be adversely affected** by serious inconvenience to passengers on affected flights if some checked baggage may have to be left behind.

FAA has accepted the concept of 10 pounds per carry-on bag, as proposed by ARAC, for Standard Passenger Weights under Paragraph 10. Paragraph 10a contains a table of Standard Average Passenger Weights, which includes 20 pounds of carry-on bag weight - two carry-on bags per passenger at 10 pounds each. Paragraph 10b, which applies to smaller airplanes with

limited cabin stowage space, contains a similar table which includes 10 pounds of carry-on bag weight per passenger when limited to a single carry-on bag.

It is inconsistent and illogical for FAA to accept a figure of 10 pounds per bag for carry-on bags - **except when those bags are carried by a passenger to the airplane and which are loaded in the baggage compartment instead of under the passenger's seat!** These bags, which would be accounted for at 10 pounds each on a larger airplane, obviously do not gain an additional 15 pounds simply because they are placed in the baggage compartment instead of the passenger cabin.

SUMMARY

In summary, RAA opposes the change FAA has proposed to Paragraph 10b of Advisory Circular 120-27C, regarding accountability for carry-on bag weight on airplanes with limited cabin stowage capacity. RAA strongly urges FAA to restore intent of this paragraph as recommended by consensus of the ARAC Working Group. This intent was developed by ARAC after careful and painstaking effort to assure that it was, as with all other changes to the AC, justified by valid survey data as appropriate guidance for use under normal airline operating conditions.

Having tasked ARAC to develop these recommended changes, FAA is obligated to consider carefully the resulting ARAC recommendations - particularly when arrived at by consensus - and is expected to accept them unless there are compelling legal or technical flaws, which FAA should fully explain. In this case, this has not occurred.

Respectfully submitted,

William C. Keil
Vice President, Technical Services

attachment

ATTACHMENT I

AVERAGE CARRY-ON BAG WEIGHTS - SURVEY DATA

CARRIER	SURVEY DATE	AVG WT PER BAG, LBS.	AVG WT PER PSGR, LBS.
WESTAIR	APRIL 1989		8
WESTAIR			7
TRANS STATES	JUNE/JULY '88	12.8	10.6
GP EXPRESS	MAY 1993	10.3	
GP EXPRESS	JAN 1994	13	
UK CAA	'81-'82		12.3
FRONTIER	1986	12.2	13.25
UNITED AIRLINES	1976		12.6
FAA - AURORA, CO	1984	10	15
SWEDISH CAA	1990		11.24
SWEDISH CAA (COMMUTER)	1990		12.57

U.S. Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

JUN 22 1995

Mr. Steven R. Erickson
Assistant Chair for Maintenance Issues
Aviation Rulemaking Advisory Committee
Air Transport Association of America
Washington, DC 20004-1707

Dear Mr. Erickson:

In response to the task announced in the Federal Register on August 27, 1991 (56 FR 42373), the Aviation Rulemaking Advisory Committee (ARAC) developed an advisory circular (AC) establishing standard weights for passengers, carry-on baggage, and checked baggage.

Comments received in response to the AC are considered to be non-substantive with the exception of one comment from the Regional Airline Association (RAA). RAA's comment concerning average weights of carry-on bags for aircraft with limited cabin stowage was previously discussed by ARAC and the Federal Aviation Administration (FAA) without resolution during ARAC's development of the AC. Consequently, RAA's comment will be resolved by the FAA during its development of the final AC.

Again, let me thank ARAC and, in particular, the Weight and Balance Working Group for its dedicated efforts in completing the task assigned by the FAA.

If you have any questions, please contact Mr. Fred Leonelli at (202) 267-3546.

Sincerely,

Brenda D. Courtney

Chris A. Christie
for Director, Office of Rulemaking

AFS-1 Act
AVR-1 sig —

Regional Airline Association
1200 19th Street, NW • Suite 300 • Washington, DC 20036-2401 • 202/857-1170 • FAX 202/429-5113 • ARINC "WASRAXD"

before writing, pls
let's have a
discussion w/
appropriate folks —
Thanks
8/7/95
cc ARM

July 27, 1995

Mr. Anthony Broderick
Associate Administrator
Regulation and Certification
Federal Aviation Administration
800 Independence Ave. SW
Washington, DC 20591

Re: ARAC Recommendation and FAA Action on Weight and Balance Control AC

Dear Tony:

The purpose of this letter is to request that FAA accept the recommendations of the ARAC Weight and Balance Control Working Group and not amend a key element of the Working Group's recommendations.. That key element is the determination of the weight of what is effectively carry-on baggage, but may not be permitted in the passenger cabin of some regional/commuter aircraft due to interior space limitations.

The ARAC Working Group developed a proposed Weight and Balance Advisory Circular which was submitted to FAA in 1992. The Working Group had a representative membership from industry and received FAA staff participation and support throughout. One of the issues which was examined very closely and subsequently agreed upon, was a determination of the weight of hand carried luggage which was or could be carry-on, when traveling on aircraft with larger cabins, but on many regional/commuter aircraft, due to cabin size limitations, i.e. no or minimal overhead and underseat storage, it became checked baggage. As carry-on it is assigned a weight value of ten pounds but as checked baggage it has a weight value of twenty-five pounds. Regional airline interests were represented on the Working Group and this issue was thoroughly discussed. The result was that the recommendations included guidance that luggage that would be or had been permitted as carry-on, but had to be checked due to regional/commuter aircraft cabin size limitations, would be classified as carry-on with an assumed weight of ten pounds.

A draft AC was published in December, 1994. RAA provided comments on the draft. A copy of the RAA comments, dated February 23, 1995 is enclosed. Earlier this month, RAA staff was advised that FAA did not intend to include the ARAC guidance on weight determination in the advisory circular or accept the RAA comments requesting that the ARAC recommendations be accepted. This apparent rejection of a portion of a properly chartered ARAC Working Group's recommendations is contrary to the role that ARAC has been designated to fulfill.

In communicating this concern to you, I am representing two related but separate responsibilities. The first is in my position as President of RAA representing the interests and concerns of our members. RAA participation in this Working Group sought to identify and find agreement on safe and practical guidance material for this advisory circular. The second responsibility is to express my concern with the integrity of the ARAC process. I have been affiliated with ARAC from its initial formation and preceding that with several other similar and successful government/industry efforts including the Joint Government/Industry Task Force on Flight Crew Performance. The rejection by FAA staff of a recommendation of this ARAC Working Group will raise legitimate concerns on the value of their efforts among those who work on ARAC issues.

Support for ARAC by the industry exists because there are many industry participants who believe that their participation in the ARAC process will produce regulations, guidance material or other disposition of issues that will be superior to the normal practice of developing such material. If the industry participants determine that the time and resources they have dedicated to reaching consensus views on ARAC tasks are subject to subsequent FAA revision, their support will diminish or disappear. If we do not have adequate industry support for ARAC, then ARAC will become ineffective or cease to exist.

Request that FAA accept the ARAC Working Group recommendation on the Weight and Balance Control Advisory Circular.

Sincerely,

Walter S. Coleman
President

Enclosure

ARM
Action

Air Transport Association

July 28, 1995

Mr. Anthony J. Broderick
Associate Administrator, Regulation & Certification (AVR-1)
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

Dear Tony:

ARAC Maintenance agreed to accept the maintenance training task relating to FAR § 121.375, and has created a new Maintenance Training Working Group to develop a recommendation. Dick Yeatter, USAir, has been appointed the working group chair.

ARAC members expressed concern about the scope of the maintenance training task, but did not agree on specific recommendations for change in the task statement. This matter will be reviewed at the next ARAC Maintenance meeting, September 18. In the meantime, there is no objection to publishing the Federal Register notice and formally commencing the task.

ARAC Maintenance also agreed to terminate the Weight & Balance Working Group, since the Agency has advised that docket disposition for the advisory circular will be accomplished internally.

Finally, ARAC Maintenance agreed to support a series of exploratory meetings regarding harmonization of FAR Part 65/66, to begin in early 1996. These meetings will be supported by ARAC members for the time being, in lieu of re-tasking the Part 65 Working Group or creating a new working group. The timing of the activity is geared to the projected completion of the recommendation for FAR Part 65/66, and is being supported with the understanding that the feasibility effort will not impede processing of the recommendation for rulemaking.

Sincerely,

Steven R. Erickson

Steven R. Erickson
Assistant ARAC Chair
Air Carrier/General Aviation
Maintenance Issues

Air Transport Association of America
1301 Pennsylvania Ave., NW – Suite 1100 Washington, DC 20004-1707
(202) 626-4000

cc: Chris Christy, FAA (ARM-1)
Fred Leonelli, FAA (AFS-300)
Barbara Herber, FAA (ARM-205)
Dick Yeatter, USAir
Don Collier, ATA
Jim Casey, ATA
Fred Workley, NATA

U.S. Department
of Transportation
**Federal Aviation
Administration**

Memorandum

Subject: **INFORMATION**: Average Passenger and Carry-on Weights

Date: FEB 31 [illegible]

From: Statistician, Statistics and Forecast Branch, APO-110

Reply to Attn. of:

To: Benjamin Burton, Team Leader, FAA Internal Weight & Balance Working Group, AFS-330

As you, Chris Christie, Director of Rulemaking, ARM-1, and I discussed, the standard passenger weights listed in Advisory Circular AC 120-27c, Aircraft Weight and Balance Control were based on surveys done by American Airlines in the fall of 1989 and United Airlines conducted in 1990 or 1991. As requested, I reviewed the surveys' documentation to determine the method used to calculate the average weight of carry-on items. Although the specific calculations are not shown, the text clearly indicates that the weight is the average per passenger whether or not the passenger had any carry-on items. It is not the average for only those passengers that had carry-on items.

With respect to the average passenger weights for aircraft with limited cabin stowage capacity, the passenger weight must be 180 pounds--the same as for the large carriers. This weight was developed from data compiled by the large carriers. There is no evidence to suggest that passengers on aircraft with limited storage are different from those on the large aircraft. Therefore, the average weight of 180 pounds must be used in both cases.

If the average passenger weight for aircraft with limited cabin storage were set at 170 pounds and if any carry-on items were taken from the passengers and assessed at 10 pounds, then the average weight of only those passengers with removed carry-on items would be 180 pounds. The average weight of the other passengers would be 170 pounds; thus, changing the average weight of all the passengers. Therefore, the average weight for passengers and their carry-on items on aircraft with limited cabin storage must be set at 180 pounds regardless of where the carry-on items are carried in the aircraft.

I reviewed the survey material provided to me by the Regional Airline Association. I cannot accept the findings of these surveys because the survey

methodologies are not described. Therefore, it is impossible to determine if the surveys are probability samples or how the samples were selected. One of the carriers took averages of averages to calculate a final "average" weight which is an invalid statistical operation. If you should receive other studies from any of the regional carriers I will be glad to evaluate them.

If you have any questions, please call me on 267-8032.

Patricia Beardsley
Patricia Beardsley

ORDER: 8300.10, 8400.10

APPENDIX:

BULLETIN TYPE: Joint Flight Standards Information Bulletin (FSIB) for Airworthiness (FSAW) and Air Transportation (FSAT)

BULLETIN NUMBER: FSAW XX-XX and FSAT XX-XX

BULLETIN TITLE: Adherence to Advisory Circular 120-27C, "Aircraft Weight and Balance Control"

EFFECTIVE DATE: XX-XX-XX

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1. PURPOSE. This bulletin provides information requesting principal maintenance and operations inspectors to advise their respective operators, who have approved weight and balance control programs, to revise those programs in accordance with the guidance found in the recently published AC 120-27C. Also, this bulletin contains additional guidance to help principal inspectors assigned to regional operators of aircraft with limited carry-on baggage storage, in the development of their weight and balance control programs.

2. BACKGROUND. AC 120-27B, "Aircraft Weight and Balance Control", was issued in October of 1990 and was not well received by the aviation industry. Due to the partnership efforts of the Federal Aviation Administration (FAA) with industry, an agreement was negotiated that allowed for AC 120-27B to only apply to new operators requesting the FAA approval of their weight and balance control programs. Operators that were using AC 120-27A, could continue to do so until the development of AC 120-27C. Upon the issuance of AC 120-27C, all operators would be expected to make changes to their programs to incorporate the current guidance.

In 1991, the FAA launched the Aviation Rulemaking Advisory Committee (ARAC) to create a forum in which representatives of industry, labor, consumers, academia and government could work together toward consensus on regulatory issues. The FAA assigned ARAC the task of reviewing the existing method of establishing standard weights for passengers, carry-on baggage, and checked baggage contained in Advisory Circular

In summary, certain FAA changes to the AC removed some of the flexibility needed by some of the operators of aircraft with limited carry-on baggage storage. Therefore, the need for this FSIB which facilitates a dual purpose. First, to establish the year time frame for the revising of all currently approved programs and secondly, to allow for flexibility in the application of AC 120-27C to operators of aircraft with limited carry-on baggage storage.

3. ACTION. Principal Maintenance and Operation Inspectors are to:

A. Become thoroughly familiar with AC 120-27C.

B. Foster and monitor their respective operators progress in revising their weight and balance control programs in accordance with AC 120-27C.

C. Weight and Balance Program revisions are to be completed within one year from the effective date of AC 120-27C.

D. Principal Maintenance and Operation Inspectors for operators of aircraft with limited carry-on baggage storage can use the following guidance and examples to facilitate a program that allows for their operators to develop a program that will meet their needs:

1. The operator of aircraft with limited carry-on baggage storage develops for approval by the FAA, a program that identifies how the operator would accurately identify what is carry-on baggage and what is checked baggage. This program would clearly explain how the operator would handle passengers that have 2 pieces of carry-on baggage for a total of 20 pounds. Example no. 1 (The regional air carrier operates aircraft that are 19 passenger seat aircraft and uses a standard passenger weight of 170 pounds which includes one piece of carry-on baggage, the program could identify a maximum of 19 more pieces of baggage that fit the guidelines of being considered carry-on baggage at an average of 10 pounds each to be stored not in the cabin but in the baggage compartment. All other baggage would be considered checked baggage for a minimum weight of 25 pounds or actual weight). This would allow for each passenger to be considered as an 180 pounds which includes an average of 20 pounds of carry-on baggage when the passengers have 2 pieces of carry-on baggage as supported by the statistical

U.S. Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

OCT 10 1995

Mr. Walter S. Coleman
President, Regional Airline
Association
1200 19th Street, NW.
Washington, DC 20036-2401

Dear Mr. Coleman:

Thank you for your letter communicating your concerns about the proposed Advisory Circular (AC) 120-27C, Aircraft Weight and Balance Control, which was submitted to the Federal Aviation Administration (FAA) in September 1992. I share your interest in maintaining the integrity of the Aviation Rulemaking Advisory Committee (ARAC) process and assure you that every effort is made to accommodate the concerns of all ARAC members, and that will always be the case.

When the comment period for the AC closed in February, the FAA compiled all the comments received, which included the ones submitted by the Regional Airline Association (RAA). The FAA team that provided support to the ARAC Weight and Balance Working Group was tasked with reviewing and addressing all comments received on the proposed AC. In an effort to resolve RAA's concerns, Flight Standards officials met with Mr. Bill Keil of the RAA in June to attempt to reach consensus on any differences.

Following this meeting, the FAA team revisited the weight and balance survey documentation provided to the FAA by several airlines to revalidate weights that are supportable by these data. A copy of the memorandum reflecting these data, which was prepared by the FAA's Statistics and Forecast Branch, is enclosed for your information. New changes to the AC are an end result of the reevaluation of the airlines' data. These final changes are an effort to come as close as possible to an equitable solution which ensures that the technical data are statistically valid without compromising safety.

The FAA intends to publish AC 120-27C with some modifications reflecting comments received and information obtained during meetings with RAA representatives. The FAA will also issue a Flight Standards information bulletin (FSIB) for use by the principal inspectors as expanded guidance material. The FSIB, Adherence to Advisory Circular 120-27C, Aircraft Weight and Balance Control, will be incorporated in FAA Orders 8300.10, Airworthiness Inspector's Handbook, and 8400.10, Air Transportation Operations Inspector's Handbook.

Again, let me thank you for your interest in and continued support of the ARAC.

Sincerely,

Anthony J. Broderick
Associate Administrator for
Regulation and Certification

Enclosure

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: AIRCRAFT WEIGHT AND BALANCE CONTROL

Date: 11/7/95 **Initiated by:** AFS-330

AC No: 120-27C **Change:**

1. PURPOSE. This advisory circular (AC) provides one means, but not the only means, for obtaining approval of a weight and balance control system.

2. FOCUS. This document provides guidance to certificate holders that are required to have an approved weight and balance program by Title 14, Code of Federal Regulations (14 CFR) part 121 or choose to have an approved program under 14 CFR part 135. It should be particularly useful to current 14 CFR part 135 operators who may be affected by requirements proposed in the Commuter Operations and General Certification and Operations Requirements Notice of Proposed Rulemaking (60 FR 16230, March 29, 1995).

3. CANCELLATION. AC 120-27B, Aircraft Weight and Balance Control, dated October 25, 1990, is cancelled.

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 weight and balance limitations during operation. The approval of such a weight 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 which 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. Weight and balance control systems encompass the following:

a. Methods for establishing, monitoring, and adjusting individual aircraft or fleet empty weight and center of gravity (CG) in conjunction with the initial and periodic reweighing of aircraft.

b. A loading schedule composed of graphs, tables, and computations and/or computer programs, etc., whereby the various weight 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 weight and CG limits.

d. A load manifest to document loading information by personnel responsible for weight 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 weight 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 Weight. The weight of the airframe, engines, propellers, rotors, and fixed equipment. Empty weight excludes the weight of the crew and payload but includes the weight of all fixed ballast, unusable fuel, undrainable oil, and total quantity of hydraulic fluid. The empty weight of an aircraft is the maximum certificated weight 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 deicing 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 Weight. The basic operating weight established by the operator for a particular model aircraft should include the following standard items in addition to the empty weight 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 weight and operating weight should be included in the operator's program.

d. Structural Limits. Weight 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 weight 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 weight. The following are general definitions of structural weight limits normally considered in weight and balance programs.

(1) Maximum Zero Fuel Weight. The maximum zero fuel weight means the maximum permissible weight of an aircraft with no disposable fuel and oil (see FAR Sections 121.198(b) and 135.2(e)(3)).

(2) Maximum Landing Weight. This landing weight limit is the maximum weight at which the aircraft may normally be landed. Some aircraft are equipped to jettison fuel to reduce aircraft weight down to the landing limit in an emergency situation.

(3) Maximum Takeoff Weight. This is the maximum allowable, total loaded aircraft weight at the start of the takeoff run.

(4) Maximum Ramp Weight. This is the maximum allowable, total loaded aircraft weight for taxi.

7. AIRCRAFT WEIGHT ESTABLISHMENT. Aircraft weight and balance control systems normally contain provisions for determining aircraft weight in accordance with the following procedures:

a. Individual Aircraft Weight and Changes. The loading schedule may utilize the individual weight of the aircraft in computing pertinent maximum certificated weight and balance. The individual weight and CG position of each aircraft should be confirmed at the specified reweighing periods. In addition, it should be reestablished by computing or reweighing whenever the cumulative change to the operating weight exceeds plus or minus one-half of 1 percent of the maximum landing weight 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 weight and balance should be reestablished.

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

(1) An operator's empty fleet weight 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 weight and CG position have been determined for aircraft weighed and the fleet operating weight established, necessary data should be computed for aircraft not weighed but which are considered eligible under such fleet weight. If the operating weight of any aircraft weighed or the calculated operating weight 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 weight from the established operating fleet weight or the CG position varies more than plus or minus one-half of 1 percent of the length of the MAC from the fleet weight CG, the aircraft shall be omitted from that group and operated on its actual or calculated operating weight and CG position. The Federal Aviation Administration (FAA) 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 weight. 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 weight tolerance but the CG position varies in excess of the tolerance allowed, the FAA would accept an operator using the aircraft under the applicable operating fleet weight and with an individual CG position.

(3) Reestablishment of the operator's empty fleet weight or operating fleet weight and corresponding CG positions may be accomplished between weighing periods by calculation based on the current empty weight of the aircraft previously weighed for fleet weight purposes. Weighing for reestablishment of fleet weights 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 Weight. Prior to being placed into service, each aircraft should be weighed and the empty weight and CG location established. New aircraft are normally weighed at the factory and are eligible to be placed into operation without reweighing if the weight and balance records have been adjusted for alterations or modifications to the aircraft. Aircraft transferred from one operator, that has an approved weight 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 weight 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 Weights. Aircraft operated under a loading schedule utilizing individual aircraft weights in computing the maximum certificated weight 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 weight and balance records maintained are sufficiently accurate to indicate aircraft weights 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 which is equivalent to the aircraft overhaul period.

e. Periodic Weighing - Aircraft Using Fleet Weights. Aircraft operating under fleet weights should be weighed in accordance with procedures outlined for the establishment of fleet weights. Since each fleet is normally reestablished 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 recognized facility such as a civil department of weights and measures, periodically as recommended in the manufacturer's calibration schedule. If a calibration schedule is not available from the manufacturer, the FAA would find it acceptable to use the scale to weigh the aircraft within one year after the calibration of the scale. The FAA 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 utilizes 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 weight 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 weight 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 weights are otherwise undeterminable.

10. STANDARD PASSENGER WEIGHTS. Actual weights, or when appropriate, average passenger weights are used to compute passenger loads over any segment of a certificate holder's operations. Actual weights are used for operations with aircraft having nine or less passenger seats and aircraft carrying nonstandard passenger loads as described in paragraph 11. The loading system should readily accommodate nonstandard weight groups, and the manifest should indicate whether average or actual weights, or a combination thereof, were used in the computation.

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

a. Average Passenger Weights. The standard average passenger weights listed in the following table were 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 weights or special ratios may be established for particular operations based on surveys that: (1) indicate that those weights consistently provide for loading within prescribed weight and balance limits; and (2) meet the criteria for surveys and statistical analysis outlined in Appendix 1.

STANDARD AVERAGE PASSENGER WEIGHTS

(Includes 20 pounds carry-on baggage for adult passengers)

Summer - for the period of May 1 through October 31:

Adult Passenger (60%/40% male/female mix).....180 pounds

Male.....195 pounds

Female.....155 pounds

Winter - for the period of November 1 through April 30:

Adult Passenger (60%/40% male/female mix).....185 pounds

Male.....200 pounds

Female.....160 pounds

Summer/Winter

Children.....80 pounds
(Applicable between ages 2 and 12 years)

(1) The table above is for certificate holders authorized to use an approved carry-on baggage program with a specified 2-bag limit as described or referenced in paragraph A-11 of their operations specifications.

(2) For certificate holders authorized to use an approved carry-on baggage program with a specified bag limit of other than 2 bags, the standard average passenger weights will be different. These operators may contact their Certificate Holding District Office for assistance in determining the appropriate standard average passenger weights. Additional guidance for the Aviation Safety Inspector assigned this task is provided in the Airworthiness Inspector's Handbook, FAA Order 8300.10, and in the Air Transportation Operations Inspector's Handbook, FAA Order 8400.10.

(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 weight, 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 weights. Any movement of these carry-on bags from the cabin to the baggage compartment may not require any weight recalculations but the operator must ensure that CG calculations are not adversely effected.

b. Average Weight for Children. The average weight 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 weight of children less than 2 years old has been factored into the adult weight.

11. NONSTANDARD PASSENGER WEIGHTS.

a. Actual Passenger Weights. Actual passenger weights are used for nonstandard weight groups, unless average weights have been established for those groups. This includes athletic squads and other groups which are larger or smaller than the U.S. average. When such groups form only a part of the total passenger load, actual weights, or established average weights for the nonstandard group, may be used for such exception groups and average weights 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 Weight. Actual passenger weights 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 weight 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 consider particular routes and seasonal variations, when applicable. Personnel listing passengers on this basis should receive instruction for estimating passenger weights to reasonably confirm their accuracy.

c. Nonstandard Average Passenger Weights - Military Groups. In lieu of actual weights (preferred), the following average weights may be used for military groups, unless the passengers or their carry-on baggage appreciably differ from these standard weights:

Noncombat-Equipped Military Personnel.....195 pounds

Note: This weight includes 20 pounds of hand-carried baggage.

Combat-Equipped Military Personnel.....225 pounds

Note: This represents the standard combat soldier as would be seen on contract flights involving large movements. This includes 195 pounds as shown above, 20 pounds for additional hand-carried mobility pack, and an additional 10 pounds for hand-carried weapons.

12. CREW WEIGHT. For crewmembers, the following approved average weights may be used:

a. Male cabin attendants 180 pounds; female cabin attendants 130 pounds; or 140 pounds average for all flight attendants.

b. Male flight crewmembers 180 pounds; female flight crewmembers 130 pounds.

13. PASSENGER AND CREW BAGGAGE AND MAIL. 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 weight may be used. Mailbags and checked baggage average weights may be used as described below. Actual weights should be used for aircraft of nine or less passenger seats. Actual weights are used when it is noticeable that the checked baggage or the mailbags exceed the average weights.

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

b. Domestic Operations. Not less than an average of 25 pounds should be used.

c. International Flag and Supplemental Operations. Not less than an average of 30 pounds should be used.

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

d. Normal Operations. All mail bag manifested weight should be used in determining the weights of mailbag shipments. Should it be necessary to separate (break bulk) a manifested shipment or should manifested weights not be available, the FAA would accept the use of average individual bag weights, in circumstances where the average has been determined and substantiated by recent surveys that follow the survey and statistical models suggested in Appendix 1.

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 weight and balance system should include methods by which the operator will maintain a complete, current, and continuous record of the weight and CG of each aircraft. Such records should reflect all alterations and changes affecting either the weight 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 weights are used, pertinent computations should also be available in individual aircraft files.

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

17. CONTENT OF OPERATIONS SPECIFICATIONS PROCEDURES FOR AIRCRAFT WEIGHT AND BALANCE CONTROL. The operations specifications should contain the procedures (or make reference to the operator's approved weight and balance control program document) used to maintain control of weight 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 weight and CG limitations. This description should include a reference to the procedures used for determining weight of passengers/crew, weight 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 AC, 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.

William J. White
Deputy Director, Flight Standards Service

APPENDIX 1. PROCEDURES FOR CONDUCTING SURVEYS AND ESTABLISHING AVERAGE WEIGHTS

1. FOCUS. The methodology presented can be used to determine standard average weights 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 Advisory Circular (AC).

2. DETERMINATION OF STANDARD AVERAGE WEIGHT VALUES FOR PASSENGERS, BAGGAGE, AND CARGO/MAIL. It is critical that operators determine that average weights used for passengers, baggage, and cargo/mail do not adversely affect operational safety. In lieu of using the standard average weight values contained in this AC, average weights 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 weights.

b. Average weight 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 weight values may be rounded to the nearest whole number in pounds, and the checked bag weight 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, airport selections with consideration given to check point or gate/flights within those airports. 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 weights 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 Weights.

(1) Adults and Children. For purposes of this AC only, 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 weight figures shall be arranged so that they are only visible to authorized survey people.

(3) Surveys should be conducted inside an airport 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 weight of the passenger. If desired, carry-on baggage may be weighed separately and added to the passenger weight.

(5) Survey data should include, but not be limited to: sex, adult or child categorization, survey location, weight with carry-on, weight 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 weights of all the pieces or the actual total weights of the contents of the baggage containers they are in.

(2) As an alternative, an approved standard average bag weight, specific to the individual carrier's operation, multiplied by the total count of the number of pieces, may be used. Those average weights may be determined as specified in this document.

(3) Checked baggage averages specified in the AC may be used in lieu of determining specific averages.

(4) A form should be designed to include boarding point, destination, weight 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) Mail weights may be as specified in paragraph 13d of the AC.

(2) Survey data should include boarding point, destination, weight 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 weight surveys shall have a capacity of at least 400 pounds. All weights should be displayed at a minimum interval of 1 pound and should be accurate to within ± ½ pound. The tolerance shall not exceed ± 1 pound for every 200 pounds of weight.

5. WEIGHT DATA. The recording of weight 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 weights. If the survey is being conducted to determine only male/female percentages, use the methodology in subparagraph f.

a. Calculation of Passenger Average Weight.

(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 weight distribution three cases of mean and standard deviation have to be distinguished:

μ, σ = The true value of the average passenger weight and standard deviation which are unknown and which are to be estimated by weighing passenger samples.

μ^1, σ^1 = The initial estimates of the average passenger weight and standard deviation (values obtained from earlier survey samples).

$\bar{x}, s$ = The estimates for the current true values of μ and σ calculated from the sample.

b. Formulas. The following formulas will be necessary in determining the correct results:

(1) FORMULA - Calculation of the sample size:

$$n = \max\left[1500, \frac{(1.96 * \sigma^1 * 100)^2}{(e^1 * \mu^1)^2}\right]$$

where:

n = No. of passengers to be weighed (sample size),

e^1 = Allowed relative confidence range (accuracy) for the estimate of μ by $\bar{x}$,.

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, e^1 will be 1 in the above formula.

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

(2) FORMULA - Calculation of the arithmetic mean:

If the sample of passengers weighed is random, the arithmetic mean of the sample, $\bar{x}$, is an unbiased estimate of the true average weight μ of the population.

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

(3) FORMULA - Calculation of the standard deviation:

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

where $(x_j - \bar{x})$ is the deviation of the individual value from the sample mean.

(4) 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 μ^1 and σ^1). It has to be checked after the sample has been evaluated and can be done using the following formula:

$$e = \frac{1.96 * s * 100}{\sqrt{n} * \bar{x}} \ (\%).$$

e should not exceed:
1 percent for an adult average weight;
2 percent for an average male or female weight; or
4 percent for checked baggage and mail weights.

(5) FORMULA - Calculation of the confidence range of the sample mean:

This means that with 95 percent probability, the true average weight μ lies within the interval:

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

c. Example - Adult Average Weight. 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 weight 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 weight 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 weight

Step 2: Estimated standard deviation

j	x_j (lb)		$(x_j-\bar{x})$	$(x_j-\bar{x})^2$
1	176.1		+20.5	420.2
2	150.1	$\mu = \bar{x}$	- 5.5	30.2
3	171.1		+16.1	259.2
4	164.2		+ 8.6	73.9
5	119.2	$= \frac{\Sigma x_j}{n}$	-36.4	1324.9
6	137.2		-18.5	342.2
7	196.8		+41.2	1697.4
8	239.6		+84.0	7056.0
.	.	$= \frac{13385.4}{86}$	.	.
.	.		.	.
.	.		.	.
.	.		.	.
85	139.3	= 155.616 lb.	-16.3	265.6
86	166.2		+10.6	112.4
Σ 86	13,385.4			168,559.3

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

$$= \frac{\sqrt{168,559.3}}{\sqrt{85}}$$

$$= 44.53 lb.$$

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

$$n = \max\left[1500, \frac{(1.96*\sigma^1*100)^2}{(e^1*\mu^1)^2}\right]$$

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

$$= \max(1500, 3146)$$

$$\therefore n = 3146$$

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 Weight.

Step 1: After having collected the required number of passenger weight values, the average passenger weight can be calculated. For the purpose of this example, it has been assumed that 3,180 passengers were weighed. The sum of the individual weights amounts to 509,673.0 pounds.

$$n = 3{,}180.$$

$$\Sigma x_j = 509{,}673.0 \ lbs.$$

$$\overline{x} = \frac{509{,}673.0}{3180}$$

$$= 160.27 \ lbs.$$

Step 2: Calculation of the standard deviation.

$$\Sigma (x_j - \bar{x})^2 = 3,621,079.6 \ (given)$$

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

$$= \frac{\sqrt{3,621,079.6}}{\sqrt{3179}}$$

$$= 33.75 \ lbs.$$

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

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

$$= \frac{1.96 * 33.75 * 100}{\sqrt{3180} * 160.27}$$

$$= 0.73\%$$

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

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

$$\bar{x} \pm \frac{1.96 * 33.75}{\sqrt{3180}} =$$

$$160.27 \pm 1.2$$

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 159.07 to 161.47 pounds.

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 weights from paragraph 10 of the AC and the percentages found in the survey to calculate the standard average adult weight.

Let:

k_m = number of males in the sample

k_f = number of females in the sample

$k = k_m + k_f$ = total sample size

p = percentage of males

q = percentage of females

$p + q = 100$

$s_p = s_q$ = standard deviation of percentage

$\overline{x_a}$ = standard average adult weight

$\overline{x_m}$ = standard average male weight from paragraph 10 of the AC

$\overline{x_f}$ = standard average female weight from paragraph 10 of the AC

s_m = standard deviation of male weight

s_f = standard deviation of female weight

$s_{\overline{x}}$ = standard error of average adult weight

(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.

$$p = \frac{k_m}{k} * 100 \ (\%)$$

$$q = \frac{k_f}{k} * 100 \ (\%)$$

$$s_p = \frac{\sqrt{p*q}}{\sqrt{k-1}}$$

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

$$p \pm 1.96*s_p$$

(iii) FORMULA - Calculation of standard average adult weight using male and female weights from paragraph 10 of the AC.

$$\overline{x_a} = \frac{\overline{x_m}*p}{100} + \frac{\overline{x_f}*q}{100}$$

(iv) FORMULA - Calculation of the standard deviation of the standard average adult weight.

$$s_{\overline{x_a}} = \sqrt{\left(p^2*\frac{s_m^2}{n_m}\right)+\left(q^2*\frac{s_f^2}{n_f}\right)+\left((\overline{x_m}-\overline{x_f})^2*s_p^2\right)}$$

(v) FORMULA - Calculation of the accuracy of the standard average adult weight.

$$e = \frac{1.96 * s_{\overline{x_a}}}{\overline{x_a}} * 100(\%)$$

(vi) FORMULA - Calculation of the 95 percent confidence range of the standard average adult weight.

$$\overline{x_a} \pm 1.96 * s_{\overline{x_a}}$$

(vii) FORMULA - Calculation of the sample size.

$$k = \max\left(1500, \frac{(\overline{x_m}-\overline{x_f})^2 * p * q}{\left(e * \frac{\overline{x_a}}{1.96}\right)^2 - \left(\frac{p^2 * s_m^2}{n_m} + \frac{q^2 * s_f^2}{n_f}\right)}\right)$$

Note: Data from the surveys yielding the averages in paragraph 10a of the AC may be used to derive the sample size needed for update surveys. These values apply: $n_m = 1039$; $n_f = 640$; $\overline{x_m} = 195$; $\overline{x_f} = 155$; $p = .619$; $q = .381$; $\overline{x} = 180$; $s_m = 35.1$ and $s_f = 34.8$.

Thus, for male/female averages, $e = .02$, and

$$k = \max\left(1500, \frac{(40^2 * .619 * .381)}{\left(\frac{.02*180}{1.96}\right)^2 - \left[\left(\frac{(.619)^2 * (35.1)^2}{1039}\right) + \left(\frac{(.381)^2 * (34.8)^2}{640}\right)\right]}\right)$$

$$= \max(143, 1500)$$

$$\therefore k = 1500$$

This sample size can be used until the average weights in the AC are updated with later survey data.

g. 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 weight 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.

$$p = \frac{k_m}{k} * 100$$

$$= \frac{910}{1500} * 100$$

$$= 60.7\%$$

$$q = 100.0 - 60.7 = 39.3\%.$$

Step 2. Calculation of the standard deviation. Note that the standard deviations for the percentage of men and women are equal.

$$s_p = \frac{\sqrt{p*q}}{\sqrt{n-1}}$$

$$= \frac{\sqrt{60.7*39.3}}{\sqrt{1499}}$$

$$= 1.26\%$$

Step 3. Calculating the confidence range.

$$p_m \pm 1.96 * s_p =$$

$$60.7 \pm 1.96 * 1.26 =$$

$$60.7\% \pm 2.47\%$$

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 weight. Use the standard average male and female weights shown in paragraph 10a of the AC (assume summer weights for this example) and the percentages of men and women found in the survey. When doing this calculation, divide p_m and q_f by 100 to express them in decimal form.

$$\overline{x_a} = \frac{\overline{x_m} * p}{100} + \frac{\overline{x_f} * q}{100}$$

$$= \frac{195 * 60.7}{100} + \frac{155 * 39.3}{100}$$

$$= 179 \ lbs.$$

Step 5. Calculation of the standard deviation of the average adult weight. When doing this calculation, divide p, q, and s_p by 100 to express them in decimal form.

$$s_{\overline{x_a}} = \sqrt{\left(p_m^2 * \frac{s_m^2}{n_m}\right) + \left(q_f^2 * \frac{s_f^2}{n_f}\right) + (\overline{x_m} - \overline{x_f})^2 * s_p^2}$$

From the survey supporting the AC averages:

$s_m = 35.1$; $n_m = 1039$; $s_f = 34.8$; $n_f = 640$; $\overline{x_m} = 195$; and $\overline{x_f} = 155$. Thus,

$$s_{\overline{x_a}} = \sqrt{\left((.607)^2 * \frac{(35.1)^2}{1039}\right) + \left((.393)^2 * \frac{(34.8)^2}{640}\right) + 40^2 * .0126^2}$$

$$= .99$$

Step 6. Calculation of the accuracy of the standard average adult weight.

$$e = \frac{1.96 * s_{\overline{x_a}}}{\overline{x_a}} * 100$$

$$= \frac{1.96 * .99}{179} * 100$$

$$= 1.1\%$$

Step 7. Calculation of the confidence range of the standard average adult weight.

$$\overline{x_a} \pm 1.96 * s_{\overline{x_a}} =$$

$$179 \pm 1.96 * .99 =$$

$$179 \pm 1.9 \ lbs.$$

This indicates that there is a 95 percent probability that the actual standard average adult weight is between 177 and 181 pounds.

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