

Revision 2

## Passenger, Crew and Baggage Weights

Xx xxxx 202x

### General

Civil Aviation Authority (CAA) Advisory Circulars (ACs) contain information about standards, practices, and procedures that the Director has found to be an **acceptable means of compliance** with the associated rule.

Consideration will be given to other methods of compliance that may be presented to the Director. When new standards, practices, or procedures are found to be acceptable they will be added to the appropriate AC.

### Purpose

This AC describes an acceptable means of compliance for generating exposition passenger weights for an operator who chooses not to use the other options (standard passenger weights, actual weights or passenger-declared weights) made available under **Civil Aviation Rule** CAR Parts 121, 125 and 135.

This AC provides information relating to the procedural requirements prescribed under CAR Parts 121, 125 and 135 relating to passenger, crew member and checked baggage weights.

~~The Interpretative and Explanatory Material contained within this AC~~ It also explains the auditing and monitoring provisions contained within the CAR **specific** rules Parts as they relate to passenger, crew member, and checked baggage weights.

### Related Rules

This AC relates specifically to ~~Civil Aviation Rule~~ Parts 121, 125, and 135.

### Change Notice

Revision 2 updates the style to align with other ACs, and adds information about calculating weights and balances with the aid of a computer tool or app. It also adds a Further Resources section and a Version History.

~~Revision 1 clarifies Section 1.4 relating to Exposition Passenger Weights providing more detail on survey methods. This includes additional survey options for a Part 135 operator to use a standard passenger weight derived from data of a CAA sponsored passenger weight survey or derived from data of a New Zealand population weight survey, provided that the weight used is acceptable to the Director.~~

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Changes are highlighted in grey shading.

### Version History

#### History Log

Revision No.	Effective Date	Summary of Changes
AC119-4, Rev 0	25 Nov 2004	Initial issue
AC119-4, Rev 1	28 Oct 2005	<p>Clarified Section 1.4 relating to Exposition Passenger Weights providing more detail on survey methods. This included additional survey options for a Part 135 operator to use a standard passenger weight derived from data of a CAA sponsored passenger weight survey or derived from data of a New Zealand population weight survey, provided that the weight used is acceptable to the Director.</p> <p>Changes were highlighted in grey shading.</p>
AC119-4, Rev 2	Xx xxxx 202x	<p>Updates information about average passenger weights.</p> <p>Adds information about calculating weights and balances with the aid of a computer tool or app.</p> <p>Adds a Further Resources section.</p> <p>Adds a Version History.</p> <p>Updates the style to align with other ACs.</p>

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**Note:** Only rules requiring guidance ~~and informative/explanatory material~~ are included in this section. Where the rule is self-explanatory no information is given.

## 1. Introduction

Accurate calculation of the take-off weight of an aircraft prior to flight is fundamental to any flight planning process. Aircraft manufacturers place weight limitations on the maximum take-off weight of an aircraft, ~~and this is based on the performance capabilities of the aircraft.~~ The passenger load weight makes up one component of the total take-off weight of an aircraft. As more passengers are loaded onto an aircraft, the ~~amount of weight~~ capacity available for fuel, baggage and other payload is reduced. Further to this, as the mean weight of passengers increases, the number of passengers that an aircraft can safely carry may reduce.

For many years, industry practice has ~~used~~ ~~made use of~~ standardised passenger weights to calculate the take-off weight of aircraft conducting air transport operations. Standardised weights are based on an assumption that the individual weights of all passengers will average out to a mean passenger weight. It is assumed that the use of a mean passenger weight will not cause the aircraft weight limitation to be exceeded.

~~However~~ When using a mean passenger weight, ~~however~~, errors can occur between the actual passenger load weight and the calculated passenger load weight. ~~For statistical reasons~~ These errors become more significant in terms of their effect on aircraft performance as the size of the aircraft (and therefore seating capacity) reduces.

These errors are dealt with in various ways by international safety regulators. For example:

- the ~~European Union Aviation Safety Agency (EASA)~~ ~~Joint Aviation Authorities of Europe~~ apply standard passenger weights that are higher than the mean passenger weight to “smaller” aircraft (Part 125 and 135 operations) ~~in order to minimise these errors. On the other hand, but~~
- the Federal Aviation Administration (FAA) does not allow the use of standard passenger weights for small aircraft (those with less than 10 seats).

An efficient and accurate means of establishing the passenger load weight for each aircraft flight needs to be completed ~~before~~ ~~prior to~~ flight.

### Parts 121 and 125 Operations

Under rule 121.303(b) and 125.303(b) an air operator must ~~use one of the following means to~~ determine the total weight of passengers ~~either by~~:

- *actual passenger weight* through the use of weighing scales
- *a standard passenger weight (Exposition Passenger Weight)* established by the certificate holder in accordance with procedures acceptable to the Director and the standard passenger weight ~~as is detailed in the certificate holder’s exposition, or~~
- *a standard passenger weight* as prescribed in the applicable ~~Civil Aviation~~-rule.

### Parts 135 Operations

Under rule 135.303(b) an air operator must ~~use one of the following means to~~ determine the total weight of passengers ~~either by~~:

- *actual passenger weight* through the use of weighing scales
- *a standard passenger weight (Exposition Passenger Weight)* established by the certificate holder in accordance with procedures acceptable to the Director and the standard passenger weight **as** is detailed in the certificate holder's exposition, **or**
- *a passenger's declared weight plus an additional 4 kg.*

The passenger's declared weight **method** requires a passenger to state their known weight. Passengers should be advised why their weight information is required and why it is important for them to declare an accurate weight. The passenger's declared weight must then **be** incremented by 4 kg per passenger to account for differences that may arise between the "bathroom scales" weight of the passenger and their weight as they present to the air operator.

When it is clear that the exposition passenger weight, standard passenger weight, or a passenger's declared weight is significantly under-representative of a passenger, the operator is required under the rules to apply a more indicative weight for that passenger (or group of passengers).

Similar rule provisions are made for crew member weights.

Domestic checked baggage weights are determined through actual weighing. However, Part 121 provides for an operator to use a standard baggage weight for international flights originating outside of New Zealand when actual baggage weights cannot be obtained.

## 2. Surveys of passenger weights

As part of an ongoing process to have an up-to-date standard passenger weight, regular reviews of the mean adult passenger weight are required<sup>1</sup>. ~~The CAA intends to carry out surveys of passenger weights when there is sufficient evidence to indicate that the actual mean passenger weight has shifted by 2% or more. This figure is in line with the International Air Transport Association's (IATA) guidelines for conducting passenger weight surveys.~~

Surveys conducted on behalf of the CAA, or by air operators, seek to establish representative standard weights for passengers. A standard weight from a survey that is representative of the wider travelling public is included in the rules **121.303, 125.303, with a more general guidance in rule 135.303**, as a means of applying this weight throughout the aviation industry. The resultant survey weight may be influenced by factors such as gender ratios, specific tourist groups, or the amount of carry-on baggage taken on board an aircraft. The effect of these factors may result in a standard passenger weight from a survey being different to the figure prescribed in the rules. ~~and this could initiate a rule amendment.~~

The effective use of exposition passenger weights or standard passenger weights relies on the air operator's application of the rules and how this weight information is used to calculate the weight of the aircraft. For example, there may be occasions when the use of a standard passenger weight is not appropriate. In these circumstances the rules require the operator to apply procedures that prevent the use of standard weights for passengers who are clearly greater than the standard weight. Procedures, such as recording on the load manifest, or the

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<sup>1</sup> IATA Airport Handling Manual AHM 531- *Procedure for Establishing Standard Weights for Passengers and Baggage*

daily flight records for Part 135 operations, when weights other than the exposition or standard passenger weight are used are acceptable for compliance purposes.

Exposition passenger weights need to remain current. Operators should verify that the standard weight specified in their exposition (**exposition passenger weight**) is **kept** up to date to reflect changes in the type of passengers being carried or whenever the CAA establishes a shift (of over 2%) in the general mean weight of passengers. Initial indication of a mean weight shift will be achieved through conducting a sample survey (typically of around 200 passengers).

### 3. Exposition and standard weight review period

The Swedavia-McGregor report of 1988 identified five years as being a sufficient period within the aviation industry for significant change to have occurred. By comparison, in **assessing** reference to standard (and exposition) passenger weights, IATA recommends a review when random sampling indicates a movement of 2% from the standard weight. **Current information from the Ministry of Health aligns with these two figures, by stating the mean weight of New Zealanders is increasing at a rate of 3 kg per decade. A 2011 University of Otago and Ministry of Health nutrition survey put the mean weight of Kiwi men at 85.1 kg and women at 72.6 kg, a 5% rise from 1997<sup>2</sup>. CAA also refers to results from the Ministry of Health's New Zealand Health Survey which can be accessed on their website [here](#).<sup>3</sup>**

### 4. Exposition passenger weights

An exposition passenger weight is the weight per passenger that is specified in an air operator's exposition.

#### Part 121 and Part 125 Operators

This weight may be derived through:

- a survey ~~that is~~ carried out by, or on behalf of the air operator that follows the IATA methodology, or
- a survey ~~that is~~ carried out by, or on behalf of the operator that follows the acceptable methodology included under section 1.7 of this AC, **Evaluation of data**.

#### Part 135 Operators

~~Due to the inability of~~ **If** some operators **are** not being able to obtain a sample large enough to survey, ~~there are three additional options~~ this weight may be derived through:

- a survey ~~that is~~ carried out by, or on behalf of the air operator that follows the IATA methodology, or
- a survey ~~that is~~ carried out by, or on behalf of the operator that follows the acceptable methodology included under section 1.7 of this **AC Advisory Circular**

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<sup>2</sup> **(Updated) New Zealand Diet and Nutrition Survey - Experts Respond - Science Media Centre**

<sup>3</sup> **<https://www.health.govt.nz/nz-health-statistics/national-collections-and-surveys/surveys/new-zealand-health-survey>**

- data of a CAA-sponsored passenger survey, noting that this option requires the Director's acceptance that the weight derived from the survey data is representative of the particular air operator's passenger composition before the weight can be used as the operator's exposition passenger weight, or
- data from a New Zealand population weight survey, noting that this option requires the Director's acceptance that the:
  - survey has been conducted in accordance with acceptable policy and procedures, and This option requires the Director's acceptance that the
  - weight derived from the survey data is representative of the particular air operator's passenger composition before the weight can be used as the operator's exposition passenger weight.

Part 135 operators in tourist type areas who are part of a local user group may wish to pool their resources and conduct a combined survey of their passengers. The aim of this is to establish a more reliable survey result that each operator could use for their exposition passenger weight. An operator who uses an exposition passenger weight that is derived from a combined survey would need to be able to show that their passengers were typical of the wider group of passengers that the survey was based upon.

The exposition passenger weight will normally be the mean weight established through the passenger survey. The process for acceptance of a survey result into an air operator's exposition includes developing a survey plan that is acceptable to the Director that establishes assurance that the resultant mean weights have been obtained through a reliable methodology.

During an operator's passenger weight survey, the CAA audit staff may carry out either continuous monitoring or spot checks to ensure the survey plan is being adhered to.

Where the CAA believes a survey plan has not been conducted correctly, the survey may be deemed invalid and a decision must will need to be made as to whether to accept any further survey plans from that operator.

Once accepted into an operator's exposition, along with those procedures required by the rule, the exposition weight remains valid until such time as the Director deems, or the operator considers, the figure to be out-of-date. Generally, this will be on a five yearly basis.

Re-surveying will be required to establish an exposition passenger weight if a sample survey confirms the exposition weight to be out-of-date.

## 5. Acceptable procedures

Before using exposition passenger weights or standard passenger weights, an operator is required to develop procedures that are acceptable to the Director for applying the passenger weights. These procedures need to remedy factors that may lead to an understated passenger load weight, such as using a more indicative weight for passengers who clearly weigh more than the exposition or standard weight.

Each passenger weight survey should be used to generate a weight distribution curve that identifies the spread of passengers across particular weight bands. A Bell Distribution curve of survey results showing numbers of samples gained for specific weight bands is useful in

demonstrating where the mean weight sits relative to the survey population, and the extent of outlier “out-lier” or extreme sample results.

The procedures need to include information about when to use a more representative weight for passengers and the rules require details of any such weight adjustments to be included on the load manifest, or daily flight record in the case of Part 135 operations.

Individual passenger weights can only be assessed in general terms. It is unlikely that an operator will be able to assess an individual passenger’s weight any more accurately than to the nearest 20 kg. For example, it is unlikely than an operator will be able to differentiate between an 85kg passenger and a 90kg passenger. However, it is expected an operator will be able to differentiate between an 85kg passenger and a passenger whose weight is (for example) 120kg. Procedures for this assessment, as well as how to record those occurrences for safety monitoring purposes, should be included in the operator’s exposition.

Procedures other than those referred to above will also be considered as an alternative means of compliance where they:

- establish an equivalent level of safety, and
- are found to be acceptable to the Director.

A fundamental element of flight safety is that the pilot-in-command (PIC) of the flight must be able to make assessments of how an aircraft is loaded. The pilot-in-command PIC is to be made aware of the weight and balance of the aircraft prior to flight in order to satisfy himself/herself that the flight may be conducted safely. Procedures to this effect are to be specified in the operator’s exposition.

### CAA monitoring for compliance

It is the operator’s responsibility to implement procedures to ensure compliance with the manufacturer’s flight manual limitations. These procedures may need to be demonstrated to the CAA before prior to being accepted into an operator’s exposition.

The CAA will use load manifests and daily flight records to assess gauge how effective the operator’s procedures are in identifying those occasions when the use of the exposition or standard weight is are inappropriate. The operator should specify in their procedures when actual, exposition or other more indicative weights are to be used and recorded on the load manifest or daily flight records.

Where the Director is not satisfied that the operator’s procedures are effective in identifying passengers who are clearly greater than the mean weight, operators will be required to amend their procedures to make them effective.

## 6. An acceptable methodology for determining exposition passenger weights

The IATA Airport Handling Manual AHM 531- *Procedures for Establishing Standard Weights for Passengers* is an acceptable means of compliance for establishing an exposition passenger weight.

Exposition passenger weights can be determined by random sample, i.e. every member of the survey population must have a chance of selection. Alternatively, a survey may set about



weighing every passenger. The selection of random samples must be representative of the passenger composition normally carried by the operator.

For practical purposes, while conducting the survey the passenger weight values may be rounded to the nearest half kilogram.

The survey plan should cover weighing the greater of:

1. A number of passengers calculated from a sample survey using normal statistical procedures and based on a relative confidence range of 1% for all adults and 2% for separate male and female average weights, and
2. Either:
  - (a) (Where the passenger seating capacity is 40 or more) a total of 2000 passengers, or
  - (b) (Where the passenger seating capacity is less than 40) a total number of  $50 \times$  (passenger seating capacity).

Other factors that need to be accounted for in the survey plan are:

- evidence that the plan will be representative of the route sectors flown
- whether carry-on baggage will be weighed separately
- whether school holidays are in progress during the survey, and
- what time of the day the survey will be run, together with evidence that this will be representative for all intended uses of the exposition weight.

The statistical procedure referred to in (1) above, as well as a worked example for determining the minimum required sample size, standard weight and degree of confidence is included in section 1.8 *Calculation of Mean and Standard Deviations*.

In determining the exposition passenger weight for adults, the result should be based on a male/female ratio of 60/40, unless another ratio can be shown to be more appropriate.

Passenger weights are broken into three broad categories: *adult*, *child*, and *infant*. Adults are defined as persons aged 13 years and over. They may be further classified as male or female. Children are categorised into those under 13 years but aged two years and over. Infants are those under the age of ~~2~~ two years. No gender-based differentiation is made for children or infants.

~~In order~~ To encourage passengers to co-operate in the survey, it is recommended that they are suitably informed about the reasons for being weighed. Assurance should be given that the passenger and their weight will remain totally anonymous in terms of the data recorded.

Carry-on baggage should be accounted for as part of the total weight of the passenger for Parts 121 and 125 operations. If desired, carry-on baggage may be weighed separately and subtracted from the combined passenger/carry-on baggage weight. This may reduce passenger anxiety about their weight being displayed and therefore ~~so~~ may be viewed as a more acceptable method of obtaining their weights.

Choice of location for weighing passengers is important. The weighing needs to be carried out somewhere between the check-in counter and the aircraft. It should be as close as possible to

the aircraft and at a point where a change in the passenger weight (for example, by disposing of or by acquiring more carry-on baggage) is unlikely to occur before the passenger boards the aircraft.

The choice of scales used during a survey can have an influence on the final survey result. Scale displays should be able to be arranged in such a way that it is visible to authorised persons only. Additionally, the design of the weighing machine should be such that it does not cause any inconvenience to passengers and airline operations and conforms to occupational safety and health regulations.

The weighing scales need to have a weight capacity of up to 200kg. The weight measurements should be displayed at minimum intervals of 500 grams. The weighing machine should be accurate to within 500 grams per 100 kg. The acceptable degree of accuracy is therefore  $\pm 0.5\%$  per sample. The scales will need to be calibrated to a minimum of 400 divisions to achieve this degree of accuracy. Scales used in the survey will require current calibration certificates that meet trade and commerce scale standards.

The use of data obtained through means other than that described above may be submitted in support of an exposition weight. However, the CAA will need to be satisfied that the data has been obtained by means it considers satisfactory before the exposition weights are accepted.

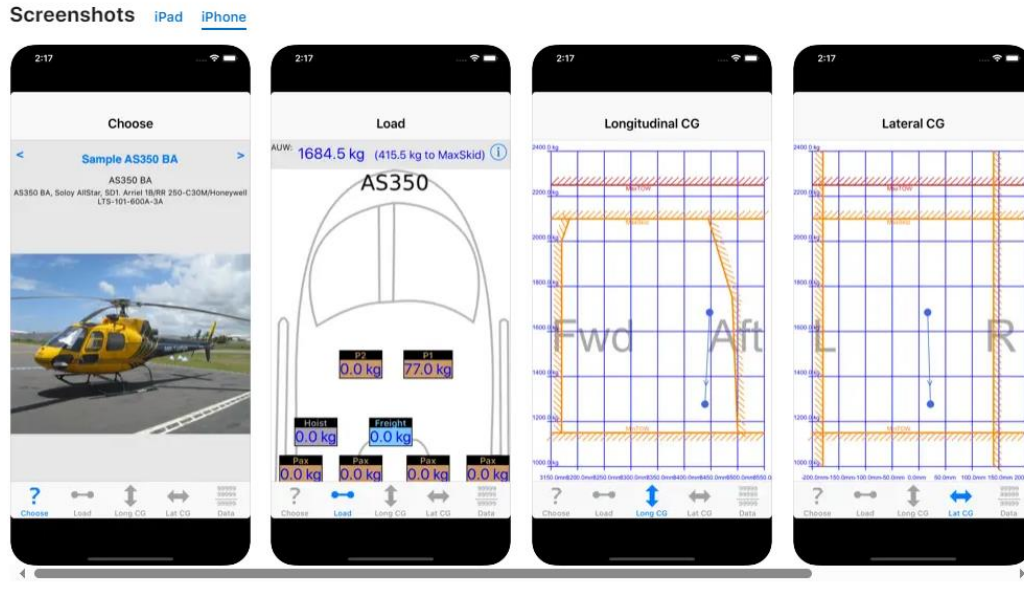
Survey data should include (but not be limited to): the number of adults, gender ratios, survey location, rejection ratio, and weight with carry-on baggage or without carry-on baggage.

## 7. Evaluation of data

The following statistical equations may require the input of a suitably qualified person to ensure the calculations are performed correctly. [There are also more resources in the Further Reading section, below.](#)

### Electronic data programmes

Many operators use electronic data programmes (or apps) to perform this function. These can range from the comprehensive tools used by large operators, which carry out a range of other tasks, to simpler apps that can be downloaded onto a tablet or most phones:



While these programmes can cut down the time needed to calculate safe weights and balances, like all tools they are only as good (or accurate) as the data that is entered into them.

When using electronic programmes, the most important considerations for operators to ensure are that the specifications they enter for their aircraft:

- continue to accurately reflect the aircraft's weight and balance throughout the entire duration of the flight, and
- continue to meet all requirements listed in the Aircraft Flight Manual (AFM).

CAA does not favour one application over another: the main focus for CAA inspectors and auditors is to ensure that these tools are being used to accurately reflect weight and balance. To this end, most inspectors will be ensuring that:

- the validity check of the data is recent and current, and
- the data entered into the tool matches the data in the AFM.

Operators should also be able to show:

- samples of loads that they have flown
- how they have ensured that the weights are safely within the parameters of the aircraft (whether it is transport of goods, such as agricultural products, or passengers), and
- how they ensure that the weight and balance is managed through the entirety of the flight, as fuel burns and effects balance.

**Note:** As shifting centre of gravity is more of an issue for helicopters than fixed-wing aircraft, management needs to be prominent in the plans for helicopters.

In summary, whether operators use manual calculations, or electronic tools, their overarching goals are the same: to transport their passengers, crew and goods safely. No matter what

method, it is the operator's responsibility to ensure the safety of their crew and passengers and goods, even on short flights, and to be able to show CAA how they achieve this.

### Manual calculations

In order to calculate the required sample size, it is necessary to make an estimate of the standard deviation on the basis of **based on** standard deviations **is** calculated for similar populations.

It is common practice to compute the precision of a sample estimate to some specified degree of reliability or "significance". In industrial engineering, a reliability of 95% is commonly used (i.e. there is a 95% probability that the true value falls within the specified confidence interval around the estimated value). In order to keep the sample size at an economical level and achieve a reasonable degree of accuracy, a reliability of 95% will be used for the calculation of the standard passenger weights.

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

- $\mu, \sigma =$  the true value of the mean passenger weight and the standard deviation, which are unknown and which are to be estimated by weighing a sample of passengers;
- $\mu', \sigma' =$  the *a priori* estimates of the mean passenger weight and the standard deviation, i.e. values resulting from an earlier survey, which are needed to determine the current sample size; and
- $\bar{x}, s =$  the estimates for the current true values  $\mu$  and  $\sigma$ , resulting from the current sample.

#### Sample size

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

$$N \geq \left( \frac{1.96 \times \sigma' \times 100}{e'_r \times \mu'} \right)^2$$

where

- $N =$  number of passengers to be weighed (sample size);
- $e'_r =$  allowed relative confidence range (accuracy) for the estimate of  $\mu$  by  $\bar{x}$
- 1.96 = value from the Gauss distribution for the 95% significance level of the resulting confidence interval.

## 8. Calculation of Mean Weight and Standard Deviation

If the passengers weighed are drawn at random, then the arithmetic mean of the sample ( $\bar{x}$ ) is an unbiased estimate of the true mean weight ( $\mu$ ) of the population.

#### Arithmetic mean of sample

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \dots + x_n}{N} = \frac{\sum x_j}{N}$$

where

$\sum$  = the sum of all the values.

$x_1 \dots x_n$  = the values of the different variables in a distribution

### Standard deviation

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

where

$x_j - \bar{x}$  = deviation of the individual value from the sample mean.

### Checking the accuracy of the sample mean

The accuracy (confidence range) which can be ascribed to the sample mean as an indicator of the true mean, is a function of the standard deviation of the sample (which is why there had to be an estimate *a priori* of  $\mu'$  and  $\sigma'$ ). It has to be checked after the sample has been evaluated.

This can be done by using the formula:

$$e_r = \frac{1.96 \times s \times 100}{\bar{x} \times \sqrt{N}} \%$$

where  $e_r$  should not exceed either 1% or 2% (depending on whether an adult or male/female mean weight is being established). The result of this calculation gives the relative accuracy of the estimate of  $\mu$  at the 95% significance level. This means that with 95% probability, the true average weight  $\mu$  lies within the interval:

$$\bar{x} \pm \frac{1.96 \times s}{\sqrt{N}}$$

### Example

The following example shows the various steps required for establishing the sample size and evaluating the sample data. All weight figures used throughout the example are entirely fictitious.

For calculating the required sample size, estimates of the exposition passenger weight and the standard deviation are needed. The *a priori* estimates from an earlier survey may be used for this purpose. If such estimates are not available, a small sample of approximately 100 passengers has to be weighed so that the required values can be calculated. The latter has been assumed for the example.

**Step 1: Estimate mean passenger weight.**

$n$	$x_j(\text{kg})$
1	93.8
2	82.0
3	91.8
4	88.4
5	68.0
6	76.1
7	103.2
8	122.6
.	.
.	.
85	77.1
86	89.3
$\sum_{j=1}^{86}$	7,267

$$\bar{x} = \frac{7,267}{86} = 84.5 \text{ kg}$$

**Step 2: Estimate standard deviation.**

$n$	$x_j$	$(x_j - \bar{x})$	$(x_j - \bar{x})^2$
1	93.8	+9.3	86.49
2	82.0	-2.5	6.25
3	91.8	+7.3	53.29
4	88.4	+3.9	15.21
5	68.0	-16.5	272.25
6	76.1	-8.4	70.56
7	103.2	+18.7	349.69
8	122.6	+38.1	1,451.61
.	.	.	.
.	.	.	.
85	77.1	-7.4	54.76
86	89.3	+4.8	23.04

$$\sum_{j=1}^{86} \quad 86 \quad 7,267 \quad 88,185.80$$

$$\sigma = \sqrt{\frac{\sum (x_j - \bar{x})^2}{n-1}} = \sqrt{\frac{88,185.8}{86-1}} = 32.21$$

**Step 3: Required sample size.**

The required number of passengers to be weighed should be such that the confidence range,  $e'r$ , does not exceed the limits specified above.

$$N \geq \left( \frac{1.96 \times \sigma \times 100}{e'r \times \mu'} \right)^2 \geq \left( \frac{1.96 \times 32.21 \times 100}{2 \times 84.5} \right)^2$$

$$\geq 1,395$$

The result shows that at least 1,395 passengers have to be weighed to achieve the required accuracy.

## 9. Determining the exposition weight

### Step 1: Calculating the mean passenger weight

After the required number of passenger weights has been collected, the mean passenger weight can be calculated. For the purpose of this example, it has been assumed that 2,003 passengers were weighed. The sum of the individual weights amounts to 168,618.1 kg.

$$\sum_{j=1}^{2,003} x_j = 168,618.1 \text{ kg}$$

$$\bar{x} = \frac{\sum x_j}{N} = \frac{168,618.1}{2,003} = 84.2 \text{ kg}$$

### Step 2: Calculation of the standard deviation.

$$\sum (x_j - \bar{x})^2 = 664,729.8$$

$$s = \sqrt{\frac{\sum (x_j - \bar{x})^2}{N - 1}} = \sqrt{\frac{664,729.8}{2,002}} = 18.22$$

### Step 3: Calculate the accuracy of the sample mean.

$$e'_r = \frac{1.96 \times s \times 100}{\bar{x} \times \sqrt{N}} = \frac{1.96 \times 18.22 \times 100}{84.2 \times \sqrt{2,003}} = 0.95\%$$

### Step 4: Calculate the confidence range of the sample mean.

$$\bar{x} \pm \frac{1.96 \times s}{\sqrt{N}} = 84.2 \pm \frac{1.96 \times 18.22}{\sqrt{2,003}} = 84.2 \text{ kg} \pm 0.8 \text{ kg}$$

The result of this calculation shows that there is a 95% probability the population mean for all passengers will lie within the range 83.4 kg to 85.0 kg.

## 10. Use of more indicative weights

Operators need to establish procedures that amend a load manifest (or daily flight records for Part 135) when the standard or exposition passenger weight is not adequate due to the clearly greater weight of a passenger or group of passengers.

Such procedures need to comply with other legislation such as the Human Rights Act 1993 ~~1990~~ and the Privacy Act 2020 ~~1993~~, which are intended to protect individuals from embarrassment based on their physical appearance. It is therefore inappropriate to physically single out a passenger assessed as being clearly greater than the exposition passenger weight



for the purpose of weighing them. Other more discrete means of compliance need to be established such as applying a more indicative weight to the load manifest or daily flight records when the operator assesses a passenger as not being represented by the standard or exposition weight.

A suggested indicative weight may be derived from a weight that is the sum of the mean weight plus one standard deviation above the mean weight. For example, if the passenger weight survey generated a mean weight of 85 kg, and a one standard deviation weight of 16 kg, an acceptable indicative weight is 101 kg.

The air operator's "indicative weight" procedures should address issues such as:

- a) who will assess passenger weights prior to boarding
- b) how will that assessment be effectively carried out
- c) what training and on-going checking of staff will be in place, and
- d) how will amendments to the load manifest or daily flight record be carried out,

In developing appropriate procedures, an air operator should consider how the pilot-in-command is to satisfy himself/herself that the aircraft can be operated safely, and within the limitations set down by the aircraft manufacturer.

## 11. Checked baggage weights

Checked baggage needs to be accounted for when calculating the take-off weight of an aircraft. For operations originating within New Zealand, facilities are available to preserve the current practice of weighing all checked baggage using scales. A change from this practice is not desirable.

However, some international flights inbound to New Zealand may not have facilities available ~~to them~~ that allow the weighing of checked baggage prior to departure. Additionally, some carriers may have received trans-ship baggage which has a standardised baggage weight allocated to ~~a~~ a group of bags. For these flights, provision is made within the rules for the use of a statistically generated "per piece" baggage weight.

The "per piece" baggage weight will need to be accepted into an air operator's exposition before being used for such operations. Part 121 air operators wishing to use standard baggage weights need to have information systems in place that ~~determining what~~ **can determine** ~~are capable of~~ the mean standard baggage weight is for a particular route.

In using standard baggage weights, an operator is still required to ensure the aircraft is operated within the aircraft flight manual limitations.

## 12. Crew member weights

Crew member weights are to be calculated using either the use of *actual crew member weights*, *exposition crew member weights*, or for Parts 121 and 125, a *standard crew member weight*.

The means for determining the exposition crew member weight is similar to those used for determining the exposition passenger weights.

It is acceptable for an operator to seek acceptance of the exposition passenger weight as an exposition crew member weight.

## ~~Interpretative and Explanatory Material~~

### 13. General purpose of rules governing standard and exposition weights

A desired safety outcome of these rules is for air operators to specify how they intend accounting for passengers whose actual weight is clearly greater than a standard (or exposition) passenger weight used in a passenger load calculation. The rules addressing passenger and crew member weights provide the air operator with a degree of flexibility when specifying those procedures ~~required by the rules~~.

An air operator needs to submit for approval those procedures specified in the rule. The CAA will have to be satisfied that those procedures will achieve an acceptable level of **safety in order to approve them**, ~~prior to their use~~.

#### Self check-in terminals

The use of self check-in terminals does not remove the **responsibility** ~~onus~~ on an operator to ensure that some form of assessment takes place when self check-in terminals are used in conjunction with standard or exposition passenger weights. When self check-in terminals are used for smaller Part 121 and Part 125 aircraft, some form of correction process should ~~to be~~ specified that will address the variance in weight caused by a large number of heavy passengers travelling together. A possible means for achieving this may be to have staff who collect boarding passes ~~make the assessments of passengers~~. ~~The staff member would then notify the appropriate person when a number of heavy passengers present for boarding on the same flight.~~

#### Variations between actual weight and standard weights

~~The CAA accepts a variation may exist between actual passenger weights and that calculated using standard or exposition passenger weights. However the operator's procedures will need to minimise this variation and achieve an acceptable level of safety.~~

### 14. Rule Subpart E — Weight and Balance

~~IEM Rule 121.303 — Goods, passenger, and baggage weights~~

~~IEM Rule 125.303 — Goods, passenger, and baggage weights~~

~~IEM Rule 135.303 — Goods, passenger, and baggage weights~~

~~These rules makes a distinction between goods and baggage as and these are defined in Part 1.~~

Baggage is the personal property of passengers or crew members which will be carried on an aircraft by agreement with the operator. Baggage can be further distinguished into carry-on baggage and checked baggage. The rules require checked baggage to be weighed (except for baggage that is subject to a standard baggage weight under Part 121). Carry-on baggage may be accounted for by increasing the standard or exposition passenger weights to allow for the extra weight of the baggage.

Since carry-on baggage is treated separately in Parts 121 and 125 from the broader definition for goods, the intent within this rule is that carry-on baggage does not need to be weighed if it

is accounted for in the standard or exposition passenger weight being used. Under Part 135 carry-on baggage is excluded from the passenger weight that is used and all baggage must be weighed except on commercial transport operations when it is not practicable to establish the actual weight of the baggage.

A distinction exists between baggage and “unaccompanied baggage”. Unaccompanied baggage is treated as goods, and **has** is required to be weighed.

Provision is made for the total weight of passengers to be established by using actual passenger weights, an exposition passenger weight, the rule standard passenger weight for Parts 121 and 125, and passenger-declared weights increased by 4kg per passenger for Part 135 operations.

### Actual weights

The use of actual weights is the most accurate method of maximising payload capacity while at the same time complying with the manufacturer’s aircraft weight limitations set out in the flight manual. No provision within any **of the rules** CAR should be interpreted as diminishing the operator’s responsibility to comply with the manufacturer’s limitations regarding an aircraft weight and balance. It is the operator’s responsibility to ensure that this requirement is met for each flight.

Actual weighing is more commonly practised by Part 135 operators. This is in part due to the smaller number of passengers being carried which makes this option less disruptive than for Part 121 and 125 operators.

### Exposition passenger weights

International standard practice allows operators to use mean passenger weights to calculate the total passenger load for a flight. This weight is carefully derived through accepted survey methodology that statistically determines an appropriate mean weight.

Mean weights may be applied by an operator as the exposition weight when they use accepted procedures that mitigate the risk of cumulative errors. Such errors are caused by the application of an unrepresentative weight to passengers who are clearly greater than that weight.

Details on how an exposition passenger weight may be derived and information relating to the procedures required are contained in section 1.9, ~~Determining the exposition weight~~, of this AC, **Determining the exposition weight**.

### Standard passenger weights

There is no relief provided in the rules for an aircraft to operate overweight when using standard passenger weights. Rules also require air operators to adhere to the limitations set by the aircraft manufacturer. When using a standard passenger weight from the rules, an operator is required to establish and comply with procedures that help identify those factors which may lead to the aircraft weight limitations being violated.

### Passenger-declared weights

Operators within the scenic tourist aviation industry requested the use of passenger-declared weights as a means of establishing a total passenger load weight. It was claimed that due to it being an efficient means of generating total passenger load weights without the problems associated with applying an exposition or standard weight, it was a suitable alternative to weighing passengers.

There are two problems associated with passenger-declared weights. Firstly there are passengers who do not know their actual weight; and secondly, of those that do, few know what their dressed weight is. For these reasons an adjustment allowance of 4kg is added to the passenger-declared weight. A similar system of weight increase is included in ~~FAA the Federal Aviation Administration~~ regulations, where a 10 pound increment is applied in a similar manner.

Operators are required to have procedures that address instances when a passenger may state an incorrect weight. Such procedures should include provision for a briefing to passengers informing them of the importance of declaring an accurate weight. It is unacceptable for an operator or pilot to prompt, suggest or otherwise encourage a weight less than the passenger's actual weight for the purposes of calculating the total passenger load.

The provision of passenger-declared weights diminishes the need for exposition weight usage in Part 135.

### **Standard checked baggage weights**

For operations originating within New Zealand, there are ample facilities to weigh all checked baggage. A move away from this practice is therefore undesirable. As a consequence, the use of a standard checked baggage weight is limited to those Part 121 operations originating outside New Zealand where there is no alternative but to accept baggage weight on a standard weight per piece basis.

In using standard baggage weights, an operator is still required to ensure the aircraft is operated within the aircraft flight manual limitations.

### **Specified Procedures**

Air operator procedures ~~will~~ need to detail the means by which a more indicative passenger weight is required to be used to account for those passengers who are clearly greater than the exposition or standard weight. A suggested indicative passenger weight suitable for this purpose could be based on the value equivalent to one standard deviation added to the mean passenger weight.

The term "clearly greater" refers to a passenger whose weight can be readily assessed as being over the applicable exposition or standard weight. For example, this includes being able to differentiate between a passenger who approximates the exposition, standard or declared weight and a passenger who is 40 kg over that weight. This would amount to being able to assess when a passenger weighing 120 kg is not 86 kg.

When there is doubt, as would be expected when assessing a passenger who weighs (say) less than 110 kg, the term "clearly greater" than is not applicable and a more indicative weight is not necessary.

The more indicative weight that is applied to individual passengers will not always equate to the passenger's actual weight. However it will mitigate any cumulative error that is possible when an unusual number of heavier passengers travel on the same flight.

The ~~place repository~~ for these procedures and passenger weights is the certificate holder's exposition, and may only be used once accepted into the exposition by the CAA.

## 15. Rule Subpart L — Manuals, logs, and records

### **HEM Rule 135.857 — Daily flight records**

It has been stated by industry representatives that load sheets are not always practical and the same record can be achieved by having the information available in the daily flight records.

Records of flights **must** ~~are required to~~ be kept to facilitate any search and rescue operations and, as a secondary consideration, to facilitate monitoring for compliance by operators as part of the CAA's audit and monitoring responsibilities.

Information relating to the weight and balance of an aircraft needs to be made available to the ~~pilot-in-command~~ **PIC** ~~before~~ ~~prior to commencement~~ of the flight so that he or she can assess the safety of the proposed flight. It is the responsibility of the operator to make this information available, and the **PIC's** ~~pilot-in-command's~~ responsibility to use the information to satisfy ~~themselves~~ ~~himself/herself~~ that each flight can be conducted safely.

## 16. Further reading

While the [IATA Airport Handling Manual AHM 531- Procedure for Establishing Standard Weights for Passengers and Baggage](#) remains the definitive guide on how to calculate passenger, crew and baggage weights and standard deviations, there are other sources of information which may be of interest:

- <https://www.aviation.govt.nz/assets/publications/gaps/caa-gap-weight-and-balance-october-2023-web.pdf>
- <https://www.casa.gov.au/sites/default/files/2021-08/multi-part-advisory-circular-121-05-ac-133-04-ac-135-08-passenger-crew-baggage-weights.pdf>
- <https://www.casa.gov.au/sites/default/files/2021-08/multi-part-advisory-circular-121-08-ac-133-08-ac-135-06-carry-on-baggage.pdf>
- <https://www.easa.europa.eu/en/downloads/1934/en>
- <https://www.iata.org/en/publications/store/airport-handling-manual/>
- <https://skybrary.aero/sites/default/files/bookshelf/2136.pdf>
- <https://www.scribd.com/document/367806218/IATA-Airport-Handling-Manual-Contents>
- [\(Updated\) New Zealand Diet and Nutrition Survey - Experts Respond - Science Media Centre](#)