



The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Équipement de l'Aviation Civile

MINIMUM OPERATIONAL PERFORMANCE STANDARD FOR ON BOARD WEIGHT AND BALANCE SYSTEMS

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ED-263

June 2019

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INTRODUCTION

GENERAL

There have been a number of accidents and serious incidents that have resulted in fatalities in which aircraft failed to rotate, to achieve the correct climb rates or to achieve the proper descent profile or landing flare. One of the primary causes of such accidents and serious incidents has been attributed to incorrect weight and balance. The aircraft were either at overweight or an incorrect centre of gravity position was calculated. To date there are no requirements or standards prescribing the installation and specifying performances of systems to provide weight and balance information and warnings to the flight crew.

Two accidents in 2003 (BEA 3X-GDO – 25 December 2003 and NLR TC-ONP – 17 June 2003) resulted in the first recommendations to EASA to provide regulatory material on On-Board Weight and Balance Systems. After a review of the accident and investigation teams' recommendations, EASA has concurred that such a system would result in a safety benefit.

EUROCAE WORKING GROUP 88

Based on a review of the currently available technology EUROCAE was requested to evaluate the feasibility of developing standards for an OBWBS. As a result Working Group 88 was set up by the EUROCAE council in 2011 to develop EUROCAE documents dealing with Weight and Balance On board Systems.

WG-88 has been established to develop a feasibility report in a first step and then, depending on the outcome of this report, develop Minimum Operational Performance Specifications (MOPS) for OBWBSs for civil aviation. The specification should define the required standard for the equipment necessary to establish the aircraft's weight and balance, to be used either as a possible ETSO standard or as AMC/GM of the relevant CS. The feasibility report was published on 9 April 2013.

EASA rulemaking program 2017-2021 identifies RMT.0161 to mandate an OBWBS to future and existing aircraft, based on the results of WG-88. This task is scheduled to start in 2019.

THIS MOPS

As a start, the Working Group identified (EASA) requirements applicable to Weight & Balance. Together with a generic workflow with regard to Weight & Balance and performance from an operator's point-of-view, it formed the basis for a detailed Concept of Operations for an On-Board Weight and Balance System, listing individual functionalities for such a system, including both operational and safety risks and benefits. Refer to Appendices A to D.

The W&B incidents that were reviewed for the Working Group's interim feasibility report were subsequently analysed with the help of this CONOPS. The results of which are documented in dedicated Appendix D.

This version of the MOPS defines standards for a most simple system; an advisory OBWBS that displays measured gross weight and calculated centre of gravity only for the flight crew to use as an independent means of verifying the conventional weight and balance documentation. This system is defined as an 'OBWBS.'

These MOPS may apply to on-ground and in-flight operations.

Appendices C to D however, are maintained in this MOPS to aid in a possible extension of the Working Group and to aid manufacturers in establishing requirements for an OBWBS that goes beyond a 'OBWBS' as described in this MOPS.

To allow for future incorporation of additional functionalities in this MOPS, the document is modular in structure. Applicable paragraphs and chapters each start with the requirements for a OBWBS as the first (sub)paragraph. Additional functionalities may be described in subsequent (sub)paragraphs in which only the additional requirements are listed, unless specifically stated otherwise.

CHAPTER 1

GENERAL

1.1 PURPOSE AND SCOPE

This document contains the Minimum Operational Performance Standard for On Board Weight and Balance Systems for Large Aeroplanes (CS-25). These standards specify the minimum performance expected from such an On Board Weight and Balance System.

Compliance with this standard is recommended as one means of assuring that the equipment will perform its intended function(s) satisfactory under all conditions normally encountered in routine aeronautical operation.

This minimum operational performance standard is designed to ensure that equipment compliant to it will get the necessary regulatory approval (this is generally facilitated by the recognition of such standards by the relevant authorities as an acceptable means of compliance with the applicable regulations).

Applicable regulations and certification specifications are (for other relevant standards refer also to Chapter 1.6):

- EASA CS-25,
- EC Regulation 965/2012 CAT.POL.MAB.100 Mass and balance, loading, and
- EC Regulation 965/2012 CAT.POL.MAB.105 Mass and balance data and documentation

The document is structured as follows:

Chapter 1 of this document provides information required to understand the need for the equipment characteristics and tests defined in the remaining chapters. It describes typical equipment applications and operational objectives and is the basis for the performance criteria stated in Chapter 2 to Chapter 4. Definitions essential to proper understanding of this document are also provided in Chapter 1.

Chapter 2 contains general design requirements.

Chapter 3 contains the minimum performance specification for the equipment, defining performance under standard conditions.

Chapter 4 contains the minimum performance specification for the equipment, defining performance under operational conditions..

Chapter 5 describes recommended test procedures for demonstrating compliance with Chapters 3 and 4.

Operational performance standards for functions or components that refer to equipment capabilities that exceed the stated minimum requirements are identified as optional features. If applicable, performance requirements and associated test procedures are developed for these optional features as well.

The word "equipment" as used in this document includes all components and units necessary for the system to properly perform its intended function(s). For example, the "equipment" may include sensors, displays, wire harnesses, software. In the case of this example, all of the foregoing components and units comprise the "equipment." It should not be inferred from this example that each design will necessarily include all of the foregoing components or units. This will depend on the specific design chosen by the manufacturer.

This MOPS applies to a specific defined function. The equipment may have additional features related to that function for which there are no specified minimum performance requirements. For example, many VHF radios have an active-standby frequency "flipflop" feature for which there are no specified requirements or tests. Equipment may also have additional functions for which other MOPS or ETSOs may be applicable or, it may contain additional functions not defined by any MOPS or ETSO and, non ETSO function guidance may be applicable.

1.2 APPLICATIONS

Compliance with this MOPS by manufacturers, installers and users is recommended as a means of assuring that the equipment will satisfactorily perform its intended function(s) under all conditions normally encountered in routine aircraft operations. Any regulatory application of this document in whole or in part is the sole responsibility of appropriate government agencies. As the measured values of equipment performance characteristics may be a function of the method of measurement, standard test conditions and methods of test are recommended in this document.

1.2.1 MANDATING AND RECOMMENDATION PHRASES

1.2.1.1 "Shall"

The use of the word "Shall" indicates a mandated criterion; i.e. compliance with the particular procedure or specification is mandatory and no alternative may be applied.

1.2.1.2 "Should"

The use of the word "Should" (and phrases such as "It is recommended that...", etc.) indicate that though the procedure or criterion is regarded as the preferred option, alternative procedures, specifications or criteria may be applied, provided that the manufacturer, installer or tester can provide information or data to adequately support and justify the alternative.

1.3 DESCRIPTION OF SYSTEM

1.3.1 MEASUREMENTS

WoW, WiF, Payload

1.3.2 OBWBS

An OBWBS is an onboard system that:

- Measures the actual aircraft Gross Weight;
- Calculates the actual position of the Center of Gravity through measurements;
- Determine its operational accuracy at time of measurement (unless a conservative constant value is defined in the AFM);
- Provides a visual indication of these values to the flight crew before flight allowing for comparison of these values to the values from the conventional weight & balance documentation (if the operational accuracy is within acceptable range).

NOTE: *This MOPS does not describe systems that generate weight & balance information through other methods than direct measurement.*

NOTE: *In addition to a OBWBS that can only be used on-ground and on-blocks, depending on the technology, this OBWBS might be used off-blocks as well, e.g. during taxi.*

1.4 COMPOSITION OF EQUIPMENT

The OBWBS consists of the following components:

- Sensors
- CPU
- Data transfer
- Power Supply
- Human Machine Interface

1.5 DEFINITIONS AND ABBREVIATIONS

For definitions and abbreviations, as well as terms and acronyms, refer to Appendix F.

1.6

REFERENCES

TABLE 1.1: REGULATIONS

Regulations	Title
EC Regulation 965/2012	European Air Operations (EASA-OPS)
Annex 1 (Part 21) of EC Regulation 748/2012	Certification of aircraft and related products, parts and appliances, and of design and production organisations

TABLE 1.2: CERTIFICATION SPECIFICATIONS

Certification Specifications	Title
EASA CS 25	Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes

TABLE 1.3: ACCEPTABLE MEANS OF COMPLIANCE / GUIDANCE MATERIAL

Advisory Circulars	Title
FAA AC 20-161	Aircraft Onboard Weight and Balance Systems
AMC 25.1309	System Design and Analysis
AMC 25-11	Electronic Flight Deck Displays
AMC 25-19	Certification Maintenance Requirements

TABLE 1.4: INDUSTRY DOCUMENTS

Industry Documents	Title
RTCA DO-160F	Environmental Conditions and Test Procedures for Airborne Equipment
RTCA DO-178B	Software Considerations in Airborne Systems and Equipment Certification
RTCA DO-254	Design Assurance Guidance for Airborne Electronic Hardware
SAE ARP 1409C	Aircraft On Board Weight and Balance System Requirements
SAE ARP 4102/1	On Board Weight and Balance System (flight deck display)
SAE ARP 4754	Certification Considerations for Highly-Integrated or Complex Aircraft Systems
SAE ARP 4761	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment
SAWE RP 1	Requirements for Aircraft On Board Weight and Balance System

1.7

OPERATIONAL APPLICATION(S)

The OBWBS is used as a safety net to check that the actual aircraft gross weight and associated CG are in line with the provided weight and balance documentation for the dispatch of the aircraft.

The data provided by the OBWBS is used for comparison to the actual aircraft gross weight and associated CG defined through the conventional loads build-up method (load sheet) in order to identify gross errors.

Two kinds of usage (classes) of On Board Weight and Balance System are anticipated. Nevertheless, only the design and installation aspects of Class II (secondary) OBWBS shall be addressed in subsequent chapters of this initial Issue of this MOPS. The guidelines for design and installation of Class I (primary) OBWBS may be defined at a later stage.

Due to the different operational applications, Class I and Class II OBWBS will have

- different severity for similar failure conditions on aircraft level
- different minimum accuracy specifications
- different reliability and dependability minimum specifications.

1.7.1

CLASS I

The data provided by the class I system are considered to be the primary means to be used for dispatch of the aircraft including the take-off performance calculation.

The outputs of the system consist of:

- Gross weight
- Center of gravity

The information may be displayed for cross-check by the flight crew.

The flight crew should be informed on the validity of the data, but the flight crew shall be informed at the latest if the validity of the data is outside acceptable limits.

For safety purposes it is highly recommended that the actual weight and center of gravity of the A/C as measured and computed by the system is directly transmitted to other systems (for example FMS, EFB based applications, ...) avoiding any manual transfer of data by the flight crew.

1.7.2

Class II

The crew uses the load manifest as the primary means and uses the OBWBS to verify the results of the data provided by the operations. The outputs of the system consist in:

- Gross weight
- Center of gravity

The information:

- Should be displayed to the flight crew on the CDU or other ECAM or flight deck display.
- Should be adequate for comparison by the flight crew with the data used for the take-off performance calculation in order to identify any discrepancies that would jeopardize a safe take-off.

1.8

INTENDED FUNCTION

1.8.1

OBWBS

The intended function of an OBWBS is to provide:

- actual aircraft Gross Weight
- position of the Center of Gravity

The system shall be designed in accordance with CS 25.1301.

Loss or malfunction

In case that the OBWBS is intended to be used as a secondary means (class II) to determine aircraft gross weight and CG, a loss of the function has no safety effect.

A malfunction of the class II OBWBS is considered to have no safety effect as well but it could potentially trigger the initiation of a re-check of the aircraft loading by the flight crew.

In case that the OBWBS is intended to be used as primary means (class I) to determine aircraft gross weight and CG, a loss of the function has no safety effect

either, but an alternative system or process need to be defined for determination of the data required for dispatch of the aircraft.

An undetected malfunction of the class I OBWBS is considered to have potentially catastrophic repercussion.

1.9 OPERATIONAL GOALS

The main operational goal of the OBWBS is to avoid gross errors in aircraft weight and CG determination.

Additionally, the design should avoid to the most possible extent spurious identification of errors in aircraft weight and/or CG causing an unnecessary check of aircraft loading.

1.9.1 ACCURACY, RESOLUTION, RANGE AND SENSITIVITY

The operational accuracy of the OBWBS should be sufficient to support the above operational goals. The range shall be such as to allow detection of gross errors throughout the envelope of the aircraft. Additional range may aid in detecting the amount of envelope exceedance.

1.9.2 MANUAL DATA INPUT

Unless there is a continuous measurement of the system, the initiation of the measurement has to be done by the flight crew.

1.9.3 OUTPUT / DATA DISPLAY

The output shall enable the flight crew to make a decision on when a re-check of the aircraft loading has to be initiated.

1.9.4 FAILURE MODES, WARNING AND FLAGS

There are no warnings expected from the OBWBS, when it is intended to be used as a secondary (class II) system.

Detectable failure modes should be displayed to the flight crew in order to avoid unnecessary re-loading and re-check of the aircraft loading.

1.9.5 SELF TEST

A self test is not necessarily required for a secondary system. However if part of design, it should aid the flight crew in detecting failure modes.

1.9.6 INTERFACE WITH OTHER AIRBORNE EQUIPMENT / SYSTEMS

In order to enhance its functionality an OBWBS may feature interfaces with other systems. However, its data shall not be used for safety related functions performed by other systems.

There may be other systems that benefit from OBWBS data.

1.10 TEST PROCEDURES

Reserved

1.11 ANTICIPATED FUTURE GROWTH

As a first start the Working Group defined standards for a most simple system; an advisory OBWBS that displays measured gross weight and calculated centre of gravity only, while on ground and on-blocks, for the flight crew to use as an independent means of verifying the conventional weight and balance documentation. This system is defined as an 'OBWBS.' Additional requirements were established for on-ground, off-blocks use, e.g. during taxi.

However, in the course of the Working Group, additional functionalities were identified that are listed in this paragraph and are further expanded in Appendix C – Concept of Operations for Future Growth.

Additionally, Appendices A and B respectively contain an overview of applicable EASA regulations on Air Operations and a basic work flow of operational weight and balance procedures.

The information in these three appendices was produced in the course of the Working Group and are retained in this MOPS to:

- Assist in further expanding this MOPS in a future continuation of WG-88, and
- Support manufacturers who wish to design an OBWBS with functionalities that go beyond that of a OBWBS with off-blocks use.

Additional functionalities the Working Group considered include:

- Primary / Class I use
An OBWBS that provides gross weight and balance data that is accurate enough to be used for primary dispatch of the aircraft (generation of weight and balance documentation and take-off performance data).
- Connectivity
An OBWBS that is able to transmit its output to external Systems. This may be done wirelessly to e.g. a centralised computer system, a class I or II EFB, or a portable device held by the aircraft ground crew. Another option is to connect the OBWBS through the aircraft's systems to the FMS, MCDU or a class II or III EFB.
- Advanced OBWBS
An OBWBS that is able to meet weight and balance documentation requirements in that it is able to produce weight and balance documentation by itself, either by manual input by the flight crew or by input from external (flight planning) systems.
NOTE: *An Advanced OBWBS for instance would also be able to generate the required data for autonomous air taxis.*
- In-flight use
An OBWBS that is able to generate actual weight and balance data during the entire flight phase from take-off up to landing, including a missed approach.
- CAS alerting
An OBWBS that is able to generate CAS indications to alert the aeroplane's flight and/ or ground crew.

Furthermore, OBWBS data could be used for:

- Take-off performance calculations
- Flight data monitoring
- On-condition maintenance (HUMS)
- Hard landings measurements
- Enhancement of existing aircraft systems and/or their associated AFM procedures
- Enhanced interfaces with aircraft systems performing safety related functions, such as:
 - Ground contact
 - Tire and strut pressure
 - Braking forces
 - Fuel level measurement verification.

CHAPTER 2

GENERAL DESIGN REQUIREMENTS

2.1 INTRODUCTION

This chapter establishes the design considerations and general specification for the equipment comprising the On Board Weight and Balance System.

2.2 AIRWORTHINESS AND CERTIFICATION

In the design and manufacture of the equipment, the manufacturer shall provide for installation so as not to impair the airworthiness of the aircraft.

Airworthiness regulations to be addressed, include but are not limited to the following regulations:

TABLE 2.1: MINIMUM REGULATIONS TO ADDRESS

Equipment - Function and Installation	CS 25.1301
Equipment, Systems, and Installations	CS 25.1309
Pilot Compartment	CS 25.771(a)
High-intensity Radiated Fields (HIRF) Protection	CS 25.1317
Cockpit Controls	CS 25.777(a)
Instrument Arrangement and Visibility	CS 25.1321
Flight crew alerting	CS 25.1322
Electrical Systems and Equipment – General	CS 25.1351
Circuit Protective Devices	CS 25.1357
Hydraulic Systems	CS 25.1435
Pressurisation and low pressure Pneumatic Systems	CS 25.1438
Weight, centre of gravity and weight distribution	CS 25.1519
Instructions for Continued Airworthiness	CS 25.1529 and associated Appendix H
Aeroplane Flight Manual – General	CS 25.1581
Operating Limitations	CS 25.1583
Electrical and electronic system lightning protection	CS 25.1316
Fire Protection - Systems	CS 25.869
Electronic Equipment	CS 25.1431
Instrument Systems	CS 25.1333

Applicants seeking an airworthiness approval of their OBWBS design and installation in large transport aeroplanes should demonstrate compliance to the applicable airworthiness specifications addressing the following aspects:

1. Demonstrate the system accuracy under standard (laboratory/hangar) and operational conditions (including effects of operating under any environmental conditions for which the approval of system usage is being sought) , and repeatability of the installed OBWBS. See chapters 3 and 4 in the MOPS for guidance.
2. Demonstrate system accuracy for the maximum period allowed between OBWBS calibration on the installed OBWBS.
3. Include limitations and systems operating instructions in the AFM/AFM Supplement and the instructions for continued airworthiness.
4. If software is used, applicants should meet the requirements in:
 - EUROCAE ED-12C, *Software considerations in airborne systems and equipment certification*, dated 19 October 1999, or the most current revision, and
 - Society of Automotive Engineers (SAE) International Aerospace Recommended Practice (ARP) 4754, *Certification Considerations for Highly Integrated or Complex Aircraft Systems*, dated 1 November 1996, or the most current revision.

For additional guidance see EASA AMC 25.1309, *System Design and Analysis*.
5. If the hardware contains complex electronic devices then the design should meet the requirements in *EASA Certification Memorandum SWCEH – 001, Issue 01, Revision 01 dated 9th March 2012*.
6. Applicants should also follow the environmental requirements in EUROCAE ED-79A / SAE ARP4754A, *Guidelines for Development of Civil Aircraft and Systems.*, dated December 2010, of the most current revision.

The manufacturer shall provide the following information:

- System accuracy under standard conditions
- Define all parameters affecting operational accuracy.
- Define allowable ranges for these parameters, resulting in a valid measurement.
- Optionally: Define compensation for parameter variation
- Account for indication of invalid measurement if parameters are outside of allowable range.

2.3 OPERATION OF CONTROLS

The equipment shall be designed so that controls intended for use during flight and flight preparation cannot be operated in any position, combination or sequence that would result in a condition detrimental to the reliability of the equipment or operation of the aircraft.

2.4 ACCESSIBILITY OF CONTROLS

The OBWBS should be powered up and down with the aircraft. If not, a dedicated power switch shall be available within easy reach of the flight crew.

Controls that do not require adjustment during flight shall not be readily accessible to flight personnel.

2.5 EFFECTS OF TESTS

Unless otherwise stated, the design of the equipment shall be such that, during and after the application of any specified start up / built-in tests, no condition exists which would be detrimental to the subsequent performance of the equipment.

2.6 EQUIPMENT INTERFACES

Equipment interfaces shall be described.