

The Boeing 767 Weight and Balance Manual: A Definitive Technical Guide for Aviation Professionals

Published: January 26, 2026 | Index ID: #471

In the high-stakes environment of commercial aviation, precision is the bedrock of safety and operational efficiency. For an aircraft as versatile and enduring as the **Boeing 767**, the management of **Weight and Balance (W&B)** is not merely a regulatory requirement but a fundamental engineering necessity. Since its introduction, the 767 has served as a bridge between narrow-body and large wide-body aircraft, making its loading characteristics unique in the industry. This article provides an exhaustive analysis of the technical principles, regulatory frameworks, and practical procedures involved in maintaining the Boeing 767's center of gravity within certified limits.

The Fundamental Importance of Weight and Balance

Every aircraft is designed to operate within a specific envelope of weight and a localized **Center of Gravity (CG)**. For the Boeing 767, which operates in both passenger and dedicated freighter configurations, the consequences of improper loading are severe. An overweight aircraft may fail to clear obstacles during takeoff or suffer structural failure during turbulence. Conversely, an aircraft with an improper CG can become aerodynamically unstable or impossible to control in the pitch axis.

Weight and Balance management is a discipline that integrates **aerodynamics**, **structural engineering**, and **logistics**. By ensuring the aircraft is loaded according to the **Weight and Balance Manual (WBM)**, operators maximize fuel efficiency, minimize airframe stress, and ensure that the flight control systems—both manual and automated—function within their design parameters.

Core Concepts and Theoretical Framework

To master the Boeing 767's loading requirements, one must first understand the primary metrics and terminology used in the **Aircraft Weight and Balance Handbook** and specific Boeing documentation.

Primary Weight Definitions

- **Manufacturer's Empty Weight (MEW)**: The weight of the aircraft structure, powerplants, and fixed equipment. This is the baseline weight before any airline-specific equipment is added.
- **Operating Empty Weight (OEW)**: The MEW plus the weight of the crew, fluids (oil, unusable fuel), and emergency equipment. This is the starting point for all daily weight calculations.
- **Zero Fuel Weight (ZFW)**: The OEW plus the total payload (passengers, cargo, and mail). It is critical because the wings must support this weight without the relieving effect of fuel stored in the wing tanks.
- **Maximum Takeoff Weight (MTOW)**: The maximum weight authorized for the start of the takeoff run. This is limited by structural strength and performance requirements (e.g., climb gradient in the event of an engine failure).
- **Maximum Landing Weight (MLW)**: The maximum weight at which the aircraft is permitted to land. This is strictly enforced to prevent structural damage to the landing gear and fuselage.

The Physics of Balance: Moments and Arms

The 767's balance is calculated using the principle of the lever. The **Arm** is the horizontal distance from a reference datum to the item. The **Moment** is the product of the weight and the arm ($\text{Weight} \times \text{Arm} = \text{Moment}$). Because these numbers can be unwieldy for a large aircraft like the 767, engineers use **Index Units (IU)** to simplify the arithmetic.

The **Mean Aerodynamic Chord (MAC)** is the average longitudinal distance from the leading edge to the trailing edge of the wing. In large aircraft, the Center of Gravity is almost always expressed as a **percentage of MAC (%MAC)** rather than a station number. This allows pilots and dispatchers to understand the aircraft's stability regardless of its specific size or variant.

Technical Analysis of Boeing 767 Variants

The Boeing 767 has several variants, each with distinct loading envelopes. The table below compares the typical technical specifications for the most common models used in modern operations.

Specification	767-200 (Standard)	767-300ER	767-400ER
Length	159 ft 2 in	180 ft 3 in	201 ft 4 in
Typical OEW	176,650 lbs	198,440 lbs	227,400 lbs
Max Takeoff Weight (MTOW)	315,000 lbs	412,000 lbs	450,000 lbs
Max Zero Fuel Weight (ZFW)	238,000 lbs	288,000 lbs	330,000 lbs
Cargo Capacity	3,070 cu ft	3,750 cu ft	4,580 cu ft

As seen in the data, the **767-300ER** and **-400ER** variants offer significantly higher MTOWs, which necessitates more rigorous W&B calculations. The increased length of the -400ER, in particular, creates a much longer **fuselage moment arm**, meaning that weight placed at the extreme ends of the aircraft has a much greater impact on the CG than in the -200 series.

The Weight and Balance Manual (WBM) and Regulatory Compliance

The **Weight and Balance Manual (WBM)** is a document specific to each airframe, identified by its registration or tail number. It is an extension of the **Airplane Flight Manual (AFM)** and is approved by the regulatory authority, such as the **FAA** or **EASA**. For Boeing 767 operators, the WBM is the definitive source of truth for loading limitations.

FAA Weight and Balance Requirements

Under FAA regulations (such as Part 121 for scheduled carriers), an operator must have a systematic program to ensure that the aircraft is weighed periodically (typically every 36 months) and that the load manifest is accurate for every flight. The WBM contains:

- Loading Envelopes: Graphical representations of the allowed CG range at various weights.
- Pallet and Container Limitations: Maximum floor loading densities (lbs per sq ft) for the main and lower decks.
- Compartment Limits: The maximum weight allowed in specific zones of the aircraft to prevent structural overstress.

Special Freighter Conversions (STC)

Many Boeing 767s currently in service are converted freighters, such as the **767-300BDSF** (Bedek Special Freighter). These conversions require **Supplemental Type Certificates (STC)**. When an aircraft is converted from passenger to freighter, its OEW changes significantly, and its CG often shifts forward due to the removal of seats/galleys and the addition of a main-deck cargo door and floor reinforcement. The **Weight and Balance Manual Supplement** is crucial for these aircraft, as the original manufacturer's data no longer applies.

Mathematical Models for CG Calculation

Determining the CG on a Boeing 767 involves a series of summations. The goal is to find the **Total Moment** and divide it by the **Total Weight** to find the **Center of Gravity Station**.

The Basic Formula

CG Station = Total Moment / Total Weight

To convert this to %MAC, the following formula is applied:

$$\%MAC = [(CG\ Station - LEMAC) / MAC] \times 100$$

Where:

- LEMAC: Leading Edge of the Mean Aerodynamic Chord (the station number where the MAC begins).
- MAC: The length of the Mean Aerodynamic Chord itself.

Example Calculation Scenario

Consider a Boeing 767-300 with an OEW of 200,000 lbs and a starting index of 50.0. If 40,000 lbs of cargo is loaded into the forward hold (Station 500) and 20,000 lbs into the aft hold (Station 1200), the dispatcher must calculate the shift in Index Units to ensure the final ZFW CG remains within the allowable envelope for the duration of the flight, accounting for fuel burn.

Practical Implementation: The Field Guide to Loading

Loading a 767 is a coordinated effort between the **Load Master**, **Ground Handling**, and the **Flight Dispatcher**. The process follows a strict sequence to ensure safety.

Step-by-Step Loading Procedure

1. Preparation of the Load Plan: Based on the anticipated cargo and passenger count, the dispatcher creates an initial load plan. This plan identifies which Unit Load Devices (ULDs) will be placed in which positions.
2. Pre-Loading Inspection: The load master ensures that the aircraft is clean and that the Cargo Loading System (CLS)—the rollers and locks—is functional.
3. Sequential Loading: To prevent the aircraft from tipping on its tail, the cargo is usually loaded in a specific order. On a 767 freighter, it is common to load the forward sections first or utilize a tail stand during the process.
4. Securing the Load: Each ULD must be locked into the floor tracks. For heavy or non-containerized cargo, tie-down straps must be used, with tension calculated according to the WBM.
5. The Final Load Sheet: Once the actual weights are confirmed, a final load sheet is produced. This document provides the pilots with the Zero Fuel Weight, Takeoff Weight, and the Stabilizer Trim Setting (derived from the Takeoff %MAC).

Fuel Management and CG Shift

Fuel is stored primarily in the wings and a center tank on the 767. As fuel is consumed during flight, the CG of the aircraft shifts. The Boeing 767 is designed so that the fuel CG is generally close to the aircraft CG, but the sequence of fuel usage (usually emptying the center tank first) is critical. If the fuel is not managed according to the **Airplane Flight Manual**, the aircraft could potentially drift out of the CG envelope as it becomes lighter.

Case Studies and Operational Challenges

Even with sophisticated software, operational errors can occur. Analyzing these scenarios provides vital lessons for technical crews.

The Risk of Tail-Tipping

The Boeing 767, particularly the stretched -300 and -400 variants, has a relatively long fuselage behind the main landing gear. During the unloading process, if the forward cargo is removed while the aft cargo remains, the CG can shift aft of the main gear, causing the nose to rise and the tail to strike the ground. This results in massive

structural damage to the rear pressure bulkhead. **Prevention:** Strict adherence to unloading sequences and the use of tail tethers or stands.

The "Late Bag" and Manual Revisions

In passenger operations, "late bags" or last-minute passenger swaps can alter the weight. While 500 lbs might seem insignificant on a 300,000 lb aircraft, if that weight is added at the extreme aft of the aircraft, it can change the stabilizer trim requirement. Modern **Electronic Flight Bags (EFBs)** allow pilots to recalculate these changes instantly, but manual errors in data entry remain a significant risk factor.

Icing and Contamination

Weight and Balance calculations assume a clean airframe. The accumulation of ice or snow on the fuselage and wings not only increases the total weight but can significantly shift the CG. Since ice often accumulates more heavily on the horizontal stabilizer and the rear of the fuselage, it can create a dangerous tail-heavy condition. De-icing is not just an aerodynamic necessity; it is a weight and balance necessity.

Advanced Engineering: Lateral Balance

While longitudinal balance (nose-to-tail) is the primary concern, **lateral balance** (wing-to-wing) is also regulated for the Boeing 767. This is particularly relevant for freighters where heavy pallets might be loaded on one side of the main deck. An imbalance can lead to:

- Increased drag due to constant aileron/spoiler deflection required to maintain level flight.
- Uneven tire wear on the landing gear.
- Reduced roll authority in crosswind landings.

The WBM provides a **Lateral Unbalance Envelope**, specifying the maximum allowable difference in weight between the left and right sides of the aircraft.

Future Trends in Weight and Balance

The industry is moving toward more automated and integrated W&B systems. For the Boeing 767 fleet, this includes:

- On-Board Weight and Balance Systems (OBWBS): Sensors in the landing gear struts that measure the actual deflection to calculate the weight and CG in real-time, providing a cross-check against the manual load sheet.
- Digital Twin Integration: Using tail-specific data to predict how structural repairs or modifications affect the W&B over the aircraft's lifecycle.
- Sustainable Aviation Fuel (SAF) Considerations: As fuel densities may vary slightly with new fuel types, W&B systems must be updated to ensure volume-to-weight conversions remain precise.

The Boeing 767 remains a cornerstone of global logistics. Its ability to carry vast amounts of cargo over long distances is entirely dependent on the rigorous application of weight and balance principles. From the initial engineering of the Mean Aerodynamic Chord to the daily execution of the load manifest, the pursuit of balance is what keeps the 767 safe and efficient. For the technical writer and aviation professional, understanding the **Weight and Balance Manual** is not just about numbers—it is about mastering the physics of flight to ensure every takeoff leads to a safe landing.

Baca Juga (Artikel Terkait)

- [The Definitive Technical Guide to the Lycoming O-235 Series: Engineering Architecture, Operational Performance, and Maintenance Optimization](#)

URL: <http://www.amlakerbil.com/lycoming-o-235-engine-technical-guide.pdf>

- [The Ultimate Technical Guide to the Cessna 206 and T206 Series: Maintenance, Documentation, and Engineering Architecture](#)

URL: <http://www.amlakerbil.com/cessna-206-t206-technical-maintenance-guide.pdf>

- [Comprehensive Technical Guide to Boeing 737 Maintenance Manuals: Operational Procedures and System Standards](#)

URL: <http://www.amlakerbil.com/boeing-737-maintenance-manual-technical-procedures-guide.pdf>

- [Comprehensive Technical Analysis of Boeing 737 Next Generation \(NG\) Maintenance and Operational Documentation](#)

URL: <http://www.amlakerbil.com/boeing-737-ng-maintenance-operations-technical-guide.pdf>

Tags: [#Boeing 767](#) [#Weight and Balance](#) [#Aviation Safety](#) [#WBM Manual](#) [#Aerospace Engineering](#)

