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# Incorrect pitch trim setting at takeoff

## 1. Introduction

In 2008, an A330 flight crew was surprised by the rapid rate of rotation of the aircraft at takeoff.

Analysis of the flight revealed that the crew selected an erroneous takeoff pitch trim setting. This trim setting was based on a Takeoff Center of Gravity (TOCG) determined through a simplified load and trim sheet calculation method. This TOCG did not correspond with the aircraft's CG at takeoff.

This event highlights three issues:

- The AFTER START procedure, which calls for the setting of the pitch trim according to the CG indicated on the ECAM, was not properly applied.
- The pitch trim setting was set according to a load and trim sheet TOCG instead of the ECAM CG.
- The TOCG on the load and trim sheet was erroneous, because of the simplified TOCG calculation method.

The aim of this article is to:

- Explain why this simplified TOCG calculation method can lead to differences between the calculated TOCG and the real TOCG at brake release.
- Propose an improved simplified TOCG calculation method.
- Highlight the existing Standard Operating Procedures (SOP) relating to the TOCG.

## 2. TOCG calculation methods

### 2.1. Complete calculation

To determine the TOCG (expressed in percent of the Mean Aerodynamic Chord, %MAC) it is necessary to determine the Takeoff Weight (TOW) and the Takeoff Index (TOI) (fig. 1).

The TOW and TOI are calculated with the following formulae:

$$\begin{aligned} \text{TOW} = & \text{Zero Fuel Weight} \\ & + \text{Ramp Fuel weight} \\ & - \text{Taxi Fuel Weight} \end{aligned}$$

$$\begin{aligned} \text{TOI} = & \text{Zero Fuel Index} \\ & + \text{Ramp Fuel Index} \\ & - \text{Taxi Fuel Index} \end{aligned}$$

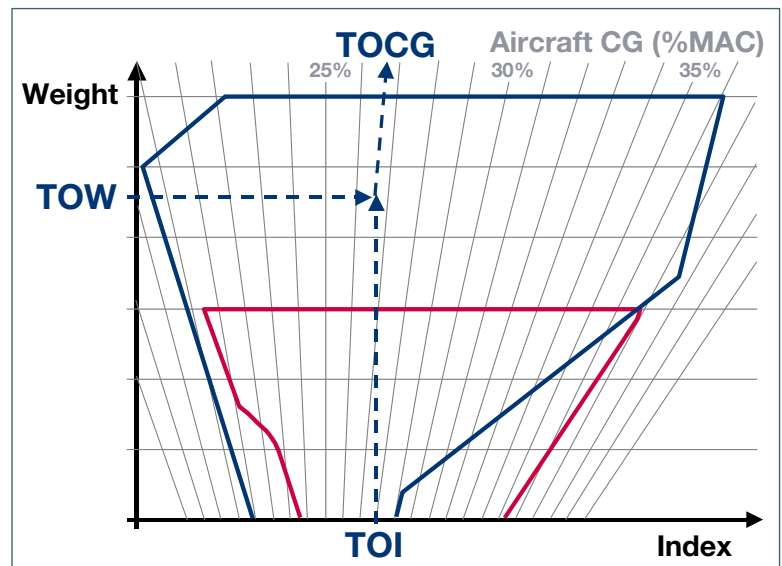
For TOW, airlines use a standard value for taxi fuel weight. This is an acceptable simplification. However for TOI, the determination of the Taxi Fuel Index is complex because it depends both on the amount and the location of the fuel consumed during taxi. Therefore airlines often prefer to use the simplified calculation method described here below.

### 2.2. Simplified TOCG calculation

(As used during the 2008 A330 event.) The TOI is calculated with the following formula:

$$\begin{aligned} \text{TOI} = & \text{Zero Fuel Index} \\ & + \text{Takeoff Fuel Index} \end{aligned}$$

Figure 1  
Determination of the TOCG



The Takeoff Fuel index is taken from the ramp fuel index table, which gives for each fuel weight the corresponding total fuel index. The table assumes a pre-determined tank refueling sequence, (fig. 2).

Fuel Weight	Index
...	...
37500	- 6
38000	0
38500	+ 5
39000	+ 10
...	...

The utilization of the ramp fuel index table to calculate the takeoff weight index is possible as long as the taxi fuel burn sequence is the reverse of the tank refueling sequence, i.e. if the taxi fuel is consumed from the last refueled tank.

If the taxi fuel is not consumed from the last refueled tank, the distance between the CG after refueling and the aircraft's CG at takeoff is:

- Negligible if the taxi fuel quantity is low or if the tank used for taxi is near the last refueled tank.
- Large if the fuel used for taxi is high and if the tank used for taxi is far from the last refueled tank.

On the A330 example mentioned in the introduction, the Ramp Fuel was 39 tons and the Taxi Fuel was 2.6 tons. In this configuration, the last refueled tank is the trim tank, and the taxi fuel is burnt from the inner tanks, as shown in fig.3.

The simplified TOCG calculation gives a TOCG at 22.2%MAC, that corresponds to a pitch trim setting of 6.4 degrees NOSE UP. The complete calculation taking into account the taxi fuel burn gives a TOCG at 26.7%MAC, that corresponds to 4.1 degree NOSE UP.

The aircraft CG moves backward during the taxi-out, whereas the simplified method considers that the CG moves forward.

The respective TOCG positions are shown in fig.4.

The cause of the rapid rate of rotation of the aircraft was the difference in pitch trim settings.

### 3. Improved simplified TOCG calculation

To avoid any large CG discrepancy, Airbus recommends an improved simplified method where the TOI is calculated with the following formula:

$$\text{TOI} = \text{Zero Fuel Index} + \text{Ramp Fuel Index}$$

The Ramp Fuel Index replaces the Takeoff Fuel Index of the original simplified calculation because, on all Airbus aircraft, the taxi fuel is burnt in the tanks located near the aircraft's CG position.

On Airbus aircraft the taxi fuel is consumed from:

- The inner/wing tanks on the A300/A310/A318/A319/A320/A321/A330/A340.
- The feed tanks on the A380.

As a consequence, the taxi fuel index can be considered to be negligible.

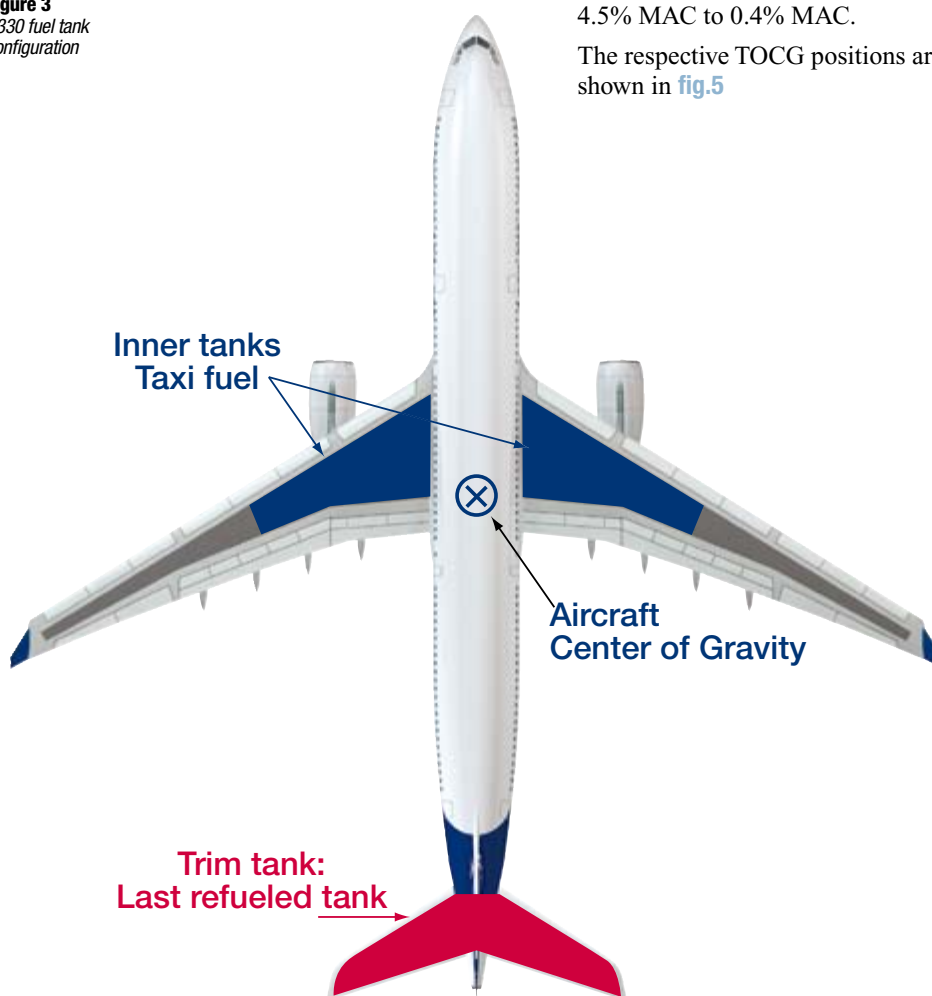
On the A330 used to illustrate our article, the calculation of the TOCG by means of the improved simplified calculation would have given a TOCG at 26,3% MAC, corresponding to a pitch trim setting of 4.3 degrees NOSE UP. This is very close to the TOCG at 26,7% MAC and the pitch trim setting of 4.1 degree NOSE UP that would have resulted from calculation using the complete calculation.

With the improved simplified TOCG calculation, the difference between the calculated TOCG and the real TOCG decreases from 4.5% MAC to 0.4% MAC.

The respective TOCG positions are shown in fig.5

Figure 2  
Excerpt from an A330  
ramp fuel index table

Figure 3  
A330 fuel tank  
configuration



## 4. Standard Operating Procedures

### 4.1. BEFORE PUSHBACK OR START procedure

(FCOM 2.03.07 on A300-600/A310, FCOM 3.03.07 on A318/A319/A320/A321/A330/A340, FCOM > Procedure > Normal Procedure > Standard Operating Procedure > Before Pushback or Start on A380).

The loadsheet check in the BEFORE PUSHBACK procedure requires the Captain to :

- ▶ Ensure that the load and trim sheet is filled properly.
- ▶ Control that the ZFW/CG data is entered in the FMS correctly.
- ▶ Verify that the TOCG is within the load and trim sheet operational limits.

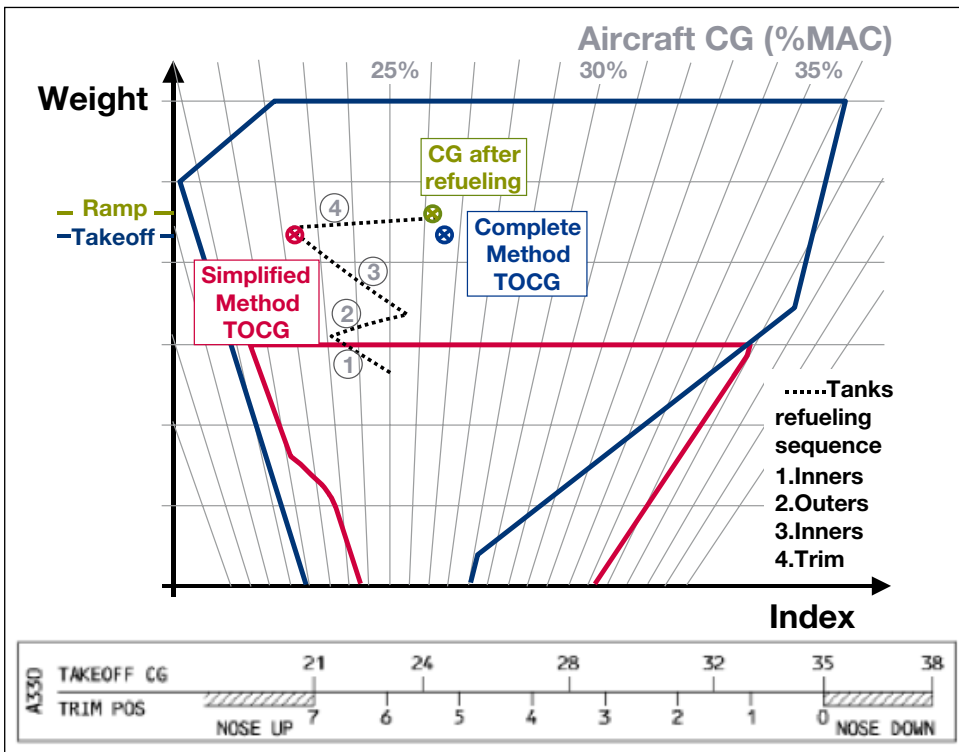
In addition, on the aircraft types where the ECAM displays the Gross Weight (GW) and CG (A300-600R/A310-300/A330/A340/A380), the loadsheet check calls for the comparison of the load and trim sheet CG against the ECAM CG.

A significant difference may be due to:

- ▶ An error in the load and trim sheet
- ▶ An erroneous ZFW/ZFWCG entry in the FMS.
- ▶ A non standard fuel distribution on board, which may be caused by an inoperative part of the fuel system.
- ▶ An erroneous TOCG on the load and trim sheet, calculated with the simplified TOCG calculation.

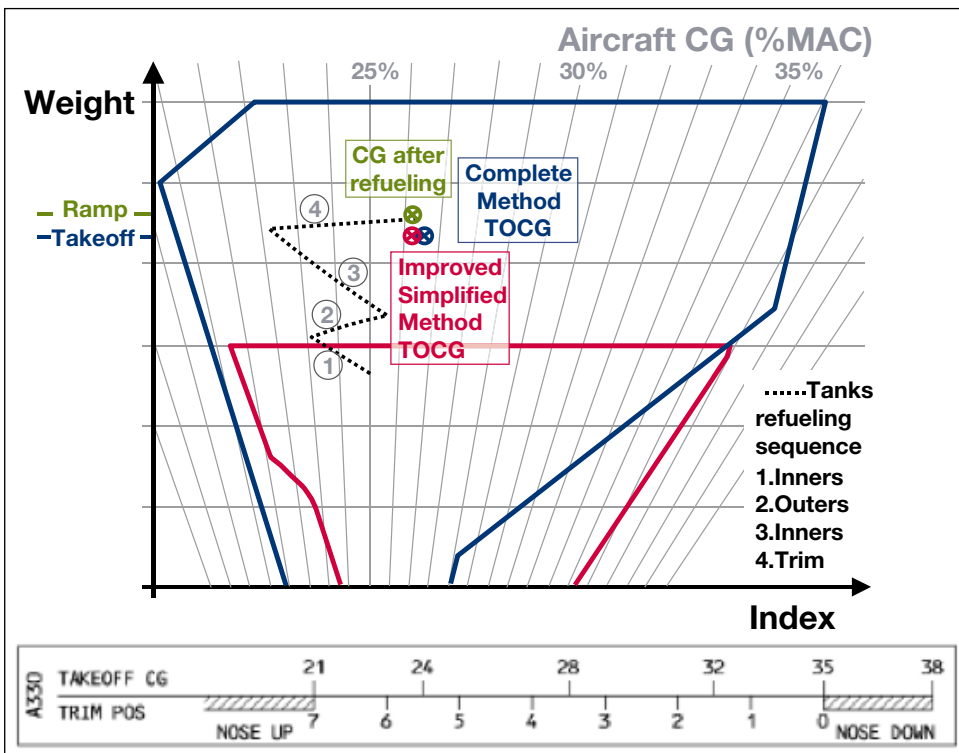
On these aircraft types, the pitch trim must be set according to the ECAM CG:

- ▶ Manually on A300-600R/A310-300/A330/A340.
- ▶ Automatically on A380, A340-500/A340-600 and A330/A340 equipped with takeoff automatic pitch trim setting.



**Figure 4**  
TOCG positions using the simplified and complete calculations

**Figure 5**  
TOCG positions using the improved simplified and complete calculations



**4.2. AFTER START procedure**

The A300-600/A310-200 procedures (FCOM 2.03.09) are as follows:

PITCH TRIM.....SET for T/O

The flight crew uses the TOCG from the load and trim sheet, which is close to the TOCG at brake release if the improved simplified TOCG calculation method is used.

The A300-600R/A310-300 procedures (FCOM 2.03.09) are as follows:

PITCH TRIM.....SET for T/O

The flight crew uses the CG displayed on the ECAM, which is close to the TOCG at brake release.

The A320 family procedures (FCOM 3.03.09) are as follows:

PITCH TRIM.....SET  
*Set takeoff CG on pitch trim wheel.*

The flight crew uses the TOCG from the load and trim sheet, which is close to the TOCG at brake release if the improved simplified TOCG calculation method is used.

The A330/A340 procedures (FCOM 3.03.09) are as follows:

PITCH TRIM.....SET  
*Set CG on pitch trim wheel. For this purpose use CG indicated on ECAM.*

The flight crew uses the CG displayed on the ECAM, which is close to the TOCG at brake release.

The A340-500/A340-600 and A330/A340 equipped with takeoff automatic pitch trim setting procedures (FCOM 3.03.09) are as follows:

PITCH TRIM..... CHECK  
*Check the takeoff CG on the pitch trim wheel using the ECAM'S CG indication.*

The flight crew checks that the pitch trim is correctly set.

The A380 procedures (FCOM>Procedure>Normal Procedure>Standard Operating Procedure>After Start) are as follows:

PITCH TRIM..... CHECK  
*Check that the pitch trim is at the takeoff target on the pitch trim position indication of the PFD.*

The flight crew checks that the pitch trim is correctly set.

**5. Conclusion**

Caution must be exercised when determining the TOCG value on the load and trim sheet through a simplified calculation method. This may lead to erroneous results, particularly on aircraft equipped with trim tanks and/or Auxiliary Center Tanks (ACT).

Airbus therefore recommends the use of either the complete or improved simplified calculation for the TOCG value. This insures that the TOCG values always remain as close as possible to the real aircraft CG at takeoff.

The AFTER START Standard Operating Procedures call for the pitch trim to be set according to:

- ▶ The CG displayed on the ECAM on the A300-600R/A310-300/A330/A340/A380.
- ▶ The calculated TOCG value on the load and trim sheet on the A300-600/A310-200/A318/A319/A320/A321.

**note**

The FCOM 2.01.40 for A318/A319/A320/A321/A330/A340 has been updated with the improved simplified TOCG calculation method in the revision released in SEPT09.

The FCOM 2.06.40 for A300-600/A310 will be updated at next revision in MAY10.

The subject was presented at the IATA Load Control and Aircraft Messaging Working Group in Geneva in SEPT09.

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