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Numerical and Analytical Takeoff Field Length Calculations for Jet Aircraft

Purpose – The greater of two distances (Balanced Field Length or Takeoff Distance +15%) results in the Takeoff Field Length (TOFL). The TOFL is a takeoff distance with safety margins according to Certification Standards for Large Aeroplanes by EASA (CS-25) and FAA (FAR Part 25). Simple analytical approximations for the TOFL are checked against more demanding numerical simulations to determine the validity of the simple solutions and to implement adjustments for them as necessary.

Methodology – The differential equation of the aircraft's acceleration is solved in MATLAB together with varying engine failure speeds. Analytical calculations of the Balanced Field Length by Torenbeek, Kundu, and Loftin are investigated. This includes the evaluation of statistical data.

Findings – Analytical approximations deviate by 0.1% to 28.2% from the numerical solution. The most accurate analytical approximation is the simple method proposed by Loftin based on statistics (Figure 1). It shows deviations of less than 5.4%. The results confirm that the TOFL for jets with four engines is determined by the Takeoff Distance +15%, while for jets with two engines, the Balanced Field Length is decisive for TOFL (Figure 2).

Research limitations – Simplifying assumptions had to be made e.g. regarding rotation time and speed, flap geometry, and asymmetric drag. While ground distances were solved numerically from acceleration and deceleration, air distance and rotation distance had to be determined analytically.

Practical implications – A reliable and tested analytical procedure is useful for quick aircraft performance estimates and to include an inverse TOFL method into aircraft preliminary sizing.

Originality – This seems to be the first report to provide a systematic check of available analytical approximations for the TOFL in comparison with a numerical solution.

This informative poster is based on a Bachelor thesis with the same title. Details here: <u>https://nbn-resolving.org/urn:nbn:de:gbv:18302-aero2022-06-15.018</u>



Figure 1: Modified analytical solution from Loftin to estimate Take-Off Field Length (TOFL).



Figure 2: Balanced Field Length (BFL) and Take-Off Distance (TOD) with All Engines Operative (AEO) factored with 1.15 to give TOD_{1.15}. Aircraft with 2 engines are sized from BFL. Aircraft with 4 engines are sized from TOD_{1.15}. This is an abstract answering the Call for Papers of the German Aerospace Conference 2025 for an informative poster at the conference.

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