Shortcomings in current modelling for modern aircraft

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Short abstract: Future Sky Safety is a Joint Research Programme (JRP) on Safety, initiated by EREA, the association of European Research Establishments in Aeronautics. The Programme contains two streams of activities: 1) coordination of the safety research programmes of the EREA institutes and 2) collaborative research projects on European safety priorities.

This deliverable is produced by the Project P3 *Solutions for Runway Excursions*. The main objective of this deliverable is to Identify shortcomings in current methods and models for analysing modern aircraft ground. Special attention is given to aircraft ground control in crosswind and on slippery runways.

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EXECUTIVE SUMMARY

Problem Area

Accident and incident data on runway excursions shows that the combination of a slippery runway and crosswind significantly increases the likelihood of a veer-off. Pilot guidance material provided by aircraft manufacturers for these operations is often based on simplified simulation models.
Past research and development efforts using instrumented test aircraft have concentrated on defining the braking problem while, because of safety constraints, the ground directional control aspect has proven to be more difficult to study using test aircraft. Instead widespread use is made of ground-based simulation to model aircraft ground directional control behaviour under crosswind conditions. Previous research has shown that the basis of a successful simulation of the ground-roll lies in the mathematical model which accurately represents the component elements and the inter-action between them. The behaviour of the aircraft on the ground is greatly influenced by the forces generated between the tyres and the runway, and the transmission of these forces through the landing gear to the airframe.
The present report identifies the shortcomings of these models and explores the areas of improvement.

Description of Work

A literature study is conducted on methods and models for analysing aircraft ground control, particularly in crosswind conditions and on slippery runways.

An overview is given of recommended operational and handling techniques, limitations and guidelines for crosswind operations provided by aircraft manufacturers. This includes the background of the maximum demonstrated crosswind values provided by manufacturers. It is explained how these values are determined, and how they are used in practice by operators.

Finally, this study investigates the methods and models that are used to evaluate crosswind operations.

Results & Conclusions

Regarding the guidance material on crosswind operations provided by aircraft manufacturers, this literature study identifies shortcomings in the interpretation of crosswind limitations. Specifically, inconsistencies are identified concerning:

- The assessment whether or not a demonstrated crosswind is limiting from a flight handling perspective;
- The definition of crosswind used to determine the maximum demonstrated value;
- Whether or not the crosswind guideline for dry runways should correspond to the maximum demonstrated crosswind; and
- The interpretation of crosswind guidelines by operators.

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Furthermore, concerns are expressed on the methods used in determining the crosswind guidelines, relating to:

- The use of piloted flight simulator evaluations; and
- The exclusion of gust and turbulence; and
- The use of standard friction values for non-dry runways

Regarding aircraft ground models used to evaluate ground handling in crosswind conditions, the following (potential) shortcomings are identified in the literature reviewed in this study:

- Over-simplified models for landing gear sub-systems;
- Lack of valid models for extreme conditions, for instance cornering friction values at large yaw angles;
- Inability to simulate local variations, for instance in runway contamination (patches);
- Neglecting the influence of certain runways characteristics like undulations, roughness, and camber;
- Lack of experimental data for the validation of ground handling models; and
- The limited bandwidth of most real-time models.

Applicability

The shortcomings identified in this study can be used as focal points in future efforts to improve methods for analysing aircraft ground control on slippery runways under crosswind so that more consistent and accurate crosswind guidance material can be developed by aircraft manufacturers.

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