UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF ENGINEERING, SCIENCE & MATHEMATICS

SCHOOL OF ENGINEERING SCIENCES

Doctor of Philosophy

A THEORETICAL AND EXPERIMENTAL APPRAISAL OF AIRWORTHINESS EVALUATION TECHNIQUES FOR SMALL LIGHT AEROPLANES

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A thorough evaluation of the airworthiness of a manned aircraft is vitally important, regardless of the size or function of the aircraft. However, the methods used in light and particularly microlight aircraft certification were largely based upon rules of thumb or methods better suited to larger, higher energy, aircraft programmes.

A programme of research has been carried out to develop means by which microlight aircraft certification could be carried out appropriately to this class of aircraft The stall and immediately post-stall behaviour of an aircraft are shown to be a function of the deceleration rate prior to the stall; therefore it is necessary to use a representative deceleration rate when determining the acceptability of stall and post-stall handling qualities. This research has found means by which the range of deceleration rates likely to be seen in a particular type can be estimated, so that flight test programmes can ensure these rates are included, and thus aircraft are confirmed to have acceptable stalling characteristics.

Weightshift controlled microlight aeroplanes, using a Rogallo type wing, rarely show a conventional (square law) relationship between stalling speed and loading; the reason being identified as aeroelastic deformation of the wing with loading. A means by which stalling speed may be estimated for such aircraft at a variety of loadings has been developed. This will allow designers the maximum flexibility in determining operating limits and shows how the stall speed at various flight conditions may be predicted in aircraft operating documentation.

The spin is a series and potentially fatal mode of flight; a spinning evaluation, even for non-aerobatic aeroplanes, is therefore essential. A best practice has been developed and tested for the spin-resistance or spinning evaluation of microlight aeroplanes, including equipment, aircraft and crew preparation, and reporting. The developed methodology is shown to be successful, using the results of certification flight test programmes, and the in-service safety record of aircraft which had been evaluated using these methods.

The tumble mode is a little known mode of departure from controlled flight experienced by weightshift controlled microlight aeroplanes. It has been a very significant factor in fatal accident records, being non-recoverable without the use of external safety devices. The mode consists of a nose-down autorotation at a rate of up to 400^{o}/s. The tumble entry mechanism is explained, and advice to operators developed which should prevent tumble entry. Evidence is shown of the nature of the developed tumble – both modelled and through wind tunnel results, which explain how the autorotation occurs. It is also shown how this theory may be applied during testing of an aircraft to develop a tumble resistant aircraft.