THE HANDLING CHARACTERISTICS OF SAILPLANES - PART 1

by Bernard Paiewonsky

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Introduction

The original conception of this paper envisioned a lecture developing in detail the techniques involved in making a stability and control analysis of a sailplane. It soon became clear that such a paper would take several weeks to present, and would really be a short course in stability and control.

It was decided instead to present a survey of the ideas involved in stability analyses, pointing out certain specific problem areas that I felt needed attention. The actual details of the calculation of an airplane's stability I will leave to the references that are available, or in preparation. However, some specific examples will be provided.

My hope is to make the sailplane designer aware that satisfying simple static stability criteria is not enough to guarantee a safe aircraft. The designer must pay close attention to many details; for example, balancing the control surface and choosing gadgets in control systems. Simple fixes are often available for aircraft having unsatisfactory characteristics, while in other cases a complete redesign is necessary.

An additional goal of this paper is the development of interest in a flight test program to determine desirable handling characteristics from a soaring pilot's viewpoint.

Longitudinal Stability and Control

The flying qualities of a sailplane are those characteristics of stability and control that affect the flight safety and form the basis of the pilot's impressions as to the ease of flying and maneuvering the craft. We can draw from past experience as well as from theoretical analysis in formulating requirements to be imposed upon aircraft. We will be concerned here with two problems. The first problem deals with the design of a sailplane so that it is *safe* to fly. This means that the pilot can make the aircraft perform maneuvers or take-off and land without fear of encountering violent oscillations or uncontrolled divergences. The second problem is concerned with making the sailplane pleasant and easy to fly. This is really the more difficult of the two tasks, since it is sometimes very hard to get pilots to agree as to what they like regarding flying qualities.

Most sailplanes exhibit two distinct longitudinal modes of response with the stick fixed. If a sailplane is disturbed slightly from equilibrium, for example by a gust, and the controls are locked so that they cannot move, there will be a very rapid adjustment of the angle of attack and a resultant normal acceleration. This is felt as a high frequency heavily damped oscillation. This behavior is referred to as the short period mode. The pilot would observe this response principally as a normal acceleration. The other mode of longitudinal motion is a long period lightly damped oscillation that appears mainly as speed and altitude variations. This is called the Phugoid mode.

In many works on stability the phugoid receives scant attention because in many cases there seems to be very little correlation between the phugoid damping and the pilot's opinion of the aircraft's handling qualities. This may be reasonable for some aircraft; however, for sailplanes the phugoid may influence the flying qualities appreciably. The phugoid damping can be shown to vary inversely as the L/D and the frequency is proportional to C_L.

> **ABOUT THE AUTHOR**
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Thus, the cleaner the aircraft the less the damping, and the phugoid is usually worse at high C_L's. Sailplanes have high L/D's and so the phugoid may be expected to be lightly damped or unstable. This instability may cause the aircraft to seem difficult to trim with respect to speed.

Let us look at a sailplane in a steady glide. The sailplane is said to be trimmed, stick fixed, when there is no net force on the aircraft and there is no net pitching moment. Thus the aerodynamic forces balance the gravitational forces as shown in figure 1 and the pitching moment about some reference point, for example the c.g., is zero. The sailplane is said to be trimmed stick free if the stick force is also zero. The total aircraft pitching moment is adjusted by means of the elevator. The stick force is adjusted by means of tabs, springs or movable stabilizers. The adjustable pitching moment provided by the tail is used to control the aircraft angle of attack and thus controls the speed or the load factor. Abrupt control deflections rapidly produce normal accelerations at nearly constant air speed. The air speed

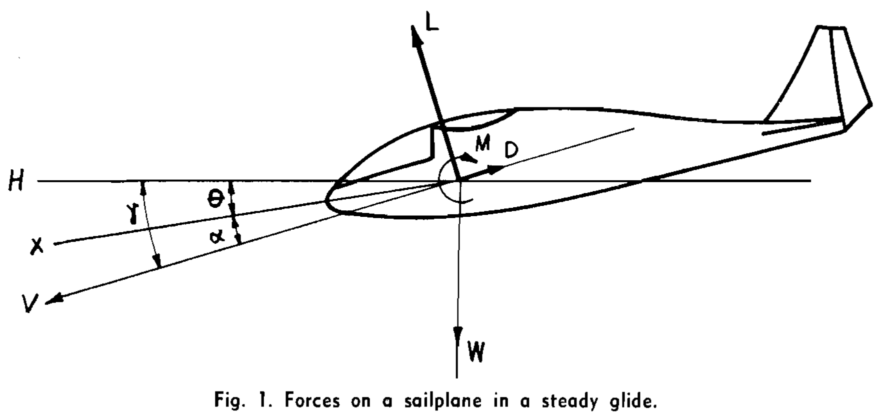

Fig. 1. Forces on a sailplane in a steady glide.