INTRODUCTION

During the past several years there has been a growing realization that development programs for tailoring flight control systems to operational aircraft are not producing the optimum flight control systems. This condition exists largely because of the greater extremes of conditions through which the aircraft are operating. These varying conditions cause changes in the aircraft characteristics which require changes in the control system parameters if the response of the aircraft-control systems combination is to remain a constant. At present the required changes in the control system are made in a predetermined fashion based upon instantaneous air data measurements. Thus, there is no guarantee of true relationship between these changes in parameters and the aircraft stability.

Changing the control parameters in this manner is often referred to as an open-loop adjustment accomplished by a process of omphaloskepsis. Several important points about these open loop adjustments should be emphasized. First, accurate and detailed information about the aircraft characteristics is required for the entire flight regime. Second, the capability must exist for measuring air data for all flight conditions. Third, the calculation of the required adjustments is a long process and must be confirmed by flight test data, and fourth, subsequent changes in airplane configuration often require more autopilot testing and adjustment.

Because of the above mentioned factors, the Air Research and Development Command (ARDC) initiated a program to determine methods of adjusting automatic flight control systems in a closed-loop fashion requiring no air data measurements, using some sort of aircraft stability criteria. This program reached a point where it was felt that in the best interests of the Air Force the information now known should be presented to industry to encourage applications. Therefore, a symposium was held with the immediate objectives of:

(1) Acquainting Industry with the progress thus far realized in adaptive systems.

(2) Exchanging technical information between all who have done work or have ideas in this field.

(3) Stimulating the thinking of military and industrial personnel with work in fields in which adaptive controls are applicable.

This report is a composite of the papers presented. Because of the speakers' time limitations, they were permitted to publish a more comprehensive paper in these transactions than that which was presented. However, in most cases the paper herein is very similar to the oral presentation.

Throughout the symposium, there was considerable confusion regarding the definition of an adaptive, self adaptive, or self optimizing system. Speakers used the three terms interchangeably and presented conflicting views regarding them. It is felt that the confusion could be best cleared up by recourse to semantics. All too often, engineers working in a new field assign a unique meaning to a stock English word for technical purposes. This practice leads to much confusion when others try to understand the new field.

In the present case, consultation of the Webster Dictionary reveals that the term adaptive means " tending to or showing adaption" . Adaption, in turn, is defined as " adjustment to environmental conditions" . Thus, an adaptive system would be one which has the capability of adjusting in some manner to changing environmental conditions.

The key to this definition lies in the requirement for adjustment. Thus, if a system's parameters are not adjusted or changed in some manner the system is not adaptive. Under this definition present flight control systems with an air data programmed gain change would be adaptive.

" Webster" defines the prefix self as " the agent that of itself acts in a manner implied by the word with which it is joined" . Thus, a system that changed its own parameters to adapt to a changing environment would be a self-adaptive system.

An optimalizing or optimizing system would be one which operates at the best or most favorable condition. A self-optimizing system should be one which adjusts its own parameters to achieve an optimum condition and could be considered as a particular self-adaptive system.

As Dr. Aseltine points out later in this volume, there is a three-step process consisting of measurement, evaluation, and then adjustment required for adaption. In order for a system to be self-adaptive, it must perform these three steps itself.

A self-adaptive system will be defined as one which has the capability of changing its parameters through an internal process of measurement, evaluation, and adjustment to adapt to a changing environment, either external or internal to the vehicle under control.

If the above definitions are accepted, then, for example, a conventional linear system with fixed feedback values cannot be considered self-adaptive or adaptive, even though it may provide satisfactory response over a wide range of operating conditions. However, a system designed by the use of non-linear techniques will be an adaptive system but not a self-adaptive system because no parameter is changed when the environment changes.

The author would like to express his appreciation to Mr. M. F. Marx, General Electric Company, who stimulated this definition through remarks made at a discussion following the symposium.

The open forum discussions are included in their entirety based upon a transcript taken by the symposium recorder.

The speakers' introductions and other comments dealing with the operation of the symposium have been omitted for the sake of brevity.