

**AIR RESEARCH AND DEVELOPMENT COMMAND
PLANS AND PROGRAMS**

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With such a distinguished group as this, it might seem inconsequential to try to establish the problem of why we are here, and what we are doing. However, certainly there are a few people here who are not familiar with self adaptive controls. Most of you know that with the advent a few years ago of hypersonic and supersonic aircraft, the Air Force was faced with a control problem. This problem was two-fold; one, it was taking a great deal of time to develop a flight control system; and two, the systems in existence were not capable of fulfilling future Air Force requirements. These systems lacked the ability to control the aircraft satisfactorily under all operating conditions. Because of the non-linear aerodynamic link between the control surfaces and the stability of the aircraft, the flight control systems had the capability of working only where we could predict they would be operating. Obviously, if we always know what this link is we can program it into our control system and work with it, but if we don't know what it is or if our control system undergoes unexpected changes during flight then we experience control difficulties.

Approximately three years ago, the Air Force became interested in removing the effects of this non-linear link from the flight control system by the use of self adaptive techniques. I will not at this time attempt to describe to you our past programs. That is largely the purpose of this symposium. I will, however, mention two programs that are being initiated. A contract has been signed with Lear, Incorporated to mechanize and flight test a version of the MIT system which will be presented here this morning. This will be a three-axis system installed in an F-101A and will be flight tested sometime this summer. This system includes control stick steering, G-limiting, and an angle of attack warning system. Another contract will be signed soon for the installation of a three-axis self adaptive system in an X-15 test vehicle. Flight test should start during the summer of 1961.

The Air Force approach to the problem of self adaptive controls has been to try to determine techniques that would work, to prove the feasibility of these techniques through simulation and study, and then flight test systems designed by these techniques to achieve a degree of confidence in them. We have many plans for the future of our systems. I think there is one general statement that we can make about most of our systems and that is, they work, but why do they work? In the future we intend to try to establish the basic fundamentals of why our systems work and how we can analyze them better.

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We intend to try to categorize our techniques, break them down into different philosophies and different methods of solution. We also intend to continue with our flight test program. We have several techniques that have not been flight tested and we have other techniques under development. Several of our present techniques that are approaching operational capability have been developed from existing flight control systems. There are undoubtedly a great many other ways by which present systems could be modified so that they would have a self adaptive capability; however, the Air Force feels that more would be gained by using the basic fundamental physics of the problem to develop new self adaptive control systems. Our future plans reflect this thinking. We intend to devote more of our program to the development of the basic fundamentals.

We intend to try to apply our present techniques in new ways. We have several "in the house" efforts working on control problems that are of interest to the Air Force. Our policy regarding these "in the house" efforts is that we will attempt to establish the basic fundamentals regarding the problem and to define the problem in such a manner that a procurement can be written. Then other commercial research groups are contacted to do most of the work and finish the problem. We do not attempt to find a complete solution through the "house" efforts. Some of the areas in which we have been working are aeroelasticity, its effects on self adaptive control systems, the integration of aerodynamic and reaction controls, with the implication of space vehicle re-entry and exit; the possibility of the re-entry of a vehicle maintaining constant temperature at some point, a truly universal autopilot, and several other imaginary or visionary concepts.

Along with Wright Air Development Center, another Air Force group that has been working on self adaptive controls is the Air Force Office of Scientific Research. They have sponsored several projects, one of which is being done by the University of California, Los Angeles and will be reported on later. UCLA has been doing basic research regarding self adaptive control systems theory. AFOSR has a contract with Stanford, where Mrs. Flugge-Lotz is conducting an extension of her previous work. She is studying means of reducing non-linear transients in switching contacts. Rennseler Polytechnic Institute is studying the non-linear effects of on-off control devices in the presence of viscous damping. Bell Aircraft has a program underway to study the effects of structural damping on flutter. Westinghouse is studying the control requirements imposed by orbital transfer under perturbations experienced in space flight.

The purpose of the Air Force Office of Scientific Research is to establish the basic fundamentals regarding origins or sources of non-linear effects in self adaptive flight control systems, determine the parametric relationships regarding these non-linear effects, and develop procedures or techniques which will solve these relationships.

It should perhaps be emphasized at this point that there is no conflict between the Office of Scientific Research and the WADC effort. They are starting from basic fundamentals and working toward a development aspect. We started on the development end because of the necessity of proving that these systems would work and we are now working to establish basic theories.

Another related area in which we hope to sponsor some work is component development. As you will note from the following papers, most of our systems have a gain changing device. Presently this is done mechanically or electro-mechanically. We would like to see this replaced by a solid state gain changing device. This should increase both the reliability and the rate of adjustment. We would also like to see more work being done on special action devices such as hot gas servos and pulse-modulated servos. Another area in which we feel significant improvement could be made is in the design of devices to measure higher order derivatives such as acceleration and perhaps jerk.

With the aid of our contractors, and with the aid of a number of people from industry, Wright Air Development Center has been attempting to monitor the "state of the art" of self adaptive control systems. This has been very successful to date, due to the cooperation of this group. However, the program has expanded to the point now where there are people working on self adaptive ideas who have not been in touch with us. So I would like at this time to make an appeal to those of you who are working in this area to let us know what you are doing when you make any significant advances. This information will, of course, be treated as you desire. Most of the organizations with which we have been in contact do not regard any of their developments as proprietary in nature; however, if you feel that your development is proprietary we will regard it as such. If we are in contact with your organization, we will then be able to say that someone is working in this area, and we can refer interested parties to you. This procedure has the obvious advantage of rapid dissemination of information to avoid duplication of results and speed the application of new ideas.

I would like to make one other point in closing. We in ARDC feel that the self adaptive control system is here to stay. It is the future means of control for Air Force vehicles. As General Davis has mentioned, we have a whole field of application to missiles yet to investigate. We would like to apply these techniques to missile control. There are other areas where we know they will be helpful. We would like to impress upon you, during these two days, the abilities of self adaptive control systems. We think we have established some operating techniques and now we are hopeful that you will apply them. Thank you.