Projecting Guidance and Control Technology to 2000

ABOUT the time most of you receive this issue of the *Journal of Guidance, Control, and Dynamics,* a workshop will be in progress at the University of Texas aimed at identifying advances in aircraft technology which could be achieved by the year 2000 if programmatic and funding considerations were not an issue. As I write this in early November, I am returning from a preliminary session dedicated to the guidance, control and navigation subset of such technology. Since most contributors and readers of this journal are concerned with advances in the state of our art, I'll excerpt some of the conclusions from this meeting.

Aircraft design has always been an integrated process, with various disciplines involved, all affecting the others. Advances in the state of the art of controls and dynamics will play an increasingly important part of this integrated process. Many of the performance increases projected for a next-generation aircraft will result from such advances. Some of the projected capabilities are remarkable in the context of today's existing aircraft. That observation is the good news. The bad news is that systems and components which have already become very complex are likely to become dramatically more so by the year 2000. To cope with this we all must keep firmly in mind that the development, deployment and support of our complex control systems is already expensive. Total cost of ownership must always be a primary design thought and goal. Simple, sound, good engineering practices have always been the solution to our most successful systems. Nothing will change this, something to remember as our systems get more and more complex.

We can expect significant advances in three broad areas by the end of the century: aircraft performance, information integration, and integration of the aircraft with its mission environment. The notion of unusually dramatic improvement of aircraft performance is familiar to almost everyone in our field. Relaxing the design constraints classically introduced for reasons of stability, aeroelastic integrity, handling qualities, etc., will enable the other aircraft disciplines, both individually and collectively, to provide efficiency and performance never before possible. Aircraft which are significantly unstable or nonlinear in all or part of their flight envelopes could become both practical and safe. To accomplish this, however, will require understanding of the interrelationships of control power, flying qualities, and aeroelastic, aerodynamic and propulsion modeling far beyond our current capability. It will also require an ability to organize and understand such complex issues which are currently beyond our reach. The full exploitation of very high speed integrated circuit technology and the improvements which can be expected in that area (under the same ground rules) will permit the integration of information on a scale orders of magnitude beyond our current day accomplishments. Advances in both Von Neumann and alternative computer architectures, if properly managed, should enable capabilities in both the civil and military arena which are only dreams today. Integration of external information which would in turn be combined with on-board data could make an awareness of the combat situation and real-time on-board tactical planning far more effective than current technology and practice will permit. Similar improvement in the integration of air traffic services could be made available in the civil sector. Finally, the partitions between various aircraft disciplines such as aerodynamics, structures, guidance, etc., will evaporate. The aircraft will truly be designed as an integrated vehicle and the operation of such aircraft will also be highly integrated. All of these advances will be very dependent upon the role and imagination of dynamics and control engineers. Hopefully we are capable of the challenge.

Samples of the technology items which could be goals for the year 2000 are the following:

1) Software will become an increasingly significant part of the cost of systems. In order to address both cost and complexity issues, we will need software generation schemes which eliminate the need for tedious manual verification. Systems could be configured for verification and validation and could be more readily understood by designers either directly or with computer assistance.

2) We should be able to accomplish full integration of aircraft propulsion, aerodynamic, structural, guidance, navigation, and mission systems in a totally fault-tolerant fashion. These will be exceptionally complex systems to design, comprehend, and operate. The design methods associated with the development of these systems will have to mature considerably. Perhaps a major breakthrough is needed. One such breakthrough could be the development of a restructurable controls theory. This would enable the design of a truly fault-tolerant and adaptive control system without the necessity of anticipating all failure configurations.

3) We will need a powerful set of computer-aided design tools for preliminary and detailed design and simulation of these complex systems. We should have methods for tactics management in both the civil and military sector which greatly simplify the problem presented to the human operator, and facilities for verification and validation of these systems will be of such power that understanding, managing, and financing the systems will be tractable problems.

4) These complex systems should be designable with full understanding of the role and allocation between the human and automated system. Such systems will probably run the gamut from reasonably manual approaches such as today's through, at the other end of the spectrum, completely autonomous systems. An understanding of human error patterns and their implications in system design will have to be obtained. Clearly such achievement will require major breakthroughs in the area of human factors and the integration of such factors with automated systems.

The above is a sample of the thoughts that surfaced after two days of discussions in this general area. The rule of the study, unlimited programmatic and resource limitations, of course, is totally unrealistic. I'll be surprised, however, if by the year 2000, some of the above doesn't become practical. It's difficult not to have this attitude, given our technological accomplishments looking back for the same period of time. In that period of time, we have landed on the Moon, developed and deployed the Space Shuttle and made commonplace automatic landing in almost any weather for enormous aircraft such as the one which is in the process of returning me from the West Coast to the East Coast in only a matter of hours. Many of us own computers for our personal use which have more capacity than the machine which landed the Apollo astronauts on the Moon. Why shouldn't we be optimistic?

Before closing, I'd like to remind all of our authors that the revenue required to operate and publish this journal comes from three sources: subscriptions, member dues, and page charges. We depend upon page charges to cover approximately 30% of our expenses. Page charges are allowable under Government contracts. Without them, we could not continue publication at anywhere near the current subscription rates. We'd appreciate your help in assuring that your companies do cover the page charges on your papers.

Finally, I'd like to express my appreciation and that of the Associate Editor team to the list of people that follows—our reviewers. Without them this whole archival journal system would not be possible. We realize the task is not simple and we appreciate your efforts on our behalf.

Donald C. Fraser
Editor-in-Chief