Summary: GROUP 5, PILOT-IN-THE-LOOP CRITERIA DEVELOPMENT

Session Moderator: Frank L. George, AFFDL

In this session, an effort was made to focus discussion on the following three issues:

1) the role of pilot-vehicle analysis in relation to design, criteria and specification requirements;
2) the type, and role, of closed loop criteria appropriate for flying qualities;
3) viable approaches to the Mil Prime Standard philosophy of performance oriented requirements.

Discussion and interchange occurred on a number of points related to the above topics. Only a summary can be presented here even though all the discussion was considered worthwhile and contributed to the consensus reached on the three discussion topics.

The Role of Pilot-Vehicle Analysis

It was readily agreed that pilot-vehicle analysis methods are useful tools in preliminary design and analysis studies. This application includes evaluation of proposed configurations, or competing designs, against established criteria. However, most people were reluctant to commit themselves to rely on pilot-in-the-loop analysis as an analytical means for formally demonstrating compliance with specification requirements. It follows from this also that it is generally not desirable to state criteria in terms of pilot-vehicle analysis parameters (for example, pilot model parameters or performance measures).

The topic of high-order nonlinear aircraft systems was discussed as highly appropriate for application of pilot-in-the-loop methods. One difficulty with such systems is that responses may differ significantly with pilot activity, resulting in flying quality "surprises". Also, several small items may combine to rapidly create an overall bad effect reflected in the pilot's performance or evaluation. Because the characteristics of such systems are input-dependent, it is essential to include the pilot's characteristics for complete analyses.

Closed Loop Criteria for Flying Qualities

The first point discussed under this topic involved developing a common understanding of the meaning of the term "closed loop criteria." It was generally agreed that, for flying qualities, closed loop criteria and pilot-in-the-loop criteria are synonymous. In other words, closed loop flying qualities criteria must address the combination of the pilot and the airplane dynamics as a coupled system. From this perspective, three different ways of quantifying criteria were suggested.

One approach would be to state criteria in terms of desirable, or acceptable, closed loop task performance measures. This approach addresses most directly the end product's capability to complete a mission or task. However, it was pointed out that it is common to experience poor correlation between task performance and the pilot's subjective flying qualities evaluation.

An alternative approach would be to specify closed loop, or pilot-in-the-loop, dynamic characteristics that would assure reasonable task performance. While this approach has much the same weakness as the method above, there are techniques for relating the

pilot's dynamic requirements to his evaluation and standard analysis methods would permit adjusting the airplane characteristics to achieve the best combination.

The second alternative discussed leads directly to a third - defining acceptable pilot dynamic characteristics for achieving desired closed loop dynamics or performance. This approach also suffers from the problem of correlating the pilot's dynamic characteristics with his subjective evaluation. An additional problem, at least for the present, is the limited range of tasks for which pilot dynamics can be reliably defined, or measured.

Thus, the general consensus from the first two topics discussed was that closed loop analysis and closed loop criteria are viable for design purposes but not for military specification requirements. It was recommended that the approach of specifying aircraft dynamics necessary to achieve acceptable task performance be continued. [Ed. note: It is not felt this conclusion was intended to preclude the use of closed loop analysis methods in the development and validation of requirements, however.]

Mil Prime Standard and Performance Oriented Requirements

In view of the consensus on the first two topics, it seemed essential to discuss the philosophy of performance oriented requirements proposed for the new Mil Prime Standard on flying qualities. According to that philosophy, the government standard should describe what the product is supposed to do, and give the supplier responsibility for providing a product with the necessary capabilities. It was pointed out that this philosophy is, in general, consistent with the attitudes of System Program Office management personnel. However, this philosophy becomes more difficult to interpret and apply when considering an item such as flying qualities which is not

like a piece of equipment. One suggested way of considering the difference is to consider the need for defining an acceptable level of quality of performing a task, in addition to the quantitative performance characteristics. In other words, we must continue to consider in some way the Levels of flying qualities as done in the present specification. However, a definitive approach to accomplish this goal was not defined.

Much of the discussion involved peoples' impressions of what the specification (or standard) is supposed to do. In general, it was concluded there are two important aspects of the specification that must be retained. First, it describes the desirable characteristics in general. Second, it provides ways to measure closeness to desired characteristics. These two aspects of the requirements must be in consonance. In other words, satisfying the individual measures of flying qualities should insure meeting the overall goal. In addition to separating good and bad airplanes, the specification should provide for some margin of safety to prevent any surprises in the handling characteristics. This latter objective becomes much more difficult to achieve when considering complex nonlinear aircraft systems.

The general conclusion regarding closed loop task performance requirements in the Mil Prime Standard was that they are undesirable. The principal reason for this attitude was the feeling that such requirements would result in too many side constraints. For example, the test and evaluation method, environment and possibly even the pilot skill level would have to be clearly defined in order to evaluate an airplane against such requirements. Many of these factors are both difficult to define quantitatively and practically impossible to measure and control. Hence, it appears a major area for research is the definition and development of flying quality metrics that reliably correlate closed loop task performance to airplane

system dynamic parameters which can be measured, and controlled in some sense, during design and development.

Attendees at Pilot-in-the-Loop Criteria Working Session

This working session was well-attended by a cross-section of government and industry representatives. Everyone participated and contributed positively to the discussions. Therefore, within the limits of the moderator's memory and note taking capability, the conclusions summarized above are felt to represent the feelings of the entire group. A list of the attendees and their affiliations is given below to give the reader a feel for the backgrounds and viewpoints represented in the group.

Name	Affiliation
Ed Aiken	Army Aeromechanics Lab
Ron Anderson	AF Flight Dynamics Lab (FGC)
Dan Cichy	Rockwell International/Columbus
Bob Fortenbaugh	Vought Corp.
Frank George	Flight Dynamics Lab (FGC)
John Hodgkinson	McDonnell Aircraft Co.
Roger Hoh	Systems Technology, Inc.
William Levison	Bolt, Beranek & Newman
Jerry Lockenour	Northrop Corp.
Walt McNeill	NASA/Ames Research Center
William Pearson	6570 AMRL/HEB
Bruce Powers	NASA/Dryden Flight Research Center
Dave Quam	Univ. of Dayton
Bill Rickard	Douglas Aircraft Co.
Grady Saunders	ARO, Inc.
John M. Schuler	Boeing Co.
Paul Shipley	Rockwell International (Space Shuttle)
Rogers Smith	Calspan Corp.
Hansel Stegall	NASA/Johnson Space Center
Wayne Thor	ASD/YXEF (A-10 SPO)
Frank Wilson	Lockheed-Georgia