Subject: Display and Control Recommendations Made During the Gemini-Apollo Guidance and Navigation System Comparison Study - Case 110

Date: May 21, 1963

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MEMORANDUM FOR FILE

During the period from April 22 to May 8, P. R. Knaff and I were engaged in the collection, collation, and analysis of information relating to the control and display portions of the Gemini and Apollo Guidance and Navigation Sub-Systems. This study resulted in a series of evaluative statements and recommendations presented in the briefing to J. F. Shea and J. A. Gautraud on May 9. The evaluations and recommendations were:

General Statements

1. All the C and N displays and controls surveyed appear capable of performing their required function in the specific vehicle of which they are a part.

Supporting Comments:

Human Factors concepts have, in the area of Control and Display Design, penetrated to the hardware design groups. All of the displays and controls planned for Gemini and Apollo appeared to be able to carry out required functions for a particular vehicle. However, the design of a workable man-machine interface permits a number of solutions of almost equal merit, and, with few exceptions, the designers of Gemini, Apollo-CM, and LEM have settled upon different display-control configurations to accomplish essentially similar tasks in each vehicle. As it stands, three different control and display philosophies are proposed.

2. Commonality in controls and displays is essential to ensure astronaut reliability. Similar spacecraft functions must be accomplished by similar astronaut actions on all vehicles.

Supporting Comments:

If astronauts are expected to become proficient in handling more than one type of spacecraft or, are expected to transition from one craft to another, it is essential that controls and displays in all vehicles operate in the same manner. The entire personnel training literature stresses that the probability of erroneous action is greatly increased

if alternate and conflicting ways of accomplishing a given function are permitted, (i.e., do the faucets in the men's room turn on in a clockwise or a counter clockwise direction? Are you sure?) Although this point seems obvious, little attention has been paid to commonality in the design of the control and display equipment aboard the three vehicles. We feel that the most significant human factors contribution to this study is to stress the importance of employing common modes of astronaut action for similar vehicle control tasks.

Specific Recommendations

1. A three axis attitude display with flight director needles capable of showing rate or attitude error information in a fly-to configuration should be used in all vehicles. (Gemini type)

Supporting Comments

Both the Gemini and Apollo attitude indicators have three axis display balls deriving attitude information primarily from the IMU. The ball rotates around the polar axis for yaw indication, the horizontal axis for pitch indication, and the longitudinal axis for roll indication. The LEM display has a two axis ball showing roll and yaw and indicates pitch on a vertical tape. The Apollo-CM display as proposed by Minneapolis-Honeywell shows attitude change error on fly-to needles but rate of attitude change magnitude (fly-from) on separate needles situated around the periphery of the ball. The Lear instrument, as planned for Gemini, has a single set of director needles which can display either the rate or attitude error or a combination signal of rate plus attitude error, at the astronaut's option. Generally, when flying in a manual mode, the astronauts prefer to control the vehicle using rate information on the director needles since the astronauts have considerable experience flying this type of presentation on conventional flight director instruments. (In the "fly-to" configuration, moving the control stick toward the needle tends to null out the error. In the "fly-from" format, moving the control stick away from the needle corrects the error.) From the point of flying ease and astronaut preference, the Gemini display has a more desirable configuration. Since this instrument meets the attitude display requirements for all vehicles, we suggest that the configuration embodied in the Gemini concept be standardized across the three spacecraft.

2. The three axis ball on the attitude display should have horizontal pitch lines. (MIT configuration)

Supporting Comments:

Regardless of the attitude indicator chosen, we recommend that the three axis ball have horizontal pitch markings rather than vertical longitude lines. This configuration has already been adopted in the Apollo Program and would have been adopted several months ago in the Gemini Program if sufficient funds could have been made available to implement the change. Such a configuration would also be desirable on the LEM. Since most of the people concerned with the various spacecraft programs favor this type of presentation, adoption of a standard set of ball markings should meet little resistance.

3. A vertical type, palm pivot attitude control stick should be used in all vehicles.

Supporting Comments:

Each of the three vehicles has proposed a different type of manual attitude control. Gemini proposes a vertical pivoting type control stick, Apollo a horizontal displacement type control stick, and LEM a vertical pencil type joy-stick. In an unprecedented move, the astronauts have gone on record as agreeing upon a Gemini type stick for use in all vehicles. The stick suggested by the astronauts pivots around a point in the palm in a longitudinal plane to control pitch, in a transverse plane to control roll, and rotates about the center line of the control stick to control yaw. This control is similar to that flown in the X-15 and currently being used on Gemini. While there is no experimental data to prove the superiority of one control over another, the astronauts feel quite strongly about this particular control device, and we concur with their recommendation.

4. A vertically mounted translation control stick should be used, motion of the stick along any axis moving the vehicle in that direction.

Supporting Comments:

The configuration of the translation control stick is held to be of relatively little importance since it is used predominantly under conditions of zero gravity; however, we feel that the motions of the stick required to produce vehicle translation in a particular direction should be the same in all spacecraft. In general, we prefer a vertically mounted Apollo type translation control stick. Motion of the control handle in the desired direction produces vehicle motion in that direction.

5. A circular type radar range and range rate indicator (Gemini type) should be used in all vehicles.

Supporting Comments:

The Gemini radar range and range rate indicator consists of a circular dial with three needles. The outer needle indicates radar range to the target, the middle needle indicates closing rate, and the inner needle serves as a vernier indicator for closing rates under 5 feet per second. The scales are so configured that if the range rate needle is kept aligned with the range needle or held at a lesser range rate quantity, the vehicle can successfully complete a rendezvous with a target at the prescribed range. As the range decreases, the astronaut decreases the closing velocity proportionately until at zero range he possesses zero velocity. This display presents a clever solution to the problem of presenting range and closing rate data. With suitable modification of scales and pointers, the same display could be used for all vehicles.

6. Effort should be given towards standardizing the configuration of all displays and controls which serve the same function, e.g., computer input panel, delta velocity indicators, fuel management displays, and reentry displays.

Supporting Comments:

The functions commented upon in previous recommendations were identical for all vehicles. The present recommendation covers those control and display devices which, although similar in function, are not identical for the three vehicles. We have suggested that whenever similarities occur, they be emphasized. If possible, operations should be made functionally the same in all vehicles. This is particularly true in the case of such devices as computer key boards, for even if computer capabilities and functions are different in each vehicle, data entry and readout should be made the same.

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