AN OVERVIEW OF THE DEMONSTRATION ADVANCED AVIONICS SYSTEM GUEST PILOT EVALUATION CONDUCTED AT AMES RESEARCH CENTER

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ABSTRACT

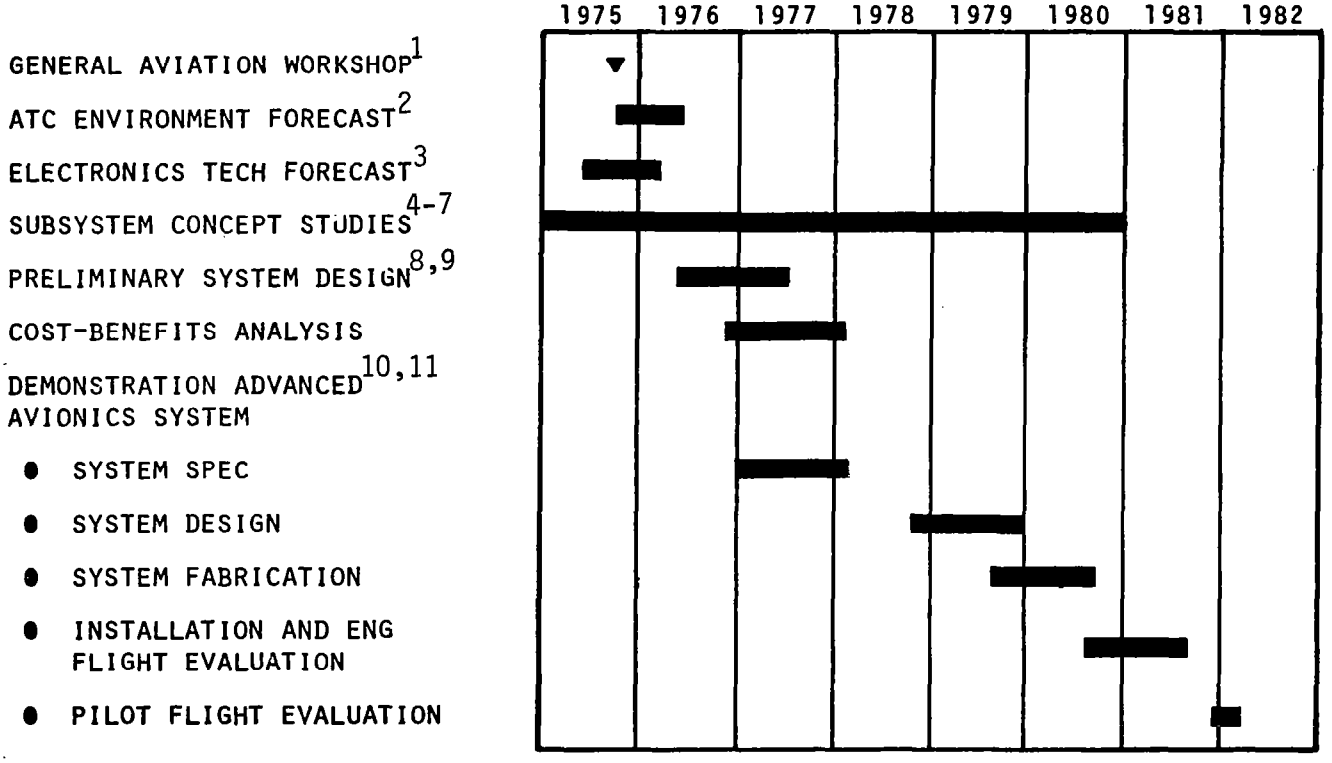
The Ames Research Center has recently completed a program which led to the development and flight evaluation in a Cessna 402 of a fully integrated, microprocessor based, digital avionics system referred to as DAAS. The program was initiated in 1975 in anticipation of an increasing dependence by general aviation on avionics and the supposition that the corresponding increase in their cost and complexity could potentially be offset by the introduction of fully integrated systems. The program objective was to provide information required for the design of reliable integrated avionics that would enhance the utility and safety of general aviation at a cost commensurate with the general aviation market.

DAAS integrates most general aviation present and projected avionic requirements into a single system. It includes the basic flight control and navigation functions as well as more novel capabilities such as flight planning; computerized performance and weight and balance functions; stored checklists; engine and aircraft configuration monitoring and warning capabilities; built-in test; and a simulation mode for pilot training. The DAAS system utilizes a distributed microprocessor architecture with shared electronic displays, and a complete set of navigation and aircraft sensors. All processing, display, and sensor resources are interconnected by a standard bus to enhance overall system effectiveness, modularity, reliability, and maintainability.

This paper describes the guest pilot flight evaluation of the DAAS. The results are based on the fifty-nine questionnaires that were completed by the participants.

PROGRAM OVERVIEW

The major elements of the General Aviation Advanced Avionics Systems Technology Program are contained in the program overview chart. The program was initiated in 1975 and completed in April 1982. Reports resulting from each of these elements are listed in the references. The program culminated in the design and flight test of the Demonstration Advanced Avionics System (DAAS). In this presentation, the results of the pilot flight evaluation are summarized.



PILOT FLIGHT EVALUATION

The primary purpose of the pilot evaluation was to expose the Demonstration Advanced Avionics System to the various segments of the general aviation community and solicit comments in order to determine the effectiveness of integrated avionics for general aviation. The figure lists the segments of the community that were represented in the evaluation. A total of sixty-four (64) flights were conducted in which one hundred and seventeen (117) pilots and observers participated.

GUEST PILOT EVALUATION PARTICIPANTS

- AIRFRAME COMPANIES
- AVIONICS COMPANIES
- FIXED BASE OPERATORS
- UNIVERSITIES
- MAGAZINE EDITORS
- GOVERNMENT ORGANIZATIONS (NASA-FAA-DOD)

64 EVALUATION FLIGHTS

117 PILOTS AND OBSERVERS

FLIGHT EVALUATION AGENDA

A typical flight evaluation included a review of the DAAS that lasted two to three hours, an hour-long simulation in the DAAS aircraft exercising the DAAS functions and reviewing the flight scenario, a 75-minute flight, and a debriefing usually lasting about one hour. At the conclusion of the debriefing the subject was given a questionnaire that was to be completed at a later time and returned. The results presented in this paper are from the fifty-nine questionnaires that were returned.

- REVIEW OF THE DAAS FUNCTION ≈ 2 HOURS
- GROUND DEMONSTRATION/SIMULATION 1 HOUR
- EVALUATION FLIGHT 1 HOUR 15 MINUTES
- POST FLIGHT DEBRIEFING ≈ 1 HOUR
- QUESTIONNAIRE

FLIGHT SCENARIO

The flights originated at Moffett Field which is at the south end of the San Francisco Bay and proceeded to Salinas which is located in the Salinas Valley about 12 miles from Monterey Bay. The standard instrument departure was followed leaving Moffett Field, and except for take-off and landing the DAAS provided all of the steering commands for the entire flight.

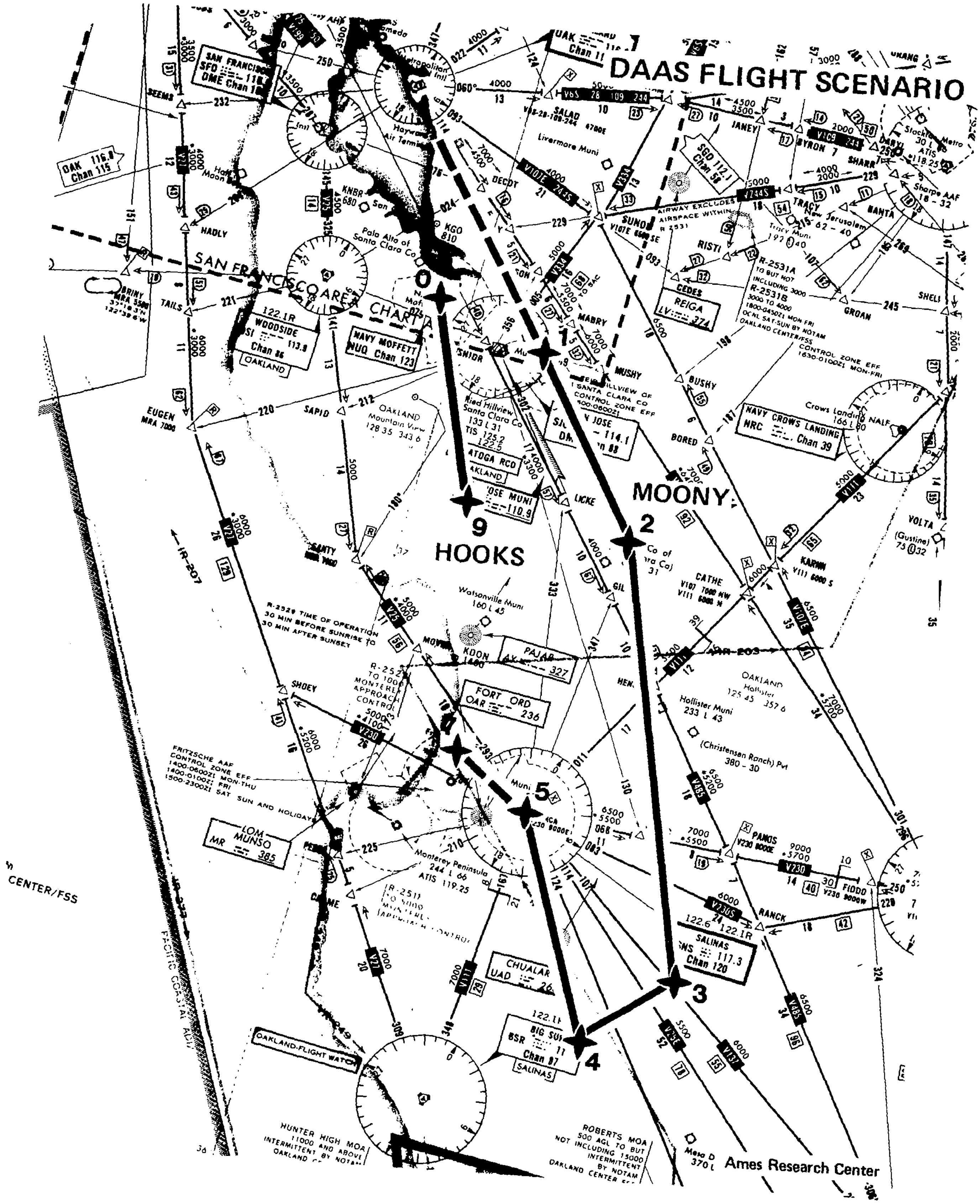
The waypoints were defined at key intersections enroute to Salinas and back to Moffett. Waypoints 6 and 8 are not labeled on the map. Waypoint 6 (WP6) is the Salinas ILS which is marked on the map by the Salinas VOR which was stored as WP5. WP8 was left blank in the flight plan so that the waypoint generate feature of the map edit page could be exercised. The long leg between WP2 and WP3 allowed the pilot ample time to exercise the flight planning and performance functions. The leg between WP3 and WP4 was used to set up the intercept to the Salinas ILS in order to demonstrate the EHSI display in the ILS mode as well as the autopilot/flight director performance during the missed approach at Salinas.

After the missed approach and before reaching the missed approach point, WP7, two additional map edit features were demonstrated. The first was the "waypoint present position" which moved WP7 under the aircraft, and the second was the "waypoint generate" feature which inserted WP8 between waypoints 7 and 9.

Once WP8 was defined, the map cursor feature was used to move it to the left several miles to avoid a simulated storm cell that could be shown on the EHSI had a radar system been included as part of the DAAS.

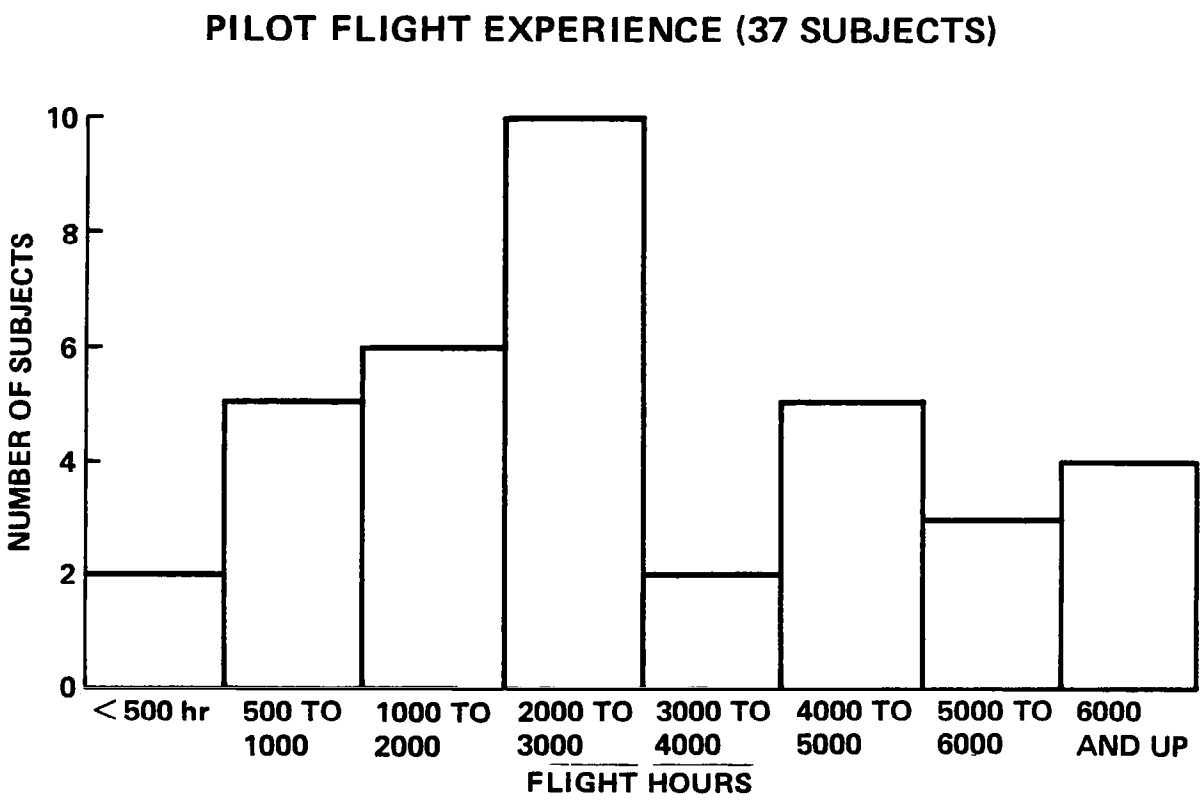
At WP9 the vertical navigation feature of the autopilot was demonstrated by making a coupled VNAV approach into Moffett. After landing and before system shutdown, the DAAS reconfiguration feature was demonstrated.

The DAAS flight scenario was designed to demonstrate most of the key flight functions. Those functions not used in flight, such as the Built-In Test function, or the Discrete Address Beacon System (DABS or Mode S), were demonstrated using the simulation function.


DAAS FLIGHT SCENARIO
0
1
2
3
4
5
9
HOOKS
MOONY
Ames Research Center

PILOT FLIGHT EXPERIENCE

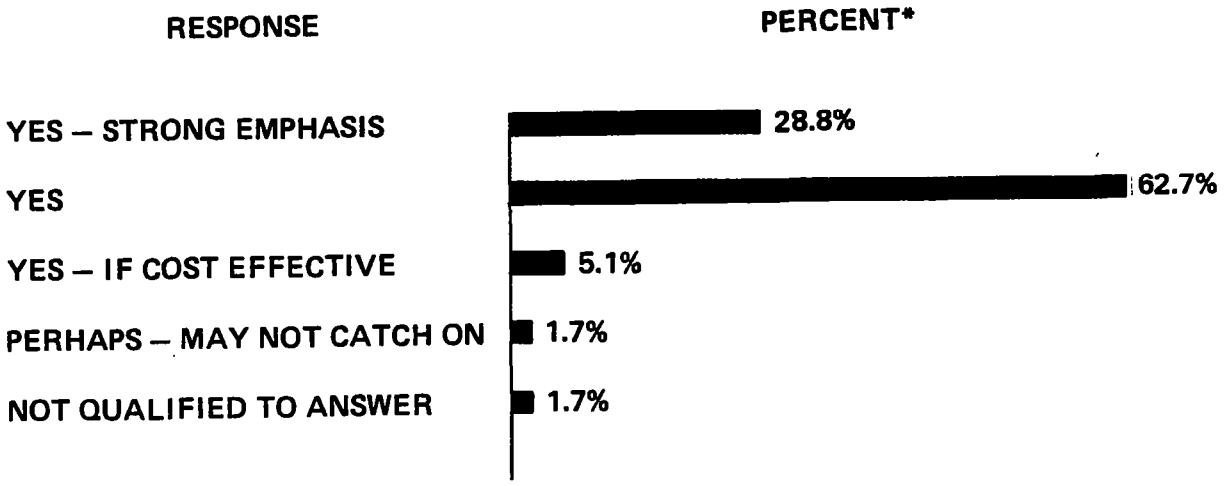
The experience levels of the pilots who participated in the test are summarized below. Of the 37 respondents who listed their experience, 28 had more than 50 hours of instrument experience.



QUESTIONNAIRE RESPONSE

QUESTION 1: DO YOU FEEL THE DAAS CONCEPT REPRESENTS THE DIRECTION THAT FUTURE GUIDANCE, NAVIGATION AND FLIGHT MANAGEMENT SYSTEMS WILL EVOLVE?

The responses to the question are ordered with the highest level of agreement at the top decending to the lowest level with (in this case) one subject (1.7%) at the bottom who felt unqualified to answer. The responses given in the left column summarize the questionnaire responses of the 59 subjects. The results indicate that nearly everyone thought that the DAAS concept or something similar is the direction of future general aviation systems. Three subjects were concerned with the cost effectiveness.

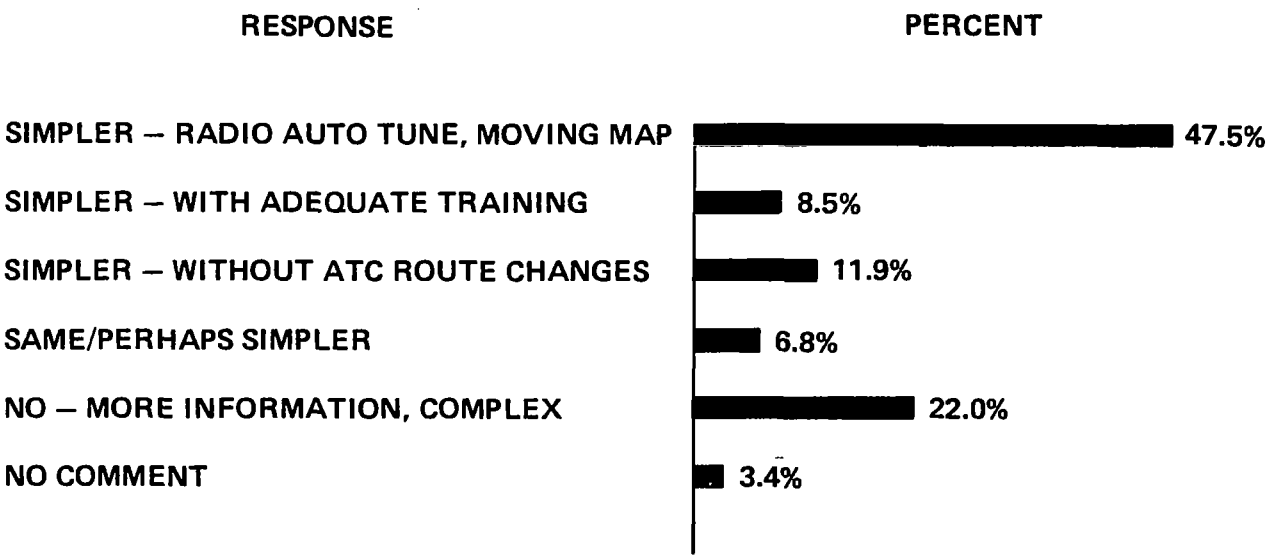


*RESULTS FROM 59 QUESTIONNAIRES

QUESTIONNAIRE RESPONSE

QUESTION 2: DO YOU FEEL THAT WITH ADEQUATE TRAINING THE DAAS SYSTEM WOULD BE SIMPLER OR LESS COMPLEX TO USE THAN THE CONVENTIONAL SUITE OF AVIONICS FOR IFR FLIGHT?

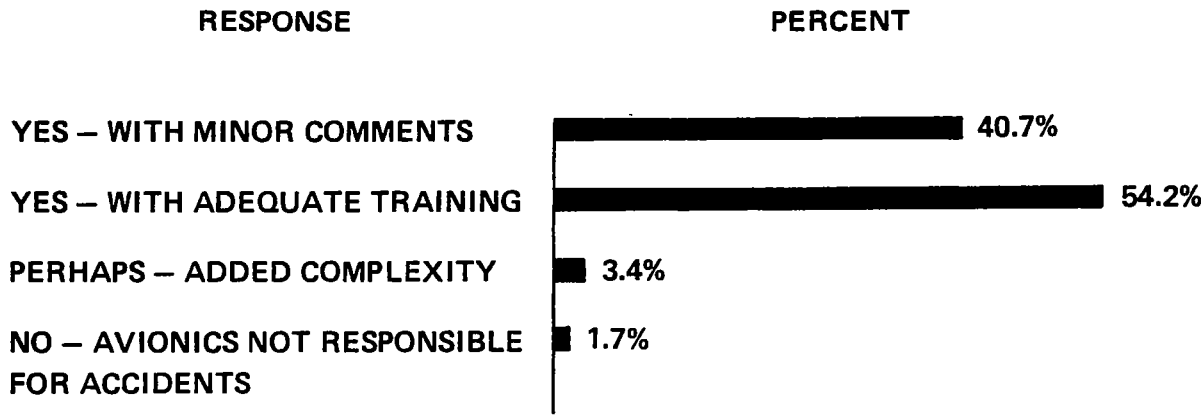
Nearly half the subjects responded with "simpler" or "simpler with some particular feature such as radio auto tune or the map display being primarily responsible". These subjects were followed by about 9% who had concerns about training level. Twelve percent thought the system would be simpler as long as there were no ATC route changes. Over 20% felt that it would be less simple or more complex because of the greater amount of information and modes available to the pilot.



QUESTIONNAIRE RESPONSE

QUESTION 3: DO YOU FEEL THE FUNCTIONAL CAPABILITY PROVIDED BY DAAS COULD ENHANCE SAFETY?

About 40% of the subjects responded "yes" because of certain features such as the map, the weight and balance function, the check-lists, the performance and flight status functions, or the built-in test function. Over 50% thought adequate training was a prerequisite. Two subjects (3.4%) were neutral, feeling that the added complexity might override the other system advantages. One subject felt that avionic systems were not responsible for most accidents and therefore would have a minimal impact on safety.

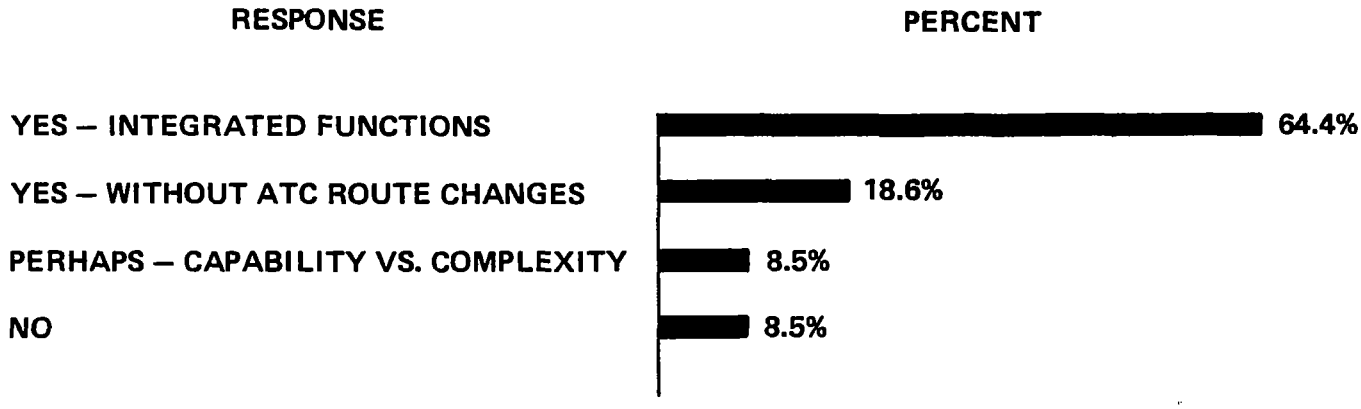


QUESTIONNAIRE RESPONSE

QUESTION 4: DO YOU FEEL THAT THE FUNCTIONAL CAPABILITY PROVIDED BY DAAS WOULD REDUCE PILOT WORKLOAD IN HIGH DENSITY IFR CONDITIONS?

About 65% of the subjects responded "yes" and indicated the feature that in their opinion reduced the workload. Typical were the map, the flight status and the flight warning functions. About 19% responded "yes" provided there were no ATC route changes. Five subjects (8.5%) felt the added capability might be offset by the increased complexity, and another 5 subjects responded "no" either because the configuration was cumbersome or because the existing avionics have been optimized for the present ATC system.

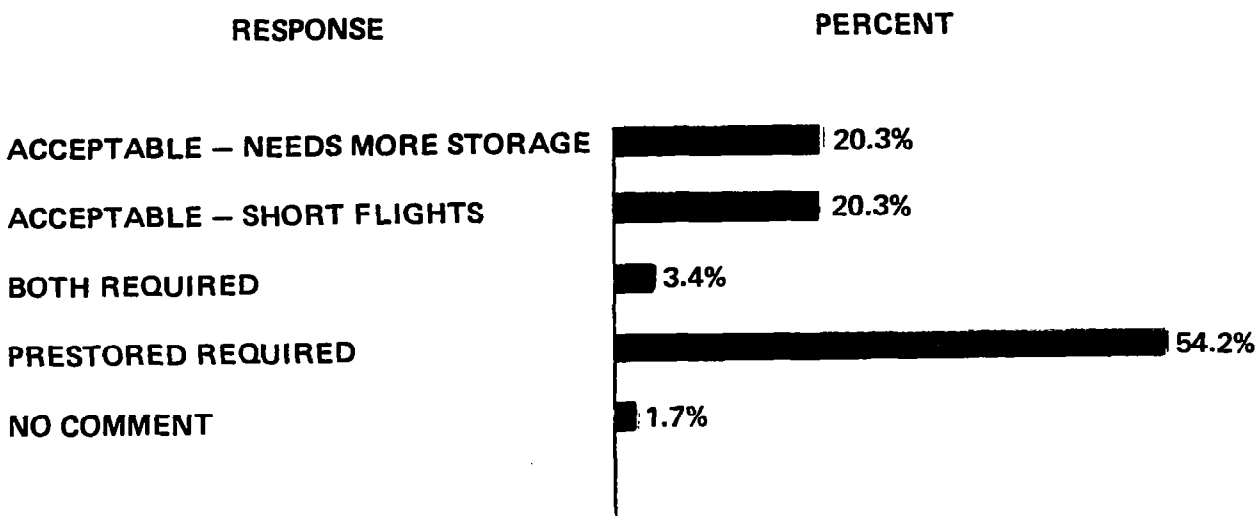
One function that was not mentioned in the questionnaire was the Discrete Address Beacon System (DABS) function. There was almost universal agreement that a data link system will significantly reduce pilot workload especially when used in conjunction with an integrated system such as DAAS. During the debriefings several subjects suggested that the DABS data link could provide the capability to transfer an ATC clearance directly from the DABS receiver into the navigation/flight planning function.



QUESTIONNAIRE RESPONSE

QUESTION 5: DO YOU FEEL THAT MANUAL ENTRY OF THE NAV-AID DATA IS ACCEPTABLE OR IS A PRESTORED DATA BASE REQUIRED?

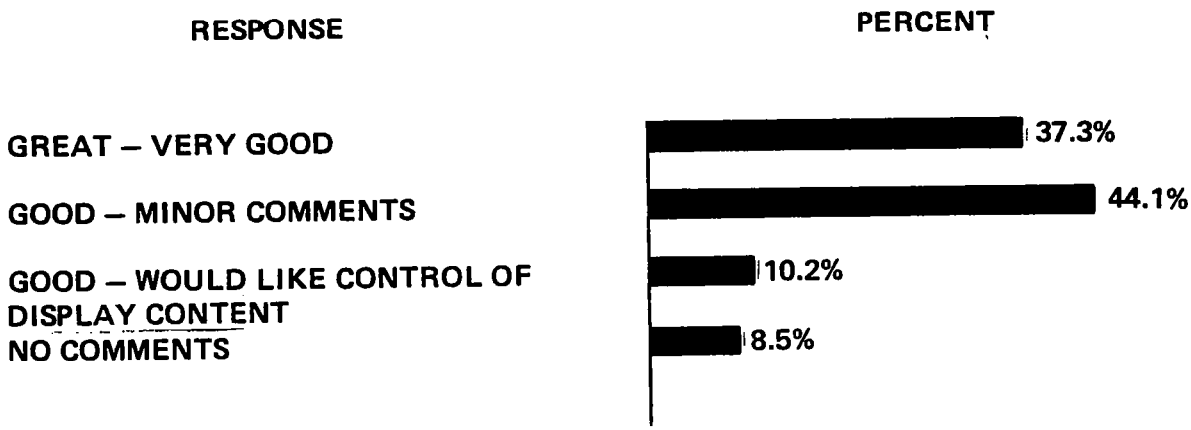
Nearly 40% of the responses indicated it was "acceptable", but preferred that the system have more NAV-AID and WP storage capability. About 55% (32 subjects) felt that an automated entry of NAV-AID data through a tape or disk would be preferred.



QUESTIONNAIRE RESPONSE

QUESTION 6a: WHAT COMMENTS DO YOU HAVE REGARDING THE HORIZONTAL SITUATION INDICATOR, EHSI?

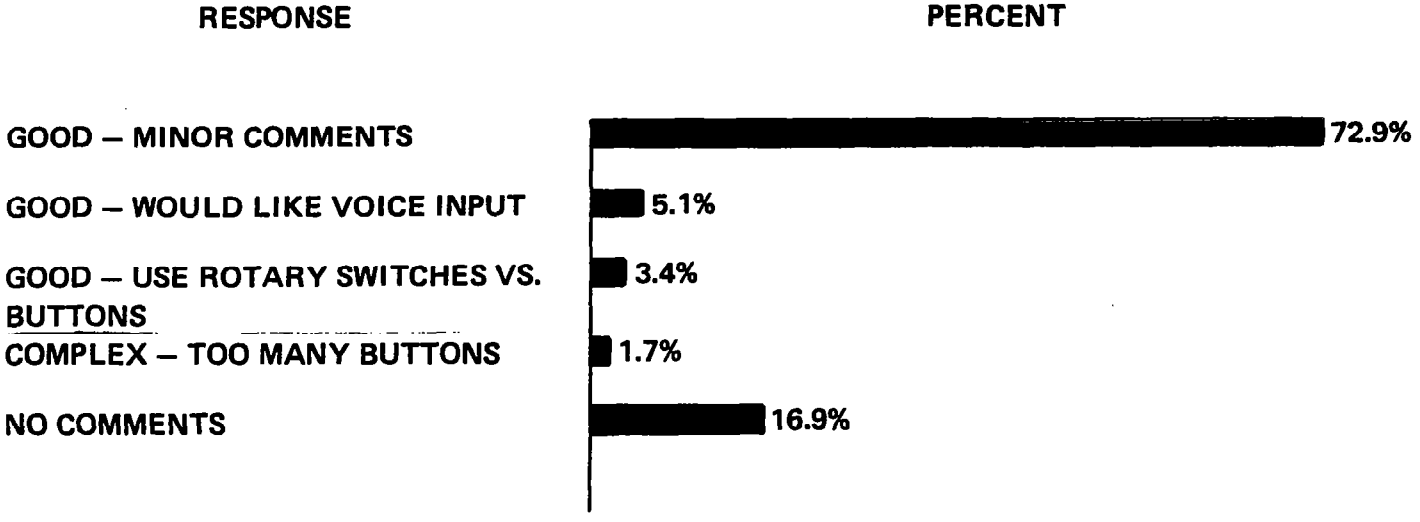
Nearly 40% gave it an unqualified "great or very good" while 44% (26 subjects) felt it was good but needed improvements such as color, better ILS presentation, different map scales, etc. Ten percent would like to control the display format with, for example, a declutter mode. Five subjects (8.5%) made no comments.



QUESTIONNAIRE RESPONSE

QUESTION 6b: WHAT COMMENTS DO YOU HAVE REGARDING THE INTEGRATED DATA CONTROL CENTER, IDCC?

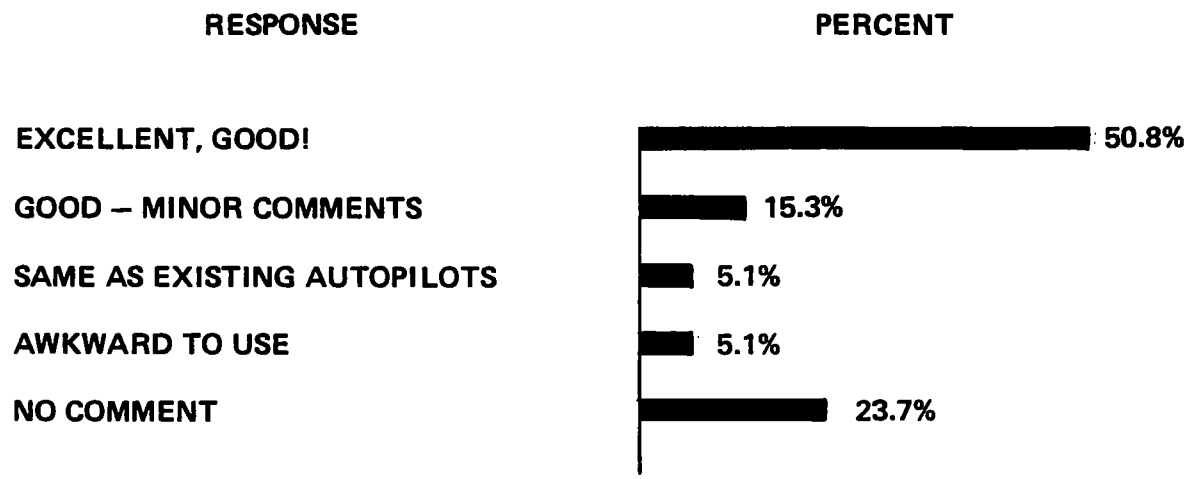
The first response group, 73%, felt it was good but needed some improvements. Some of the comments included: "needs better tactile feel on buttons", "color might help", "reduce parallax", etc. Three subjects (5.1%) suggested voice input while two subjects (3.1%) felt rotary switches would be better than push buttons. One subject felt there were far too many buttons while 10 subjects (16.9%) made no comments.



QUESTIONNAIRE RESPONSE

QUESTION 6c: WHAT COMMENTS DO YOU HAVE REGARDING THE AUTOPILOT FUNCTIONS?

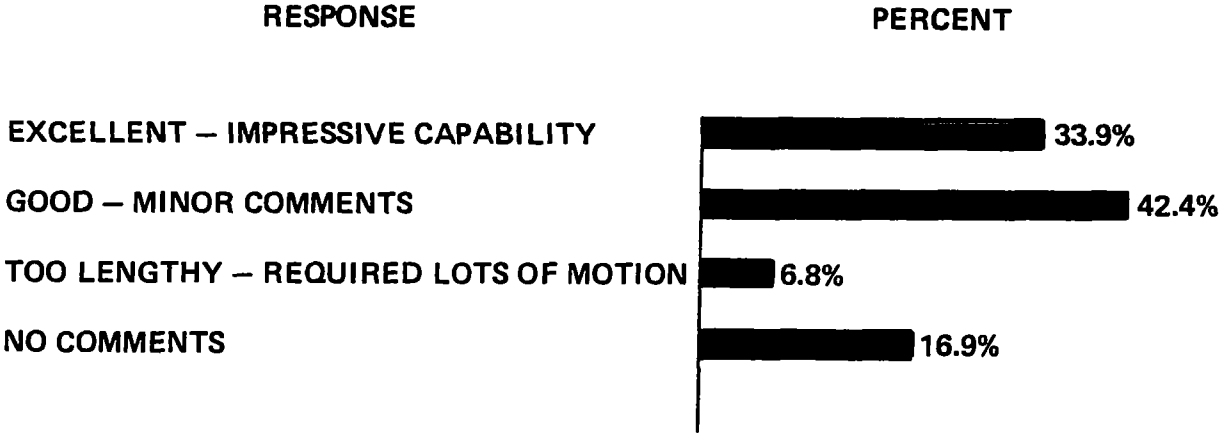
The first two response groups, nearly 66%, felt it was "Excellent" or "Good", listing some minor comment. Three subjects (5.1%) felt it was similar to existing autopilots, and another three subjects felt it was awkward to use principally because the mode enunciation was remote from the mode select keys. Fourteen subjects (24%) made no comments.



QUESTIONNAIRE RESPONSE

QUESTION 6d: WHAT COMMENTS DO YOU HAVE REGARDING THE NAVIGATION/FLIGHT PLANNING FUNCTION?

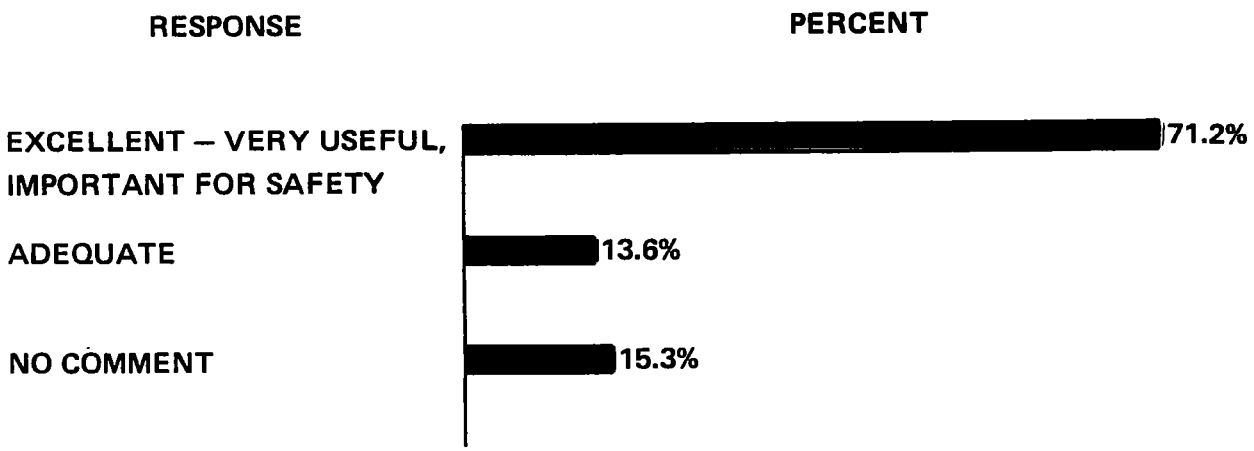
The first response group, nearly 34%, felt that it was "Excellent" and gave the pilot an impressive capability. The second group, nearly 42%, felt it was good but suggested changes such as a dedicated altitude preselect display, an automatic data base, etc. Four subjects (6.8%) felt the function was too lengthy or required excessive motion. Ten subjects (16.9%) made no comments.



QUESTIONNAIRE RESPONSE

QUESTION 6e: WHAT COMMENTS DO YOU HAVE REGARDING THE WEIGHT AND BALANCE FUNCTION?

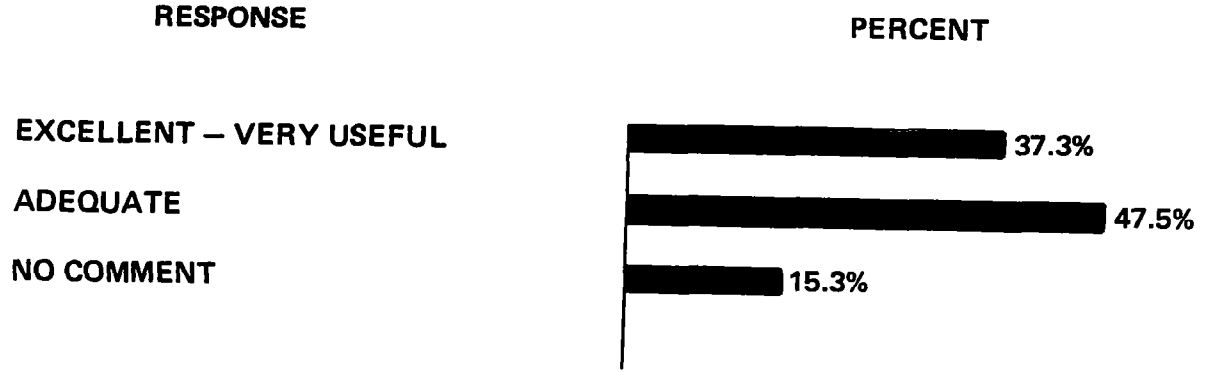
Everyone who responded felt positive about this function. Nine subjects (15.3%) made no comment.



QUESTIONNAIRE RESPONSE

QUESTION 6f: WHAT COMMENTS DO YOU HAVE REGARDING THE PERFORMANCE FUNCTIONS?

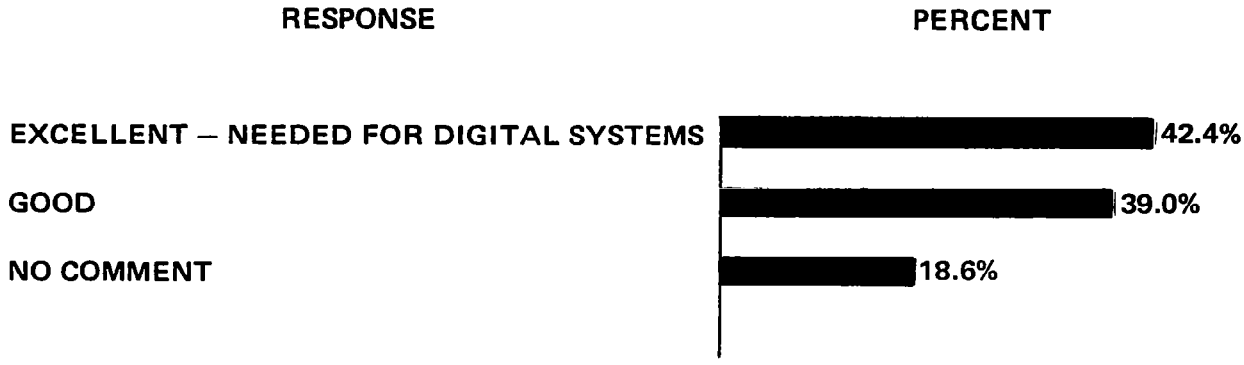
Nearly 40% responded with an "excellent" and commented that it was "very useful". About 48% felt that the function was "adequate" or a "nice" feature. Nine subjects (15.3%) made no comments.



QUESTIONNAIRE RESPONSE

QUESTION 6g: WHAT COMMENTS DO YOU HAVE REGARDING THE BUILT-IN TEST (BIT) FUNCTION?

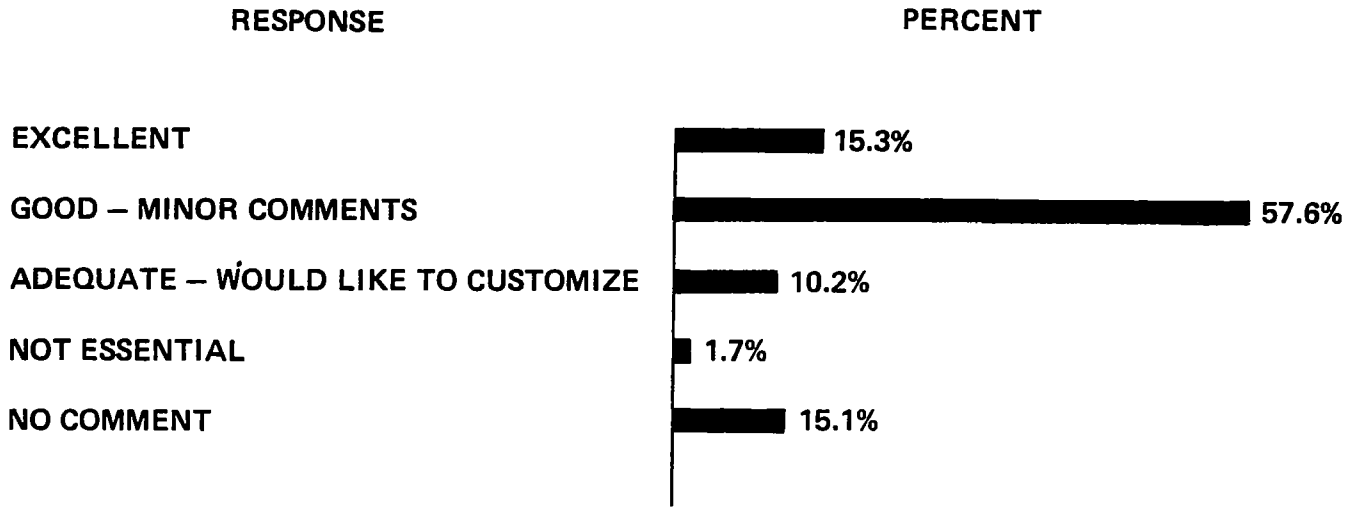
Over 40% responded with an "Excellent" and indicated that BIT was needed in a digital system. Nearly 40% felt that it was "Good", "Complete", or "OK". Eleven subjects made no comment.



QUESTIONNAIRE RESPONSE

QUESTION 6h: WHAT COMMENTS DO YOU HAVE REGARDING THE CHECK-LIST FUNCTION?

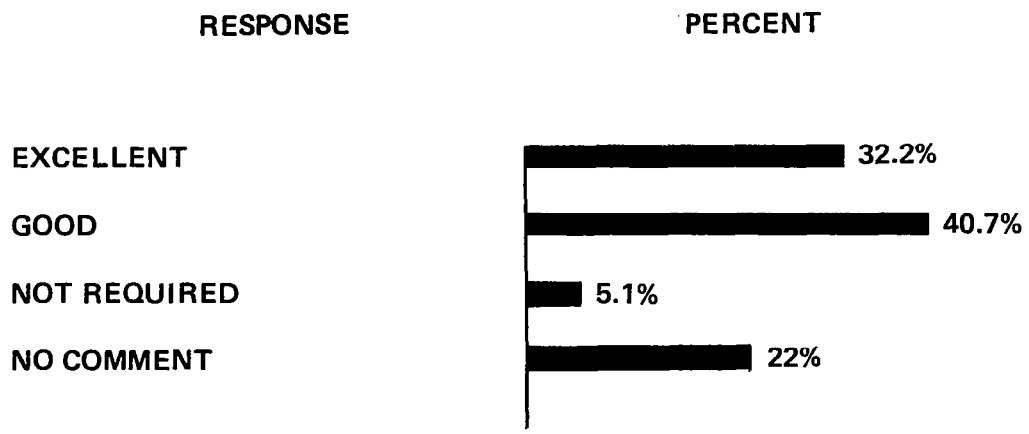
The first three response groups, nearly 50%, responded positively. Six subjects, about 10%, would like to customize the check-list, and one subject (1.7%) felt check-lists were not essential. Nine subjects (15.1%) made no comment.



QUESTIONNAIRE RESPONSE

QUESTION 6i: WHAT COMMENTS DO YOU HAVE REGARDING THE GROUND SIMULATION FUNCTION?

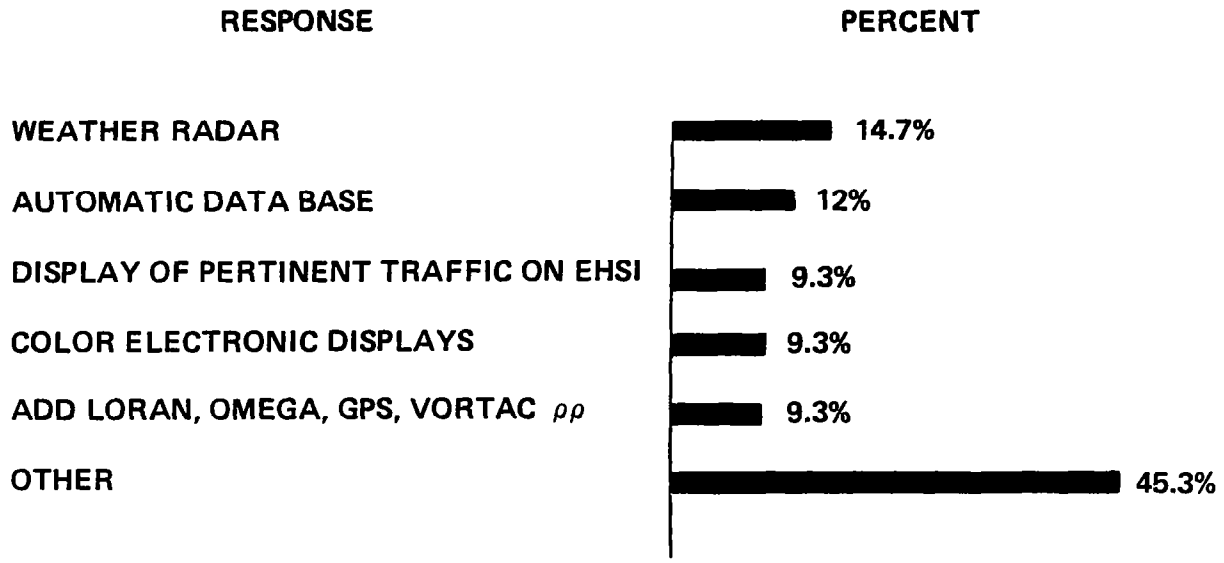
Nearly 73% responded with either "Excellent" or "Good". Some felt that this function should be part of a product system and others felt it could satisfy currency requirements for IFR flight and be cost effective. Three subjects (5.1%) felt the function was not required and 13 subjects (22%) made no comment.



QUESTIONNAIRE RESPONSE

QUESTION 7: DO YOU FEEL THERE ARE ANY OTHER CAPABILITIES THAT SHOULD BE INCLUDE IN A DAAS TYPE SYSTEM TO IMPROVE THE OVERALL SYSTEM EFFECTIVENESS?

In 59 questionnaires there were seventy-five responses with 27 different ideas. The 5 most common suggestions are summarized below. The most popular response (15%) felt the addition of weather radar on the EHSI was most desirable, while 12% felt that the automatic data base would improve system effectiveness. The next three response groups each had 4 subjects (9.3%) and felt that the display of pertinent traffic on the EHSI, color electronic displays, or the addition navigational receivers for LORAN, OMEGA, GPS or VORTAC, would improve system effectiveness. Of the remaining 45% of the suggestions, no one function was mentioned by more than three subjects.



PILOT EVALUATION CONCLUSIONS

The Demonstration Advanced Avionics System Program objectives were accomplished. Most of the responses from the questionnaire indicated that future systems will resemble the DAAS. The DAAS architecture and functions were adequate to demonstrate the benefits of integration. The integrated functions could reduce pilot workload and enhance safety. The elements or functions the respondents felt most useful were: (1) the electronic map, EHSI, (2) the autopilot, (3) the Navigation/Flight Planning Function, (4) the Weight and Balance Function, (5) the Built In Test (BIT) Function and (6) the Discrete Address Beacon System (Mode S Transponder).

The questionnaire responses indicated that the functional capability provided in the DAAS was adequate to demonstrate the program objectives and that the implementation was satisfactory for nearly all of the functions. It was felt that additional human engineering in the mechanical design would be required in a production system.

DAAS OBJECTIVES ACCOMPLISHED

- RESPONDENTS FELT FUTURE SYSTEMS WILL RESEMBLE DAAS
- DAAS ARCHITECTURE AND FUNCTIONS WERE ADEQUATE TO DEMONSTRATE THE BENEFITS OF INTEGRATION
- DAAS INTEGRATED FUNCTIONS COULD REDUCE PILOT WORKLOAD AND ENHANCE SAFETY
  - ELECTRONIC MAP, EHSI
  - AUTO PILOT
  - NAVIGATION/FLIGHT PLANNING FUNCTION
  - WEIGHT AND BALANCE FUNCTION
  - BUILT-IN TEST FUNCTION, BIT
  - DISCRETE ADDRESS BEACON SYSTEM, (MODE S) FUNCTION

RECOMMENDATIONS

It was felt that the exposure each subject had with the DAAS was too short to adequately assess the training requirements, pilot workload, and the reconfiguration concept of the DAAS. It is recommended that an operational evaluation of the DAAS be made to assess: (1) the training requirements for varying experience levels, (2) the pilot workload in the ATC environment with unplanned route changes, and (3) the viability of the reconfiguration concept for failures of the EHSI during various phases of flight.

OPERATIONAL EVALUATION OF DAAS TO ASSESS

- TRAINING REQUIREMENTS FOR VARYING EXPERIENCE LEVELS
- PILOT WORKLOAD IN ATC ENVIRONMENT REQUIRING ROUTE CHANGES
- RECONFIGURATION CONCEPT

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