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Glass-Cockpit Pilot Subjective Ratings of Predictive Information, Collocation, and Mission Status Graphics: An Analysis and Summary of the Future Focus of Flight Deck Research Survey

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Abstract

For several years, NASA Langley Research Center has been researching ways to improve flight crew decision aiding for systems management. Our endeavors in this area have led to our current investigation of how to display a wide variety of aircraft parameters, both old and new, in ways which will improve the flight crew's situation awareness while at the same time help to meet the United States government's goal of reducing the commercial aircraft accident rate. To accomplish these goals, new and creative means are being explored that will monitor the overall health of a flight and not only report the current status of the aircraft to the pilots but also forecast impending problems so that appropriate action can be taken earlier to prevent factors that may be detrimental to the safety of those onboard. The initial step in this research was to conduct a survey addressing how current glass-cockpit commercial pilots would value a prediction of the status of critical aircraft systems and their innumerable unique components. However, it would have been careless of us to focus solely on predictive information without addressing how this new type of data ought to be conveyed and utilized. Therefore, two other items, closely associated with predictive information, were also included in the survey. The first of these items is aimed at addressing the need for system status, alerts and procedures, and system controls to be more logically grouped together, or collocated, on the flight deck. The second idea calls for the survey respondents' opinions on the functionality of mission status graphics; a new display methodology that has the ability to group a variety of parameters onto a single display that can instantaneously convey a complete overview of both an aircraft's system and mission health.

Introduction

To safely and successfully move cargo from one point to another, be it passengers or freight, a commercial transport pilot needs to know the answers to three basic questions: (1) What is my current condition? (2) What will my condition be in X amount of time or at Y location? and (3) What is the most efficient way for me to stabilize an abnormal condition so that the flight can reach a safe conclusion? In order to provide answers to these questions, the following three ideas were investigated via a survey of the anticipated end-users – glass-cockpit qualified airline-transport pilots.

Predictive Information

The ability to predict a system failure or component malfunction in-flight has the potential not only to improve pilot situation awareness but also save lives. Looking back through National Transportation Safety Board (NTSB) accident and incident reports yields several instances of failures where predictive information would have been beneficial.

One chilling example is the May 1983 incident of flight 855, an Eastern Air Lines L-1011, enroute to Nassau, Bahamas from Miami, Florida [1]. Twenty minutes after departing Miami, flight 855 began to show indications of a possible failure event. The flight was just under an hour from Nassau when the captain was forced to shut down one of the aircrafts' three engines due to low oil quantity. However, even with one engine inoperative, the crew was still unaware of the full scope and seriousness of the problem. It wasn't until a full ten minutes later when the remaining two engines also indicated zero oil quantity that the crew realized their situation was grave. As a result, the crew elected to return to Miami because of the rapidly deteriorating weather conditions in Nassau.

With the remaining two engines still running normally, the crew concluded that the oil gauges must be faulty. Regardless, they felt it would still be better to return the aircraft to Miami. While making their approach into Miami, the last two engines failed. During a tense engineless decent, approximately 55 miles from Miami, the crew told the 162 passengers that a water ditching was eminent and that the US Coast Guard was notified of their position. Seconds later, the number 2 engine was miraculously restarted and the crew made a safe single engine landing, back where the flight originated, at Miami International Airport.

Even though the outcome was not catastrophic, investigators and airline representatives knew that it could have just as easily been a major air disaster. However, if the flight crew had the benefit of a predictive information system, they would have been aware that oil had been slowly leaking since the engines were started at the gate in Miami. In addition, the crew would have known that the decrease in oil quantity would have triggered a triple engine failure prior to their arrival in Nassau. It is likely that this higher level of awareness would have led to either a much earlier and less eventful return to Miami, or quite possibly, a cancellation prior to ever leaving the ground. Either way, the risk to human life that day would have been substantially reduced had predictive information been available.

NASA has been exploring the benefits of having predictive information capabilities on the flight deck, for several years [2–6]. Research has shown that virtually all aircraft systems can be monitored and predicted [6]. However, questions still remain with regards to pilot preferences for the level of detail that a prediction should have, the method of issuing and updating a prediction, how a prediction should be handled, as well as numerous other considerations. The Future Focus of Flight Deck Research Survey described in this document was designed to answer these questions and provide clues about which areas should be focused on in future experiments.

Collocation

The functional components of a modern commercial aircraft flight deck can be categorized as either system status, alerts and procedures, or systems controls [7 and 8]. Typically, on current transport aircraft flight decks, a system's gauges and status instruments will be found on one panel, its alerts and associated procedures will be displayed on a second panel (or on paper), and the system's controls will be found on a third panel (*e.g.*, on an overhead panel) [7 and 8]. This inefficient layout forces the flight crew to assimilate information from multiple locations while they manipulate the appropriate controls necessary to rectify an alert or perform a checklist procedure, thus creating a dependency on tactile feedback for process confirmation.

For example, on a McDonnell Douglas MD-11 (Figure 1), if a hydraulic pump fails, initial notification of the problem is displayed on the lower third of the Engine & Alert Display (EAD), located on display unit three (DU3). Simultaneously, the HYD switch/light cue will illuminate on the center pedestal's Systems Control Panel (SCP). After noticing the alert message on the EAD and the illuminated HYD light on the SCP, the pilot will press the HYD SCP button, calling up the hydraulic synoptic on display unit four (DU4). Once the hydraulic synoptic is visible on DU4, the original alert from the EAD will be transferred to the bottom third of the hydraulic synoptic screen [9].

Next, the pilot will retrieve the checklist binder and the appropriate paper checklist will be referred to. While following the checklist and monitoring the hydraulic synoptic, the pilot will then have to reach above and slightly behind his/her head to locate the hydraulic system control panel on the overhead control panel cluster. Once the appropriate controls have been identified, the checklist procedure will be followed, and the hydraulic synoptic will be monitored to verify that the problem is rectified. After this labor and time intensive process is complete, the checklist binder can be stowed, the hydraulic synoptic can be closed, and the crew can return to focusing their attention on flying the MD-11 to its destination [9].

The previous example is from one of the most modern glass-cockpit transport aircraft in service today. With that in mind, one can easily imagine the challenges that a similar failure poses to the flight crews of older, less sophisticated transport aircraft that utilize “steam-gauge” style cockpits, like the Boeing 737-200 (Figure 2). However, with the rapid growth in computer processing technology that has occurred over recent years, it is now possible to consolidate, or collocate, an aircraft’s critical elements of information and their associated controls into one centralized location [7 and 8]. The results of such an undertaking would yield a savings in space and weight onboard not only future aircraft, but those capable of being retrofitted as well. This space and weight savings can be translated into a fuel savings and ultimately a decrease in overall operating expenses [7 and 8].

Collocating system information with its associated controls will also improve the safety of flight by reducing the workload that a flight crew experiences (Table 1). More often than not, commercial transport aircraft cockpits are overloaded with instruments and controls that serve only one purpose. This clutter of gauges, dials, and switches often causes difficulty in gathering and assimilating data thereby resulting in longer response times.

NASA has conducted research in this domain to various extents [7 and 8]. Experimental data suggest that through efficient collocation of system instruments, alerts and procedures, and system controls, it may be possible to improve situation awareness, decrease workload, and speed-up response times on future flight decks [7].

In order to continue the investigation, subjective ratings, such as those gathered by the Future Focus of Flight Deck Research Survey, are necessary to determine the preferences of current glass-cockpit pilots who would be likely to see the benefits of collocation in the near future.

Mission Status Graphics

More and more, pilots are becoming monitors. With the advent of the glass-cockpit, flight crews have suddenly found themselves overseeing automation more then actually operating and controlling the functions of the aircraft. However, humans are traditionally poor monitors of highly reliable systems over time [10]. Thus, the flight crews on current glass-cockpit aircraft are being assigned a task for which they are ill equipped. Research has shown, though, that an automated monitor can assist humans in recognizing and dealing with failures [11].

The glass-cockpit of the McDonnell Douglas MD-11 is one example of where an automated monitor would simplify how system and flight status information is conveyed to the flight crew. Although the MD-11’s clean looking instrument panel may look like a revolutionary leap forward from the spread out “steam-gauge” style cockpit of older transport aircraft, in reality it is only evolutionary (Figure 3). The cleaner looking instrument panel uses cathode ray tube (CRT) displays to depict digital versions of virtually the same instruments and gauges seen on the Boeing 737-200. The MD-11 achieves its seemingly less cluttered appearance by keeping systems status information hidden from view via a series of computer menus that can be accessed by the flight crew through a sequence of button presses [9]. In its defense, the MD-11 was among the first commercial transport aircraft to logically group an entire system’s status information together within its digital menus; gauges and analog displays that were once in a myriad of places within the cockpit are located on a single CRT which the flight crew can call up at any time.

However, there are trade-offs for clean looks and logical groupings. When the systems information is called up, it is conveyed visually on highly cluttered CRT displays that can sometimes cause the human visual channel to become overloaded. It is during these situations of visual overload that abnormalities can be overlooked due to their inability to capture the monitor's attention while a visual scan is performed.

In addition, automated systems, like those onboard the MD-11, have become increasingly reliable, causing a complacency to develop within the monitor that can sometimes lead to a disbelief that something actually could be wrong. When these factors, and others, are combined, it becomes apparent that a new way of clearly depicting a system and/or mission abnormality is needed to assist pilots in their ever-expanding role as systems monitors.

This is where the mission status graphics polar star display comes in (Figure 4). A polar-star display consists of a polygon where each vertex of the polygon represents an abstracted parameter of the mission (*e.g.*, heading or fuel) [2, 12, and 13]. By applying the polar star display methodology to aircraft systems, the Mission Status Graphics (MSG) prototype display was born.

The modern flight deck has become an extremely complex environment, especially during non-normal situations. Often, individual details become compelling, causing the crew to lose sight of the "bigger picture" [13]. With mission status graphics, a single component or a whole system can be monitored and represented as only one "vertex" of a polygon, thereby making it possible for the crew to monitor either all of the aircraft's systems or mission parameters, in detail, with only one display. In other words, MSG has the ability to provide the flight crew with an instantaneous overview of the aircraft's mission and system health (*i.e.*, the "bigger picture").

To indicate normal operation, the display background would include a perfect circle that, when all systems are within their limits, will intersect each of the vertices of the polygon [13 and 14]. The addition of a MSG display would centralize monitoring, problem detection, and preliminary diagnosis of all aircraft systems onto one display; however, it would only serve as a supplement to more conventional instruments and information displays. Unlike conventional displays, the MSG display could be designed to report the status of virtually any mission or system variable with varying levels of detail. Therefore, fluctuations in an individual component or a whole system will be evident through the morphing of the polygon into an asymmetrical figure, causing one or more of the apexes to move away from the "normal operating range."

Further research needs to be conducted in this area to help determine the best way to utilize this new application of polar-star displays. The next step in this research was to collect subjective ratings, which will serve as a guide during the design and testing of future MSG displays that may one day find a home on the flight deck of tomorrow.

Survey Objectives

The Future Focus of Flight Deck Research Survey consisted of three separate and unique sections designed to gather subjective ratings and responses from current glass-cockpit line pilots in order to assess the viability of each idea as a potential future research domain.

Predictive Information

The Predictive Information section of the Future Focus of Flight Deck Research Survey (Appendix A) attempted to determine (1) what type of predictive information pilots wanted, (2) the manner in which predictions should be displayed, (3) which systems should have predictive capabilities, (4) how a prediction should be interpreted and handled by the crew, and (5) the overall value of adding predictive information to future flight decks.

To learn what type of predictive information pilots wanted, the research participants were presented with several choices for prediction format, detail, duration, and sensitivity. The location and method of displaying a prediction, a ranking of current aircraft systems that should have predictive capabilities, and the way predictions should be addressed by the flight crew were also investigated with this survey. The section was concluded with numerical rating questions that provide information on whether pilots feel that adding predictive information would improve their situation awareness and the cockpit environment in general.

Collocation

The Collocation section of the Future Focus of Flight Deck Research Survey (Appendix B) attempted to determine (1) the way in which status, alerts/procedures, and controls should be displayed and manipulated, (2) the process that the automation should follow in various situations such as cautions, warning, and normal flight, (3) what current aircraft systems are in need of collocation, (4) how malfunction propagations should be integrated into the design of collocation displays, and (5) the overall improvement, if any, that collocation may bring to future flight deck designs.

At the beginning of the question set, the research participants were presented with a variety of display and control combinations and asked to pick the one that they felt was best. This section of the survey also addressed the method of display screen navigation, checklist usage and type, the systems in need of collocation, and the best method of depicting malfunction propagation. Finally, the research participants were asked to numerically rate the effect that collocation would have on their situation awareness, as well as the overall effect that it may have if it were to be implemented on future flight decks.

Mission Status Graphics

The Mission Status Graphics section of the Future Focus of Flight Deck Research Survey (Appendix C) attempted to determine (1) display movement direction and refresh rate, (2) how attention should be brought to a parameter that has exceeded its normal operating range, (3) the location and size of the MSG display with respect to current glass-cockpit layouts, (4) the level of systems monitoring that should be delegated to the MSG system, (5) whether MSG should incorporate predictive information, and (6) whether current line pilots see a need for a system that can provide an instantaneous overview of the aircraft's mission and system health.

The pilots' preferences for relative versus absolute movement direction and discrete versus continuous vertex motion were ascertained in the beginning of this survey section. The research participants also evaluated visual, verbal, and audible annunciation methods. Further in the section, the research participants were asked where on the instrument panel an MSG display should be located and, in comparison with current CRTs, how big the display should be. In addition, the research participants were asked to indicate what percentage of systems monitoring should be done by cockpit automation and whether they felt that predictive information should be incorporated into the MSG system.

This third and final survey section was brought to a close in a similar fashion to the two previous sections, by requesting a numerical rating of the impact that the research participants felt MSG would have on their situation awareness, in addition to the overall value of including Mission Status Graphics displays on the flight decks of tomorrow.

Survey Design

Research Participants

Sixty glass-cockpit qualified, airline transport pilots received the Future Focus of Flight Deck Research Survey. Forty-one surveys were returned and analyzed thereby yielding a return rate of approximately 68%. The research participants' ages ranged from a minimum of 32 years to a maximum of 64 years, with an average of 45 years. They also had an average of 10,400 hours of flight experience with a range from 3,600 hours to 33,000 hours. In addition, a total of 25 of the research participants had previous military flying experience, and only 2 of the 41 research participants who returned the survey for analysis were female. Reasonable financial compensation for participation was sent only to those research participants who returned the Future Focus of Flight Deck Research Survey.

Survey

The aforementioned sixty research participants were randomly selected from a database of willing individuals that held current type-ratings in glass-cockpit transport category aircraft. Each received a survey packet in the mail containing a copy of the Future Focus of Flight Deck Research Survey (Appendices A – C), a cover letter, participant instructions, a background questionnaire (Appendix D), and a notice of compensation for participation. The research participants were introduced to Predictive Information, Collocation, and Mission Status Graphics via a concise overview of each topic that preceded its respective survey section.

The survey sections consisted of subjective rating questions of various lengths and styles. The questions were in the form of standard multiple choice / fill-in the blank, numerical rank ordering, and Likert-type scales using continuous numerical ratings. The research participants were asked to mark their responses directly on the survey. In addition, some questions allowed for research participant comments and each of the three main sections concluded with a page for general comments about the topic. Once a research participant completed the tasks outlined in the instructions, they simply sealed the survey, background questionnaire, and notice of compensation in a supplied pre-addressed, postage-paid return envelope and put it in the mail.

Data Analysis

Research participant responses were numerically coded and entered into a spreadsheet for analysis. Frequency counts, average ratings, in addition to research participants' comments were tabulated from the spreadsheet by SPSS® [15]. Where appropriate, an analysis of variance (ANOVA) or nonparametric Chi-square test was performed using SPSS®. Significance was set at $p \leq 0.05$, where p is the proportion of test statistics smaller than observed, given the null hypothesis is true.

Results and Discussion

For the purpose of this report, the results of the data analysis of the Future Focus of Flight Deck Research Survey have been broken into the survey's three major sections. The results discussed in each of the following sections were found to be statistically significant ($p \leq 0.05$). Further statistical analysis was done to investigate any possible relationships that may have been present between the research participants' age or flight experience and their responses to the survey questions. However, no such relationships were evident.

Predictive Information

According to the respondents (Table 2), a prediction should be issued as soon as a consistent deviation from norm is evident in an aircraft system. A unique chime should then indicate to the flight crew that a prediction has been issued. A visual form of the prediction should also be displayed on the electronic alerting system with its forecast "time to alert" in minutes and seconds. After the initial prediction has been issued, it should be updated continuously and both a visual and audible reminder should be issued only if the trend accelerates.

The level of detail of the visual prediction should be based on the severity/type of problem forecasted to occur and a new standardized procedure based on the priority class of the prediction should also be developed to assist the pilots in determining the best way to address the impending problem. In addition, the research participants indicated that the visual prediction should include an automatic link to the appropriate electronic checklist; however, they were unclear as to when and where the checklist should be viewed. Engine systems, hydraulic systems, aerodynamic and control systems, and electrical systems, were the top four aircraft systems, respectively, that the respondents felt should have predictive capabilities.

In general, the pilots overwhelmingly believed that predictive information would be a valuable item to include on future flight decks, so long as the system is not overly sensitive, causing nuisance false-alarms. However, more specifically, the research participants felt that a system capable of accurately predicting a system/component failure would be an excellent tool to help improve their situation awareness.

Collocation

The research participants completing this survey preferred having system status, alerts and procedures, and system controls all on one display (Table 3). When a caution or warning message is issued, the research participants believe that the collocated status/alerts/controls display(s) should be navigated to the appropriate gauges, information, controls, and necessary checklist items automatically by the computer. Additionally, controls should be able to be manipulated directly through the display screen. In situations of malfunction propagation, a unique hierarchal alert list should be used to show associations between alerts.

A collocated system should also automatically display the necessary electronic checklist(s) on the same screen as its associated alert. In addition, collocated systems should incorporate predictive information on their status displays. Engine systems, hydraulic systems, electrical systems, and fuel systems were the top four aircraft systems, respectively, that the research participants felt were currently in need of collocation.

Overall, the respondents strongly believed that the efficient collocation of systems status with its associated alert/procedures and controls will improve the functionality of current flights and that it is a very important item to consider when designing future flight decks.

Mission Status Graphics

The survey results indicated that the MSG system display should indicate that a parameter is out of bounds by advancing and retreating the vertex according to the respective system/component value (Figure 5) in a continuous (i.e., free-flowing) manner (Table 4). The flight crew would then acknowledge the abnormal condition by pressing a so called "acknowledgement button" on the MSG system display panel, which would be the same size as current glass-cockpit CRTs and would be located just above the center pedestal. The system's capabilities should be limited to observation and problem investigation and isolation only.

Virtually all research participants indicated, at a minimum, that the status of the engine, hydraulic, electrical, and fuel systems should be monitored and displayed on the MSG system display. The research participants agreed that mission status graphics should incorporate predictive information into its displays. Interestingly, when asked how much of the system's monitoring should be done by automation on future flight decks, the average response was 75%. Furthermore, the majority of the research participants felt that mission status graphics would be a valuable item to include on future flight decks.

Conclusions

Commercial aviation is growing at an incredibly rapid rate. Some industry experts are forecasting an increase in commercial air traffic of as much as 30% over the next decade. In addition, the major commercial aircraft manufacturers are poised to produce planes that can go higher, farther, faster, and carry more people then ever before while lowering operating costs and reducing the commercial aircraft accident rate [16].

As the skies become more congested, pilots will find themselves needing to perform a multitude of new tasks on the flight deck which will consume more of their time. It is critical that as pilot workload increases, situation awareness also increase so an alarming increase in accident rates can be avoided.

Today's glass-cockpit pilots, regardless of their age or experience level, recognize the benefits that predictive information, collocation, and mission status graphics can provide. These systems, if designed correctly with human factors as a forethought, could ultimately prove to be invaluable in our attempts to increase commercial aviation safety.

The results of the survey have provided a strong foundation from which to take the next step in forging new systems that will serve to provide pilots with a better overall picture of their current mission and system states, a reliable forecast of what their aircraft's condition will be like in the immediate future, and an efficient means of viewing, understanding, and controlling the onboard systems that are critical to the overall success of a flight. Although further experimental research needs to be conducted into each of the aforementioned systems, the participants in this survey recognize the need for such systems and have overwhelmingly shown they are prepared to embrace any or all of them, if and when they should become available.

Remarks

Based on the information gathered by the Future Focus of Flight Deck Research Survey, the following hypothetical display layouts were created (Figures 5–7). Each prototype display depicts some of the preferences of the survey respondents. Furthermore, the hypothetical displays were integrated into a generic flight deck, detailing possible locations for the predictive information, collocation, and mission status graphics system displays (Figure 8). Although they could be made to work together, it is important to remember that each of the aforementioned new displays/information are being researched independently; therefore, some of their functions may be redundant, if the systems are employed in unison as shown in the generic flight deck.

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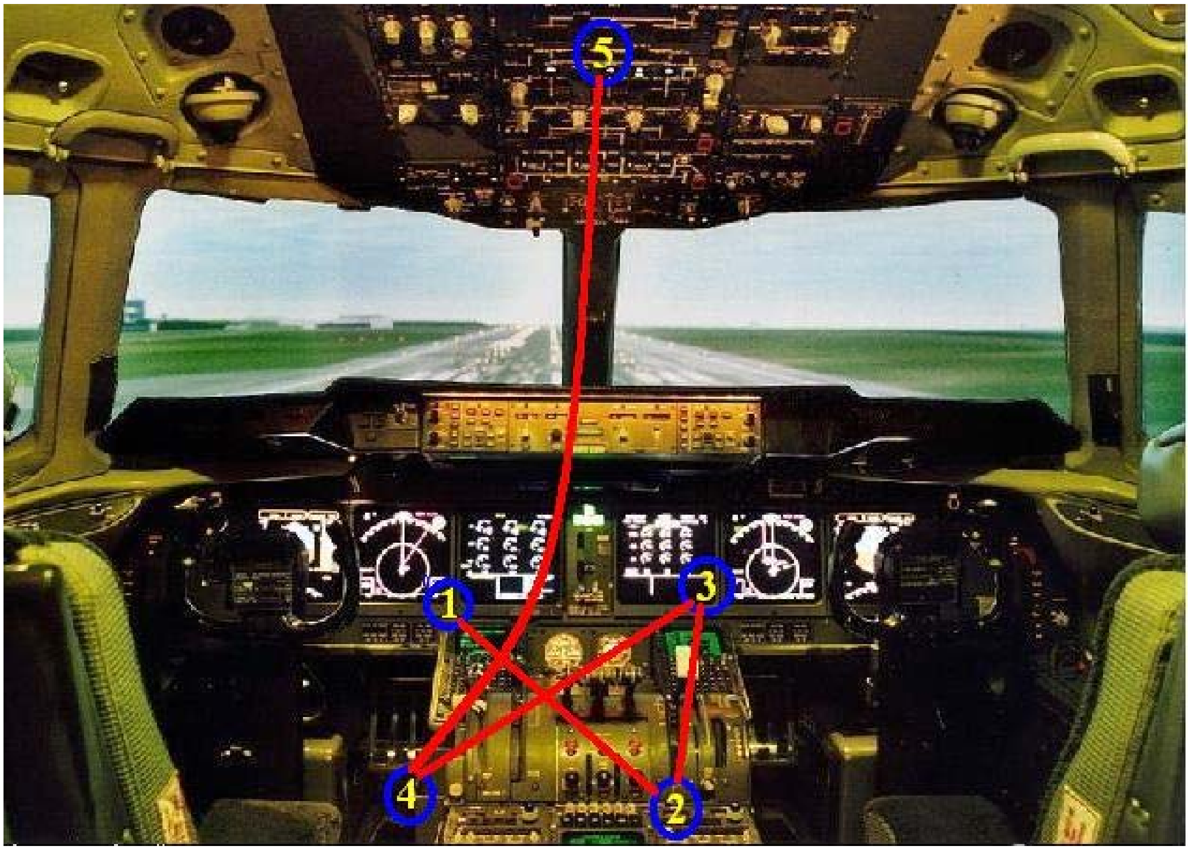
Figures



1. Engine & Alert Display (EAD) – Display Unit 3 (DU3)
2. Systems Control Panel (SCP)
3. Synoptic Display – Display Unit 4 (DU4)
4. Checklist Storage
5. Hydraulic System Control Panel

Figure 1 – MD-11 Hydraulic Pump Failure Example

Figure 2 – Boeing 737-200 "Steam-Gauge" Style Cockpit

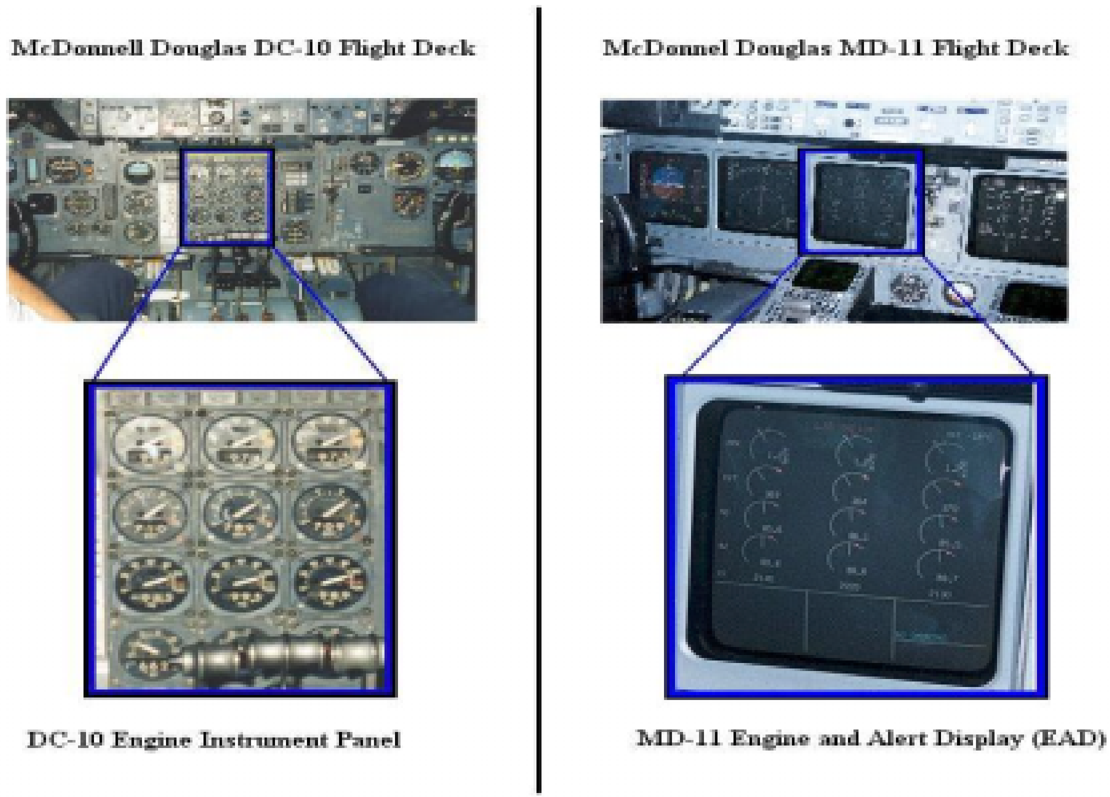


Figure 3 – Comparison of DC-10 and MD-11 Engine Gauges

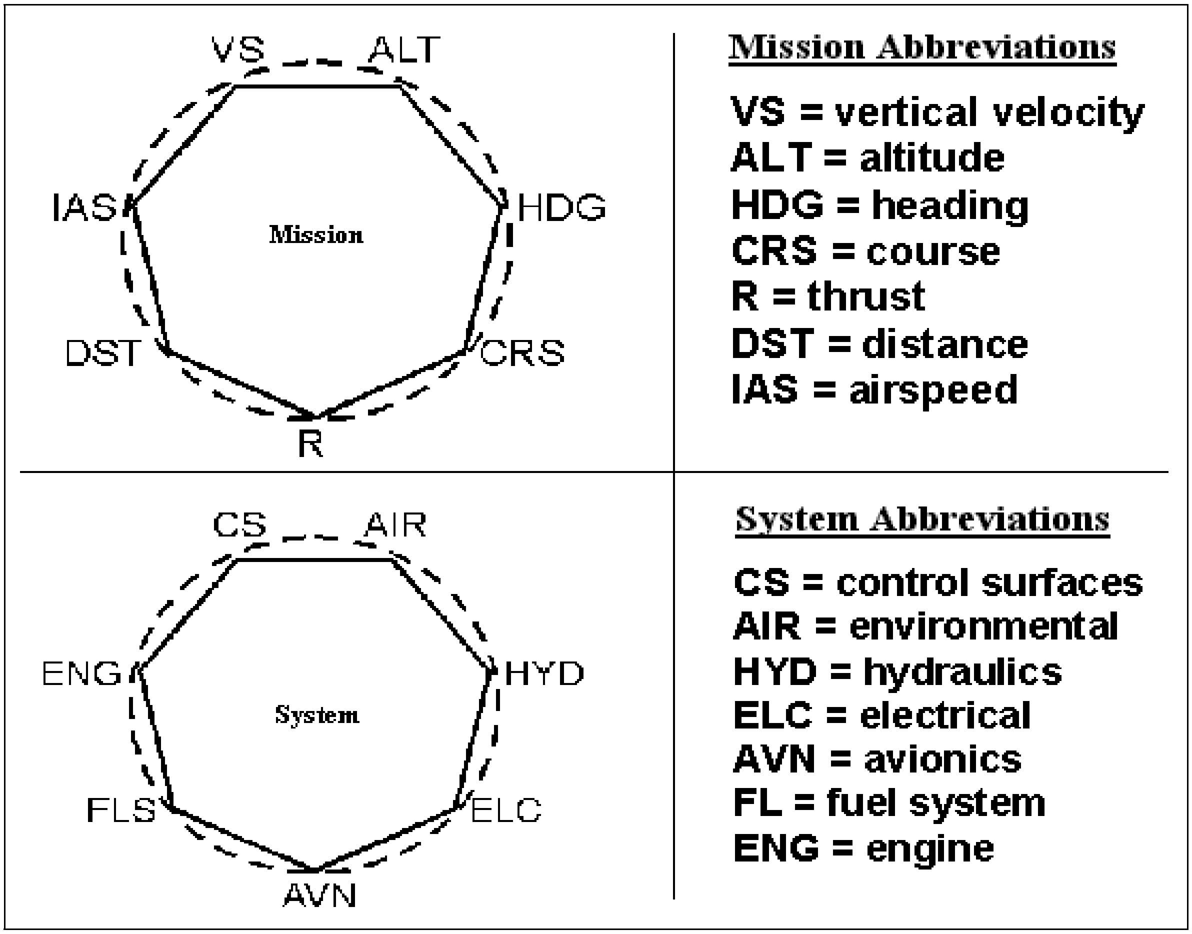


Figure 4 – Mission Status Graphics – Polar Star Displays

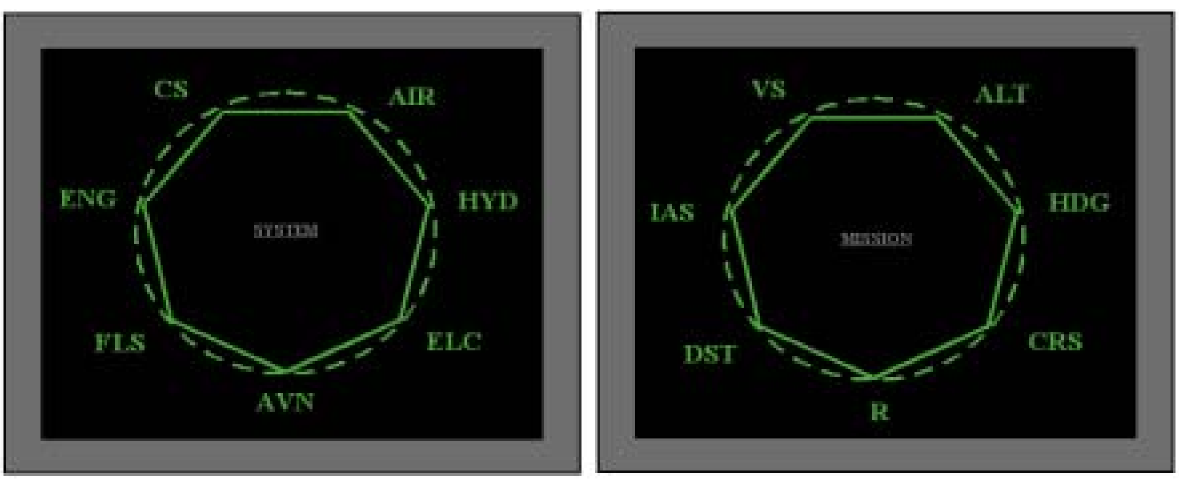


Figure 5 – Hypothetical Mission Status Graphics Displays

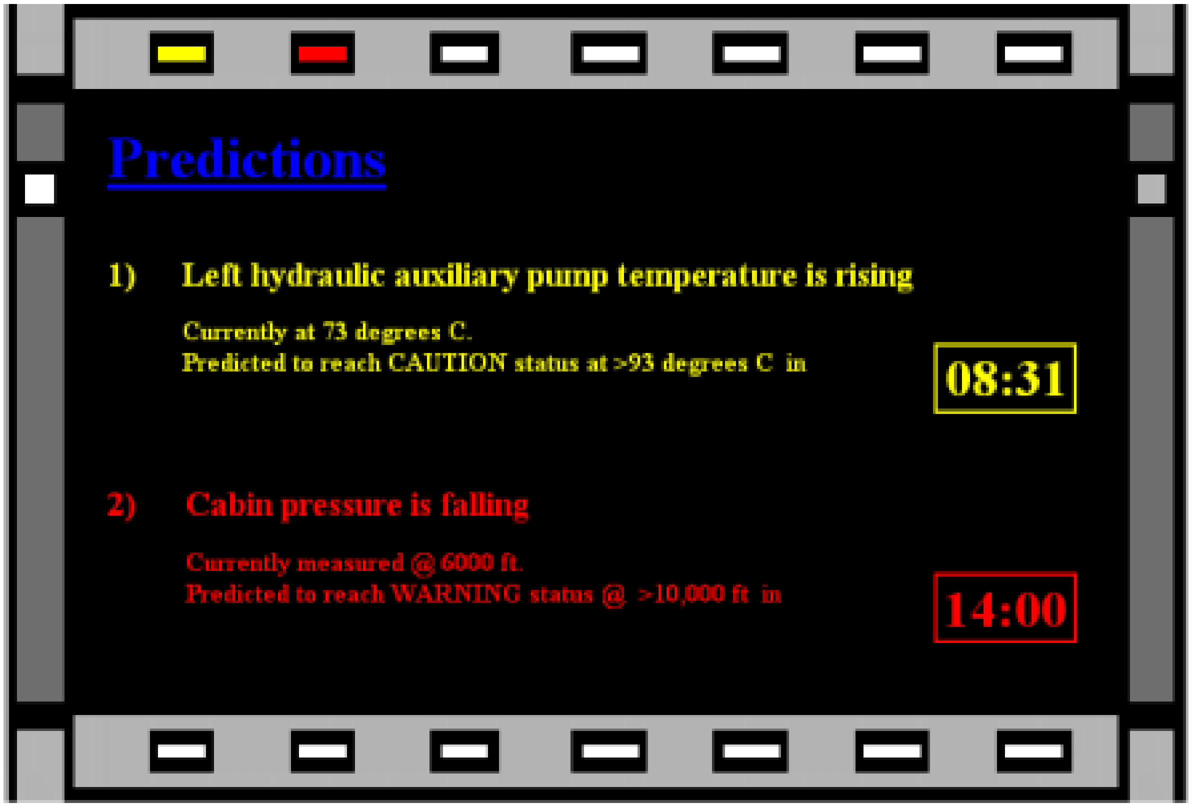


Figure 6 - Hypothetical Predictions Display

Display includes respondent preferences for “time to alert” in minutes and seconds, and a link to the appropriate electronic checklist depicted by the button with the letter “C” on it. A display of this nature could include functions and information found on present day EICAS system as well.

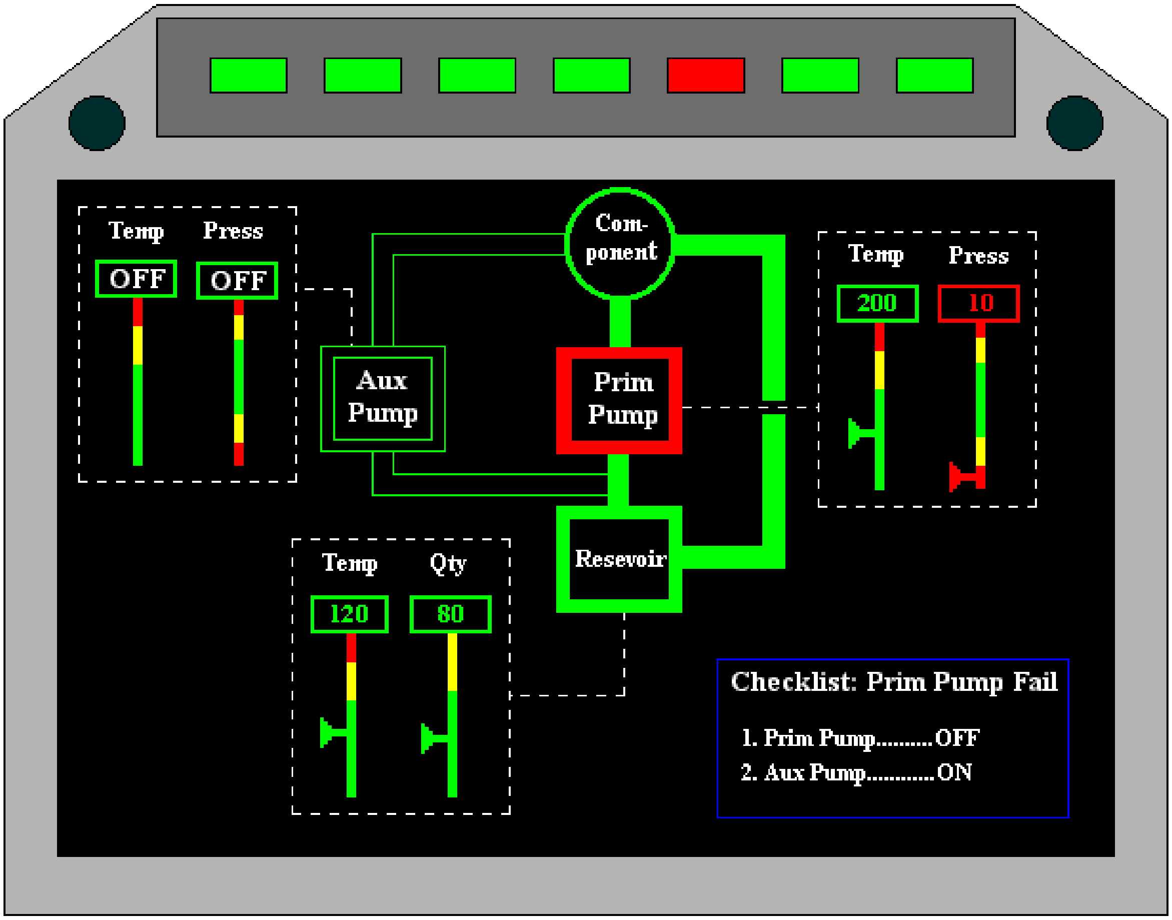


Figure 7 - Hypothetical Collocation Display

A non-specific system is experiencing a primary pump failure. The failed pump is visible in red on the system schematic. The pressure gauge of the failed pump is also highlighted in red. Checklist instructions are performed by touching the appropriate system component to change its state. The buttons on the panel above the display indicate which system has an "abnormality" in addition to allowing the user to call up a different systems' schematic and gauge/instrument readings display.

Figure 8 - Hypothetical Generic Flight Deck

Depicts possible locations of predictive information, collocation, and mission status graphics displays. The other flight deck items shown were included to provide perspective.

Tables

Table 1 – Current Research on the Collocation of Functions

Collocation	
Why?	**Why Not?**
Combine stimulus and response	Separation of displays and controls
Reduce crew workload by collocating displays and controls [17]	Better performance with less cluttered displays [10, 18]
Reduce complexity of data search [19]	Related data should be grouped and separated from unrelated data [17, 20]
Command decision aids should be augmented with status information [21]	

Table 2 – Predictive information survey respondent agreement

Predictive Information	**% of respondents that agree with statement**
Notification that a prediction has been made should be both visual and audible.	82%
A visual prediction should be displayed on the EICAS electronic alerting system.	83%
The predictions on the predictive display should be continuously updating.	54%
The predictions on the predictive display should be accurate to minutes and seconds.	98%
A reminder of a prediction and its status should only happen when the trend accelerates.	63%
The reminder of a prediction should be both visual and audible.	63%
There should be a standardized procedure addressing how to handle predictions.	75%
The level of detail of a prediction should be based on the severity/type of problem.	88%
Predictions should be categorized into priority classes.	76%
The recommended checklist should be an electronic checklist.	78%
Electronic checklists should be brought up automatically when a prediction states an alert is eminent.	68%
The system should have a low sensitivity thereby creating a low false alarm rate.	74%
Displays with predictive information will improve my situation awareness.	96%
A predictive information display would be a valuable item to include on future flight decks.	98%

Table 3 – Collocation Survey Respondent Agreement

Collocation	% of respondents that agree with statement
Status, alerts, and controls should be all on one display.	32%*
The collocation display should be navigated to the appropriate gauges/information/controls automatically by the computer during an alert.	71%
During an alert, the necessary controls and or checklist items should be able to be manipulated through the collocation display.	81%
The collocation display should use of a unique hierarchal system to indicate that related malfunctions are occurring.	68%
The collocation of status, alerts and procedures, and controls will improve the overall functionality of the flight deck.	82%
The necessary checklists should be electronic, when dealing with an alert.	80%
In a situation involving an alert, the appropriate electronic checklists should be brought up automatically by the computer.	85%
The automatic checklists should be brought up on the collocation display.	78%
The collocation display should incorporate predictive information.	80%
The efficient collocation of information and controls is an important item to consider when designing future flight decks.	98%

* Denotes non-majority agreement; all other response groupings had smaller agreement percentages.

Table 4 – Mission Status Graphics Survey Respondent Agreement

Mission Status Graphics	% of respondents that agree with statement
The MSG system display should indicate a parameter is "abnormal" by advancing and retreating the vertex according to the value of a component s gauge readings.	56%
The MSG display vertices should be continuous (i.e., free-flowing).	68%
An "abnormal" MSG parameter should be acknowledged by the flight crew pressing a dedicated acknowledgement button on the MSG display panel.	59%
The MSG system display should be the same size as typical CRT displays currently found in glass cockpit aircraft.	54%
The MSG display should be located in the center of the instrument panel above the pedestal.	54%
The MSG system should have observation and problem investigation capabilities only.	80%
The MSG display should monitor the status of whole systems and their immediate subsystems.	80%
The MSG system should incorporate predictions on its display.	62%
On future flight decks, computers should perform at least 75% of the systems monitoring.	70%
When displaying predictions on the MSG system display, the predictions should be shown in minutes and seconds.	78%
The MSG system should include a problem investigation and isolation function to help the crew determine the precise cause of a malfunction.	73%
A mission status graphics system would be a valuable item to include on future flight decks.	78%

Appendix A - Predictive Information Survey Questions

1.1 When a prediction has been issued, action should be taken to amend the problem ..(choose one)

(prediction = an indication that a system or component is going to malfunction at some time in the near future)

- ❑ Immediately.
- ❑ Before the first reminder
- ❑ After the first reminder
- ❑ Anytime before it becomes an alert
- ❑ Only once it has become an alert

1.2 Should the prediction of an alert be in time intervals (i.e. alert in 6 min.) or in percentage of flight completed (i.e. alert at 78% completed)? (choose one)

> For example: The system has predicted that the oil pressure in an engine is increasing at a steady rate and if it continues it will soon reach an alert. Would you rather know that you have six minutes until it reaches an alert (time interval) or that it will reach an alert when the flight is 78% completed (% flight completed)?

Time Intervals	either	% Flight Completed
1	2	3

Why? ____

____

____

1.3 When should a prediction be issued? (choose one)

- ❑ Once the trend has maintained itself for 20 seconds
- ❑ Once the trend has maintained itself for 40 seconds
- ❑ As soon as the trend is evident
- ❑ Once the trend has reached a level of 20% departure from normal
- ❑ Once the trend has reached a level of 40% departure from normal

1.4 A prediction should be issued _________ before its associated alert. (fill in the blank)

- ❑ no more than 1 minute
- ❑ no more than 5 minutes
- ❑ no more than 15 minutes
- ❑ as early as possible
- ❑ with sufficient time to amend a problem

1.5 What level of detail should a predictive display have? (choose one)

(predictions = an indication that a system or component is going to malfunction at some time in the near future)

- ❑ Current values with predictions
- ❑ Current values, predictions, and how long until alert
- ❑ Current values, predictions, how long to alert, impending alert class
- ❑ Current values, predictions, how long to alert, impending alert class, checklist recommendation
- ❑ Current values, predictions, how long to alert, impending alert class, checklist recommendation, and the outcome if no action is taken

1.6 How often should the predictions on the predictive display be updated? (choose one)

- ☐ Every 30 seconds
- ☐ Every 60 seconds
- ☐ Every 90 seconds
- ☐ Every 2 minutes
- ☐ Every 5 minutes
- ☐ Continuously updating

1.7 What level of detail should a prediction have? (choose one)

- ☐ Accurate to whole minutes only (i.e. 12 min),
- ☐ Accurate to whole minutes and seconds (i.e. 12 min 32 sec)
- ☐ Accurate to whole minutes, seconds, and milliseconds (i.e. 12 min 32 sec 44 msec)
- ☐ Accurate to whole percentages only (i.e. 34% flight completed)
- ☐ Accurate to percentages with one decimal place (i.e. 34.7% flight completed)
- ☐ Accurate to percentages with two decimal places (i.e. 34.75% flight completed)

1.8 Given that the false alarm rate of the predictive information system is directly related to the system sensitivity, what would be an acceptable false alarm rate?

False Alarm Rate	System Sensitivity	Choose One
Very Low	Very Low	1
Low	Low	2
Medium	Medium	3
High	High	4
Very High	Very High	5

1.9 Where on the instrument panel should a visual prediction be posted? (choose one)

- ☐ On the appropriate control and or gage cluster
- ☐ On the EICAS electronic alerting system display
- ☐ On the FMS or similar
- ☐ On a new and unique display
- ☐ Other ________________________

**1.10 What systems should have prediction capabilities?
(please rank from highest priority (1) to lowest priority (7))**

Engine systems (oil, fuel, exhaust, etc)	______
Hydraulic systems (fluid levels, fluid temp., pumps, etc)	______
Cabin systems (cabin altitude, a/c, pneumatics, etc)	______
Aerodynamic/Control systems (flaps, slats, de-icing, etc)	______
Electrical systems (APU, wiring, etc)	______
Avionics systems (TCAS, EICAS, auto pilot, etc)	______
Fuel systems (pumps, levels, temp., etc)	______
Other (please specify)________________________________	______

1.11 Once a prediction has been made, how would you like to be notified of the prediction? (choose one)

- ☐ Visually
- ☐ Acoustically
- ☐ Both visually and acoustically
- ☐ No notification
- ☐ Other (please specify):____

1.12 When should the flight crew be reminded of the prediction and its status? (choose one)

- ❑ Every 10% of predicted time interval displayed, therefore as time passes reminders become more frequent (i.e. predicted alert in 10 minutes, reminder in 1 minute)
- ❑ Every 10% of predicted percentage of time to destination displayed, therefore as time passes reminders become more frequent (i.e. predicted alert at 20% of flight completed, reminder in 2% closer to destination)
- ❑ Every 60 seconds regardless of method of presentation
- ❑ When the trend accelerates
- ❑ Only once, when the prediction is established

1.13 How should a reminder be issued? (choose one)

- ❑ Visually
- ❑ Acoustically
- ❑ Both
- ❑ There shouldn t be a reminder
- ❑ Other (please specify)____

1.14 There should be standardized procedure addressing how to handle predictions. (circle any number from 1 to 5)

Strongly Agree				Strongly Disagree
1	2	3	4	5

1.15 The level of detail of a prediction should be based on the severity/type of problem. (circle any number from 1 to 5)

For example:

The system has predicted the following:

1) Cabin pressure is falling. (Class 2 prediction, Alert is a warning)
   Currently @ 6000 ft.   Predicted to be @ >10,000 ft in 11 min 44 sec.
   Recommended checklist: Cabin Altitude
   Outcome if no action taken: Cabin depressurization
2) Left hydraulic auxiliary pump temperature is rising
   Currently at 73 degrees C.   Predicted to fail at >93 degrees C.

Strongly Agree				Strongly Disagree
1	2	3	4	5

Why?

____

____

____

1.16 Predictions should be categorized into priority classes. (circle any number from 1 to 5)

For example

Class 4	If prediction is accurate, outcome will not have an effect on the success of the flight
Class 3	If prediction is accurate, outcome may have an effect on the success of the flight
Class 2	If prediction is accurate, outcome is hazardous to the success of the flight
Class 1	If prediction is accurate, outcome is disastrous to the success of the flight

Strongly Agree				Strongly Disagree
1	2	3	4	5

1.17 The predictions display should recommend the proper checklists to amend the forecasted problem. (circle any number from 1 to 5)

Strongly Agree				Strongly Disagree
1	2	3	4	5

1.18 When should the checklist be recommended? (choose one)

- ❑ When the prediction is made
- ❑ When the prediction is halfway to alert status
- ❑ Depends on the severity and or priority class of the prediction
- ❑ The system should not recommend checklists

1.19 Should the checklist be paper or electronic? (choose one)

- ❑ Paper
- ❑ Electronic
- ❑ The system should not recommend checklists

1.20 Electronic checklists should be brought up automatically when a prediction states an alert is eminent. (circle any number from 1 to 5)

Strongly Agree				Strongly Disagree
1	2	3	4	5

1.21 When should a prediction be treated like an alert? (choose one)

- ❑ Once in alert range
- ❑ Two minutes to alert range
- ❑ Five minutes to alert range
- ❑ Depends on the system being monitored
- ❑ Depends on the severity of the prediction

1.22 When should a trend become a prediction? (choose one)

- ❑ Once a parameter has exceeded a 30% percent deviation from normal
- ❑ As soon as a parameter has shown steady movement away from normal
- ❑ Once a parameter has shown steady movement away from normal for 10 seconds
- ❑ Depends on the system being monitored
- ❑ Depends on the severity and or priority class of the pending prediction

1.23 Displays with predictive information will improve my situation awareness. (circle any number from 1 to 5)

Strongly Agree				Strongly Disagree
1	2	3	4	5

1.24 I feel that predictive information would be a valuable item to include on future flight decks. (circle any number from 1 to 7)

Strongly Agree			Neutral			Strongly Disagree
1	2	3	4	5	6	7

Why? ____

____

____

Comments on Predictive Information

End of Part 1 - Predictive Information.

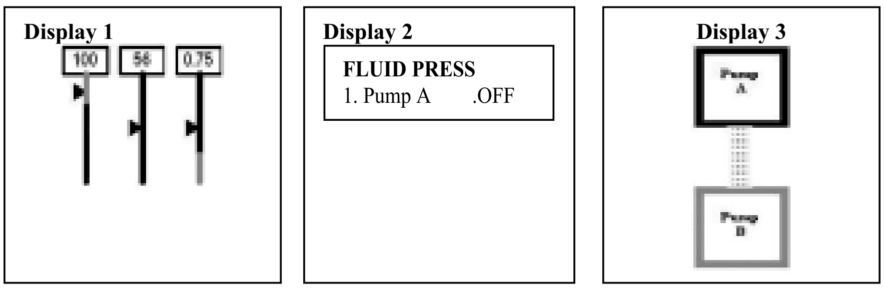
Please continue on to Part 2 — Collocation, on the next page.

Appendix B - Collocation Survey Questions

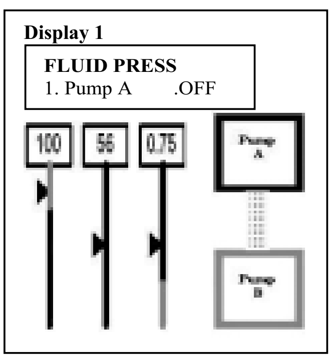
2.1 Which of the proposed Status-Alerts/Procedures-Controls combinations do you feel is the best? (choose one) (choices continued on next page)

NOTE: Example displays are NOT to scale and are NOT optimized for viewing information; they are examples created solely for this survey.

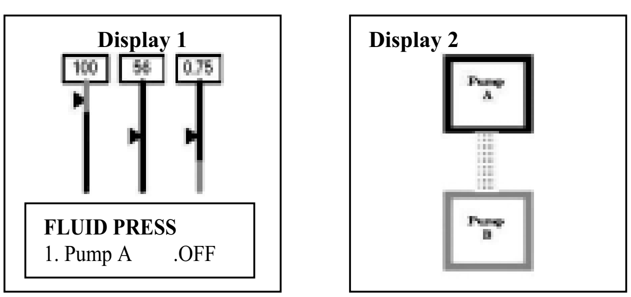
☐ Status on Display 1, Alerts/Checklists on Display 2, and controls on Display 3



☐ Status, Alerts/Checklists, and Controls all on Display 1

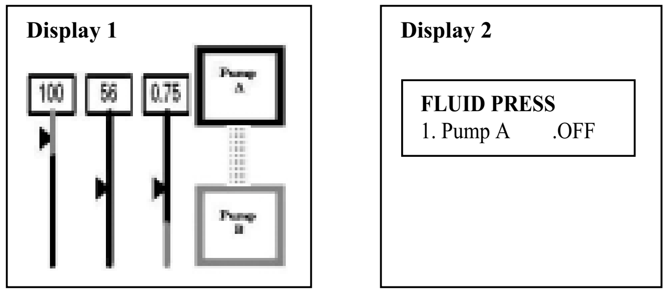


☐ Status and Alerts/Checklists on Display 1, Controls on Display 2

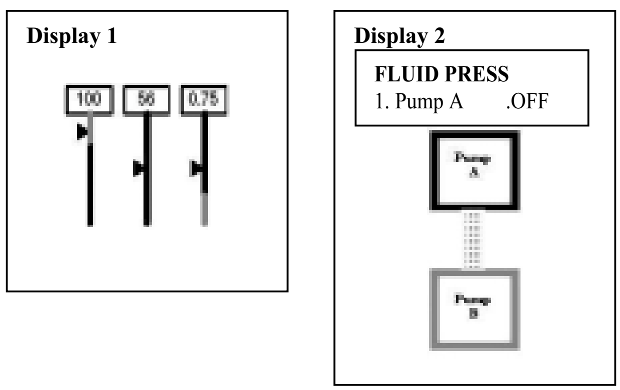


(Choices con't on next page)

❑ Status and Controls on Display 1, Alerts/Checklists on Display 2



❑ Status on Display 1, Alerts/Checklists and Controls on Display 2



2.2 When an alert has been annunciated, how should the Status-Alerts/Procedures-Controls display be navigated to the appropriate gauges/information and controls? (choose one)

❑ Automatically by the computer

❑ Manually by the pilot

2.3 During an alert, the necessary controls and or checklist items should be able to be manipulated through the Status-Alerts/Procedures-Controls display. (circle any number from 1 to 5)

Strongly Agree				Strongly Disagree
1	2	3	4	5

2.4 If a situation arises in which a malfunction affects more than one system, how should the Status/Alerts/Controls display(s) indicate that related malfunctions are occurring? (choose one)

❑ By stating inside the original alert, the alerts that occurred as a result

> **Alerts:**
> Alert A (A-1, A-2, A-3, ..)
> Alert B
> Alert C (C-1, C-2)

❑ By listing all alert(s) normally but include a reference to the original alert if applicable

> **Alerts:**
> Alert A
> Alert B^{A}
> Alert C^{A}

❑ By using a unique hierarchal system that will clearly indicate that Alert A-1 was caused by Alert A

> **Alerts:**
> 1. Alert A
>   a. Alert A-1
>   b. Alert A-2

❑ Related alerts should only be brought to the crew s attention when they are of equal or higher importance as the originating alert

❑ The system should not distinguish between originating and related alerts (i.e. current method)

2.5 What aircraft systems should have their instruments/gauges collocated with their corresponding controls? (please rank from 1 (highest priority) to 8 (lowest priority))

Engine systems ______

Hydraulic systems ______

Cabin systems ______

Aerodynamic/Control systems ______

Electrical systems ______

Avionics systems ______

Fuel systems ______

Other (please specify)________________________________ ______

2.6 I feel that the collocation of status, alerts and procedures, and controls will improve the overall functionality of the flight deck. (circle any number from 1 to 5)

Strongly Agree				Strongly Disagree
1	2	3	4	5

2.7 When dealing with an alert, would you prefer to have the necessary checklist(s) be paper or electronic? (choose one)

❑ Paper

❑ Electronic

2.8 In a situation involving an alert, the appropriate electronic checklists should be brought up automatically by the computer. (circle any number from 1 to 5)

Strongly Agree				Strongly Disagree
1	2	3	4	5

2.9 In an alert situation, automatic electronic checklists should it be brought up ______ . (choose one)

- ❑ On the status display
- ❑ On the alert display
- ❑ On the control display
- ❑ On the FMS or similar
- ❑ On a dedicated and unique checklist display

2.10 Tactile feedback from switches, dials, buttons, and toggles is important to me. (circle any number from 1 to 5)

Strongly Agree				Strongly Disagree
1	2	3	4	5

Why? ____

____

____

____

2.11 The Status-Alerts/Procedures-Controls display(s) should incorporate predictive information. (circle any number from 1 to 5)

Strongly Agree				Strongly Disagree
1	2	3	4	5

2.12 I feel that the efficient collocation of information and controls is an important item to consider when designing future flight decks. (circle any number from 1 to 7)

Strongly Agree			Neutral			Strongly Disagree
1	2	3	4	5	6	7

Why?____

____

____

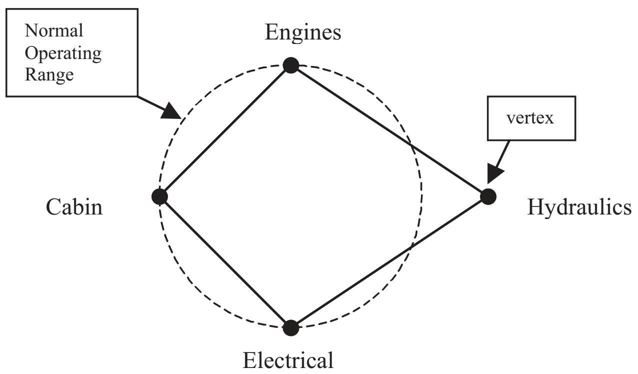
Comments on Collocation

End of Part 2 - Collocation.

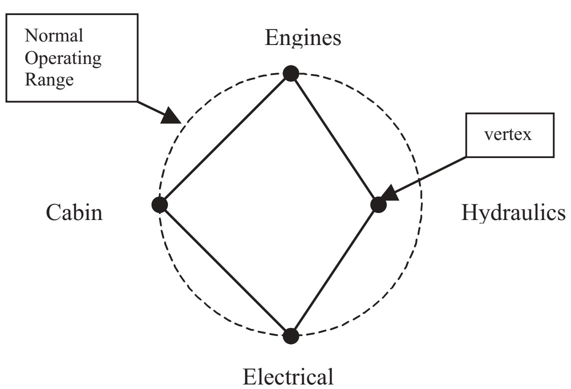
Please continue on to Part 3 — Mission Status Graphics, on the next page.

Appendix C - Mission Status Graphics Survey Questions

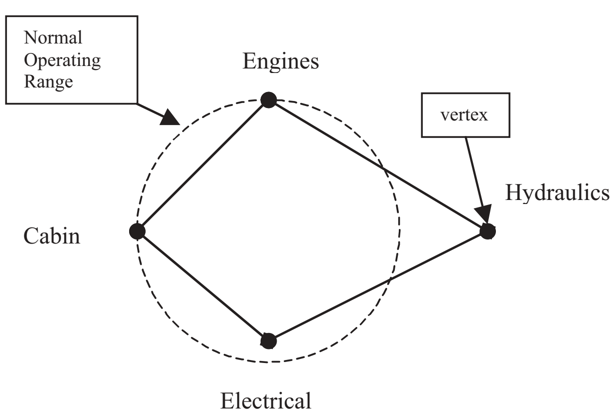
3.1 How should the Mission Status Graphics (MSG) system display indicate a parameter is out of bounds? (choose one by circling the number next to its description)



1 by advancing the vertex to outside the Normal Operating Range regardless of the parameters numerical values



2 by retreating the vertex to inside the Normal Operating Range regardless of parameters numerical values



3 by advancing and retreating the vertex according the numerical value of the affected system component (negative/decreasing = in, positive/increasing = out)

3.2 Should the MSG apex be continuous (i.e. flowing lines always in motion) or segmented (i.e. clicks in or out at a predetermined refresh rate)? (choose one)

- ❑ Continuous
- ❑ Segmented

3.3 If a parameter is out of bounds there should be (mark all that apply)

- ❑ Visual annunciation (i.e. blinking light indicates the parameter is out of bounds)
- ❑ Verbal annunciation (i.e. computer voice states the parameter that is out of bounds)
- ❑ Audible annunciation (i.e. buzzer indicates the parameter is out of bounds)
- ❑ No annunciation

3.4 Once the flight crew has been notified of a condition, how should they indicate their acknowledgement? (choose one)

- ❑ By pressing an acknowledgement button on the MSG display
- ❑ By accessing the affected system(s)
- ❑ Other (please specify)____
- ❑ They should not have to indicate their acknowledgement

3.5 In relation to typical flight deck CRT displays, what size should the MSG system display be? (circle any number from 1 to 5)

Smaller		Same		Larger
1	2	3	4	5

3.6 Current commercial aircraft cockpits present critical information in too many different locations. (circle any number from 1 to 5)

Strongly Agree				Strongly Disagree
1	2	3	4	5

3.7 Where on the instrument panel should the MSG system display be located? (choose one)

- ❑ On the center pedestal display
- ❑ On captain s displays
- ❑ On first officer s displays
- ❑ On the pilot-flying displays
- ❑ On the pilot-not-flying displays
- ❑ On both captain s and first officer s displays
- ❑ It should be able to be called up on any of the displays
- ❑ I do not feel an MSG display would be helpful
- ❑ Other (please specify)____

3.8 What capabilities would you like the MSG system to have? (choose one)

- ❑ Strictly for observation
- ❑ Observation and problem investigation
- ❑ Observation and control manipulation
- ❑ Observation, problem investigation, and control manipulation

3.9 What categories of aircraft systems would you like the MSG system to monitor? (please mark all that apply)

- ❑ Engine systems
- ❑ Hydraulic systems
- ❑ Cabin systems
- ❑ Aerodynamic/Control systems
- ❑ Electrical systems
- ❑ Avionics systems
- ❑ Fuel systems
- ❑ Other (please specify)____

3.10 How much detail should a Mission Status Graphics display have? (choose one)

- ❑ It should display the status of whole systems only (i.e. hydraulic system)
- ❑ It should display the status of the systems immediate sub-systems (i.e. hydraulic-engine driven pumps)
- ❑ It should display the status of all components of a system, regardless of system level and controllability

3.11 MSG system should incorporate predictions on its display. (circle any number from 1 to 5)

Strongly Agree				Strongly Disagree
1	2	3	4	5

3.12 On future flight decks, how much of the systems monitoring should be done by computers? (place an x anywhere on the solid line between 0% and 100%)

0%..................25%..................50%..................75%..................100%

____

3.13 The MSG system should display predictions in (choose one)

- ☐ Time intervals (i.e. alert in 6 min.)
- ☐ Percentage of flight completed (i.e. alert at 78% to destination)
- ☐ The MSG system should not display predictive information
- ☐ Other (please specify)____

3.14 The MSG system should include a problem investigation and isolation function to help the crew determine the precise cause of a malfunction. (circle any number from 1 to 5)

Strongly Agree				Strongly Disagree
1	2	3	4	5

**3.15 The Mission Status Graphics display should .
(choose one)**

- ☐ Always be visible
- ☐ Appear only when a parameter is nearing alert range
- ☐ Appear only once a parameter has reached an alert range
- ☐ Appear only when the flight crew selects it to appear

3.16 I feel that Mission Status Graphics would be a valuable item to include on future flight decks. (circle any number from 1 to 7)

Strongly Agree			Neutral			Strongly Disagree
1	2	3	4	5	6	7

Why? ____

____

____

Comments on Mission Status Graphics

End of Part 3 — Mission Status Graphics.

End of Future Focus of Flight Deck Research Survey.

Thank you for you participation in this survey.

Please mail the completed Background Questionnaire and Future Focus of Flight Deck Research Survey to:

Anthony Bartolone
NASA Langley Research Center
MS 152
Hampton, VA 23681-2199

Subject #:__________________

Appendix D

Participant Background Questionnaire

1. General Information

Full Name: ____
First, Middle, Last

Address: ____
Street and Number, or P.O. Box

____
City, State, Zip Code, and Country (if not USA)

US Citizen: Yes ❑ No ❑

Gender: Male ❑ Female ❑

Birthdate: ______________________________
Month/Day/Year

Years of Formal Education: ____________________________ (*e.g.*, high school graduate = 12)

Weight (used for weight/balance calculations): ____________

Do you wear corrective lenses when you fly? Yes ❑ No ❑

Would you like to be considered as a participant for future NASA simulator/flight experiments? Yes ❑ No ❑

2. Contact Information

Home Phone: (____) ___________ Work Phone: (____) ___________ Pager: (____)___________
Area Code Number Area Code Number Area Code Number

Email: ________________________________ How often do you check this account? _______________

****Important****

What is the best way to reach you on short term notice (2 days ahead)?

____

____

What is the best way to reach you on urgent notice (day prior to experiment)?

____

____

④ If we need to cancel on you after arriving for a test day, you will still receive compensation for that day.

Date Received:______________________

3. Flight Experience

General:

Total Hours Flying (approximate):		*notes*
Years Flying (approximate):		
Hours flown in last year:		
Hours flown in last 90 days:		
Date of last BFR or Check Flight:		
Date of last IPC (if applicable)		
Current to fly IFR:	Yes ❑ No ❑	
Hours as Pilot-in-Command:		
Hours as Second-in-Command:		
Hours as Flight Engineer:		
Hours Flight Instruction Received:		
Hours Flight Instruction Given:		
Cross Country Hours:		
Night Flying Hours:		
Simulated Instrument Flight Hours:		
Actual Instrument Flight Hours:		
Flight Simulator Hours:		
Single-Engine Land Hours:		
Multi-Engine Land Hours:		
Single-Engine Sea Hours:		
Multi-Engine Sea Hours:		
International Flight Hours:		
Rotorcraft Hours:		
Glider Hours:		
Hours in Other Aircraft Classes:		Type:
		Type:

Military Experience:

Are you currently flying military? Yes ❑ No ❑

Check those aircraft you fly/have flown in the military: Fighters ❑ Transports ❑ Rotorcraft ❑ Other _______

Years of Flying Military (approximate):___________________________________

Date of Last Military Flying Experience (approximate): _____________________

Corporate Jet Experience:

Are you currently flying corporate jets? Yes ❑ No ❑

Total Hours flying as Pilot-in-Command (approximate): _____________________

Total Hours Flying Corporate Jets:_______________________________________

Date of Last Corporate Jet Flying Experience (approximate): _________________

Commercial Experience:

Are you currently flying commercial? Yes ❑ No ❑

Total Hours flying as Pilot-in-Command (approximate): _____________________

Total Hours Flying Commercial: ____

Date of Last Commercial Flying Experience (approximate): __________________

Private/Recreational Piloting:

Do you fly for recreation?	Yes ❑	No ❑	For how many years? ____________________
Do you fly for personal/business travel?	Yes ❑	No ❑	For how many years? ____________________
Do you currently rent aircraft?	Yes ❑	No ❑	If yes, what aircraft model/type(s)__________
Do you currently own aircraft?	Yes ❑	No ❑	If yes, what aircraft model/type(s)__________
Have you previously owned aircraft?	Yes ❑	No ❑	If yes, what aircraft model/type(s)__________

Certificates/Ratings:

Do you currently hold a current and valid:

Medical Certificate?	Yes ❑	No ❑	If yes, month/year received _______________
Certificate Class: I ❑ II ❑ III ❑			
Private Pilot Certificate?	Yes ❑	No ❑	If yes, month/year received _______________
Commercial Pilot Certificate?	Yes ❑	No ❑	If yes, month/year received _______________
Airline Transport Pilot Certificate?	Yes ❑	No ❑	If yes, month/year received _______________
Certified Flight Instructor (CFI) Certificate?	Yes ❑	No ❑	If yes, month/year received _______________
Instrument Instructor (CFII) Certificate?	Yes ❑	No ❑	If yes, month/year received _______________
Multi-Engine Instructor (MEI) Certificate?	Yes ❑	No ❑	If yes, month/year received _______________
Instrument Airplane Rating?	Yes ❑	No ❑	If yes, month/year received _______________
Instrument Helicopter Rating?	Yes ❑	No ❑	If yes, month/year received _______________
Single-Engine Land Rating?	Yes ❑	No ❑	If yes, month/year received _______________
Multi-Engine Land Rating?	Yes ❑	No ❑	If yes, month/year received _______________
Single-Engine Sea Rating?	Yes ❑	No ❑	If yes, month/year received _______________
Multi-Engine Sea Rating?	Yes ❑	No ❑	If yes, month/year received _______________
Rotorcraft Rating?	Yes ❑	No ❑	If yes, month/year received _______________
Glider Rating?	Yes ❑	No ❑	If yes, month/year received _______________

Other Ratings, including Type Ratings (List ratings and month/year received):_______________________________________

Flight Experience as Employment

Do you currently derive wages directly from your piloting skills in any way? Yes ❑ No ❑

In what capacity? ____ For how long? ________________

Have you ever derived wages from your piloting skills in any way? Yes ❑ No ❑

In what capacity? ____

How long ago did you work in this capacity?________________________________ For how long? ________________

4. Specific Experience

Specific Aircraft Experience:
Please list the types of aircraft on which you have experience, *beginning with the most recently flown*.
For each aircraft, please indicate your approximate number of hours flying experience and hours of simulator experience. If you are currently type rated on this aircraft, please check the last box.
If you were an Instructor (I) or a Check Airman (CA) on any of these aircraft, please indicate by checking the appropriate column.

Aircraft Type	Hours in Type			Simulator Hours			I	CA	Currently Type Rated
	<300	300-1000	>1000	0	<50	>50			

Specific Aeronautical Experience:
Please indicate the approximate number of years of experience you have for each of the following categories:

Specific Aeronautical Experience	# Years Experience
Long-range, Over-water (Class II) Operations (2 engines)	
Long-range, Over-water (Class II) Operations (>2 engines)	
Total Multi-Engine (Captain or F/O, Military or Civil)	
Glass Cockpit (*i.e.*, EFIS/CRT or FMS)	
Turbo Jet	
Single-Engine Land	

Other Experience:
Have you ever flown with a HUD? Yes ❑ No ❑
If yes, month/year ____________ and number of hours ______________

Have you ever flown using a velocity vector display? Yes ❑ No ❑
If yes, month/year ____________ and number of hours ______________

5. Past Participation

Please list any past experiments for NASA that you have participated in. Fill-in as much as you remember.

When	Researcher	Where	Title/Description of Experiment

6. Returning the Questionnaire

All information contained herein will be kept confidential. If you have any additional information you think would be useful, please feel free to write on the back of these forms

Mail to: Regina Johns
Lockheed Martin
MS 389
NASA Langley Research Center
Hampton, VA 23681-2199

Thank you!

This information will help us notify you of NASA Langley experiments and workshops that require your expertise.

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Bartolone: Embry-Riddle Aeronautical University, Daytona Beach, Florida; Trujillo: Langley Research Center, Hampton, Virginia

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13. ABSTRACT *(Maximum 200 words)*

NASA Langley Research Center has been researching ways to improve flight crew decision aiding for systems management. Our current investigation is how to display a wide variety of aircraft parameters in ways that will improve the flight crew's situation awareness. To accomplish this, new means are being explored that will monitor the overall health of a flight and report the current status of the aircraft and forecast impending problems to the pilots. The initial step in this research was to conduct a survey addressing how current glass-cockpit commercial pilots would value a prediction of the status of critical aircraft systems. We also addressed how this new type of data ought to be conveyed and utilized. Therefore, two other items associated with predictive information were also included in the survey. The first addressed the need for system status, alerts and procedures, and system controls to be more logically grouped together, or collocated, on the flight deck. The second idea called for the survey respondents, opinions on the functionality of mission status graphics; a display methodology that groups a variety of parameters onto a single display that can instantaneously convey a complete overview of both an aircraft's system and mission health.

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