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Pilot Preferences for Information Provided and Its Format for Status, Alerts, and Controls

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Abstract

With the increased use of cathode ray tubes (CRTs) in flight decks and the computing power available, it is possible to combine status screens, alerts/procedures screens, and control screens onto a single display. This report presents the results of a survey designed to assess the perceived helpfulness and need of various pieces of information that could be included on status and control screens. The results from the survey indicate that operators want parameter ranges that change depending on the current aircraft configuration shown on bow-tie or dial displays. These displays should show the current value, normal range, alert type and range, and predictive information. Respondents wanted to see system relationships to one another for both component control and menu selection. When bringing up these various displays, this information should come up with a single button push. Finally, checklists should sense when a component has changed to the desired state.

Introduction

Currently, most flight deck displays can be categorized as either status screens, alerts/procedures screens (or paper), or control screens (on which an operator can change the state of a component; e.g., overhead panel). This arrangement is most likely a legacy from steam-gauge times when one instrument had one use. With the increased use of cathode ray tubes (CRTs) in flight decks and the associated computing power available to compute and display information, it is now possible to combine these different elements of information and control onto a single display. For older aircraft, this display may result in space and weight savings, which would translate into fuel savings and ultimately a saving of money due to a decrease in operating expenses.

Display design guidelines typically state that collocating displays will reduce crew workload (ref. 1, pp. 380–384) and reduce the complexity of the search for data (ref. 2, pp. 73–118). In particular, some guidelines state that command decision aids should be augmented with status information (ref. 3). Another general guideline is to combine stimulus and response. On the flip side, less cluttered displays mean better performance (ref. 4; ref. 5, pp. 420 and 421) and related data should be grouped and separated from unrelated data (ref. 1, pp. 235 and 236; ref. 6). In addition, another guideline states that controls should be separated from displays.

Previous research by the author indicated that all three functions (status, alerts/procedures, and controls) could be grouped together, or status and alerts/procedures could be combined while controls are presented on a separate display (refs. 7–9). Now, these displays need to be refined for these groupings rather than just taking the current display elements and combining them as was done in the authors' previous research. This amelioration will hopefully further increase the benefits of collocation. CRTs allow for the possibility of newer formats for displaying the information. A survey was conducted to determine what information pilots felt was required on the status screen, alerts/procedures screens, and control screens.

This survey measured the perceived helpfulness and need of various pieces of information that could be included on status and control screens. The survey included questions about parameter displays, component control displays, and menu systems. On parameter displays, questions encompassed traditional information commonly shown: the current value, the normal range, and the alert type and range. Newer information that might be beneficial to parameter displays included prediction of when an alert would occur (refs. 10–12), previous values (ref. 13), and displaying the numeric alert value. On component control displays, new information that could be included encompasses predictions of alerts, parameter type (i.e., pressure, temperature, quantity) that is deviating, and functional relationships. For the menu systems, operators could either bring up the parameter, alerts/procedures, and component displays separately or all three simultaneously for a particular system (e.g., hydraulic system). In addition, the menu displays could also indicate predictions and alert types. Lastly, the survey also covered preferences on how respondents preferred to complete checklists.

Survey Objectives

The first objective of this survey addressed the calculation of parameter ranges. These ranges are currently set on numeric absolute ranges; for example, the normal values are always between 0 and 90 and the alert range is always greater than 90. Another method that is now possible because of the available computing power on aircraft today is to change the ranges that depend on the aircraft settings (refs. 14 and 15). Therefore, the first objective was to determine which methods of calculating the normal and alert ranges pilots preferred.

The second objective dealt with parameter display formats and the information available on these displays. The five formats surveyed included two traditional formats seen on aircraft today—the bow-tie and the dial displays. A third format involved the Engine Monitoring and Control System (EMACS) display (refs. 14 and 15). The last two formats have not been used in aircraft and were the polar-star display (ref. 7; ref. 16, p. 111; and refs. 17–19), and the line display (ref. 16, p. 71). Respondents also indicated the information that they wanted on these displays from the following choices: current value, normal range, alert type and range, predictions, previous values, and the numeric alert range. Therefore, the second objective was to determine which formats pilots preferred on parameter displays and what information pilots wanted available on these formats.

The third objective encompassed component control. Respondents indicated whether showing the relationship of the current system to other systems was preferred and whether predictive information on the components would be helpful. Also included in this section was whether pilots thought that knowing which parameter type (i.e., pressure, temperature, or quantity) was deviating from normal was useful. Therefore, the third objective was to determine whether pilots wanted system relationship delineated, predictions, and parameter type available on component control displays.

The fourth objective involved menus to display the components. Respondents indicated whether they wanted traditional menus (in which the components are in alphabetical order) or whether they preferred a relational menu (in which the relationships between systems are shown), the type of information available on these menus—alerts and predictions, and whether one button push brought up the status, alerts/procedures, and components all at once or separately, one button push at the time. Therefore, the fourth objective was to determine pilot preferences on the menu system.

The last objective was to determine the preference pilots have on checklist completion. With increased automation, manufacturers and airlines are looking at automating checklists (ref. 20, p. 350), but with this automation comes a price: electronic checklists may "encourage flight crews *not* to conduct their own checks" (ref. 21, p. 182). This survey asked pilots about both normal and non-normal checklist completion methods.

Survey Design

Subjects

Subjects were randomly chosen from a pool of volunteers whose minimal characteristics included that they were (1) current instrument-rated flight rules (IFRs) pilots, (2) familiar with glass cockpits, and (3) familiar with electronic alerting systems. Before the survey was mailed to the volunteers, each one was contacted to ensure they were interested in completing a rather long survey. Forty pilots returned the survey from the original fifty that were sent, a return rate of 80 percent. Pilots that participated were paid a nominal fee for taking time to fill out the survey.

The average age of the subjects was 41 years, ranging from 27 to 57 years. They had an average of 8892 piloting hr, ranging from 3000 to 22500 piloting hr. The average number of piloting years was 20, with a minimum of 8 yr and a maximum of 34 yr. Thirty-six of the respondents were currently flying revenue-generating flights. Of the four that were not commercial pilots, one was a T-45 instructor for the military and the other three had been furloughed or retired recently. Their last commercial flights were 15, 16, and 18 months ago. Table 1 details the current or last glass-cockpit aircraft respondents flew.

Procedure

Each subject received a cover letter and the survey (appendix A). General directions were given at the beginning of the survey, with further descriptions specific to a section available at the beginning of each section. The sections consisted of (1) general background information, (2) calculation of parameter ranges, (3) parameter displays, (4) component control, (5) menu operation, (6) menu separation, (7) checklists, and (8) other format preferences. Within each section, subjects used a continuous, a nominal, or an ordinal scale, depending on the question. The survey provided additional room for comments and further explanation of their answers.

Measures

The data collected in this survey consisted of subjective rankings and comments. Therefore, the dependent measures were the scaling or ranking of the information requirements and the subjects' comments on their answers. Some of the scaled data were on continuous scales, while other data were nominal or ordinal. The continuous scale data were analyzed by using either a T-test or a 1-way analysis of variance (ANOVA) test, and the ordinal and nominal data were analyzed by using Chi-squared tests with equal expected values. These analyses were performed with SPSS® (ref. 22), with significance set at $p \leq 0.05$.

Continuous Data Scale

The vast majority of the continuous data consisted of asking the respondents to indicate their preferences anywhere on a scale from "Most Preferred" to "Least Preferred." See appendix A, page 33, for an example.

Ordinal and Nominal Data Scales

Most of the ordinal and nominal data consisted of three scales. See appendix A, page 40, for examples. The first scale determined information necessity by asking "[i]s this information needed?" The respondents could answer this question by replying "must have"—the information is required for the safe operation of the whole system, "nice to have"—the information may help in the safe operation of the whole system, or "not needed"—the information is not required for the safe operation of the whole system.

The second scale dealt with information availability by asking "[w]hen should this information be available?" Subjects then had a choice of the following: "always up"—the display is always present and it cannot be turned on or off, "up if alert"—the display automatically comes up if there is an alert within that system or it can be brought up at any time, "operator discretion"—the display comes up only when it is called up, or "deviation/trend"—the display automatically comes up if the value is changing or it can be brought up at any time.

The last scale was for the question "[h]ow helpful is this information?" Respondents could answer the question with "very helpful"—the information is required for the task, "helpful"—the information is nice to have for the task, or "not helpful"—the information is not really needed for the task. Subjects had to rate the helpfulness of the information while "monitoring"—observing the parameters, "diagnosing"—figuring out what is going on, and "controlling"—managing the configuration of the system.

Comments

Comments were grouped by the main points elucidated by the respondents. The results section below will indicate the majority points expounded by the subjects. Appendix B provides the complete details of the subjects' comments for each question and the number of subjects that expressed that point.

Results

Calculation of Parameter Ranges

This first section of the survey inquired about two aspects of calculating parameter ranges. The first question compared absolute value, where "[t]he ranges are always the same for a particular parameter no matter what the configuration of the rest of the system is," to relative value, where "[t]he ranges depend on the configuration of the rest of the system" (see appendix A, p. 33).

Statistically, respondents preferred relative values over absolute values ($T(78) = -3.22$, $p \leq 0.01$); in other words, they favored that the ranges change depending on the aircraft configuration rather than by having set ranges as is currently done (see figs. 1 and 2). On an absolute preference scale, 2 respondents did not have a favorite, 28 preferred relative ranges, and the remaining 10 wanted absolute parameter ranges.

Respondents commented that they preferred the relative values because this concept was more intuitive (16 respondents) and that the relative values would take into consideration aircraft configuration changes (7 respondents). Seven respondents also said that relative values provided more information than absolute values. The reason most often given for picking absolute values was to "keep it simple" (4 respondents). See appendix B, table B1, for a complete listing of respondent comments.

The second question inquired about calculating parameter values and alert ranges. Value, where "[t]he ranges are numerical," was compared to percentage, where "[t]he ranges are based on a percentage from normal" (see appendix A, p. 34).

Statistically, subjects did not have a preference (a rating of 33 for percentage versus a rating of 27 for value out of a possible 100) (see fig. 3). Five respondents did not have a favorite, 16 preferred value, and the remaining 19 wanted percentage.

Respondents commented that their predilection for value was "wanting to have a real number" (8 respondents). The most often cited reason for wanting percentages was that it was more intuitive (8 respondents). See appendix B, table B2, for a complete listing of respondent comments.

Parameter Displays

This section of the survey garnered respondent preferences about parameter display formats and the information available in these formats. The parameter display formats each respondent considered were the (1) bow-tie, (2) dial, (3) polar-star, (4) EMACS, and (5) line display (see appendix A, p. 36). The information available in each of these formats was (1) parameter status information—"information typically available on the display; that is, current value, normal range, and alert type and range"; (2) current numeric parameter value (current numeric value)—"the digital readout of the parameter's value at the current time"; (3) parameter prediction of time to an alert (predictive information)—"when the parameter is expected to reach an alert value based on its current trend"; (4) parameter historical value (historical information)—"past value(s) of the parameter if the past and current values are different; and (5) parameter numerical alert value (alert value)—"an indication of the numerical value the parameter must reach in order to be in an alert range" (see appendix A, pp. 35–42).

Display Format Preference

Statistically, respondents overwhelmingly preferred the dial and bow-tie displays ($F(4,199) = 100.02$, $p \leq 0.01$) (see figs. 4 and 5). The line and EMACS parameter displays were the next preferred formats, with the polar-star display as the least preferred format, (see fig. 4). Respondents commented that the dial and bow-tie displays were the "most comfortable [because these] two formats are used in aircraft today" (23 respondents). See appendix B, table B3, for a complete list of respondent comments.

Available Information

Statistically, a difference existed among the types of information respondents wanted on the parameter displays ($F(3,155) = 39.38$, $p \leq 0.01$). Respondents overwhelmingly preferred to have the current value displayed. Although not coveted as much as the current value, respondents also wanted predictive information, which was significantly different from current value and alert value. The least sought after piece of information was the alert value (see figs. 6 and 7).

Current value and current numeric value. Statistically, respondents felt that graphically displaying the current value was a "must have" or a "nice to have" ($\chi^2(2) = 25.55$, $p \leq 0.01$) (see table 2) and they preferred it to be "always up" or at least "up if alert" ($\chi^2(3) = 29.40$, $p \leq 0.01$) (see table 3). They also thought that digitally denoting the current value was "nice to have" to a "must have" ($\chi^2(2) = 15.05$, $p \leq 0.01$) (see table 2), and they wanted it to be "always up" or at least "up if alert" ($\chi^2(3) = 17.80$, $p \leq 0.01$) (see table 3). Subjects identified that current value and current numeric value were "very helpful" or "helpful" for monitoring ($\chi^2(2) = 26.60$, $p \leq 0.01$) and diagnosing ($\chi^2(2) = 32.15$, $p \leq 0.01$) system state (see tables 4 and 5, respectively), and for controlling systems ($\chi^2(2) = 14.45$, $p \leq 0.01$) (see table 6).

Respondents commented that the current value and current numeric value were helpful in knowing the current state of the system (16 and 11 respondents, respectively), that it showed trends (8 and 2 respondents, respectively), and that it was easy to read (4 and 6 respondents, respectively) when they are monitoring the parameters. The current value for diagnosing was perceived as good for seeing trends (11 respondents) and seeing how much a system is deviating from normal (11 respondents). The current numeric value for diagnosing illustrated the severity of a deviation (15 respondents). As for control, most said that the current value was good for feedback (14 respondents), early detection (6 respondents), and precise control (6 respondents), whereas the current numeric value indicated the effectiveness of corrective action (9 respondents), and it could be used to help keep the parameter out of the alert range (4 respondents) and to fine-tune the controls (4 respondents). See appendix B, table B4, for a complete listing of respondent comments.

Normal range. Statistically, respondents rated the normal range as a "must have" to "nice to have" ($\chi^2(2) = 21.65$, $p \leq 0.01$) (see table 2). Supporting this preference, subjects wanted its availability as "always up" ($\chi^2(3) = 40.40$, $p \leq 0.01$) (see table 3). They reported that the normal range was "very helpful" to "helpful" for monitoring system state ($\chi^2(2) = 30.65$, $p \leq 0.01$) (see table 4). For diagnosing system state and controlling systems, the normal range on the parameter displays was also "very helpful" to "helpful" ($\chi^2(2) = 17.45$, $p \leq 0.01$ and $\chi^2(2) = 12.95$, $p \leq 0.01$, respectively) (see tables 5 and 6).

Respondents commented that the normal range for monitoring systems helped with determining whether a system was normal (15 respondents) and with seeing if a trend was developing (10 respondents). Trend information that the normal range supplied was also helpful in diagnosing systems (11 respondents). Other aspects of the normal range that were helpful in diagnosing systems were seeing if a parameter was within the normal range (9 respondents) and making comparisons (7 respondents). For controlling systems, most felt that the normal range helped in determining whether corrective actions were successful or for feedback (15 respondents). See appendix B, table B5, for a complete listing of respondent comments.

Predictive information. Statistically, respondents felt that predictive information was "nice to have" ($\chi^2(2) = 326.60$, $p \leq 0.01$) (see table 2) and that it should be shown on the parameter display if the parameter was in an alert range ("up if alert") or if there was a "deviation/trend" ($\chi^2(3) = 24.60$, $p \leq 0.01$) (see table 3).

When asked "[w]hat should the alert class of the prediction be" (see appendix A, p. 43), they felt that predictive information should either be an "advisory" or "match the alert category" it is deviating towards (i.e., predictive caution alert if the alert the parameter is nearing is a caution) ($\chi^2(4) = 47.79$, $p \leq 0.01$) (see table 7). Respondents commented that they preferred it to be the same alert class as the range it is deviating towards because it would maintain an industry standard (9 respondents), while those that wanted the predictive information to be advisory said that it was because something *may* happen (15 respondents). See appendix B, table B6, for a complete listing of respondent comments.

Statistically, subjects designated that predictive information was either "helpful" or "not helpful" for diagnosing system state ($\chi^2(2) = 13.40$, $p \leq 0.01$); but it was either "helpful" or "very helpful" for controlling systems ($\chi^2(2) = 13.40$, $p \leq 0.01$) (see tables 4–6). Respondents commented that predictive information helped in monitoring systems because they could see how long it would take until a parameter would exceed its limits (9 respondents) and they could see trends (7 respondents). As for diagnosing system problems, respondents liked the trend aspect of the predictive information (14 respondents). They also liked the possible ability to prevent an alert (10 respondents). Finally, they commented on the ability to see whether corrective action was successful (9 respondents) with the predictive information in controlling tasks. See appendix B, table B7, for a complete listing of respondent comments.

Subjects also reported that they would like the prediction to be approximately 16 percent accurate on average (i.e., a prediction of 10 m means the value will be reached between 8 m 24 s and 11 m 36 s) (see fig. 8). Respondents commented that they were concerned about making sure there were few false alarms (11 respondents). They also reported that they would use the information for preparation and planning (9 respondents) and for preventing alerts (6 respondents). See appendix B, table B8, for a complete listing of respondent comments.

Historical information. Statistically, respondents felt that historical information was either "nice to have" or "not needed" ($\chi^2(2) = 17.23$, $p \leq 0.01$) (see table 2). Backing up this response, they felt that the information should primarily be brought up at "operator discretion," although when there is a "deviation/trend" or alert ("up if alert"), this information should be present ($\chi^2(3) = 25.92$, $p \leq 0.01$) (see table 3). They also indicated that historical information was either "helpful" or "not helpful" for monitoring system state ($\chi^2(2) = 9.85$, $p \leq 0.01$) (see table 4) and for controlling systems ($\chi^2(2) = 9.69$, $p \leq 0.02$) (see table 6), although they did respond that it would be "helpful" for diagnosing system state ($\chi^2(2) = 19.54$, $p \leq 0.01$) (see table 5).

Respondents commented that using historical information for system monitoring was good for seeing trends (15 respondents). It is also good for seeing trends when making a diagnosis (16 respondents). As for controlling systems, respondents liked historical information because they could observe whether the corrective action was working (6 respondents). There was no real agreement on how far back the history should be, but the reason given most often was to see trends (11 respondents). See appendix B, tables B9 and B10, for a complete list of respondent comments.

Alert numerical value and alert type and range. Statistically, respondents felt that the alert type and range were a "must have" and to a lesser degree "nice to have" ($\chi^2(2) = 33.65$, $p \leq 0.01$), but the actual numerical value was either "nice to have" or "not needed" ($\chi^2(2) = 15.05$, $p \leq 0.01$) (see table 2). They also felt that the alert type and range should be available when a parameter reached an alert range ("up if alert") ($\chi^2(3) = 33.20$, $p \leq 0.01$) and that the numerical alert value should be at the "operator['s] discretion" or "up if alert" ($\chi^2(3) = 18.21$, $p \leq 0.01$) (see table 3). For monitoring and diagnosing system state and controlling systems, the alert type and range on the parameter displays were either “very helpful” or “helpful” ($\chi^2(2) = 12.35$, $p \leq 0.01$; $\chi^2(2) = 10.85$, $p \leq 0.02$; $\chi^2(2) = 13.55$, $p \leq 0.01$) (see tables 4–6). The actual numerical value was either “not helpful” or “helpful” for monitoring and diagnosing system state and controlling systems ($\chi^2(2) = 21.35$, $p \leq 0.01$; $\chi^2(2) = 19.85$, $p \leq 0.01$; $\chi^2(2) = 19.85$, $p \leq 0.01$) (see tables 4–6).

Respondents commented that alert information for monitoring is useful because it provides trend information (18 respondents). For diagnosing, respondents reported that they use this information primarily to help with the anomaly (6 respondents for “helps,” 6 respondents for “seeing abnormalities,” and 6 respondents for “may indicate cause or action required”). For controlling, subjects associated alert information with actions—determining (8 respondents), indicating cause or action required (4 respondents), and seeing if the action worked (6 respondents). See appendix B, table B11, for a complete list of respondent comments.

Component Control

This section of the survey encompassed the display elements of component control displays. The component control display formats each respondent considered were whether to show (1) “components only” or “components and other systems,” (2) prediction of time to an alert, and (3) parameter type (see appendix A, pp. 51–59).

Statistically, respondents preferred to have “components and other systems” shown on the controls display over “components only” ($T(78) = -2.04$, $p \leq 0.05$) (see figs. 9 and 10). Of the 40 respondents, 27 rated components with other systems higher than just having the components, 11 preferred just the components, and 2 did not have a preference.

Respondents commented that wanting “components and other systems” let them see how the components were related to those other systems (18 respondents). Respondents that wanted the “components only” explained that they just wanted what they were interested in (5 respondents) and that it was less cluttered (4 respondents). See appendix B, table B12, for a complete list of respondent comments.

Statistically, respondents had an inclination for bringing up system information and parameter type at “operator discretion” or have it come “up if alert” ($\chi^2(3) = 6.05$, $p \leq 0.05$; $\chi^2(3) = 12.59$, $p \leq 0.01$) but the predictive information should be “up if alert,” present for a “deviation/trend,” or displayed at the “operator discretion” ($\chi^2(3) = 10.74$, $p \leq 0.02$) (see table 8). Predictive information and parameter type on the component control were either “nice to have” or “not needed” ($\chi^2(2) = 24.16$, $p \leq 0.01$; $\chi^2(2) = 7.55$, $p \leq 0.03$) (see table 9). The component information was either “very helpful” or “helpful” in diagnosing an event ($\chi^2(2) = 10.05$, $p \leq 0.01$) (see table 10) and controlling system state ($\chi^2(2) = 21.46$, $p \leq 0.01$) (see table 11). Predictive information was “helpful” for monitoring system state ($\chi^2(2) = 8.26$, $p \leq 0.02$) (see table 12) and “helpful” for controlling a system ($\chi^2(2) = 11.40$, $p \leq 0.01$) (see table 11). Parameter type was either “helpful” or “not helpful” for controlling a system ($\chi^2(2) = 7.00$, $p \leq 0.03$) (see table 11).

Respondents commented that, for monitoring, the parameter type was helpful in knowing the current status (9 respondents) and was easy to read (5 respondents); predictive information was good for showing trends (9 respondents) and knowing the system status with its malfunctions at a glance (12 respondents). The trend aspect of the predictive information was also important for diagnosing (6 respondents), along with the predictive capability of letting the operator know when a component would fail (5 respondents). For the parameter type in diagnosing, knowing the anomaly (7 respondents) and the current status (6 respondents) were the most important. As for controlling, the parameter type helped operators determine what action to take (3 respondents); predictive information helped operators figure out actions to take (7 respondents) and let them prevent alerts (6 respondents), and see how effective their actions were (7 respondents). See appendix B, table B13, for a complete listing of respondent comments.

Menu Operation

These two sections of the survey asked for preferences about the menu system that would bring up components. The menu system display formats each respondent considered were whether to show (1) a traditional "menu" or a "relational" menu; (2) alert type; and (3) prediction of time to an alert, and whether to bring up status, alerts/procedures, and control separately or together (i.e., all at once) (see appendix A, pp. 60–70).

Statistically, respondents had a preference for a relational menu system ($T(74) = -2.91$, $p \leq 0.01$) (see figs. 11 and 12) that brought up parameter displays, alerts/procedures, and control screens all at once ($T(74) = 3.58$, $p \leq 0.01$) (see figs. 13 and 14), with alert information available on the menu ($T(74) = 4.33$, $p \leq 0.01$) (see figs. 15 and 16). Thirty of the respondents preferred the relational menu while 8 preferred the separate menu system (2 respondents had no preference). Twenty-seven respondents wanted to bring up everything together while 11 wanted to bring up everything separately (2 were missing). Lastly, 28 respondents wanted the type of alert information over the predictive information; only 8 preferred the predictive information and 4 respondents had no preference.

Respondents commented that the relational menu system showed the relationships between components (21 respondents). The most often cited reason for preferring the menu was that it was easier to understand (3 respondents). Bringing everything up at once allowed operators to obtain the whole picture (13 respondents) and one button was easier (14 respondents), while bringing up everything separately had the benefit of being simpler (2 respondents) and more precise (4 respondents). Alerts were preferred because they gave important and straightforward information (12 respondents). Respondents who preferred the predictive information said it was because it showed the time to an alert (2 respondents) and it could be used to prevent an alert (2 respondents). See appendix B, tables B14–B16, for a complete list of respondent comments.

Statistically, alert type was either a "must have" or "nice to have" ($\chi^2(2) = 16.16$, $p \leq 0.01$), while predictive information was "nice to have" to "not needed" ($\chi^2(2) = 13.63$, $p \leq 0.01$) (see table 13). Alert type should be "up if alert" ($\chi^2(1) = 20.63$, $p \leq 0.01$) and predictive information should be available at "operator discretion" or with a "deviation/trend" ($\chi^2(2) = 10.17$, $p \leq 0.01$) (see table 14). Alert information is either "very helpful" or "helpful" for monitoring ($\chi^2(2) = 13.00$, $p \leq 0.01$) (see table 15), diagnosing systems ($\chi^2(2) = 8.90$, $p \leq 0.02$) (see table 16), and controlling systems ($\chi^2(2) = 13.63$, $p \leq 0.01$) (see table 17). Predictive information is either "helpful" or "not helpful" for diagnosing ($\chi^2(2) = 7.32$, $p \leq 0.03$) and controlling systems ($\chi^2(2) = 7.32$, $p \leq 0.03$) (see tables 16 and 17).

Respondents commented that the type of alert was good for knowing the system status at a glance when monitoring (16 respondents) and that predictive information helped in knowing when a component would fail when monitoring systems (7 respondents). For diagnosing, the alert information told operators the relationship of the problem to the system (10 respondents) and helped them prioritize (6 respondents); predictive information primarily let operators know of a problem (7 respondents). The alert type helped operators take the appropriate actions (9 respondents) when controlling a system; predictive information helped operators prevent alerts (4 respondents), evaluate corrective actions (4 respondents), and forecast future actions (3 respondents) when controlling a system. See appendix B, table B17, for a complete list of respondent comments.

Checklists

This section of the survey encompassed normal and non-normal checklist completion. The method of checklist completion each respondent considered was (1) "full manual check off" (manual)—the operator must change the component to the desired state and check off the corresponding item on the checklist as being accomplished, (2) "sensed check off" (sensed)—the operator must change the component to the desired state and the checklist will automatically check off that item once it has sensed it as being accomplished, (3) "check off on checklist and item automatically changed to appropriate state" (checkoff)—the operator checks off the item on the checklist and the components will be automatically changed to the state specified by the checklist, (4) "automatically done after asking" (ask)—the checklist is accomplished by having the components change automatically to the state specified by the checklist after asking for the operator's permission, and (5) "automatically done without asking" (automatic)—the checklist is accomplished by having the components changed automatically to the state specified by the checklist without asking the operator (see appendix A, pp. 72 and 73).

Statistically, respondents preferred a "sensed check off" overall and disliked the "automatically done without asking" checklist the most ($F(4) = 59.31$, $p \leq 0.01$) (see figs. 17 and 18). In between those two extremes, "full manual check off" was significantly different from "automatically done after asking" but "check off on checklist and item automatically changed to appropriate state" was not statistically different from those choices.

Respondents commented that operators wanted to maintain control for both normal and non-normal checklists (15 respondents for both) and maintain situation awareness (9 respondents for both). See appendix B, table B18, for a complete list of respondent comments.

Discussion

To determine what information current IFR pilots familiar with glass cockpits and electronic alerting systems felt were required on the status screen and control screens, surveyors asked their opinions on various types of information to incorporate. The previous results garnered from this survey indicate excellent starting points for designing collocated displays that either combine status, alerts, procedures, and controls onto a single display or combine status, alerts, and procedures onto a single display with controls on a separate screen.

Status Displays

The objectives related to the status displays were to determine (1) which formats (bow-tie, dial, EMACS, polar-star, and line displays) pilots preferred on parameter displays; (2) what information pilots wanted available on these formats; and (3) which methods of calculating the normal and alert ranges (absolute versus relative value and value versus percentage) pilots preferred.

Respondents preferred a bow-tie or dial display showing relative values. The bow-tie and dial displays were overwhelmingly preferred (by a ratio of 2:1), most likely because they were familiar to the respondents. Another reason for their high ratings might be because these two displays adhere to the principle of having the pointer move against a fixed scale, which is easier to read (ref. 1, p. 118).

The subjects also wanted relative values; that is, they wanted the normal and alert ranges to change depending on the aircraft configuration. Relative values should decrease mental workload because the system would be taking into consideration aircraft configuration rather than having the pilot decide whether a parameter is too high or too low, depending on the conditions. They did not have a preference on whether to display these values as actual numbers or as percentages.

On the displays themselves, respondents wanted the current value, current numeric value, normal range, and alert type and range to be displayed. Respondents reported that these values were a "must have" to a "nice to have," that they should be "always up" or "up if alert," and that this information was "very helpful" to "helpful" for monitoring, diagnosing, and controlling systems. This information is currently available on most status displays in flight decks today.

Respondents would also like predictive information ("nice to have" and it should be "up if alert" or when there is a "deviation/trend" because the information is "helpful" for monitoring, diagnosing, and controlling systems). This preference is not surprising when considering the number of comments respondents made about the usefulness of trend information (trend was mentioned in approximately 20 percent of the comments). The predictive information is just a processed form of the trend information many operators use to stay ahead of the aircraft. If predictive information is not available, historical information might be an acceptable alternative (respondents said it was "nice to have" to "not needed" because the information is "helpful" to "not helpful" for monitoring, diagnosing, and controlling systems); but operators would have to make the predictions themselves based on the historical information, which would add to the mental workload. The alert category of the predictive information should be an advisory since an alert range actually has not been reached yet. This categorization also abides by the definition of an advisory alert (ref. 23, pp. 27–32).

Component Control

The objectives for component control were to determine whether pilots wanted system relationship delineated and predictions and parameter type available on component displays.

Respondents want to see other systems displayed with the components of a particular system to give operators the ability to see how other systems affect the currently displayed system. It will also ensure that the operators' internal representation of the system matches the physical system (ref. 2, p. 179). This compatibility will help reduce knowledge base errors (ref. 24, pp. 86–95).

Respondents had no real preference about displaying parameter type or predictive information on the controls display. This information was only "helpful" to "not helpful" for controlling the system. The preference is to have it on the status displays and not to duplicate the information on the component controls, but duplication will not be a problem when combining all three functions on one screen; however, some type of duplication may prove beneficial when the functions are split up.

Menus

The objectives involving menus were to determine pilot preferences about traditional menus versus relational menus, the type of information available on these menus, and whether one button push brought up the status, alerts/procedures, and components all at once or if they were brought up separately through additional button pushes.

The results suggest that respondents want a relational layout of a menu so that they can see how the systems are interrelated. This preference is similar to subjects wanting to see other systems displayed with the components of a particular system for component control. They also wanted to bring up the status information, alerts and procedures, and controls for a system with a single button push. The highest alert category should also be shown on the button (a "must have" to "nice to have" and the information is "very helpful" to "helpful" for monitoring, diagnosing, and controlling systems) rather than predictive information, which is "nice to have" to "not needed" and "helpful" to "not helpful" for diagnosing and controlling systems. The alert category will help focus an operator's attention on the non-normal system.

Checklists

The objective involving checklists encompassed the method by which normal and non-normal checklists are completed.

Respondents wanted checklists that can sense the status of an item for both normal and non-normal checklists. This option is already familiar to some pilots, such as those who fly the Boeing 777 (refs. 25 and 26), and it affords them control over the checklist. This type of automation also follows the guidelines defined by Chandra and Mangold (ref. 27, pp. 67–76).

Concluding Remarks

Currently, most of the displays on the flight deck can be categorized as either status screens, alerts/procedures screens, or control screens (on which an operator can change the state of a component). With the advent and use of cathode ray tubes (CRTs) in flight decks and the associated computing power available to compute and display information, it is now possible to combine these different elements of information and control on a single display.

This survey assessed the perceived helpfulness and need of various pieces of information to include on status and control screens. The survey included questions about parameter displays, component control displays, and menu systems.

The results from the survey indicate that current instrument-rated flight rules (IFRs) pilots familiar with glass cockpits and electronic alerting systems want parameter ranges that change depending on the current aircraft configuration shown on bow-tie or dial displays. These displays should show the current value, normal range, alert type and range, and predictive information. This predictive information should be advisory in nature. Respondents also wanted to see how systems are related to one another for both the component control and on the menu selection. When bringing up the status displays, alerts and procedures, and controls, respondents want this information to come up with a single button push. Finally, operators want checklists to sense when a component has changed to the desired state.

Previous research performed by the author indicated that all three functions could be grouped together, or status and alerts/procedures could be grouped together while controls are presented on a separate display (refs. 7–9). Now, these displays can be refined for these groupings rather than just taking the current display elements and combining them, as was done in the previous research. These results will help advance the displays designed for the collocation research.

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Table 1. Respondents' Current or Last Glass-Cockpit Aircraft

Aircraft family	Number of respondents
Airbus A320	9
Boeing 737	8
Boeing 747	4
Boeing 757/767	8
Boeing 777	1
Boeing T-45	1
Bombardier CRJ-700	1
Cessna Citation	2
Dassault Falcon 900	1
Embraer 145	3
McDonnell Douglas DC-8	1
McDonnell Douglas MD-11	1

Table 2. Need for Information on Parameter Display

Information	Need for information		
	Must have	Nice to have	Not needed
Current value	27	12	1
Current numeric value	14	23	3
Normal range	25	14	1
Predictive information	2	30	8
Historical information missing = 1	1	17	21
Alert type and range	30	9	1
Alert value	2	21	17

Table 3. Availability of Information on Parameter Display

Information	Information availability			
	Always up	Up if alert	Operator discretion	Deviation/ trend
Current value	24	9	6	1
Current numeric value	20	12	5	3
Normal range	27	5	7	1
Predictive information	0	21	6	13
Historical information missing = 1	0	7	22	10
Alert type and range	9	25	1	5
Alert value missing = 2	5	19	12	2

Table 4. Helpfulness of Parameter Information for Monitoring

Information	Monitoring		
	Very helpful	Helpful	Not helpful
Current value	28	10	2
Current numeric value	20	16	4
Normal range	29	10	1
Predictive information missing = 1	11	18	10
Historical information missing = 1	5	13	21
Alert type and range	23	12	5
Alert value	8	8	27

Table 5. Helpfulness of Parameter Information for Diagnosis

Information	Diagnosis		
	Very helpful	Helpful	Not helpful
Current value	29	11	0
Current numeric value	20	16	4
Normal range	21	18	1
Predictive information	6	24	10
Historical information missing = 1	6	26	7
Alert type and range	22	13	5
Alert value	2	13	25

Table 6. Helpfulness of Parameter Information for Controlling

Information	Controlling		
	Very helpful	Helpful	Not helpful
Current value	19	19	2
Current numeric value	16	20	4
Normal range	21	16	3
Predictive information	10	24	6
Historical information missing = 1	4	16	19
Alert type and range	23	13	4
Alert value	2	13	25

Table 7. Alert Class Wanted for Predictive Information

Alert class	Number missing = 2
None	1
Advisory	19
Match alert category	17
1 new category	0
3 new alert categories Akin to alert categories	1

Table 8. Availability of Information on Component Control Display

Information	Information availability			
	Always up	Up if alert	Operator discretion	Deviation/ trend
Components	7	12	20	1
Predictive information missing = 1	2	16	9	12
Parameter type missing = 1	7	11	18	3

Table 9. Need for Information on Component Control Display

Information	Need for information		
	Must have	Nice to have	Not needed
Components	na	na	na
Predictive information missing = 1	1	26	12
Parameter type	7	21	12

na = not applicable.

Table 10. Helpfulness of Component Information for Diagnosis

Information	Diagnosis		
	Very helpful	Helpful	Not helpful
Components missing = 2	20	15	3
Predictive information	7	19	14
Parameter type	13	18	9

Table 11. Helpfulness of Component Information for Control

Information	Controlling		
	Very helpful	Helpful	Not helpful
Components missing = 1	13	25	1
Predictive Information missing = 1	7	24	8
Parameter type	6	17	17

Table 12. Helpfulness of Component Information for Monitoring

Information	Monitoring		
	Very helpful	Helpful	Not helpful
Components missing = 1	11	15	13
Predictive information	9	22	9
Parameter type missing = 1	13	15	11

Table 13. Need for Information on Menu Selection

Information	Need for information		
	Must have	Nice to have	Not needed
Alert type	21	18	1
Predictive information	2	20	18

Table 14. Availability of Information on Menu Selection

Information	Information availability			
	Always up	Up if alert	Operator discretion	Deviation/ trend
Alert type	1	34	5	na
Predictive information missing = 2	3	na	18	17

na = not applicable.

Table 15. Helpfulness of Menu Information for Monitoring

Information	Monitoring		
	Very helpful	Helpful	Not helpful
Alert type	21	16	3
Predictive value	8	19	13

Table 16. Helpfulness of Menu Information for Diagnosis

Information	Diagnosis		
	Very helpful	Helpful	Not helpful
Alert type	18	18	4
Predictive value	5	20	15

Table 17. Helpfulness of Menu Information for Control

Information	Controlling		
	Very helpful	Helpful	Not helpful
Alert type	10	25	5
Predictive value	5	16	19

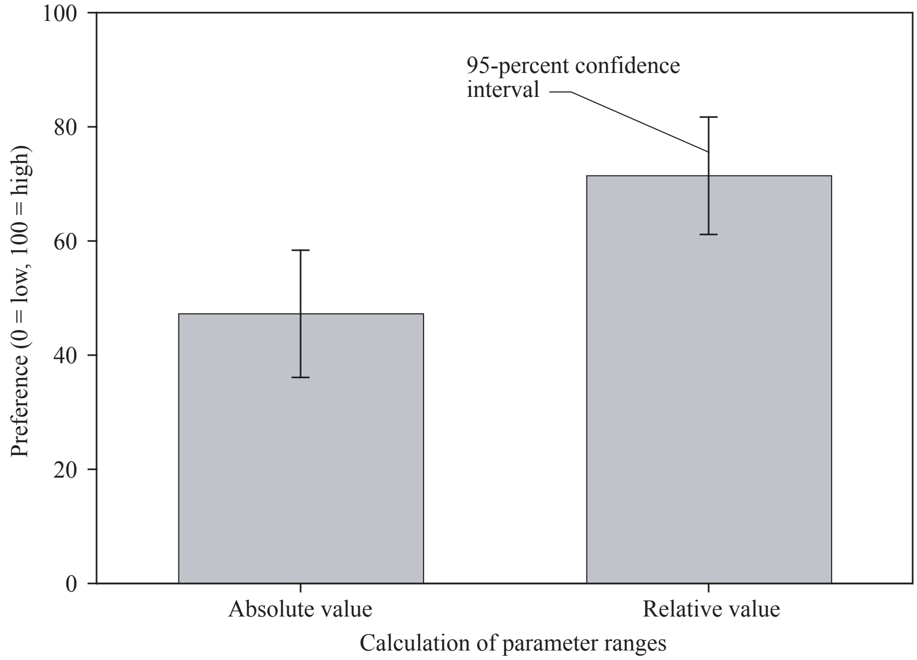


Figure 1. Calculation of parameter range preferences based on absolute and relative values.

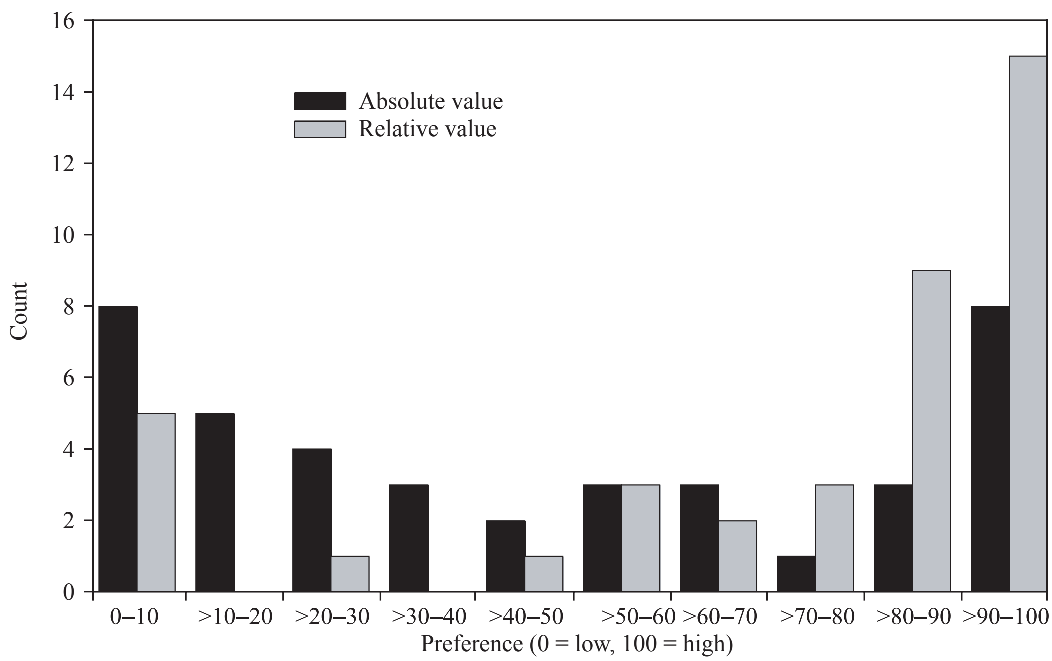


Figure 2. Count of parameter range preferences based on absolute and relative values.

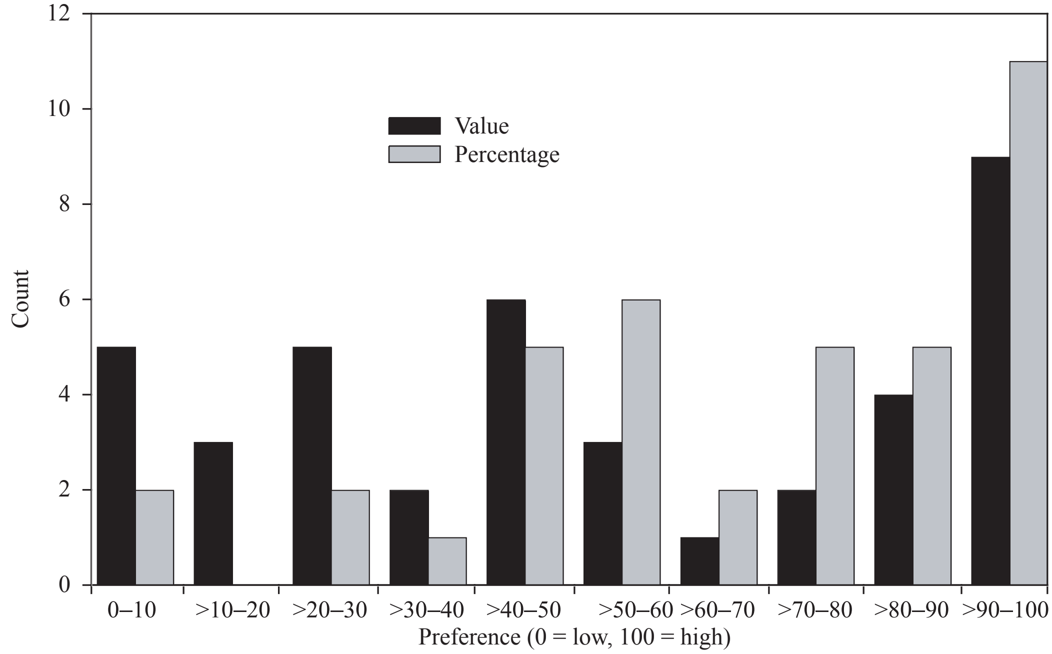


Figure 3. Count of parameter range preferences based on value and percentage.

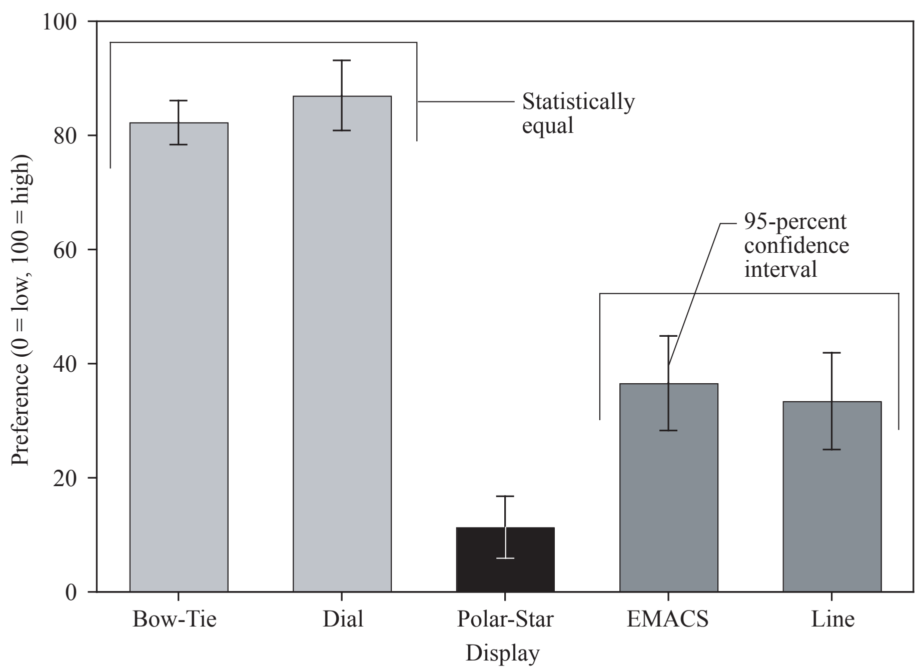


Figure 4. Parameter display format preference.

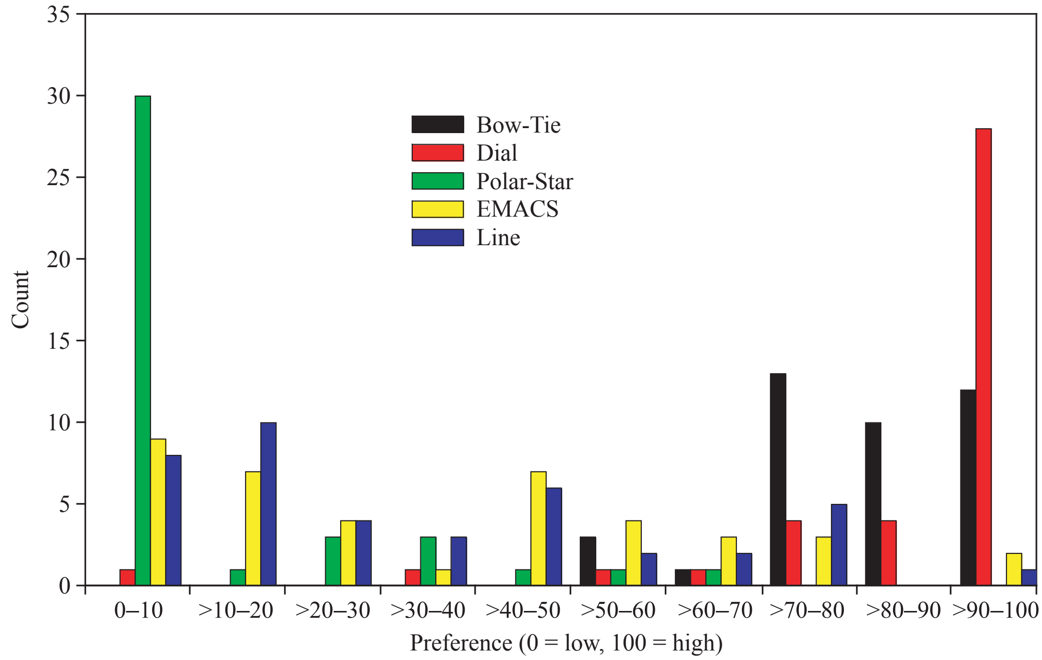


Figure 5. Count of parameter display format preferences.

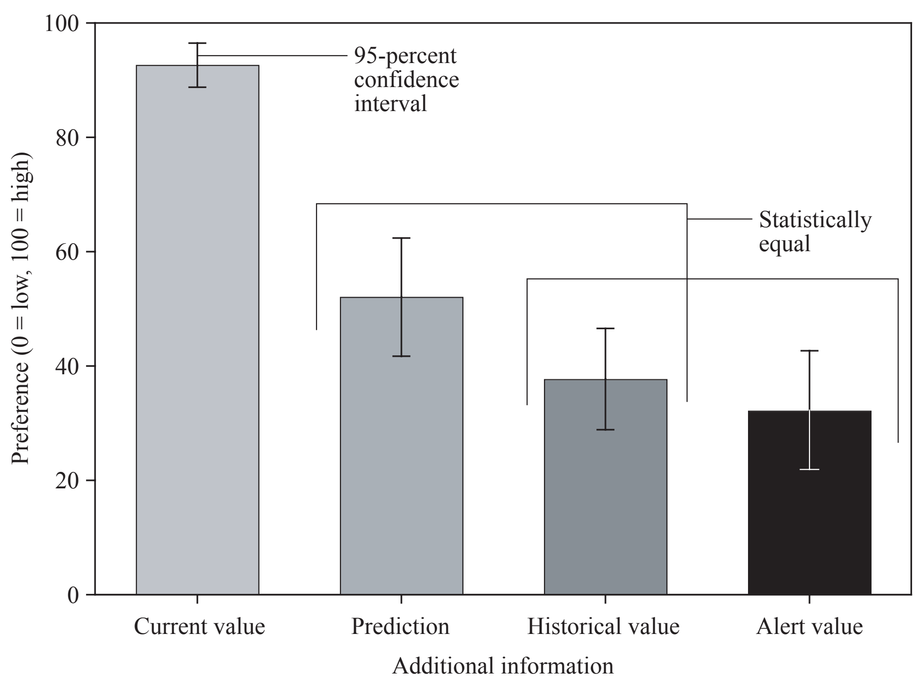


Figure 6. Additional information wanted on parameter displays.

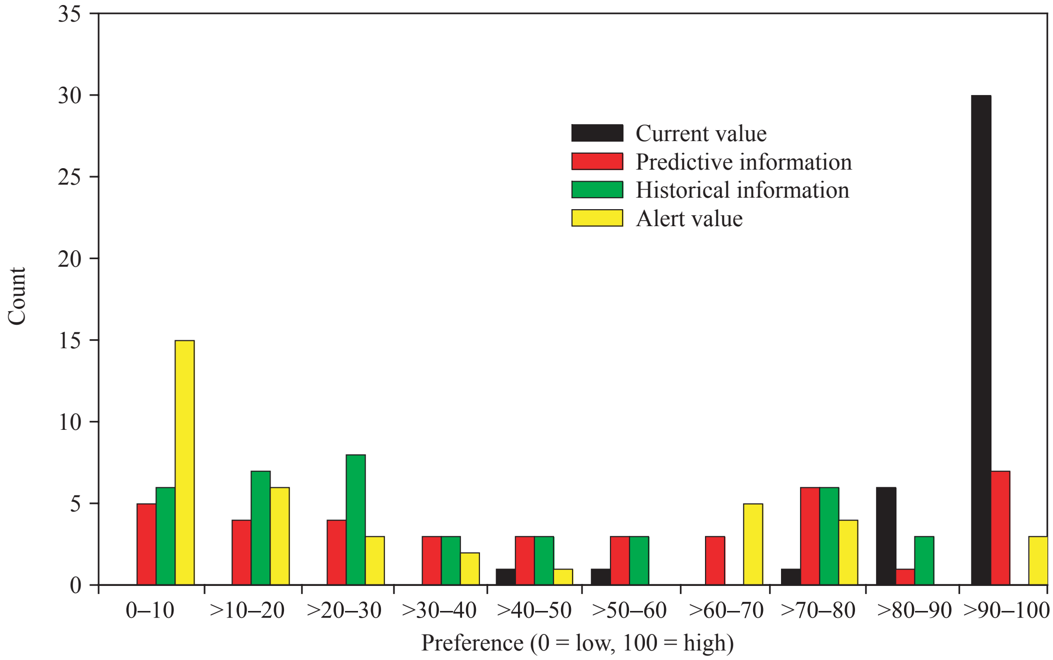


Figure 7. Count of additional information wanted on parameter displays.

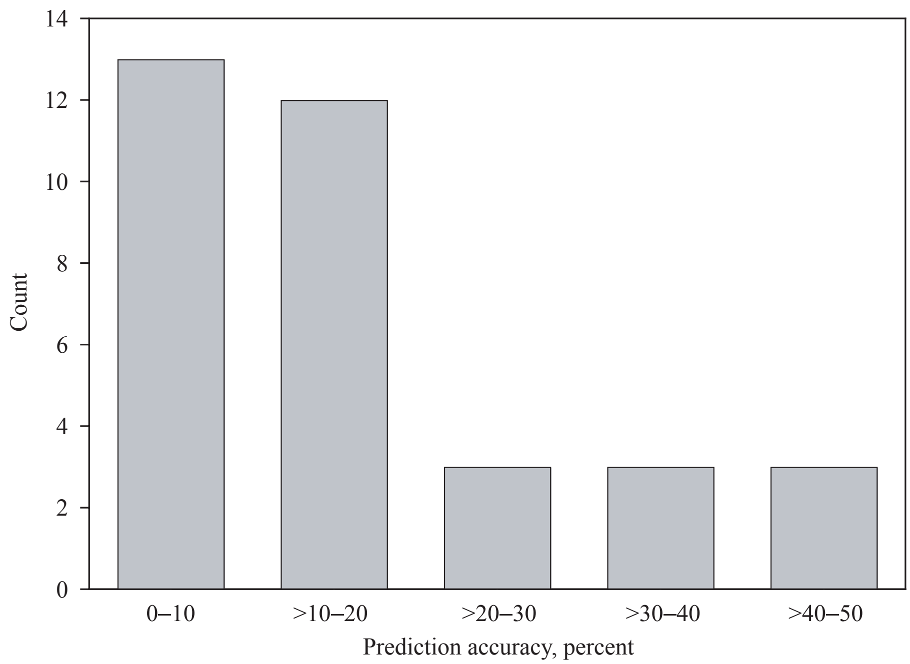


Figure 8. Count of prediction accuracy.

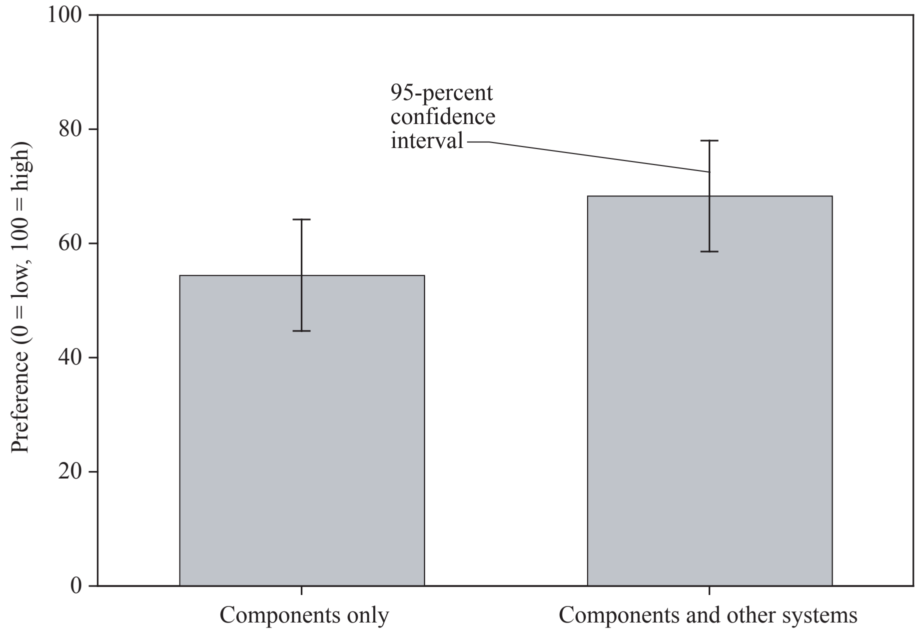


Figure 9. Functional relationships on component control preferences.

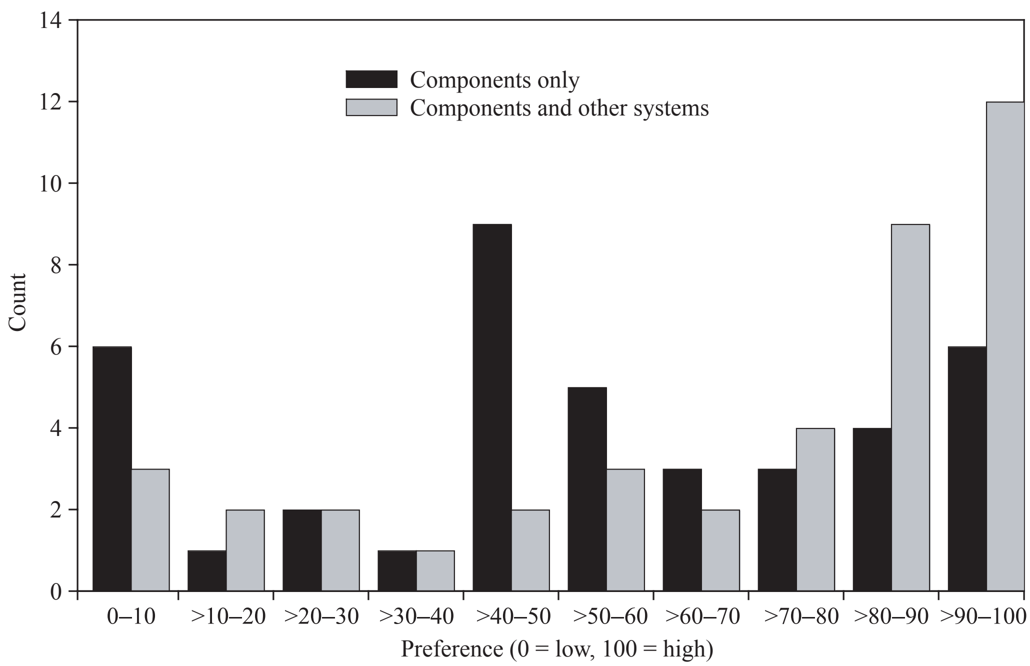


Figure 10. Count of functional relationships on component control preferences.

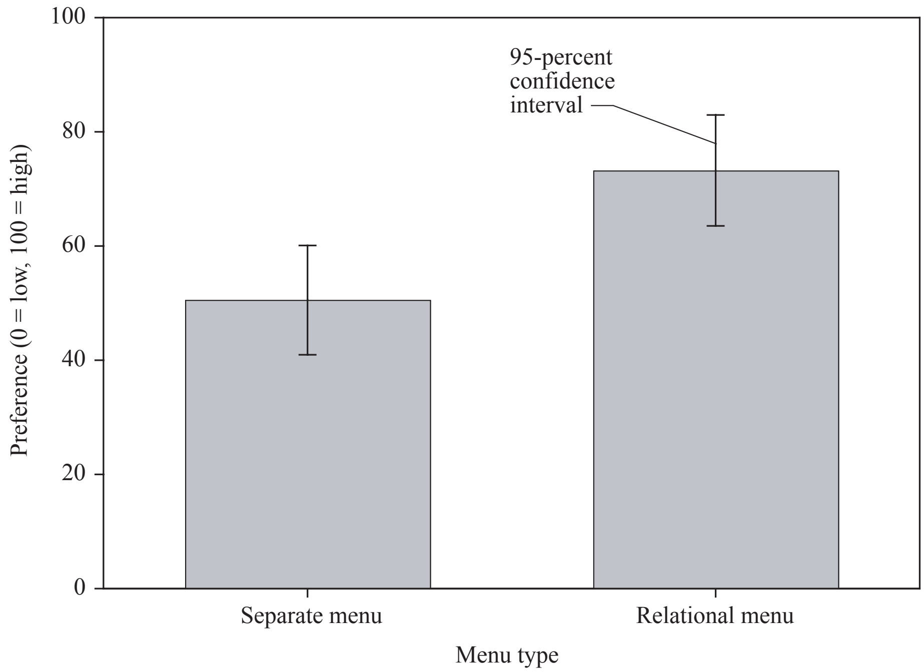


Figure 11. Menu setup.

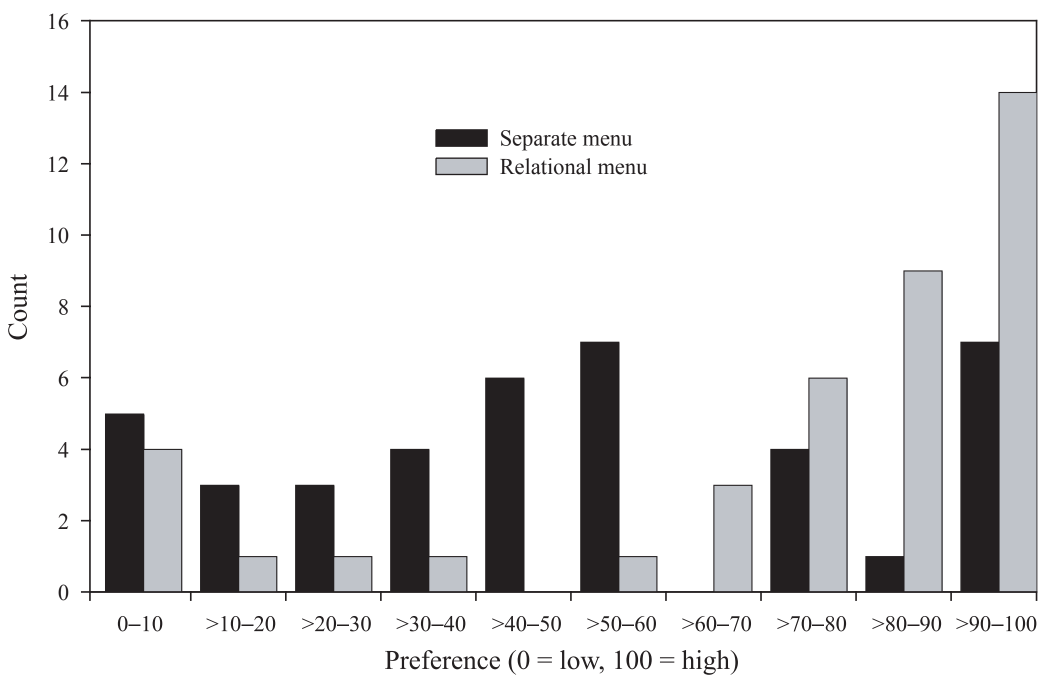


Figure 12. Count of menu setup.

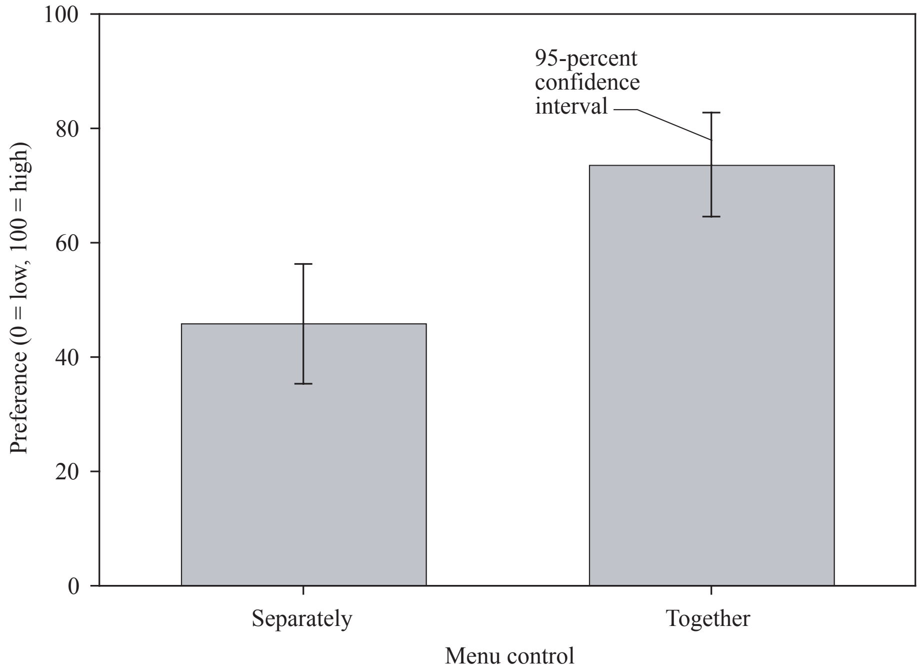


Figure 13. Menu control.

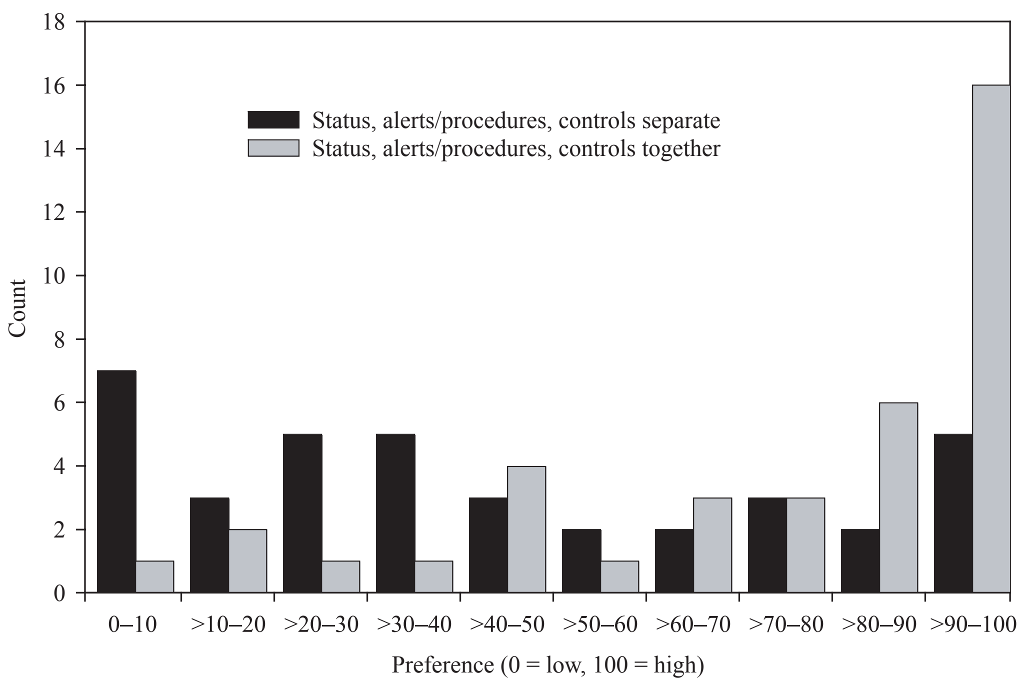


Figure 14. Count of menu control.

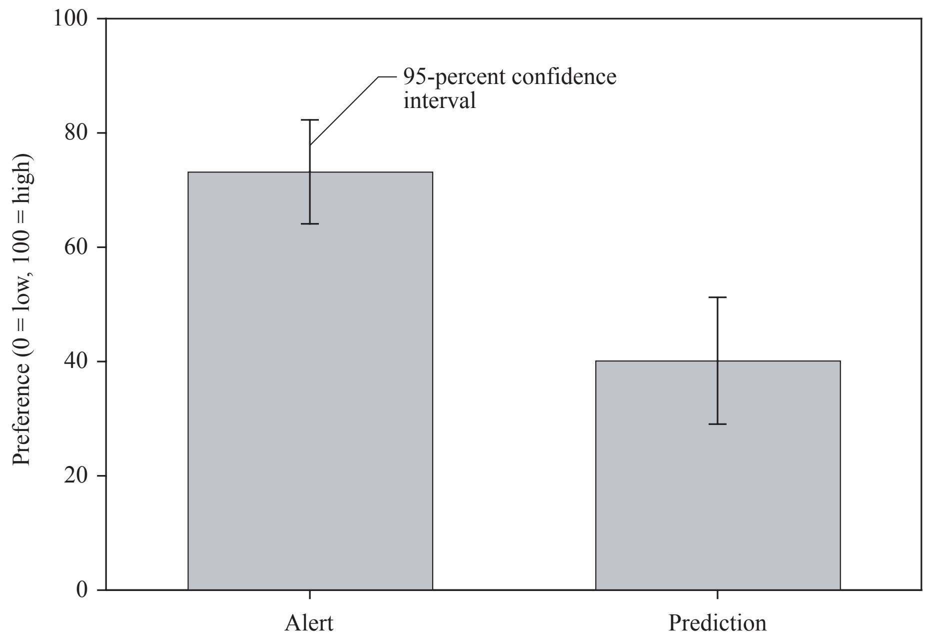


Figure 15. Information available on menu.

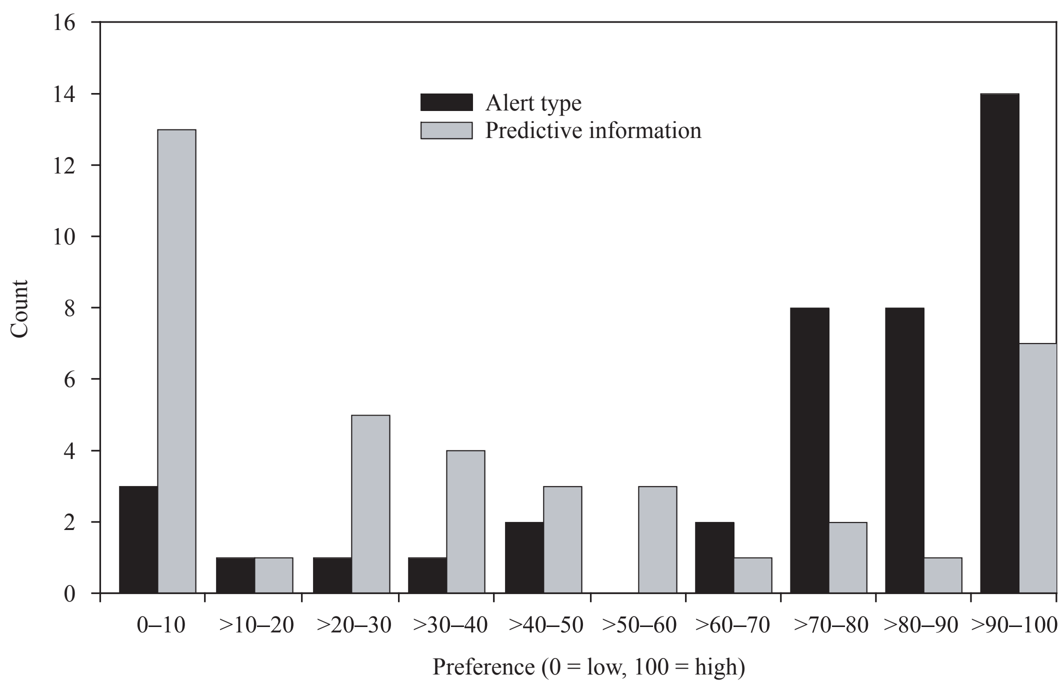


Figure 16. Count of information available on menu.

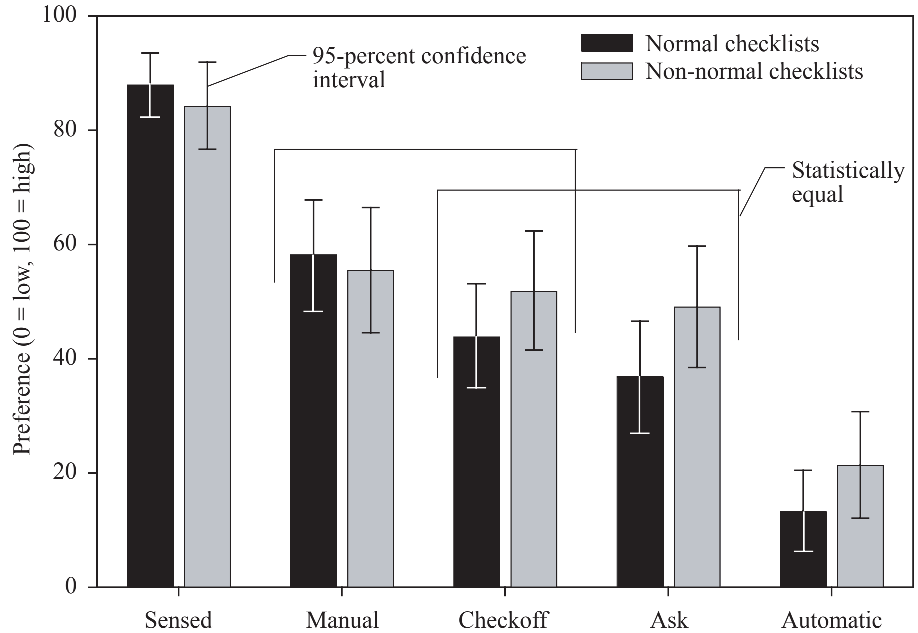


Figure 17. Checklist control by checklist type.

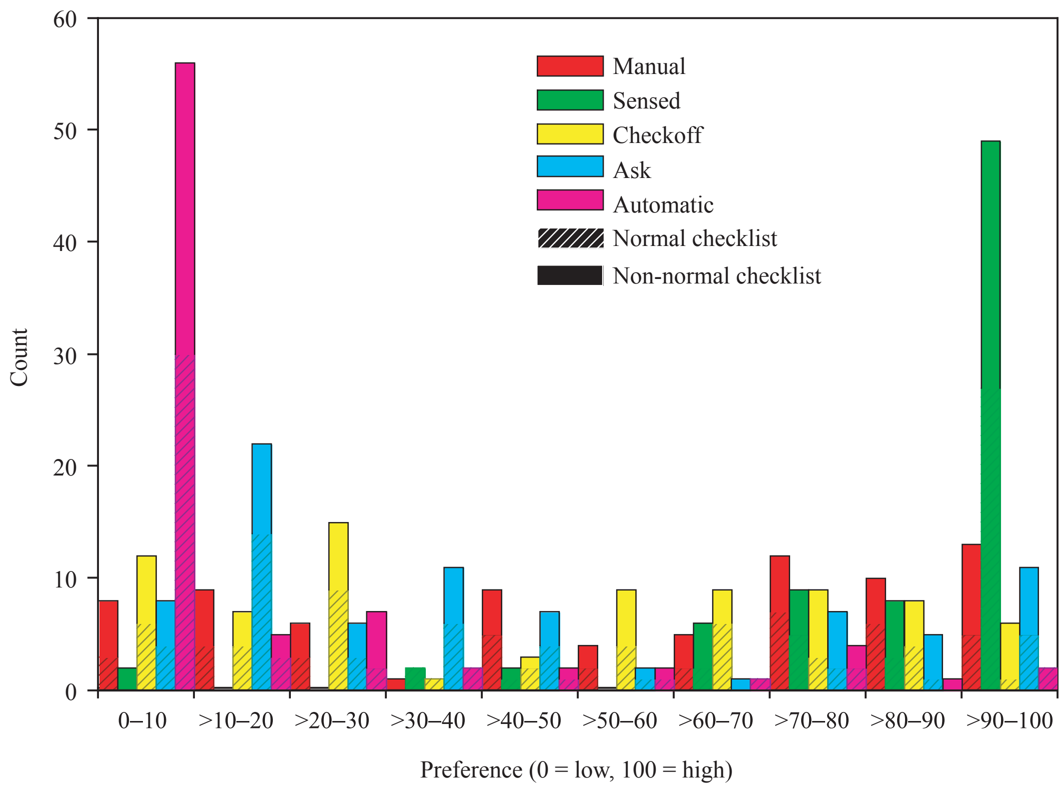


Figure 18. Count of checklist control preference for normal and non-normal situations.

Appendix A

Survey

MS 152
NASA Langley Research Center
Hampton, VA 23681
(757) 864-8047
a.c.trujillo@larc.nasa.gov

February 13, 2004

«Address1»
«City», «State» «PostalCode»

Dear «FirstName» «LastName»:

Regina Johns of Lockheed Martin mentioned that you are interested in participating in research done at NASA and she was kind enough to give me your name and address. I am a researcher in the Projects and Advanced Concepts Branch at the NASA Langley Research Center in Hampton, VA. Our branch concentrates in human factors on the flight deck. I have been working in this area for many years and my primary interest is flight crew decision aiding for systems management. This interest, and the United States government's goal of reducing the aircraft accident rate, has led me to delve further into pilot needs to monitor the health of a flight and, if need be, to diagnose a problem with the aircraft.

The first step in this research involves a survey on your preferences and needs for system information. I would appreciate your participation in this study. Please complete the survey at your earliest convenience and mail it back postmarked by March 31, 2003 in the postage paid envelope provided. The next step in this research is a desktop simulator study to be conducted at NASA Langley Research Center in Hampton, VA starting late this year. Your possible participation in this one-day desktop simulator experiment is partially determined by your responses on the survey itself and your speed of response. If you are chosen to continue on in the study, you will be notified and an appointment will be set up at your convenience. In addition, any questions you have regarding the experiment itself and compensation for your participation will be answered at that time.

In this survey, I ask you for your input on the system information you need for safe operation of the whole aircraft. Detailed instructions precede the survey. This survey is approximately 50-pages long, but there is a great deal of white space and many of the questions are similar; thus, the survey is not as daunting as it first appears. Also, you do not need to deeply consider each question (your first impression is usually the most useful). These are subjective ratings; therefore, there are no right or wrong answers.

As mentioned above, after you have completed the survey, mail it back in the postage paid envelope provided. Your data will be coded and hidden. Only I will know the key to link specific data with a particular name. Any reporting of these data will be by group statistics and, if I refer to a particular participant, only a subject number will be used. If you do not want to complete the survey, simply do not return it.

Again, thank you for participating in this research. If you have any questions or comments, please feel free to contact me.

Thank you,

Anna C. Trujillo

Survey Directions

This survey is organized into 8 sections:

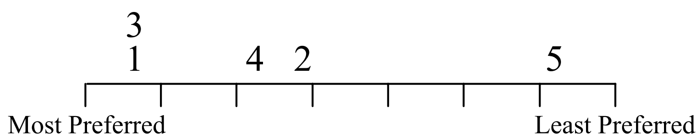
I – General Background Information
II – Calculation of Parameter Ranges
III – Parameter Displays
IV – Component Control
V – Menu Operation
VI – Menu Separation
VII – Checklists, and
VIII – Other Format Preferences

A title page and general description of what that section encompasses precedes any questions in that section. Questions may be further split into numbered subsections.

In each section, you will have similar questions encountered in other sections in addition to novel questions. For the similar questions encountered, they are asking for the same type of opinion but with different kinds of information available, so please read each question carefully.

The questions are one of three types: (1) a rank-order scale, (2) choose an option, and (3) text.

(1) For the rank-order scale, please rank order your preferences from Most Preferred to Least Preferred. The numbers correspond to the display option. Please use these numbers when rank ordering the displays. Also, you may place a mark **anywhere** along the horizontal line of the rating scale. See below for an example.



Where 1 = display A
2 = display B
3 = display C
4 = display D
5 = display E

Do not hesitate to place marks at the end of the regions if these ratings accurately represent your subjective opinion. There are no right or wrong answers.

(2) The second scale is asking you to choose between several options. Please mark only **one** of the options for each question. See below for an example.

Which option do you prefer? ○ Option W ○ Option X ○ Option Y ○ Option Z

Definitions: For the option type of questions, please use the following definitions.

For questions having to do with information availability – "When should this information be available?":

Always Up means that the display is always present. You are unable to turn it on and off.
Up If Alert means that the display automatically comes up if there is an alert within that system; otherwise, you can bring it up when you want to see it.
Operator Discretion means that the display comes up only when you call it up.
Deviation/Trend means that the display automatically comes up if the value is changing; otherwise, you can bring it up when you want to see it.

*The survey is the unedited, original version sent to participants.

For questions having to do with information helpfulness – "How helpful is this information?":

Very Helpful means that the information is required for the task.
Helpful means that the information is nice to have for the task.
Not Helpful means that the information is not really needed for the task.

And the tasks during which it is helpful are:

Monitoring means observing the parameters.
Diagnosing means figuring out what is going on.
Controlling means managing the configuration of the system.

For questions having to do with information necessity – "Is this information needed?":

Must Have means the information is required for the safe operation of the whole system.
Nice to Have means the information may help you in the safe operation of the whole system.
Not Needed means the information is not required for the safe operation of the whole system.

(3) The last type of questions asks you for your comments and opinions. If you run out of space, please use the back of the sheet.

Lastly, the alerts on the figures are color coded in the following manner:

Red is for warning
Amber is for caution
Cyan is for advisory
Green is for normal

Section I – General Background Information

On the next page, please fill out your general background information. Some of this will be similar to the information you provided on the Pilot Background Questionnaire you may have completed a while back. This duplicate information is for updating purposes. Other information is new and is pertinent to this survey.

The information will be used to categorize the data and will be kept confidential.

General Background Information

Date of Birth: ______________________
Month / Day / Year

Years of Formal Education: ______________________ (*e.g.*, high school graduate = 12)
If you have a degree, what was the discipline?

Profession: ______________________________

Total Hours Flying (approximately):______________________

Years Flying (approximately): ______________________

Hours as Pilot-in-Command (approximately):________________

Hours as Second-in-Command (approximately):______________

Do you wear corrective lenses? OYes ONo
If yes, what type of corrective lenses (*e.g.*, bifocals, contacts): ______________________

Do you wear hearing aid(s)? OYes ONo

Do you have hearing loss at certain frequencies? OYes ONo
If yes, what frequency(s): ______________________________

Does any part of your hands or fingers go numb when flying manual control? OYes ONo

Do you currently derive wages directly from your piloting skills in any way? OYes ONo
In what capacity: ______________________ For how long? ______________

Have you ever derived wages from your piloting skills in any way? OYes ONo
In what capacity: ______________ For how long? ________ How long ago? ________

Please list the most recent aircraft on which you have experience, **beginning with the most recent flown**. For each aircraft, please indicate your approximate number of hours flying experience.

Aircraft Type (beginning with the most recent flown)	**Hours in Type**
1.	
2.	
3.	

Section II – Calculation of Parameter Ranges

The following questions involve how to calculate the normal and alert ranges for each of the parameters, such as hydraulic pump pressure and oil temperature. In particular, these questions ask you to give your opinion on whether these ranges should be based on absolute values or relative values, and on numerical values or percentages. These are explained on the following page.

Calculation of Parameter Ranges

1. The parameter values and alert ranges can be based on two different methods.
   (1) Absolute value
   The ranges are always the same for a particular parameter no matter what the configuration of the rest of the system is. For example, the normal range is always from 0 to 90 and the alert range is always greater than 90.
   (2) Relative value
   The ranges depend on the configuration of the rest of the system. In other words, a mathematical model determines what the normal and alert ranges should be given the current configuration. For example, during the first 30 seconds of a component start up, the normal range may be from 0 to 90 and the alert range is greater than 90; but after 30 seconds, the normal range may be from 20 to 90 and the alert ranges may be less than 20 and greater than 90.

   Please rank order your preferences for the method of determining the ranges.

   Where 1 = absolute value
   2 = relative value

   Most Preferred ______ Least Preferred

   Why did you choose this order rather than the reverse? ____________________

2. The parameter values and alert ranges can be calculated by two different methods.
   (1) Value
   The ranges are numerical values. For example, the normal range is from 0 to 300 and the alert range is greater than 300.
   (2) Percentage
   The ranges are based on a percentage from normal. For example, the alert range may be designated as 75% above the normal value.

   Please rank order your preferences for the method of calculating the ranges.

   Most Preferred — Least Preferred

   Where 1 = value
   2 = percentage

   Why did you choose this order rather than the reverse? ______

Section III – Parameter Displays

The following questions involve the parameter displays shown on the next page. Please feel free to refer to that page at any time. In particular, the questions ask you for your opinion on having Parameter Status Information, the Current Numeric Parameter Value, the Parameter Prediction of Time to an Alert, the Parameter Historical Value, and the Parameter Numerical Alert Value.

Parameter Status Information involves information typically available on the display; *i.e.*, current value, normal range, and alert type and range.

The Current Numeric Parameter Value is the digital readout of the parameter's value at the current time.

The Parameter Prediction of Time to an Alert calculates when the parameter is expected to reach an alert value based on its current trend.

The Parameter Historical Value displays a past value(s) of the parameter if the past and current values are different.

The Parameter Numerical Alert Value is just an indication of the numerical value the parameter must reach in order to be in an alert range.

Also, please remember that:

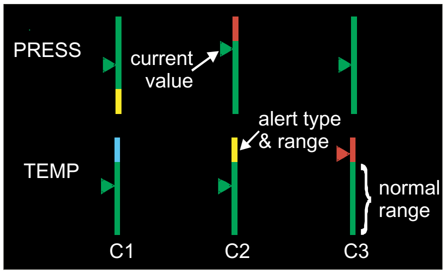
Red	is for warning
Amber	is for caution
Cyan	is for advisory
Green	is for normal

Parameter Displays

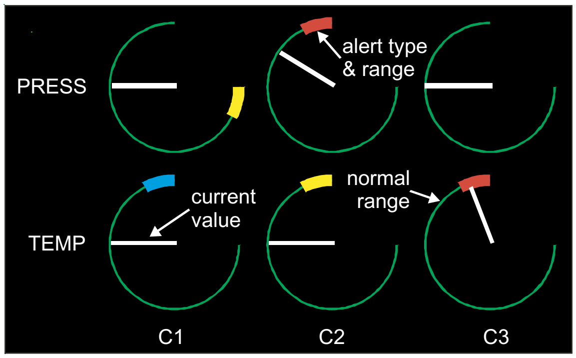
3. Parameter Status Information

For questions 3a–p, please refer to the following displays.

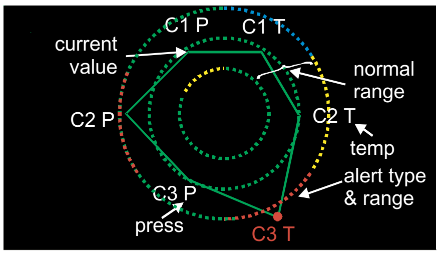
1 = Bow-Tie Display



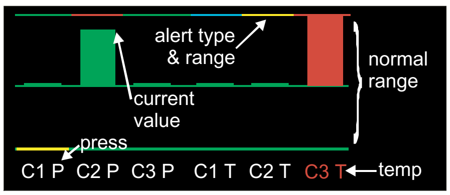
2 = Dial Display



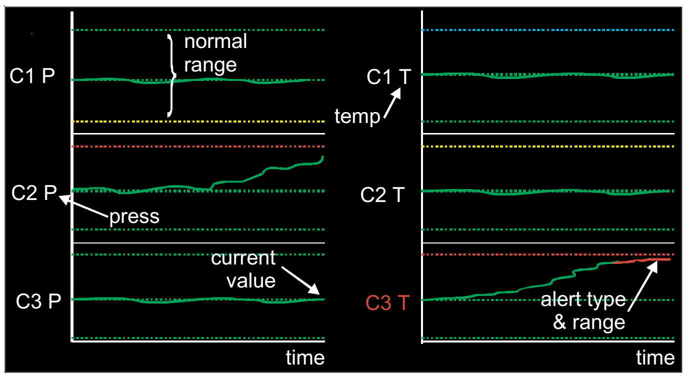
3 = Polar-Star Display



4 = EMACS Display



5 = Line Display



a. For viewing the individual parameters of a system (see page 36), please rank order your display preferences.

Most Preferred ——— Least Preferred

Where 1 = bow-tie display
2 = dial display
3 = polar-star display
4 = EMACS display
5 = line display

Why did you choose this order? ____________________

Why did you cluster the ones you did together? ____________________

Why did you separate the ones you did from the others? ____________________

b. Is the *current value* needed?

○ Must Have ○ Nice to Have ○ Not Needed

c. When should the *current value* be available?

○ Always Up ○ Up if Alert ○ Operator Discretion ○ Deviation/ Trend

d. How helpful is the *current value* for <u>monitoring</u> system state?

○ Very Helpful ○ Helpful ○ Not Helpful

How would the *current value* help you in monitoring system state?____________________________

e. How helpful is the *current value* for diagnosing possible system abnormalities?

○ Very Helpful	○ Helpful	○ Not Helpful

How would the *current value* help you diagnose possible system abnormalities?_________________

f. How helpful is the *current value* for controlling a system?

○ Very Helpful	○ Helpful	○ Not Helpful

How would the *current value* help you in controlling a system?______________________________

g. Is the *normal range* needed?

Must Have	Nice to Have	Not Needed
○	○	○

h. When should the *normal range* be available?

Always Up	Up if Alert	Operator Discretion	Deviation/ Trend
○	○	○	○

i. How helpful is the *normal range* for monitoring system state?

Very Helpful	Helpful	Not Helpful
○	○	○

How would the *normal range* help you in monitoring system state?______________________________

____

____

____

____

j. How helpful is the *normal range* for diagnosing possible system abnormalities?

Very Helpful	Helpful	Not Helpful
○	○	○

How would the *normal range* help you diagnose possible system abnormalities? __________________

____

____

____

____

k. How helpful is the *normal range* for controlling a system?

Very Helpful	Helpful	Not Helpful
○	○	○

How would the *normal range* help you in controlling a system? ______________________________

____

____

____

____

l. Is the *alert type and range* needed?

○ Must Have	○ Nice to Have	○ Not Needed	

m. When should the *alert type and range* be available?

○ Always Up	○ Up if Alert	○ Operator Discretion	○ Deviation/ Trend

n. How helpful is the *alert type and range* for <u>monitoring</u> system state?

○ Very Helpful	○ Helpful	○ Not Helpful

How would the *alert type and range* help you in <u>monitoring</u> system state? ______________________

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____

o. How helpful is the *alert type and range* for <u>diagnosing</u> possible system abnormalities?

○ Very Helpful	○ Helpful	○ Not Helpful

How would the *alert type and range* help you <u>diagnose</u> possible system abnormalities? ____________

____
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____

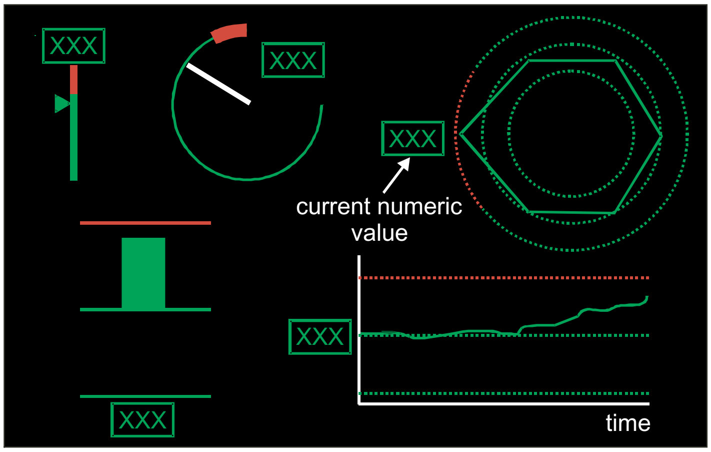
p. How helpful is the *alert type and range* for <u>controlling</u> a system?

○ Very Helpful	○ Helpful	○ Not Helpful

How would the *alert type and range* help you in <u>controlling</u> a system? _________________________

____
____
____
____

4. Current Numeric Parameter Value



For questions 4a–f, please refer to the following.

The boxed value indicates the current numeric value of the parameter. If the parameter were in the normal range, the box and value would indicate that by having a green color-coding. If the parameter moved into an alert range (cyan for advisory, amber for caution, and red for warning), the box and value would match the level of the alert based on color association.

a. Is this information needed? ○ Must Have ○ Nice to Have ○ Not Needed

b. When should this information be available? ○ Always Up ○ Up if Alert ○ Operator Discretion ○ Deviatic Trend

c. How helpful is this information for <u>monitoring</u> system state? ○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you in <u>monitoring</u> system state?_____________________________

____

d. How helpful is this information for <u>diagnosing</u> possible system abnormalities? ○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you <u>diagnose</u> possible system abnormalities? ___________________

____

e. How helpful is this information for <u>controlling</u> a system?

○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you in <u>controlling</u> a system? ______________________________

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f. Are there other formats you would like to see this information displayed as? If so, please describe.

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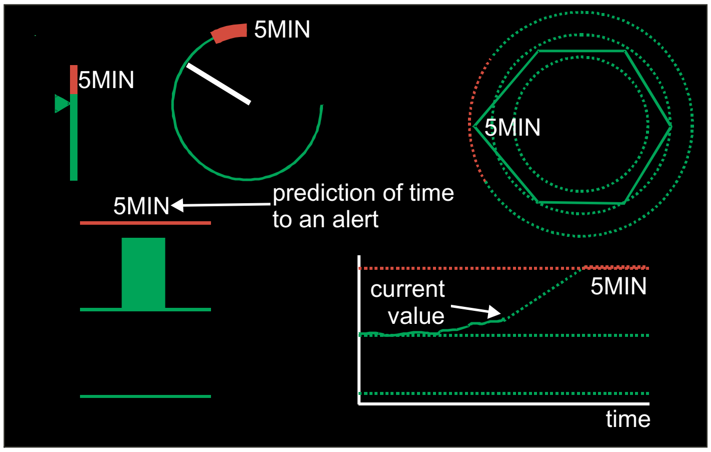
5. Parameter Prediction of Time to an Alert



For questions 5a–i, please refer to the following.

Prediction of time to an alert indicates the estimated time to an alert given the current configuration of the whole system.

a. Is this information needed?

○ Must Have ○ Nice to Have ○ Not Needed

b. When should this information be available?

○ Always Up ○ Up if Alert ○ Operator Discretion ○ Deviation/ Trend

c. What should the alert class of the prediction be?

○ None ○ Advisory ○ Match Alert Category ○ 1 New Category ○ 3 New Categories Akin to Alert Categories

Why did you assign the predictive alerts to this particular category? ______________________________

____

____

____

____

d. How accurate must the prediction be?

To ±1% | | | | | | | To ±50%

<u>For Example</u>:
If the prediction is 5m, then the parameter will reach the alert range in:

Accuracy	Minimum Time to Alert	Maximum Time to Alert
1%	4m 57s	5m 3s
50%	2m 30s	7m 30s

where m=minutes and s=seconds.

Why must the prediction be this accurate? ____________________

Why should the prediction not be <u>more</u> accurate than this? ____________________

Why should the prediction not be <u>less</u> accurate than this? ____________________

e. How helpful is this information for <u>monitoring</u> system state?

○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you in <u>monitoring</u> system state? ____________________

f. How helpful is this information for diagnosing possible system abnormalities?

○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you diagnose possible system abnormalities? ______________________

g. How helpful is this information for controlling a system?

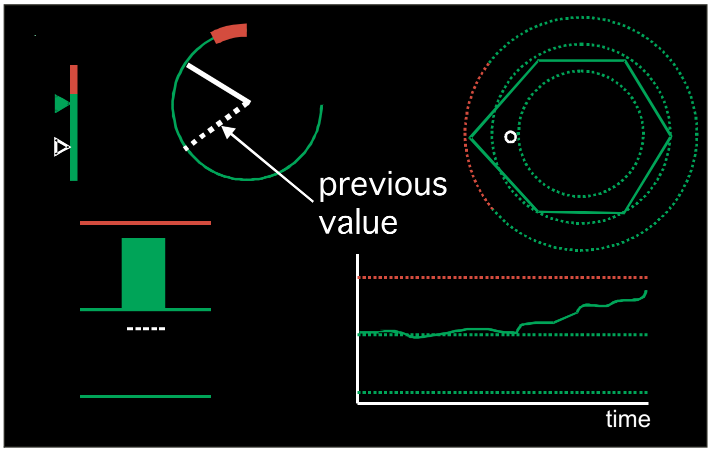
○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you in controlling a system? ______________________

h. How should the time to an alert be used? ______________________

i. Are there other formats you would like to see this information displayed as? If so, please describe. ______

6. Parameter Historical Value



For questions 6a–g, please refer to the following.

The previous value indicates the parameter's value at a point of time in the past.

a. Is this information needed?

○ Must Have ○ Nice to Have ○ Not Needed

b. When should this information be available?

○ Always Up ○ Up if Alert ○ Operator Discretion ○ Deviation/ Trend

c. How far back in time should the history "bug" be?

Why should it go back this far? ______________________________

____

____

____

____

d. How helpful is this information for <u>monitoring</u> system state?

○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you in <u>monitoring</u> system state? ______________________________

____

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____

e. How helpful is this information for diagnosing possible system abnormalities?

○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you diagnose possible system abnormalities? ______________________

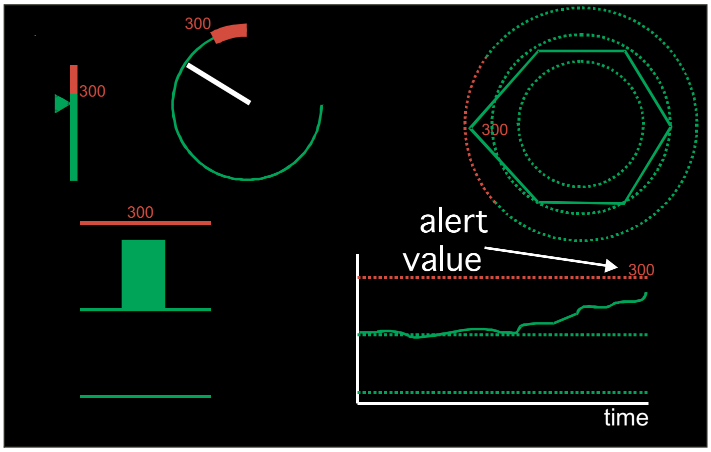
f. How helpful is this information for controlling a system?

○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you in controlling a system? ______________________

g. Are there other formats you would like to see this information displayed as? If so, please describe. ______

7. Parameter Numerical Alert Value



For questions 7a–f, please refer to the following.

The alert value indicates the numeric value that the alert range starts at. The color of the number also indicates the alert type.

a. Is this information needed? ○ Must Have ○ Nice to Have ○ Not Needed

b. When should this information be available? ○ Always Up ○ Up if Alert ○ Operator Discretion ○ Deviation/ Trend

c. How helpful is this information for monitoring system state? ○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you in monitoring system state?________________________________

d. How helpful is this information for diagnosing possible system abnormalities? ○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you diagnose possible system abnormalities? ____________________

e. How helpful is this information for controlling a system?

○ Very Helpful	○ Helpful	○ Not Helpful

How would this information help you in controlling a system? ______________________________________

f. Are there other formats you would like to see this information displayed as? If so, please describe. ______

8. **Please rank order your preferences for additional information.** (See pages 36, 41, 43, 46, and 48 for descriptions.)

Where 1 = current parameter value
2 = prediction of time to alert
3 = historical value
4 = alert value

|___|___|___|___|___|___|___|

Most Preferred Least Preferred

Why did you choose this order?______________________________

Why did you cluster the ones you did together?______________________________

Why did you separate the ones you did from the others?______________________________

Section IV – Component Control

This next section involves controlling the configuration of the systems; *e.g.*, turning components on and off. Using software displays and switches rather than hardware switches allows for additional information to be included about the component other than its functional state. This additional information includes the Functional Relationships of the components, Prediction of Time to an Alert on Component Control, and Parameter Type on Component Control.

The <u>Functional Relationships</u> of the components may include just the components within the particular system or the component relationships within that system plus that system's relationship with other systems.

The <u>Prediction of Time to an Alert on Component Control</u> displays when the parameter is predicted to reach an alert value based on its current trend.

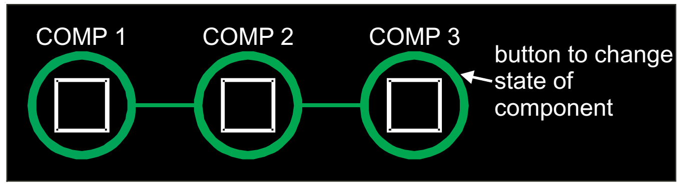
The <u>Parameter Type on Component Control</u> indicates the parameter within the component that is deviating from normal.

Component Control

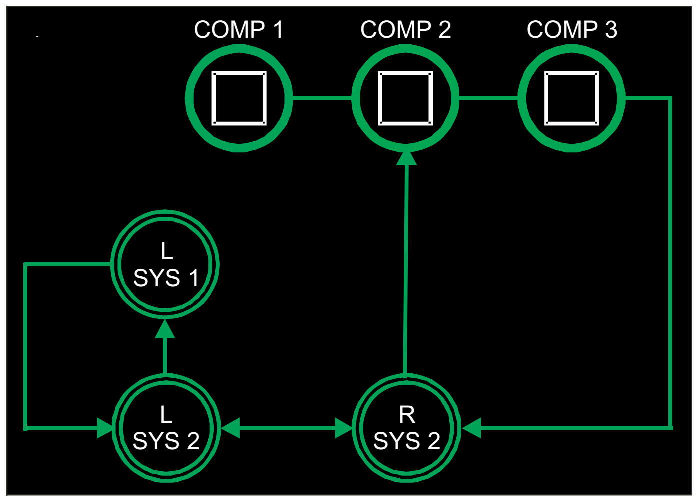
9. Functional Relationships

For question 9, please use the following displays.

1 = Components only
(*e.g.*, just propulsion)



2 = Components and other systems
(*e.g.*, propulsion and fuel)



a. For controlling the system, please rank order your preferences.

Most Preferred ______ Least Preferred

Where 1 = components only
2 = components with other systems

Why did you choose this order rather than the reverse?______________________________

b. When should this information be available?

○ Always Up	○ Up if Alert	○ Operator Discretion	○ Deviation/ Trend

c. How helpful is this information for monitoring system state?

○ Very Helpful	○ Helpful	○ Not Helpful

How would this information help you in monitoring system state? ______________________________

____
____
____
____

d. How helpful is this information for diagnosing possible system abnormalities?

○ Very Helpful	○ Helpful	○ Not Helpful

How would this information help you diagnose possible system abnormalities? ______________________

____
____
____
____

e. How helpful is this information for controlling a system?

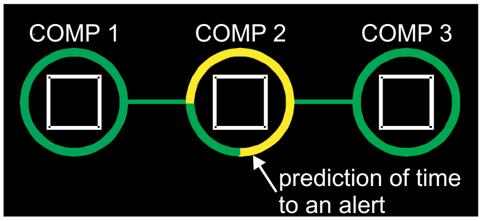
○ Very Helpful	○ Helpful	○ Not Helpful

How would this information help you in controlling a system? ______________________________

____
____
____
____

f. Are there other formats you would like to see this information displayed as? If so, please describe.

10. Prediction of Time to an Alert on Component Control



For questions 10a–f, please refer to the following.

Prediction of time to an alert indicates the estimated time to an alert given the current configuration of the whole system. The estimated time to an alert is shown by the amount that the arc goes around the component button. The color indicates the alert type should the parameter reach the alert range that it is headed for.

a. Is this information needed? ○ Must Have ○ Nice to Have ○ Not Needed

b. When should this information be available? ○ Always Up ○ Up if Alert ○ Operator Discretion ○ Deviation/ Trend

c. How helpful is this information for monitoring system state? ○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you in monitoring system state?______________________________

d. How helpful is this information for diagnosing possible system abnormalities? ○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you diagnose possible system abnormalities? ____________________

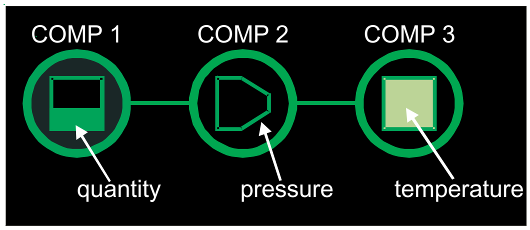
e. How helpful is this information for controlling a system?

○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you in controlling a system? ____________________

f. Are there other formats you would like to see this information displayed as? If so, please describe. ____________________

11. Parameter Type on Component Control



For questions 11a–f, please refer to the following.

For each component, parameters will be indicated in the following manner when their values deviate from normal. For quantity, the amount of fill indicates the fluid level. For pressure, the amount that the figure is pinched closed or flared open indicates the pressure level. For temperature, the hue of the fill indicates the temperature level.

a. Is this information needed? ○ Must Have ○ Nice to Have ○ Not Needed

b. When should this information be available? ○ Always Up ○ Up if Alert ○ Operator Discretion ○ Deviation/ Trend

c. How helpful is this information for <u>monitoring</u> system state? ○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you in <u>monitoring</u> system state? ______________________

____

____

____

____

d. How helpful is this information for <u>diagnosing</u> possible system abnormalities? ○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you <u>diagnose</u> possible system abnormalities? ______________

____

____

____

____

e. How helpful is this information for <u>controlling</u> a system?

Very Helpful	Helpful	Not Helpful
○	○	○

How would this information help you in <u>controlling</u> a system? ______________________________

____

____

____

____

f. Are there other formats you would like to see this information displayed as? If so, please describe. ______

____

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____

12. Please rank order your preferences for additional information. (See pages 55 and 57 for descriptions.)

Where 1 = prediction of time to alert
2 = parameter type

|___|___|___|___|___|___|___|

Most Preferred   Least Preferred

Why did you choose this order rather than the reverse?____
____
____
____
____
____
____
____

Section V – Menu Operation

This section asks you for your preferences in the menu system that would bring up the components. In particular the options include the type of Menu Operation and providing the Type of Alert Presented in Menu System, and the Prediction of Time to an Alert Presented in Menu System.

The Menu Operation choices are a menu display or a relational display that indicates generally how the systems affect one another.

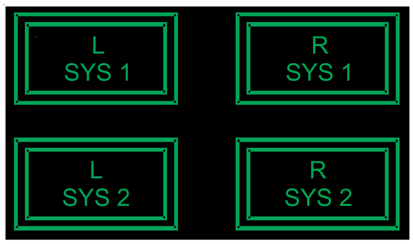
The Type of Alert Presented in Menu System would indicate an alert within the system.

The Prediction of Time to an Alert Presented in Menu System displays when the parameter is predicted to reach an alert value based on its current trend.

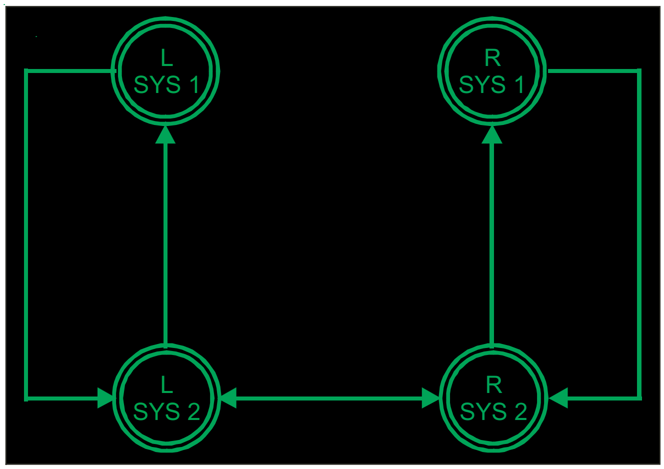
Menu Operation

For question 13, please use the following displays.

1 = menu



2 = relational



13. Please rank order your preferences for bringing up the displays.

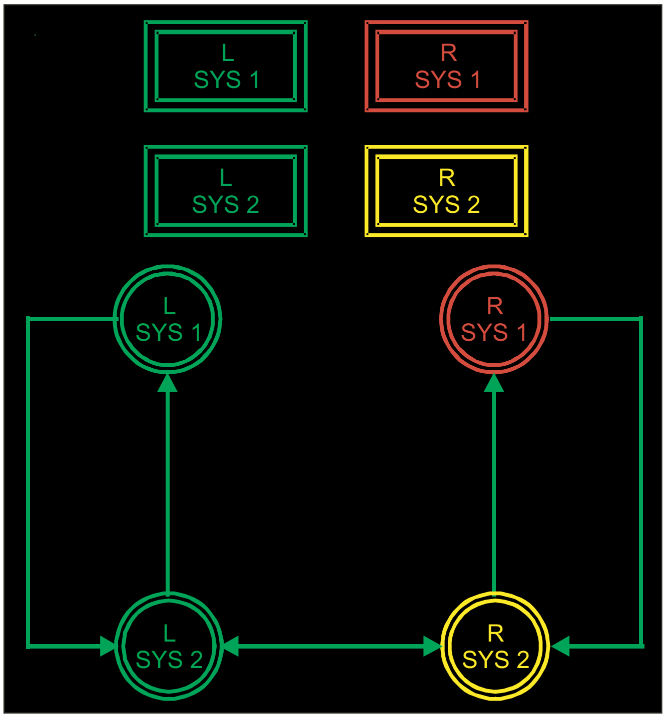
Where 1 = menu
2 = relational

Most Preferred Least Preferred

Why did you choose this order rather than the reverse?

Are there other formats you would like to see this information displayed as? If so, please describe.____

14. Type of Alert Presented in Menu System



For questions 14a–f, please refer to the following.

The menu system will indicate the highest alert in each system if there is an alert.

a. Is this information needed?	○ Must Have	○ Nice to Have	○ Not Needed
b. When should this information be available?	○ Up if Alert	○ Operator Discretion	
c. How helpful is this information for <u>monitoring</u> system state?	○ Very Helpful	○ Helpful	○ Not Helpful

How would this information help you in <u>monitoring</u> system state?______________________________

d. How helpful is this information for <u>diagnosing</u> possible system abnormalities?

○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you <u>diagnose</u> possible system abnormalities? ______________________

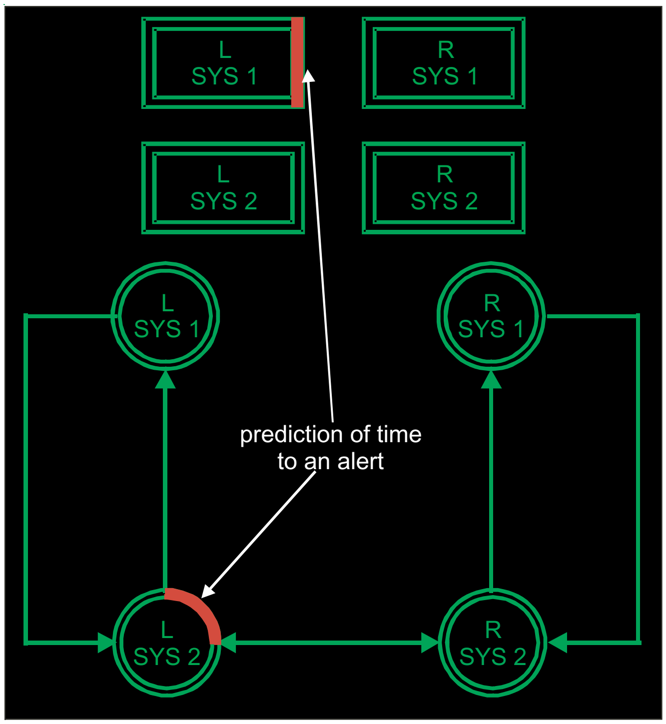
e. How helpful is this information for <u>controlling</u> a system?

○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you in <u>controlling</u> a system? ______________________

f. Are there other formats you would like to see this information displayed as? If so, please describe. ______

15. Prediction of Time to an Alert Presented in Menu System



For questions 15a–f, please refer to the following.

Prediction of time to an alert indicates the estimated time to any alert given the current configuration of the whole system. The estimated time to an alert is shown by the amount of the boundary fill around the component button. The color indicates the alert type should the parameter reach the alert range.

a. Is this information needed?	○ Must Have	○ Nice to Have	○ Not Needed
b. When should this information be available?	○ Always Up	○ Operator Discretion	○ Deviation/ Trend
c. How helpful is this information for <u>monitoring</u> system state?	○ Very Helpful	○ Helpful	○ Not Helpful

How would this information help you in <u>monitoring</u> system state?______________________________

____

____

____

____

d. How helpful is this information for diagnosing possible system abnormalities?

○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you diagnose possible system abnormalities? ______________________

e. How helpful is this information for controlling a system?

○ Very Helpful ○ Helpful ○ Not Helpful

How would this information help you in controlling a system? ______________________

f. Are there other formats you would like to see this information displayed as? If so, please describe. ______

16. Please rank order your preferences for the above information. (See pages 63 and 65 for descriptions.)

Where	1 =	type of alert
	2 =	prediction of time to an alert

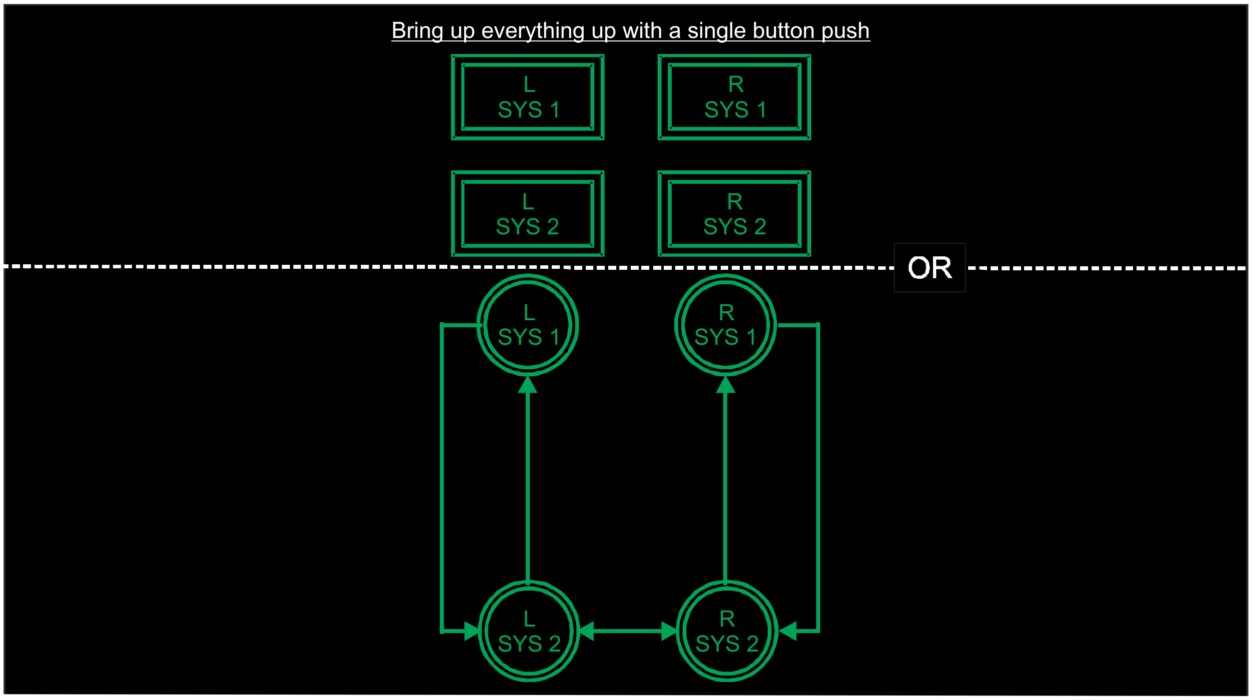
Most Preferred _____ _____ _____ _____ _____ _____ _____ Least Preferred

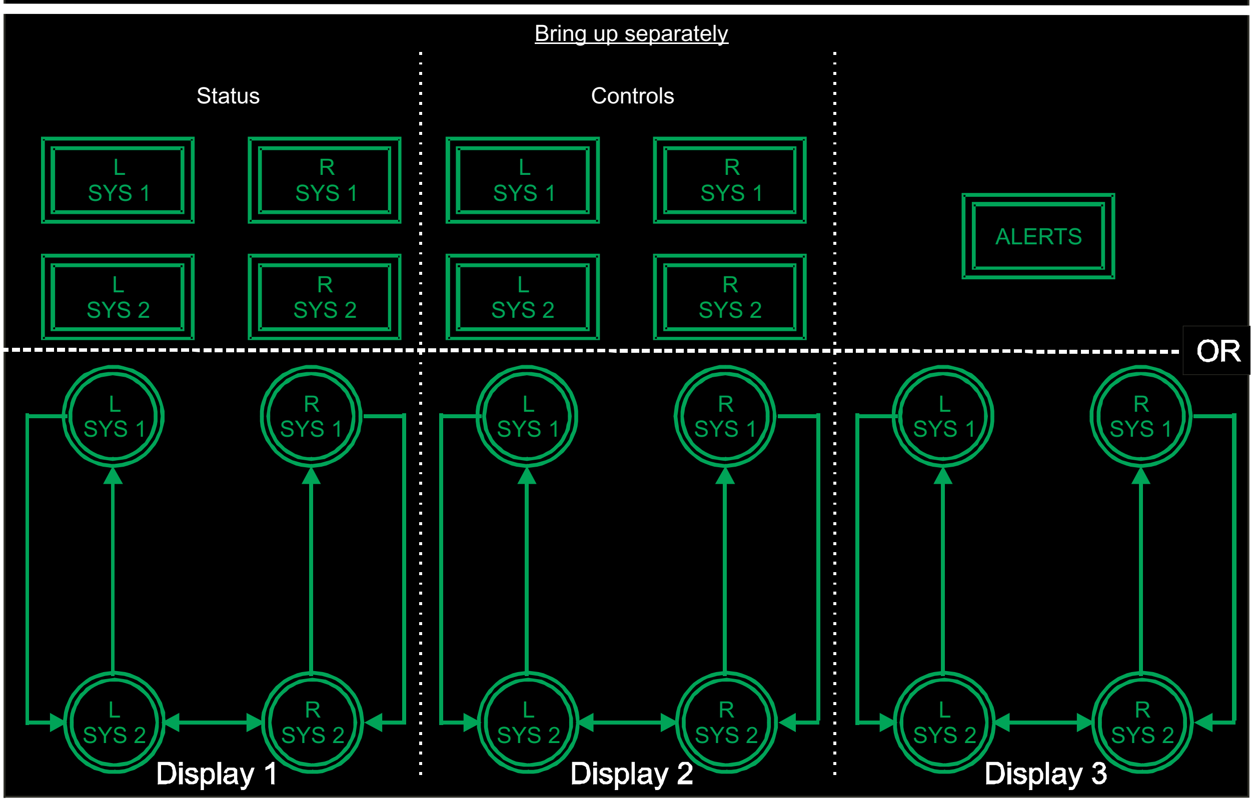
Why did you choose this order rather than the reverse?____
____
____
____
____
____
____
____

Section VI – Menu Separation

This section asks you for your preferences in how you would prefer to bring up all the related information (Status, Controls, and Alert) for a particular system. The particular options are bringing up all the information at once with a single button push or bringing up each type of information (Status, Controls, and Alerts) with separate button pushes.

Menu Separation





17. Please rank order your preferences for bringing up the displays.

Where 1 = together
2 = separate

Most Preferred ______ Least Preferred

Why did you choose this order rather than the reverse?

Section VII – Checklists

This next section asks you for your preferences on how you would like to complete normal and non-normal checklists. In particular the options are full manual check off, sensed check off, check off on checklist and item automatically changed to appropriate state, automatically done after asking, and automatically done without asking. These are fully described on the following page.

Checklists

Completing the checklists may be accomplished in several ways.

(1) <u>Full manual check off</u>
You must change the component to the desired state and check off the corresponding item on the checklist as being accomplished.

(2) <u>Sensed check off</u>
You must change the component to the desired state and the checklist will automatically check off that item once it has sensed it as being accomplished.

(3) <u>Check off on checklist and item automatically changed to appropriate state</u>
You check off the item on the checklist and the component will be automatically changed to the state specified by the checklist.

(4) <u>Automatically done after asking</u>
The checklist is accomplished by having the components change automatically to the state specified by the checklist after asking for the operator's permission.

(5) <u>Automatically done without asking</u>
The checklist is accomplished by having the components changed automatically to the state specified by the checklist without asking the operator.

18. Please rank order your preferences for accomplishing the <u>normal</u> (*e.g.*, landing) checklists.

Most Preferred ____ ____ ____ ____ ____ ____ ____ Least Preferred

Where
1 = full manual check off
2 = sensed check off
3 = check off on checklist and item automatically changed to appropriate state
4 = automatically done after asking
5 = automatically done without asking

Why did you choose this order? ____________________

Why did you cluster the ones you did together? ____________________

Why did you separate the ones you did from the others? ______________________________

19. Please rank order your preferences for accomplishing the non-normal (*e.g.*, high oil temperature) checklists.

Where
1 = full manual check off
2 = sensed check off
3 = check off on checklist and item automatically changed to appropriate state
4 = automatically done after asking
5 = automatically done without asking

Most Preferred ________________ Least Preferred

Why did you choose this order? ______________________________

Why did you cluster the ones you did together? ______________________________

Why did you separate the ones you did from the others? ______________________________

Section VIII – Other Format Preferences

This last section asks you for your general likes and dislikes of the displays and alerting technology currently in aircraft today and the ones presented in this survey.

Other Format Preferences

20. Overall, which of all of the previous displays do you like the most? ______________________

    Why is the above the most appealing? ______________________

21. Overall, which of all of the previous displays do you like the least? ______________________

    Why is the above the most unappealing? ______________________

22. Do you pilot primarily by what you see, hear, or feel? and typically in what order? (For example, do you primarily depend on your instruments to provide you with feedback on how the aircraft is operating, versus depending on how the aircraft is handling associated with what you see on your instruments?)

23. Which alert sounds are the most <u>uncomfortable</u> to hear in an aircraft and why? ______________________________

24. Which alert sounds are the most <u>comfortable</u> to hear in an aircraft and why? ______________________________

25. Which alert sounds are difficult to hear in an aircraft and why? ______________________________

26. For the displays shown in this survey, are there any alert colors you would change and what is your reason for such a change? ______________________________

27. For the displays shown in this survey, are there any panel instrumentation colors you would change and what is your reason for such a change? ______________________________

Other comments (feel free to use the backs of the pages):

Thank you for your participation.
Please mail back the survey in the postage paid envelope provided.

Appendix B

Respondent Comments

Table B1. Comments on Using Relative and Absolute Values for Calculating Parameter Ranges

Relative Preferred		Absolute Preferred	
No interpretation of situation needed, intuitive	16	Keep it simple	4
Take into account configuration changes	7	Know it, required to know it	2
Provides more information	7	Do not need additional information	1
Accurate	2		
Reduces workload	1		
Avoids nuisance alerts	1		

See Appendix A, p. 33, for the complete question.

Table B2. Comments on Using Values and Percentages for Calculating Parameter Ranges

Value Preferred		Percentage Preferred	
Want a real number	8	More intuitive	8
Better system knowledge	1	Know how close limit is	3
Makes intuitive	1	Shows deviation from nominal	3
More detailed	1	Does not depend on aircraft	3
Know when approaching a limit	1	Provides more information	2

See Appendix A, p. 34, for the complete question.

Table B3. Comments About Parameter Display Formats

Dial or Bow-Tie Most Preferred		Line or EMACS Most Preferred	
Most comfortable [since these] two formats are used in aircraft today	23	Most comfortable [since these] two formats are used in aircraft today	1
Easy to interpret	15	Easy to interpret	1
Shows trends	1	Provides more information	1

See Appendix A, pp. 36 and 37, for the complete question.

Table B4. Comments About Current Value and Current Numeric Value on Parameter Displays

Comment	Monitoring	Diagnosing	Controlling
Current value			
See current system state	16		
See trends	8	11	3
Easy to read	4		
See fluctuations	2	1	
Increase SA	2	1	
For comparison	1	4	
For diagnosis	1		
See performance	1	1	
In scan pattern	1		
See exceedences		11	2
See severity		2	1
See relationships		2	
See changes		1	
For problem understanding		1	
See performance		1	
Know what to do		1	
For feedback			14
For early detection			6
For precise control			6
For monitoring			4
See need for action			1
Current numeric value			
See current system state	11		
Easy to read	6		
For comparison	3		
See deviations	2		
See trends	2	3	1
See severity	1	15	
Increase SA	1	2	2
Draws attention	1	2	
For diagnosis		3	
Familiar		1	
See effectiveness of corrective action			9
Keep out of alert range			4
For fine tuning			4

See Appendix A, pp. 35–42, for the complete question.

Table B5. Comments About Normal Range on Parameter Displays

Comment	Monitoring	Diagnosing	Controlling
Check for normal operation	15	9	1
See trends	10	11	3
For comparison	7	7	
See limit approach	2		1
Good picture	2		
See performance	1		
For diagnosis		3	
See severity		2	
See fluctuations		1	
Feedback			15
For fine tuning			5
Keep out of alert range			2
Take actions earlier			1

See Appendix A, pp. 35–42, for the complete question.

Table B6. Comments About Predictive Information Alert Class

Advisory	
Advising that something may happen, a possible abnormality	15
Less new, additional information	2
Fewer false alarms	1
Avoid rapid responses	1
Match Alert Category	
Industry standard	9
Easy to determine seriousness of problem	4
None	
Not important	1

See Appendix A, p. 43, for the complete question.

Table B7. Comments About Predictive Information on Parameter Displays

Comment	Monitoring	Diagnosing	Controlling
See how long until parameter exceeds limit	9	1	
See trends	7	14	4
Plan action	2		
Increase SA	2		
Keep out of alert range	1		10
Eliminate guesswork	1	2	1
Monitor system more closely		3	
Indicates possible cause		3	
Time to plan		1	
See if corrective action is effective			9
Make sure system remains within limits			4
Gives more time to act			1
Prioritizes actions			1

See Appendix A, pp. 43–45, for the complete question.

Table B8. Comments About Predictive Information Accuracy

Want few false alarms	11
Useful for preparation and planning	9
Prevent alerts	6
See problems before the alert	2
Useful for diagnosis	2
Shows severity and urgency	1
Inhibit during critical phases of flight	1

See Appendix A, p. 44, for the complete question.

Table B9. Comments About Historical Information

Comment	Monitoring	Diagnosing	Controlling
See trends	15	16	3
See past value	4		2
Use for comparison		3	
Prevent alerts		1	3
Know development time		1	
See if corrective action is effective			6

See Appendix A, pp. 46 and 47, for the complete question.

Table B10. Comments About Historical Information Lag Time

How Far Back		Why	
5 m	4	See trends	2
Depends on system	3	See trends	1
		Relevance	1
From steady-state point	3	Reference point	1
10 m – 15 m	3	See trends	3
Operator discretion	2		
15 m – 30 m	2	See major deviation	1
5 s	2	See trends	2
From engine start	1	See trends	2
From lowest value	1	From steady state	1
Last trend	1	Know what to expect	1
From last clearance by crew	1	Reduces clutter	1
10 s	1	See trends	1
1 hr	1		

See Appendix A, p. 46, for the complete question.

Table B11. Comments About Alert Type and Range and Alert Value Information

Comment	Monitoring	Diagnosing	Controlling
Numerical Alert Value			
See trends	2	2	
Immediately know of problem	2	1	
See small changes	1	1	
Shows alert threshold	1		1
Less memorization	1		
Know exceedence amount		2	
Know what parameter exceeded		1	
Tells of corrective action needed		1	4
For troubleshooting		1	
See if corrective action is effective			2
Fine tune corrective action			1
Alert Type and Range			
See trends	16	3	
Shows severity	3	3	1
May indicate cause, action required	2	6	4
For comparison	2	2	
Draws attention	2	1	
Information needed	1		
See abnormalities		6	
Helps		6	
Increase SA		1	
See if corrective action is effective			6
Determines action			4
Keep in normal range			3
See alerts			3
Keep out of alert range			2

See Appendix A, pp. 40, 48, and 49, for the complete question.

Table B12. Comments About Component Control

Components Only Preferred		Components and Other Systems Preferred	
Just want components interested in	5	See how components are related	18
Less cluttered	4	Provides more information	5
Easier to operate	1	See effects of actions	4
Should already have system knowledge	1	Increases SA	3
		Double check on actions	1

See Appendix A, p. 52, for the complete question.

Table B13. Comments About Predictive Information and Parameter Type on Component Control

Comment	Monitoring	Diagnosing	Controlling
Predictive Information			
See trends	9	6	
Know system status at a glance	6		
Indicates a malfunction	6		
Provides an early warning	4		
System monitors itself	3		
Prevent alert	2	1	6
For planning	1		
Know when component will fail		5	
Shows urgency		3	
Base actions on it		3	
Pay attention		3	
Know where problem is		1	5
Know how systems are affected		1	1
Base actions on information			7
See effectiveness of actions			7
Helps monitor affected system			3
Know what to do			1
Helps prevent operator errors			1
Parameter Type			
Know current status	9	6	2
Easy to read	5		
Shows basic information	1		
Increases SA	1		
Determines action required	1		3
System monitors itself	1		
Graphical backup	1		
Know abnormality		7	
Know severity		4	
See changes from normal		2	
Quicker troubleshooting		2	
Know affects on remaining systems		1	1
Know where problem is		1	1
See problem earlier			2
See affects of fix			2
Fix before alert			1
See urgency			1
Helps keep focus on problem			1

See Appendix A, pp. 53–58, for the complete question.

Table B14. Comments About Menu Control Layout

Menu Only Preferred		Relational Menu Preferred	
Easy to understand	3	Shows relationships between components	21
Less cluttered	1	Provides more information	6
Used to it	1	More intuitive	3
Should already have system knowledge	1	Provides a big picture	3
Visually pleasing	1	Good for memory	1

See Appendix A, p. 61, for the complete question.

Table B15. Comments About Menu Control Behavior

Together Preferred		Separate Preferred	
Easier, simpler	14	Get what is wanted	4
See the whole picture	13	Simpler	2
Easy to compare	1	See more data	1
		More flexible	1
		Less cluttered	1

See Appendix A, pp. 69 and 70, for the complete question.

Table B16. Comments About Menu Control Additional Information

Alert Type Preferred		Predictive Information Preferred	
Straightforward, important information	12	Shows time to an alert	2
Shows severity of alert	4	Prevent alert	2
Not confident of predictions	3	Useful information	2
Know which action to take	2	Must be accurate	1
Visually pleasing	1		

See Appendix A, p. 67, for the complete question.

Table B17. Comments About Alert Type and Predictive Information on Menu Displays

Comment	Monitoring	Diagnosing	Controlling
Type of Alert			
Know system status at a glance	16		
Prioritizes	5	6	1
Notifies	4		
See affects on other systems	3		
Shows severity	2		
System monitors itself	2		
Know course of action to take	1		
Know relationship of problem to systems		10	
Helps		4	
Allows for fast diagnosis, intuitive		3	
Use as a guide		1	
Requires less memorization		1	
Take appropriate actions			9
Know limits and capabilities			3
Use as a guide			2
See what is being controlled			1
Predictive Information			
Know when going to lose component	7		
Must be accurate	2		
Intuitive	1		
Allows for planning	1	1	
Early warning	1		
Prevent alert	1	1	4
Distracting	1		
Helps in decision making	1		
Too hard to continuously monitor	1		
Ascertain problems		7	
Shows trends		2	1
Prioritizes		2	2
Indicates cause		2	
Draws attentions		2	
For planning		1	
More time		1	
Evaluate corrective actions			4
Forecasts future actions			3

See Appendix A, pp. 63–66, for the complete question.

Table B18. Comments About Checklist Control

Comment	Normal	Non-Normal
Maintain control	15	15
Maintains SA	9	9
Familiarity	3	1
Provides feedback	2	3
Saves time	2	4
Need to deviate from checklist	1	1
Need to concentrate on flying		1
Decreases workload		1
Reduces human error		1

See Appendix A, pp. 72 and 73, for the complete question.

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14. ABSTRACT
With the increased use of cathode ray tubes (CRTs) in flight decks and the computing power available, it is possible to combine status screens, alerts/procedures screens, and control screens onto a single display. This report presents the results of a survey designed to assess the perceived helpfulness and need of various pieces of information that could be included on status and control screens. The results from the survey indicate that operators want parameter ranges that change depending on the current aircraft configuration shown on bow-tie or dial displays. These displays should show the current value, normal range, alert type and range, and predictive information. Respondents wanted to see system relationships to one another for both component control and menu selection. When bringing up these various displays, this information should come up with a single button push. Finally, checklists should sense when a component has changed to the desired state.

15. SUBJECT TERMS
Status information; Alert; Controls; Parameter range; Predictive information; Relationship information

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