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Reduced Posting and Marking Of Flight Progress Strips for En Route Air Traffic Control

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16. Abstract

The new Display System Replacement (DSR) being implemented in air route traffic control centers (ARTCCs) will allow the data-side controller less room to post Flight Progress Strips (FPSs). We tested a new FPS marking and posting procedure designed to reduce the controller's need for, or reliance on, the FPS. The experiment was conducted at Cleveland (ZOB) and Jacksonville (ZJX) ARTCCs utilizing individual controllers and controller teams operating in either high- or low-altitude sectors. Each controller ran two, 30-minute scenarios. Scenarios were counterbalanced, but sample sizes did not allow counterbalancing of conditions. In the Normal scenario, controllers worked as they normally would. During the Experimental scenario, controllers were asked to remove FPSs that were not needed after radar contact and communications were established. Also, FPS marking was not required for any information that was recorded elsewhere, such as via computer entry or landline communication. Controllers responded to the Workload Assessment Keypad (WAK) every 5 minutes while a subject matter expert made performance ratings. Experimenters recorded activity relevant to the plan view display, computer readout device, and FPSs. At the end of each scenario, controllers provided a position relief briefing and completed a modified version of the NASA Task Load Index. For individuals and teams at ZOB and ZJX, results showed that controllers posted fewer FPSs and marked them less often in the experimental procedure. No detrimental effects on performance, workload, position relief briefings, or team communications were observed. On-line measures of workload (i.e., the WAK) were comparable and sometimes lower for the experimental condition. Most controllers reported that they preferred the experimental procedure.

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Reduced Posting and Marking of Flight Progress Strips For En Route Air Traffic Control

Currently, en route air traffic controllers use paper flight progress strips (FPS) in the constant task of providing safe and efficient radar service. The controller uses FPS to obtain information about a flight and to record changes in flight parameters such as route, speed, or altitude. However, much of the information on the FPS can be obtained elsewhere, such as the computer readout device (CRD). Much of the information recorded by the controller on the FPS is also recorded elsewhere, such as the host computer system or ground-to-air audio tapes. Although redundancy can be very beneficial, particularly when a system fails, redundancy in highly reliable systems may create additional task requirements in terms of workload or cognitive processing for the operator. One way to increase task requirements by redundancy is the execution of unnecessary procedures. For example, writing down information that has already been entered into a computer system may increase task requirements. Another way to increase task requirements is by displaying duplicate or extraneous information that must be searched in order to find the needed information.

The purpose of the current experiment was to examine the performance and workload effects of removing some of the redundant behaviors associated with the FPS that are required for en route air traffic control (ATC), namely, FPS posting and marking. The outcome is of interest due to impending replacement of workstations used by en route controllers. The old, vacuum tube dependent workstation, or M-1 console, is being replaced by the new, more reliable Display System Replacement (DSR). The DSR was designed to eliminate many of the problems associated with the poor reliability of the M-1. The DSR has much more computer power to allow for future system upgrades, including the use of color, and additional functions for the controller. One important difference is the fact that the DSR workstation provides less room for FPS management. Therefore, it was reasonable to wonder whether the benefits provided by the DSR display and its ability to accommodate new electronic displays and tools would be diminished by a restricted ability to use the FPS. It is important to note that during the initial transition, the DSR will simply replace the old M-1 console without adding any new features. If restricting controller interaction with FPS results in a deficit (e.g., poorer performance, higher workload) while using the M-1 console, then it is likely that a similar deficit will remain during a transition to DSR.

A number of researchers have emphasized the importance of active FPS usage (e.g., Hopkin, 1988, 1995; Stein, 1991; Stein & Bailey, 1994; Zingale, Gromelski, & Stein, 1992). Hopkin specifically argued that active control procedures are necessary for controllers to maintain a sufficient level of knowledge and situation awareness (SA) during the ATC task. Hopkin emphasized the importance of physical interaction such as resequencing or writing on the FPS. Without such physical interaction, he argued, controller memory, SA, and hence, overall performance would suffer. The views of Hopkin and others rest on the ideas that memory encoding is important and that it cannot sufficiently occur without such meaningful physical activity. The importance of memory and its relationship to ATC performance in general, and particularly with regard to FPS usage, is formally acknowledged in an Federal Aviation Administration publication entitled, *The Controller Memory Guide* (Stein & Bailey, 1994). This memory guide is distributed to controllers in all ATC environments to promote the importance of memory practices and to show how FPS usage can support a possibly overtaxed or undertaxed cognitive system. Field controllers from en route centers, terminal radar control, and airport towers agreed that memory is an important aspect of ATC and rated the memory guide high in terms of relevance, realism, and overall quality (Stein, 1991). Furthermore, interviews of 170 controllers throughout the United States indicated that the three memory aids used most by controllers involve the FPS (Gromelski, Davidson, & Stein, 1992). These often-used memory aids are FPS management (arrangement of FPS), offset or tilted FPS (indication that further action is needed), and FPS marking (updating and confirmation of commands issued).

The importance of physical interaction with the FPS for controller memory and performance has received some empirical support from both basic and applied research settings. For example, basic research by Slamecka and Graf (1978) used undergraduates to show the robustness of the "generation effect." They demonstrated that participants had better memory for words that were generated by the participants themselves as compared to words that were simply read. The generation effect held under numerous conditions including both recall and recognition memory regardless of whether memory was cued or not.

In a more relevant setting, Zingale, Gromelski, and Stein (1992) provided some support for the importance of interaction with FPS. These researchers trained aviation students to use TRACON II, a simplified, terminal radar ATC simulator. Participants were provided with an FPS for each aircraft in the simulation. Each participant controlled traffic in both Writing and No-Writing conditions in which they either could or could not, respectively, record control actions on the FPS. Results showed that more previous control actions were remembered in the Writing condition than in the No-Writing condition. However, a repeated-measures design was used such that the No-Writing condition always preceded the Writing condition. Therefore, it is not clear whether memory differences were due to practice or condition effects. Furthermore, the participants used in this study were not air traffic controllers and thus results provide only minimal support for the interaction position. No differences in memory for previously performed actions were found when the same basic experiment was conducted using actual controllers (Zingale, Gromelski, Ahmed, & Stein, 1993).

Further evidence contradicting the hypotheses of the interactionist view has been provided by studies that demonstrate a lack of detrimental effects on performance, workload, or cognitive processing when controllers were limited in the amount of interaction they had with the FPS or when the FPS were completely removed (Albright, Truitt, Barile, Vortac, & Manning, 1994; Vortac, Edwards, Fuller, & Manning, 1994). Vortac et al. observed controllers (FAA Academy Instructors) under both normal and restricted FPS conditions. The FPS were posted and visible during the restricted condition, however, controllers could not physically manipulate or write on the FPS. Controller performance, including visual search and recall of flights and flight data, was not impaired by the restricted condition. In fact, controllers were more likely to remember to grant requests and did so sooner under the restricted condition. Vortac et al. concluded that by restricting interaction with the FPS, the ATC task was changed such that controllers were now able to assume a more strategic outlook. The elimination of FPS responsibilities resulted in a reduction in workload, or at least a redistribution of workload, in regard to the FPS and more cognitive resources could be directed towards the task of aircraft separation.

The lack of evidence supporting a detrimental effect due to restricted interaction with the FPS suggests that whatever benefit controllers get from physical interaction with the FPS may be insufficient to result in a distinct memory or performance improvement. Because experts have better memory for task-specific information than novices, these results are in agreement with other research on expertise (Chase & Simon, 1973; Ericsson & Kintsch, 1995; Ericsson & Staszewski, 1989). Perhaps controllers generate enough information, and hence strong enough memory traces, through cognitive activity required to perform the ATC task that simply writing the information down or moving an FPS does not provide much additional benefit in terms of memory storage. Furthermore, controllers may not be remembering the verbatim information as written down or seen on the plan view display (PVD). Instead, they may be remembering more information regarding the gist of a situation or command (Gronlund, Ohrt, Dougherty, Perry & Manning, 1998). Gronlund et al. also demonstrated that memory for aircraft information was not improved by the level of interaction with a pilot, but by the importance of the aircraft. Therefore, the value of FPS interaction may not be in its benefits to memory storage, but in its ability to aid retrieval or verification of information that could not otherwise be quickly retrieved from memory.

If the FPS serve only as aids to retrieval, then limiting interaction with the FPS, either partially or completely, should interfere with controller memory and performance to the extent that an alternate means of obtaining information is unavailable. If the functions served by the FPS are needed by controllers, then they should find ways to compensate for the lack of FPS interaction. Which alternate means controllers use to compensate, for example, by writing information on a notepad or retrieving more information from the computer system via a flight plan readout, tells us more about the role of the FPS in controller activity.

Albright, Truitt, Barile, Vortac, and Manning (1995) previously examined the role of the FPS by observing how controllers compensate for the absence of FPS. They observed full performance level, en route controllers in a simulated, high altitude sector during both a normal condition and a condition in which all FPS were removed. By removing all FPS from the controllers and giving them a notepad on which to write anything they wished, Albright et al. were able to observe whether controllers could compensate for the lack of FPS and - if so - how they compensated. A subject matter expert (SME) evaluated controllers' performance and controllers provided subjective workload ratings after each scenario. Results showed no differences in performance or perceived workload when the FPS were absent. Controllers compensated for the lack of FPS by performing more flight plan readouts on the computer system. The flight plan readout provides the same basic information as does an FPS. Although this means of accessing flight information appeared to have slowed the time it took controllers to grant a request when FPS were absent, controllers spent significantly more time watching the PVD and wrote very little on the notepad. Given the results of Vortac et al. (1994) and the way in which controllers compensated for the absence of FPS in the Albright et al. study, it is arguable that the primary function of the FPS is to provide ready access to flight information and, in terms of ultimate performance and memory, very little benefit is provided by writing on the FPS.

The results of Vortac et al. (1994) and Albright et al. (1995) suggest that, given the physical limitations of the DSR and the space allotted for the FPS, it may be practical to reduce the amount of writing on the FPS and the number of FPS that must be posted. Currently, en route controllers are required to post an FPS for an aircraft from the time radar contact and communications are established with that aircraft until the controller instructs the aircraft to switch radio frequencies and contact the next controller. These requirements result in at least one FPS being posted for each aircraft in a controller's airspace. Furthermore, many control actions must be recorded on the FPS as per the FAA Air Traffic Controller Handbook, 7110.65.

Reducing the requirements for FPS marking and posting by making them optional to the controller thus should not prevent the controller from achieving adequate performance while working within the current specifications of the DSR. Reducing the FPS requirements eliminates the redundant recording of information and potentially results in fewer FPS that the controller must post and search through in order to find important information. However, the evidence in support of reduced FPS marking and posting is somewhat limited. The Vortac et al. (1994) study was limited to individual controllers who were instructors at the FAA Academy. Although Albright et al. (1995) used field controllers, their results are also limited in that they only observed individual controller behavior in a single, high altitude sector. In order to provide further support for the viability of the reduction of FPS posting and marking, questions similar to those asked by Vortac et al. and Albright et al. must be addressed in a variety of both high and low altitude sectors. Furthermore, results must be generalizable beyond the individual controller and the impact of reduced FPS activities must be assessed for the en route air traffic control team as well.

The current experiment was designed to answer two basic questions: First, does providing controllers with the option of posting and marking FPS result in significantly fewer FPS posted at any given time? Second, if the optional posting and marking of FPS does result in fewer FPS being posted, what, if any, are the effects on controller performance and workload? To answer these questions, we compared controllers under both Normal and Optional FPS Marking/Posting conditions. During the Normal condition, controllers had full use of the FPS and they controlled traffic as they usually would. Under the Optional FPS condition, with some exceptions, controllers had to post and mark FPS only until radar contact and communications were established and accepted with an aircraft.

The procedures used in the Optional FPS condition were developed by The Strip Reduction Working Group, which met from November 4-6, 1997, in Washington, D.C. The sole purpose of the meeting was to identify ways to reduce en route controllers' use of FPS and FPS marking in anticipation of the DSR upgrade. The group was organized by FAA Air Traffic Operations branch and included representatives from ATO-110, the Civil Aeromedical Institute, the National Air Traffic Control Association, the ATC Supervisors Committee, and the University of Oklahoma. The varied composition of the Strip Reduction Working Group allowed for consideration of many possibilities for the reduction of FPS activity. The group discussed and recommended changes to the current FPS procedure as possible ways to reduce FPS activity. The result of the group's effort was an alternative FPS procedure that is shown in Appendix A. An important point of the revised FPS procedure is that although it allows for a reduction in the posting and marking of FPS, such a reduction is optional and would only be used if the controller responsible for a sector decided to do so. Before adjourning, the Strip Reduction Working Group decided that an empirical study would be appropriate to test the revised FPS procedure.

The experiment was conducted at two Air Route Traffic Control Centers (ARTCC), Cleveland (ZOB) and Jacksonville (ZJX)[1]. Data on performance and workload were collected from individual controllers and controller teams operating in either high or low altitude sectors.

Method

Participants

A total of 48 full performance level (FPL) controllers volunteered to participate in the experiment (ZOB=24, ZJX=24). Just prior to the experiment, each controller read and signed an informed consent statement and then completed a biographical questionnaire (shown in Appendix B). Mean responses to the biographical questionnaire are shown in Table 1.

Materials and Equipment

Scenarios. All scenarios were selected from training scenarios that had been developed previously by the training department of each ARTCC. Once selected, scenarios were altered if necessary to meet the complexity requirements of the experiment or to insure the occurrence of particular events of interest. Sectors used at ZOB were Hudson (high altitude) and Lichtfield (low altitude). Sectors used at ZJX were Brewton (high altitude) and Florence (low altitude). General descriptions of these sectors are provided in Appendix C. All scenarios were designed to be at least 30 minutes in length. For each ARTCC, two scenarios were developed for each sector (high or low altitude) and staffing condition (individual or team) for a total of eight scenarios per ARTCC. All scenarios for individual controllers had a complexity rating of 70% and scenarios for controller teams had a complexity rating of 100%. Complexity ratings were based on the type of events that occurred during the scenario.

Within the typical occurrences of each scenario, a strip-critical event was identified in order to give the SME an opportunity to evaluate how each event was handled, especially when the related FPS had already been removed from the board. Each strip-critical event required the controller to make use of an FPS and was yoked to the scenario in which it occurred. Strip-critical events included, 1) providing holding instructions, 2) a pilot requesting a route change, 3) an aircraft flying at wrong altitude for direction of flight, and 4) an aircraft requiring special handling such as Air Force One.

Dynamic simulator (DYSIM) training facility. The DYSIM is a high fidelity simulation facility that closely resembles the real en route ATC environment. Workstations are fully functional and landline communications are provided. Flight plans for each aircraft in a scenario are pre-programmed, but controllers or simulation pilots may change any flight plan during the simulation. Training specialists execute ATC instructions to simulate the roles of pilots and other controllers during the simulation.

Workload Assessment Keypad (WAK). The WAK is a computer-controlled, on-line subjective measure of workload. The WAK is well adapted for use in the field because it is relatively small, portable, and can collect ratings from as many as four participants simultaneously. Based on the work of Stein (1985), the WAK obtains a workload rating by auditorily and visually prompting the participant. At an adjustable interval, the WAK emits a high-pitched tone and its seven, numbered buttons illuminate. The participant then makes a rating by pressing one of the buttons within a specified amount of time. The WAK records each rating as well as elapsed time from prompt to response.

[1] Additional data focusing on individual controllers in low altitude sectors were collected at Boston (ZBW). Because there was no effect of the experimental manipulation at ZBW, and because these data focused on individuals in low altitude sectors only, these data are not presented here.

Task Load Index (TLX). A modified version of the NASA TLX (Hart & Staveland, 1988) was used to collect subjective ratings of taskload. The TLX contains six separate scales to assess mental demand, physical demand, temporal demand, effort, frustration, and performance. Each scale was represented as a 100mm line, anchored from low to high. The TLX rating form, instructions, and scale descriptors are shown in Appendix D. Controllers placed an "X" on each scale after an experimenter described what the scale was intended to measure.

Procedure

The procedure was the same for both ARTCCs and is summarized in Table 2. All data were collected in the DYSIM training facility of the respective ARTCC. Once controllers arrived at the DYSIM, they completed an informed consent statement and biographical questionnaire. An experimenter then provided instructions on how to use the WAK.

Once controllers understood the WAK instructions, data collection began with the first of two scenarios. The first scenario was always the Normal condition in which participants were asked to control traffic as they normally would. Although condition (Normal vs. Optional FPS) was not counterbalanced, the two scenarios corresponding to group (individual or team and high or low altitude sector) were conterbalanced, such that each scenario appeared in each condition an equal number of times. Participants were given a notepad to record anything they wished. The scenario began with the SME providing a position relief briefing and then the participant took full control of the scenario for 30 minutes.

During the scenario, the WAK prompted the participant every 5 minutes for a workload rating (where 1 = very low workload and 7 = very high workload). The SME used a behavioral event checklist (shown in Appendix E) to record the occurrence of specific events related to controller performance. The SME also observed one strip-critical event (for example, pilot requests route change) and noted if the participant effectively handled that event. For controller teams, communication effectiveness was evaluated by the SME using the form shown in Appendix F.

Two experimenters used microcassette recorders to archive activity relevant to the plan view display (PVD), computer readout display (CRD), and flight progress strips (FPS). In addition, experimenters recorded the time at which each activity occurred. One experimenter recorded the type of actions performed by the controller involving the PVD and CRD and the time these actions were performed. These actions included request for information, use of a route display[2], J-ring[3], /0[4], and flight plan readout (FPR).[5] The second experimenter recorded the callsigns of FPS and the times each was posted and removed. The second experimenter also recorded D-side activities regarding the PVD and D-side CRD when controller teams were being observed. At the end of the first scenario, the participant used the computer-based (CRD) checklist to provide a position relief briefing to the SME. Once completed, the SME evaluated the quality of the briefing using the form shown in Appendix G. The participant then completed the TLX followed by a 15-minute break.

Participants returned to the DYSIM after the break. Before starting the Optional FPS condition an experimenter reminded the participants how to use the WAK. A representative of the National Air Traffic Controllers Association (NATCA) then summarized the proposed strip marking and posting procedure. Under the Optional FPS condition, controllers were instructed by the NATCA representative that they were to post and mark FPS only until radar contact and communications were established and accepted with an aircraft. After that, strip posting and marking became optional. Participants placed a check mark in field 21-24 of a strip to indicate that optional posting

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[2] A route display is indicated on the PVD as a line drawn from a selected aircraft's current position to that aircraft's position at some designated time, from 1 to 99 minutes, into the future. The route display is based on flight plan information that is currently stored in the computer. The route display is automatically shown whenever a route amendment is made to an aircraft's flight plan via computer entry by the controller.

[3] A J-ring (also referred to as a distance reference indicator) is displayed on the PVD as an approximate circle that can be placed around selected aircraft for means of determining horizontal separation. The J-ring is an approximate circle and has a parameter-defined number of sides. The radius of the J-ring is typically 5 miles but this parameter can also be set by each ARTCC.

[4] A "slant zero", /0, is an action performed by the controller via keyboard entry to shorten the length of a leader line (the line connecting an aircraft position symbol with a datablock as displayed on the PVD). Many, but not all, controllers use the /0 entry as an indicator, or reminder, that they have instructed an aircraft to switch radio frequencies. Because all aircraft are instructed to switch frequencies when departing one sector of airspace and entering another, controllers who use the /0 entry performed it on virtually all aircraft departing their sector.

and marking could be used for that strip. However, optional marking only applied to information that was recorded elsewhere, for example, by computer entry or voice recordings. The NATCA representative also instructed participants that information that was not redundant had to be recorded on the FPS and that an FPS could be removed from the board if it was no longer needed. Participants were also instructed that an FPS was required to be posted and marked in special situations which included, 1) radar contact would be lost, 2) an aircraft was transitioning from radar to non-radar, 3) special handling was required, 4) non-radar flight, 5) an aircraft transitioning from auto to non-auto mode, and 6) holding instructions issued. The full text of the Optional FPS usage procedure is shown in Appendix A. Finally, participants were encouraged (but not required) by the NATCA representative to follow the optional FPS posting and marking procedures as best they could so that an adequate test of the procedure could be conducted. Experimenters then provided each controller with a Procedures Summary Sheet and reviewed each item on the sheet with the controller. The Summary Sheet is shown in Appendix H. As in the Normal condition, a notepad was provided for the controller to record anything he or she wished.

Once the participant indicated that he or she understood the instructions, the Optional FPS condition began with a position relief briefing from the SME after which the participant took full control of the scenario for 30 minutes. As before, the SME and two experimenters observed the participant's activity, and controllers were prompted by the WAK every 5 minutes for a workload rating. The participant used the computer-based (CRD) checklist to provide a position relief briefing at the end of the scenario and then completed the TLX a second time. Finally, controllers were debriefed, thanked, and released.

Results

Data from ZOB and ZJX were combined yielding a total of 16 individuals (8 per sector type) and 16 teams (8 per sector type) for the analysis. Results of individuals and teams will be reported separately for each sector type. Evaluative comparisons will not be made between ARTCCs, individuals and teams, or high and low altitude sectors because the objective of this experiment was to evaluate the Optional FPS procedure, not to evaluate a particular facility. It should be noted that scenarios were used an equal number of times in each condition. Therefore, any differences between the Normal and Optional FPS conditions were not due to differences in scenarios. Statistical values are only reported for tests that were significant with a level of $\alpha = .05$.

Number of FPS posted

It would be difficult to assess the reduced posting and marking procedure without some willingness on the participant's part to try the new procedure. An examination of the number of FPS posted during the scenarios provides information regarding whether or not participants were willing and able to follow instructions and if in fact the Optional FPS procedure resulted in fewer FPS being posted over time. Figures 1 through 4 show the mean number of FPS posted by condition and scenario time for individuals and controller teams in both high and low altitude sectors.

Each of the 4 datasets were analyzed using a 2 (Normal vs. Optional FPS) X 30 (1-min intervals) within-subjects repeated measures analysis of variance (ANOVA). Individuals in low altitude sectors posted significantly fewer FPS in the Optional FPS condition ($M = 10.6$, $SD = 2.0$) than in the Normal condition ($M = 14.5$, $SD = 2.6$), $F(1, 7) = 37.41$, and the number of FPS posted declined over time, $F(29, 203) = 12.05$. The Condition X Time interaction was not significant indicating that the reduction was relatively immediate and was retained throughout the scenario. Individuals in the high altitude sectors did not post significantly fewer FPS in the Optional FPS condition ($M = 13.3$, $SD = 3.0$) than in the Normal condition ($M = 14.1$, $SD = 2.7$) and the Condition X Time interaction was not significant. Individuals in high altitude sectors did post fewer FPS over time, $F(29, 203) = 11.69$. Thus, FPS posting in this condition was not affected by the Optional FPS procedure.

Controller teams in low altitude sectors posted significantly fewer FPS in the Optional FPS condition ($M = 14.8$, $SD = 3.2$) as compared to the Normal condition ($M = 18.2$, $SD = 3.5$), $F(1, 7) = 19.12$, and also posted fewer FPS over time, $F(29, 203) = 8.35$. The Condition X Time interaction was significant, $F(29, 203) = 1.81$. Therefore, teams in low altitude sectors used the Optional FPS procedure to reduce the number of FPS that were posted early in the scenario relative to the Normal condition, but this reduction took some time. After the first few minutes of the scenario, the reduction was maintained.

Controller teams in high altitude sectors posted significantly fewer FPS in the Optional FPS condition (M = 15.0, SD = 5.2) than in the Normal condition (M = 20.1, SD = 3.5), and posted fewer FPS over time, $F(1, 7) = 25.50$ and $F(29, 203) = 54.14$, respectively. There was a significant Condition X Time interaction, $F(29, 203) = 4.25$. Like their low altitude counterparts, teams in high altitude sectors were able to use the Optional FPS procedure to reduce the number of FPS posted during the first few minutes of the scenario and then retained that reduction. Controller teams in both high and low altitude sectors removed FPS at a greater rate during the Optional FPS condition.

Although a significant advantage did not occur for individuals in high altitude sectors,[6] in general, fewer FPS were posted in the active bay during the Optional FPS condition as compared to the Normal condition. Thus, controllers were removing FPS from the board per the instructions. The advantage of having fewer FPS posted was achieved within the first 10 to 15 minutes of the scenario, then that advantage was maintained. It would be reasonable to argue that the greatest advantage for optional FPS posting and marking might have occurred for individuals in high altitude sectors. High altitude operations are typically not as complex as operations at lower altitudes because there is greater vertical spacing and routes tend to be less complex. In fact, the research of Albright et al. (1995) suggests that FPS are not needed in high altitude sectors. Nevertheless, the Optional FPS condition did result in fewer FPS being posted in the more strip intensive, low altitude sectors.

Number of marks per strip

In addition to observing how many FPS were posted, the average number of marks made on each strip were also counted. Again, this insured that participants were in fact using the optional marking procedure as instructed. Participants did in fact make about 1 less mark per strip in the Optional FPS condition than in the Normal condition. Data are shown in Figures 5-8.

Data were analyzed using a dependent measures t-test for each data set. Figure 5 shows the mean number of marks per strip for individuals in low altitude sectors. Significantly fewer marks were made in the Optional FPS condition (M = 4.19, SD = 0.20) than in the Normal condition (M = 4.8, SD = 0.15), $t(1, 7) = 2.64$. Individuals in high altitude sectors also made significantly fewer marks per FPS in the Optional FPS condition (M = 2.52 , SD = 0.10) than in the Normal condition (M = 3.65, SD = 0.13), $t(1, 7) = 3.05$. Individuals in both low and high altitude sectors made significantly fewer marks on the FPS in the Optional FPS condition as compared to the Normal condition. Data are shown in Figure 6.

Figure 7 shows that controller teams in low altitude sectors made significantly fewer marks in the Optional FPS condition (M = 2.39, SD = 0.11) as compared to the Normal condition (M = 3.74, SD = 0.49), $t(1, 7) = 3.19$. Controller teams in high altitude sectors made a comparable number of marks per FPS in the Optional FPS condition (M = 2.93, SD = 0.07) and the Normal condition (M = 3.35, SD = 0.19). Data are shown in Figure 8. With the exception of teams in high altitude sectors, participants made fewer marks on the FPS under the Optional FPS condition. This result supports the fact that participants were implementing the experimental procedure.

On-line workload ratings

It was expected that on-line rating of workload using the WAK would be lower during the Optional FPS condition due to the reduced board management responsibilities. Alternatively, the introduction of a new procedure could produce more board management duties and hence, more workload. The WAK data are shown in Figures 9 through14 which present data from both high and low altitude sectors provided by individuals and team R-sides and D-sides.

[5] The controller can display a FPR on the CRD via a Quick Action Key and keyboard entries. The FPR displays much of the critical information that is displayed on the FPS including, callsign, computer identification number, beacon code, assigned altitude, and route of flight information. The FPR is displayed indefinitely until another action resulting in a CRD message overwrites it.

[6] A number of explanations are possible. It is likely that normal operations for individuals in high altitude sectors may already be somewhat similar to the experimental condition. A second explanation could be that controllers in this group may not have understood or complied with instructions. Thirdly, the statistical test used may not have had adequate power to detect a significant difference given the small sample size. Finally, the scenarios may not have provided situations adequate for the removal of the FPS as directed by the procedural guidelines.

Missing data due to a participant not responding to a single WAK prompt were replaced by the appropriate group mean. Replacement by group means artificially reduces variance.[7] All controllers were included in the analysis even if they failed to respond to more than one WAK prompt. Each of the 4 datasets was analyzed separately using a 2 (Normal vs. Optional FPS) X 6 (5-min intervals) within-subjects repeated measures ANOVA.

The results, as shown in Figure 9, indicate that individual controllers in low altitude sectors rated workload as being significantly lower in the Optional FPS condition, $F(1, 7) = 23.69$, and as increasing over time, $F(5, 35) = 19.00$. Individual controllers in high altitude sectors also rated the Optional FPS as having lower workload, but this difference was not significant. This result coincides with the finding of no difference in the number of FPS that were posted by the same individuals. Individuals in high altitude sectors also rated workload as increasing significantly over time, $F(5, 35) = 6.47$. These data are shown in Figure 10.

Separate WAK ratings were obtained for both the R-side and D-side controllers when controller teams were being observed. R-side controllers in low altitude sectors perceived workload as being less on average in the Optional FPS condition, but not significantly so. They did perceive workload to be increasing over time, $F(5, 35) = 6.87$, as shown in Figure 11. Likewise, R-side controllers in high altitude sectors, shown in Figure 12, rated the Normal and Optional FPS conditions as being similar in workload yet increasing significantly over time, $F(5, 35) = 10.52$. D-side controllers in both low and high altitude sectors, shown in Figures 13 and 14, rated workload as being comparable under the two FPS procedures. D-side controllers in high altitude sectors rated workload as increasing significantly over time, $F(5, 35) = 6.29$.

Overall, participants tended to rate workload as low to moderate. Workload fluctuated and was generally perceived by participants, with exception of low-altitude D-sides, as changing throughout the scenario. Participants judged workload in the Optional FPS condition as being comparable and occasionally lower than the Normal condition.

Post-scenario TLX ratings

Participants provided another subjective rating of workload after each scenario by completing the TLX. Data were analyzed separately for each group of participants (Individual, R-side, and D-side in both high and low altitude sectors) using a 2 (Optional FPS vs. Normal) X 6 (TLX item) multivariate analysis of variance (MANOVA). None of the omnibus multivariate analyses reached the level of significance and no further analyses were pursued. Results are shown in Figures 15-20. Although results were not significant, some small differences are visible and the results were graphed for this purpose. The TLX results only suggest weak relationships in the data and were not supported by statistical analyses. Overall, the TLX ratings were similar for the Optional FPS and Normal conditions.

Compensatory behaviors

Participants could have written on the notepad to compensate for marking the FPS less often. However, participants wrote on the notepad infrequently. Participants made a comparable number of marks on the notepads between the Normal and Optional FPS conditions. An average of 0.5 marks was made on the notepad in the Normal condition and an average of 1.1 marks was made on the notepad in the Optional FPS condition. The small number of notes written suggest that either participants did not think writing information down was necessary or that using the notepad would have required too much work and so it was not used very often. Notes often referred to information that was not normally required but was needed to operate within the DYSIM, for example, the sector number receiving a hand-off.

In addition to the notepad, participants could compensate for reduced FPS posting and marking requirements by utilizing available computer functions such as the flight plan readout (FPR) or route display. Compensatory actions were analyzed using a 2 (Normal vs. Optional FPS) X 4 (FPR, route display, J-ring, slant-0) within-subjects MANOVA. No significant differences in the number of compensatory

[7]The replacement of missing data in subjective workload measurement remains an unresolved procedural issue. It is preferable to replace missing WAK data with group means rather than with a maximum workload rating because it was likely that a failure to respond was due to inadequate auditory and visual prompts rather than extremely high workload.

actions between the Normal and Optional FPS conditions were found. Apparently, participants did not make significant changes in their behavior to compensate for the reduction in FPS activity as evidenced by their lack of writing on the notepads and use of computer-based functions. Although not statistically significant, participants tended to use slightly more FPRs in the Optional FPS condition than in the Normal condition. Compensatory behavior data is shown in Tables 3-5.

Subject Matter Expert Observations

A SME for each sector used the Behavioral and Event Checklist to record the occurrence of 11 events including operational errors, operational deviations, missed handoff, violation of a Letter of Agreement or other directive, missed readback error, failure to grant request, failure to direct aircraft to switch frequency, cause unnecessary delay, inappropriate request of information, computer entry error, and failure to complete proper coordination. Subject matter experts selected these particular events as types of events that may have a negative impact upon operations, especially during the Optional FPS condition. Results are shown in Figures 21-24. Events on the checklist seldom occurred but when one did it was just as likely to occur in either experimental condition. One operational error[8] did occur for a controller team in a high altitude sector but the error was not related to FPS activity. Overall, the Behavioral and Events Checklist did not detect any significant differences between the Normal and Optional FPS conditions for number and type of events that occurred.

Like behavioral events, it was reasoned that the Optional FPS condition might impact team communication effectiveness and the adequacy of position relief briefings. On the contrary, these measures showed no differences between conditions. Team communication, as noted by our SMEs, was not adversely impacted. Only one negative comment was made by a SME regarding team communication. However, this comment occurred during the Normal condition and was related to participants having to repeat an action unnecessarily. Position relief briefings did not suffer either. The SMEs did not note any deficiencies regarding position relief briefings in either the Normal or Optional FPS condition.

Post-Scenario Questionnaire

Data from the post-scenario questionnaire are shown in Table 6. The concerns regarding realism typically referred to situations that were imposed by the idiosyncrasies of the DYSIM facility. Although each pair of scenarios used were constructed and evaluated by SMEs to be similar in complexity, some participants perceived the scenarios they controlled as being similar in complexity, while others did not. Likewise, some participants mentioned that either their counterpart (R-side or D-side) or a simulation pilot had done something out of the ordinary during the experiment. None of the participants indicated that the WAK measure interfered with their ability to control traffic. Finally, most participants reported that they preferred the optional posting and marking procedures.

Conclusions

Overall, participants at ZOB and ZJX posted fewer FPS and made fewer marks on those that were posted during the Optional FPS condition. Even though FPS activity was reduced in the Optional FPS condition, no detrimental effects in performance, workload, position relief briefings, or team communication were observed. It is important to note that participants performed similarly in both experimental conditions despite never having practiced using the optional FPS posting and marking procedure prior to the experiment. According to the post-experimental questionnaire, most participants preferred the optional FPS marking and posting procedures they used during the Optional FPS condition. Participants did not have to compensate for the lack of FPS by using other tools, such as the FPR or notepad, to obtain or remember information that would have otherwise been present on an FPS. No detrimental effects of the Optional FPS condition were detected.

[8] Aircraft must be separated by 5 nautical miles (NM) laterally or 1,000 feet vertically when flying below 29,000 feet mean sea level (MSL). When flying at, or above, 29,000 feet MSL aircraft must be separated by 5 NM laterally or 2,000 feet vertically. An operational error occurs when two or more aircraft violate these separation standards.

Therefore, the results of the present experiment suggest that the Optional FPS condition provided a viable procedure by which FPS activity could be reduced.

Although the data collected in the present study provide encouraging support for the use of an optional FPS posting and marking procedure, some issues remain. Participants were engaged in the scenarios for a relatively short period of time. Participants generally had a high degree of vigilance given that experimenters and a SME were observing them. It is possible that given more time, general patterns of behavior may change as participants become more relaxed. Additionally, given more time to familiarize themselves with the Optional FPS procedure, it is likely that participants may develop and adopt behaviors unlike those observed in the experiment. In particular, it is possible that with longer periods of time to use the Optional FPS procedure, similar events may be more likely to interfere, that is, be confused, with one another (McGeoch, 1942) and some means of compensation, such as cues for memory retrieval, may become more important. Controllers who interact with the same pilots and aircraft flying the same routes every day may be especially susceptible to memory interference because of the high degree of episodic similarity in temporally distinctive events.

Another pressing question for future research regards how responsibilities are passed from one controller to the next during and immediately after a position relief briefing. If the reduced requirements for FPS management are adopted as optional, that is, FPS use is at the discretion of the controller currently in charge of a sector, then how would responsibility be passed given that the controller relieving the position wishes to use a procedure different from the previous controller? The obvious problem occurs when the current controller is using the reduced posting and marking requirements and is then relieved by a controller who wishes to use and mark all available FPS. The question of how to effectively transition from one controller to another controller who wishes to use a different procedure remains to be answered.

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Figures

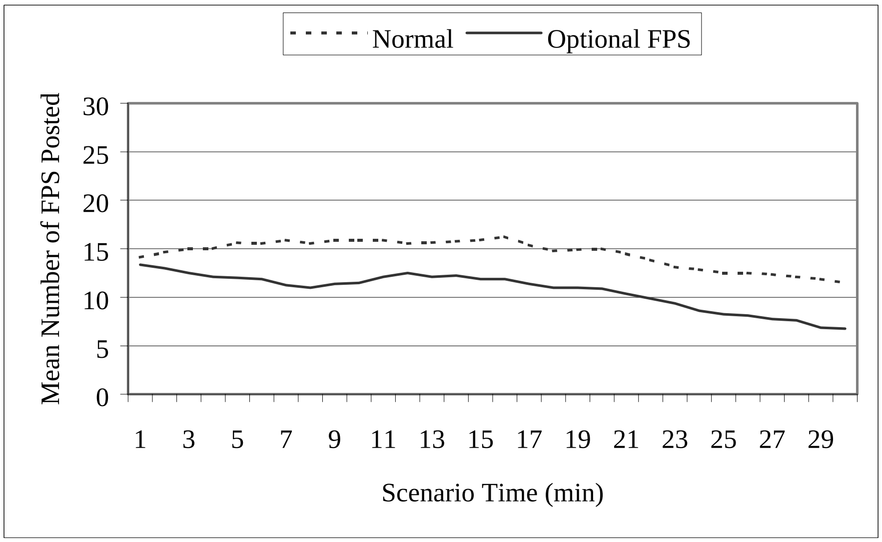

Figure 1. Mean number of FPS posted by condition and scenario time for Individual controllers in Low Altitude sectors.

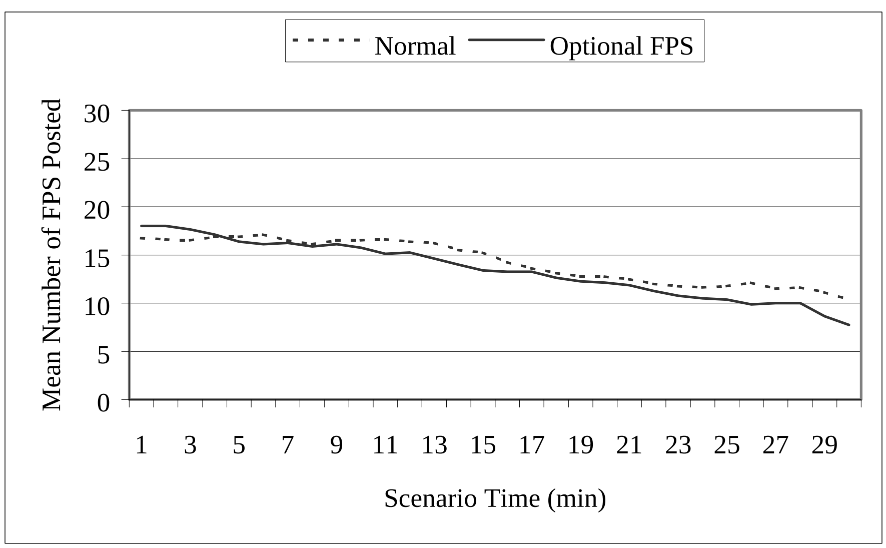

Figure 2. Mean number of FPS posted by condition and scenario time for Individual controllers in High Altitude sectors.

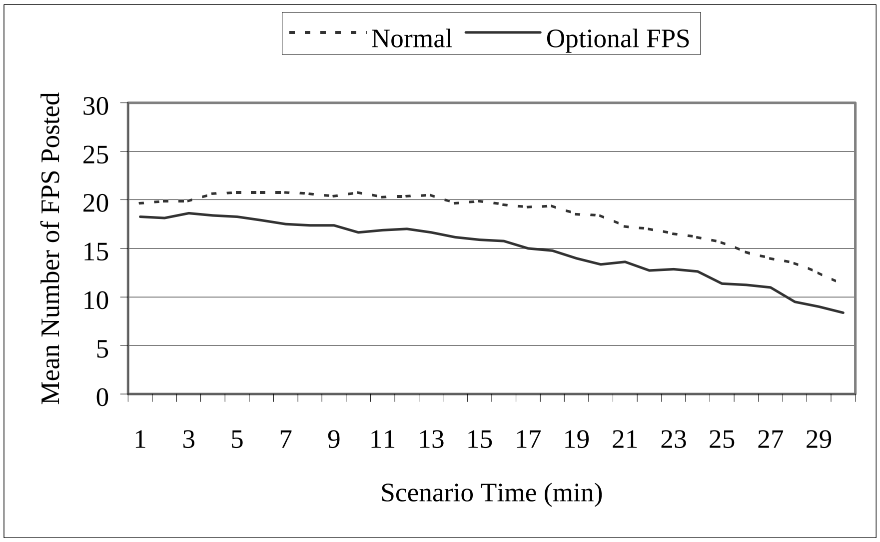

Figure 3. Mean number of FPS posted by condition and scenario time for controller Teams in Low Altitude sectors.

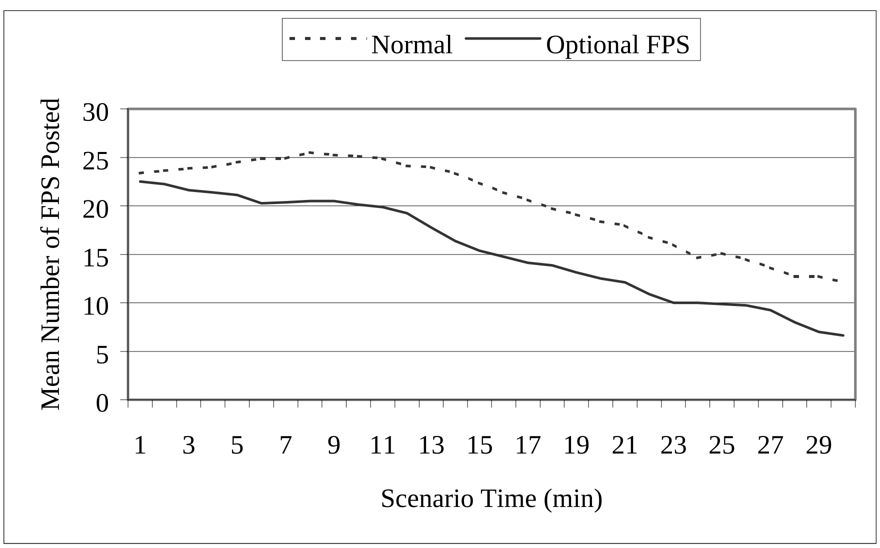

Figure 4. Mean number of FPS posted by condition and scenario time for controller Teams in High Altitude sectors.

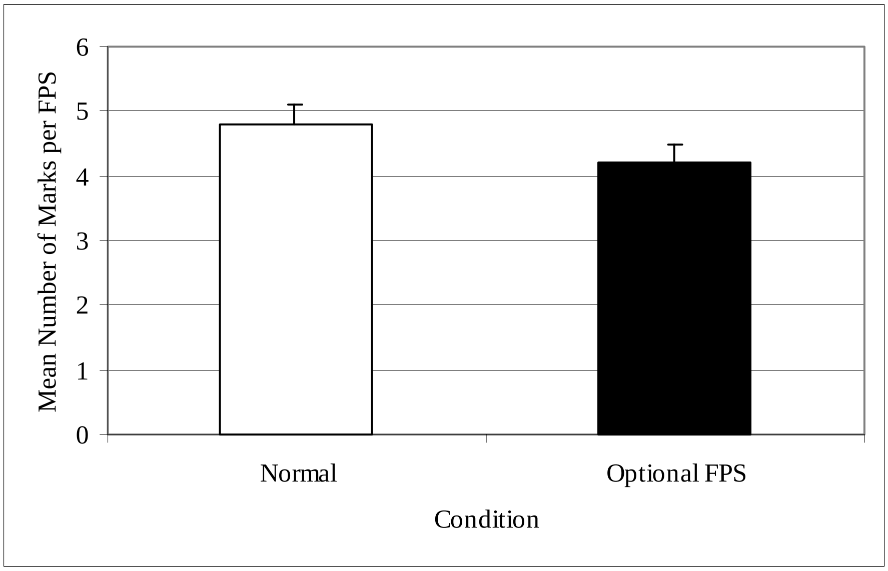

Figure 5. Mean number of marks per FPS by condition for Individuals in Low Altitude sectors.

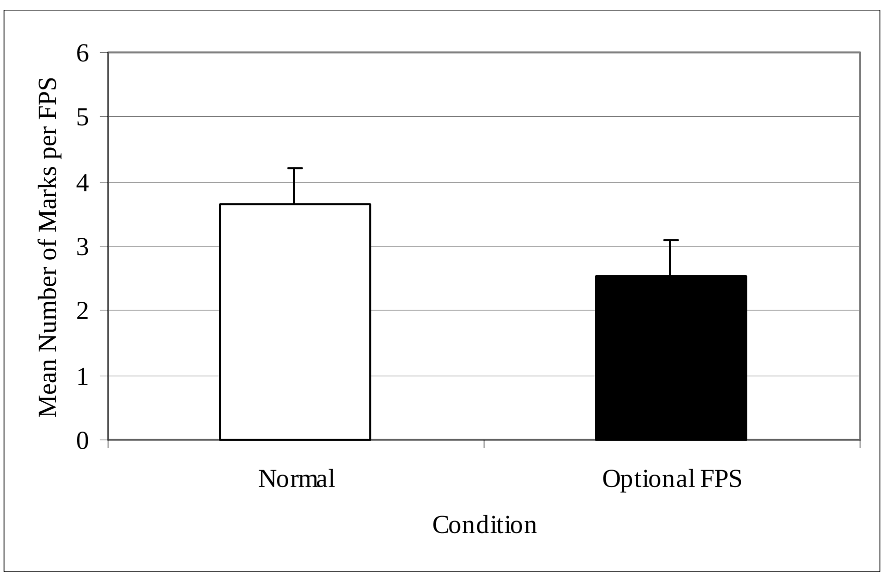

Figure 6. Mean number of marks per FPS by condition for Individuals in High Altitude sectors.

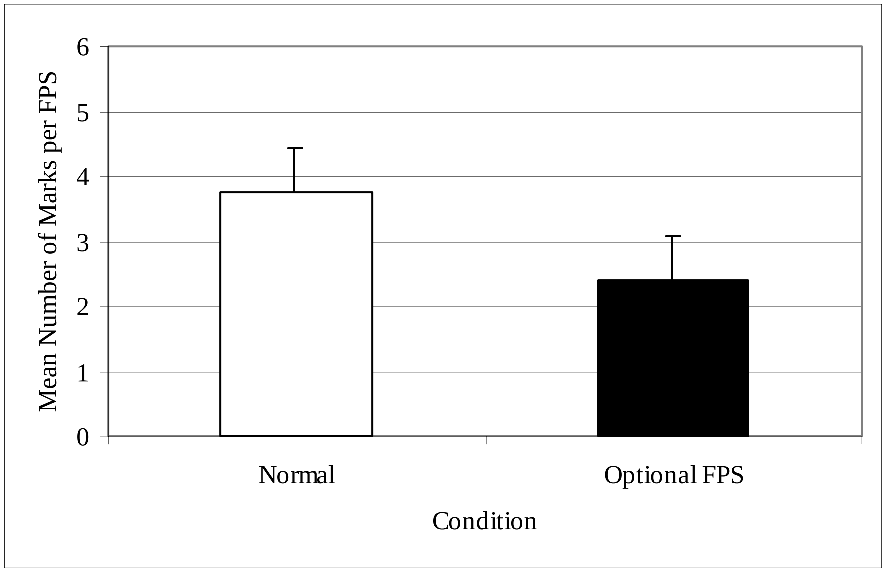

Figure 7. Mean number of marks per FPS by condition for controller Teams in Low Altitude sectors.

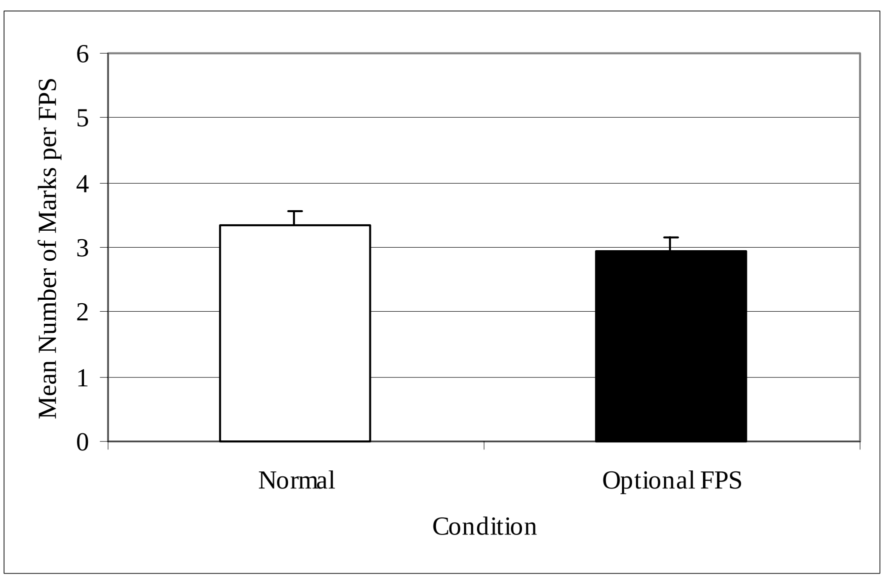

Figure 8. Mean number of marks per FPS by condition for controller Teams in High Altitude sectors.

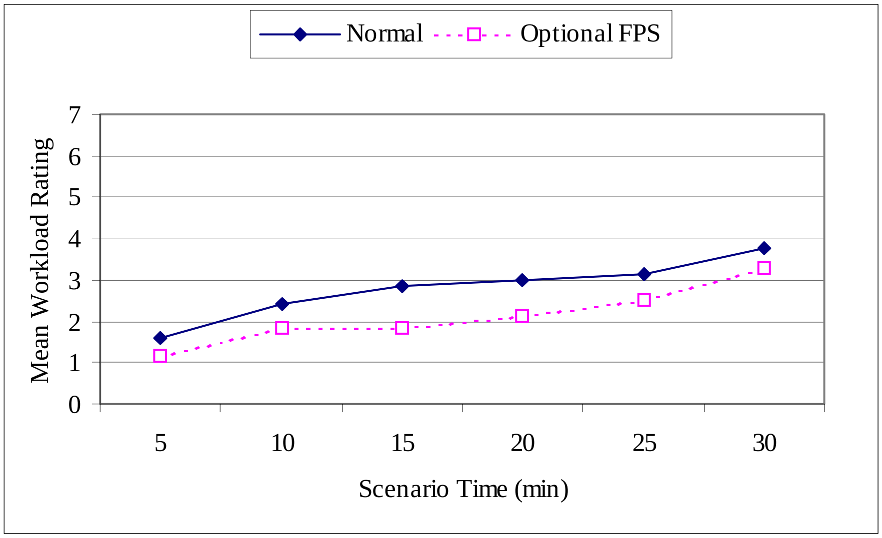

Figure 9. Mean workload (WAK) rating by condition and scenario time for Individual controllers in Low Altitude sectors.

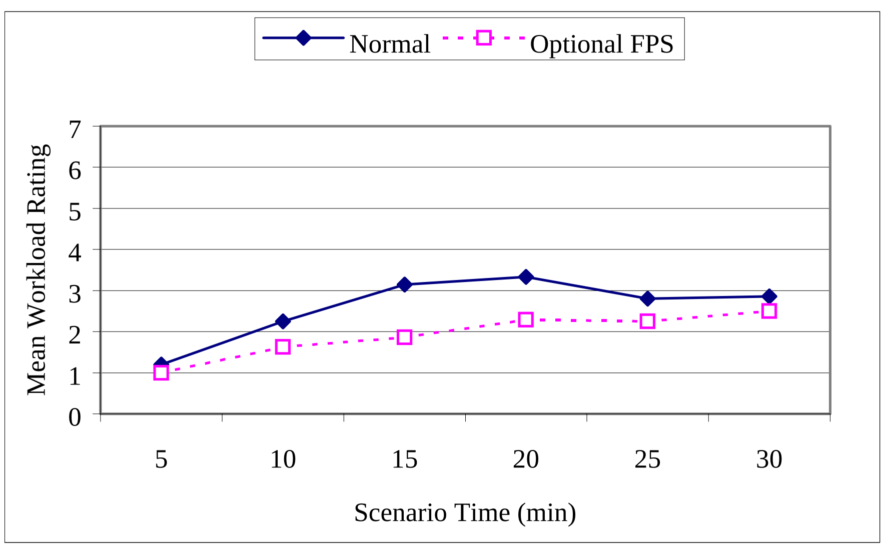

Figure 10. Mean workload (WAK) rating by condition and scenario time for Individual controllers in High Altitude sectors.

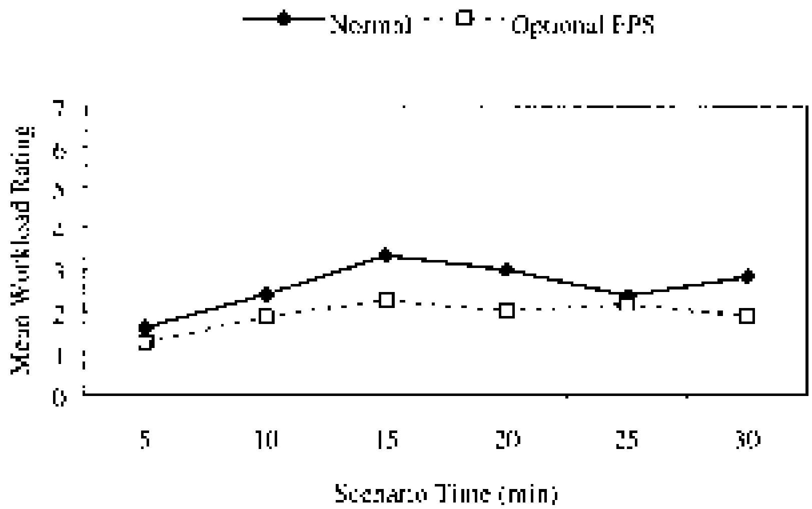

Figure 11. Mean workload (WAK) rating by condition and scenario time for Team R-side controllers in Low Altitude sectors.

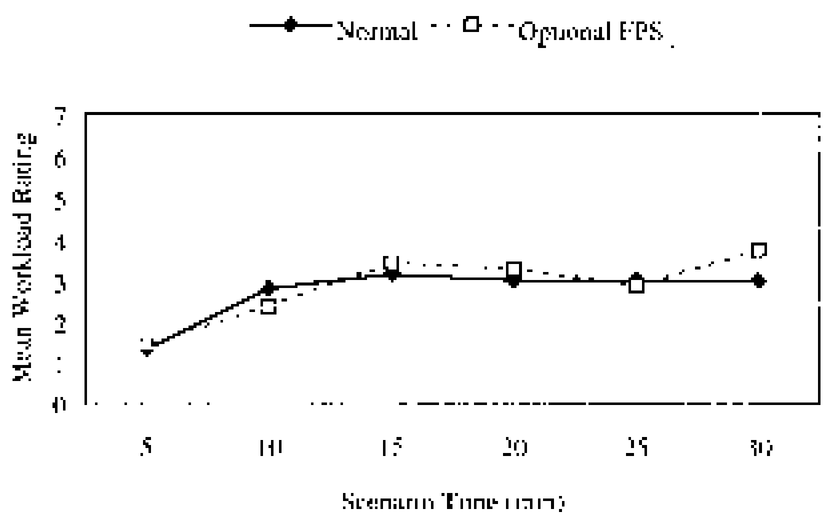

Figure 12. Mean workload (WAK) rating by condition and scenario time for Team R-side controllers in High Altitude sectors.

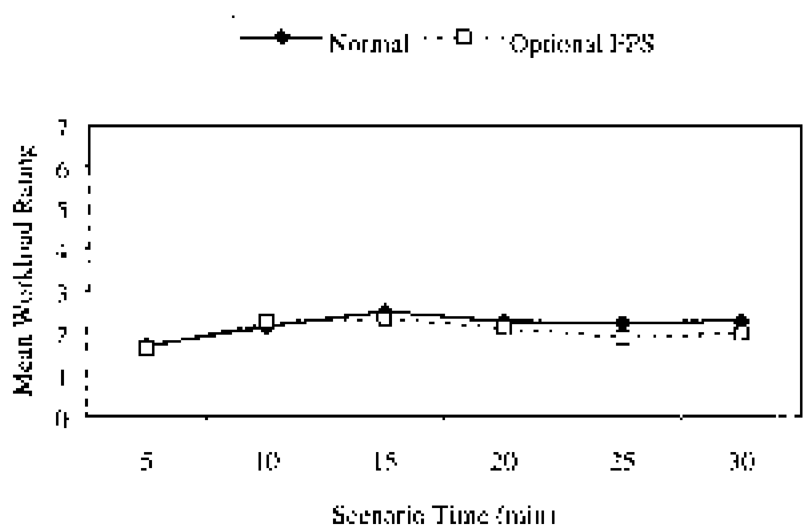

Figure 13. Mean workload (WAK) rating by condition and scenario time for Team D-side controllers in Low Altitude sectors.

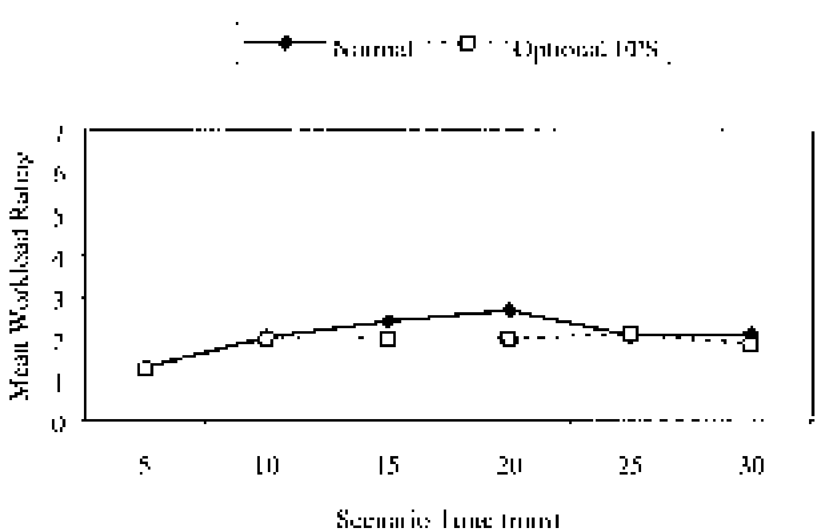

Figure 14. Mean workload (WAK) rating by condition and scenario time for Team D-side controllers in High Altitude sectors

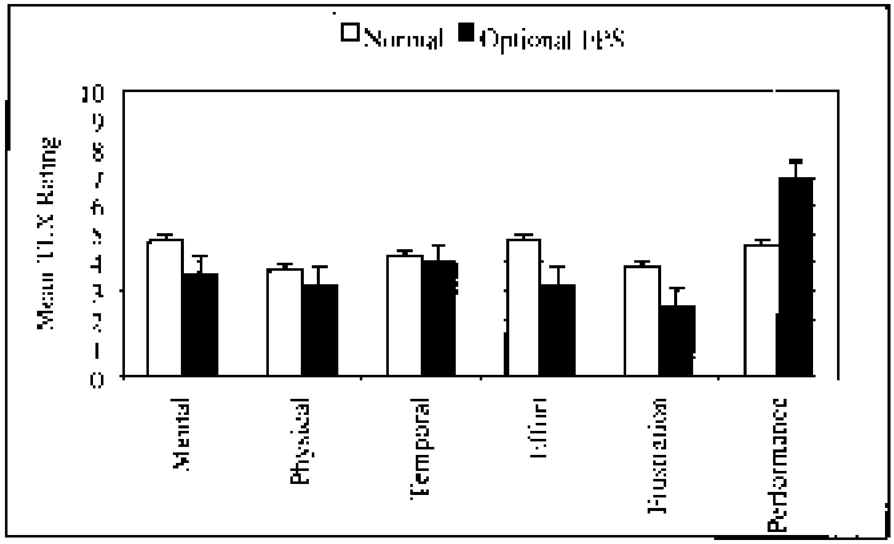

Figure 15. Mean TLX ratings by condition for Individual controllers in Low Altitude sectors.

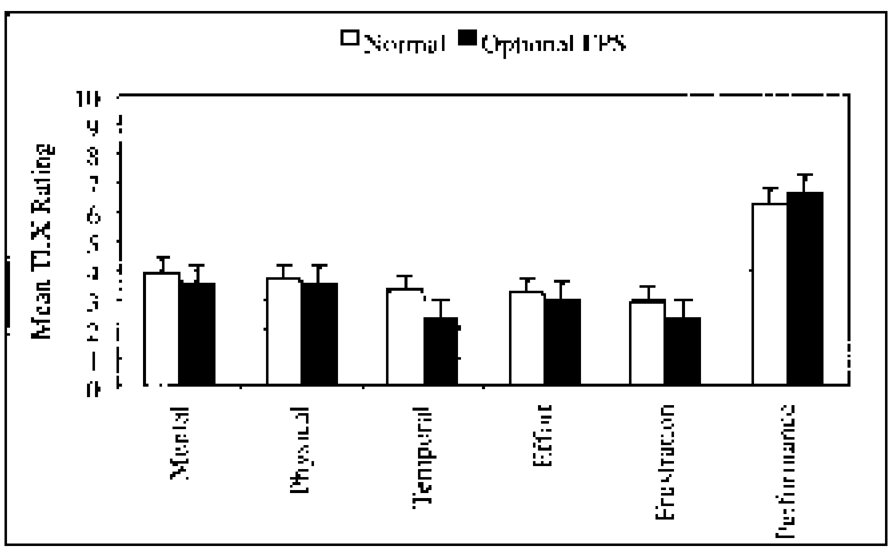

Figure 16. Mean TLX ratings by condition for Individual controllers in High Altitude sectors.

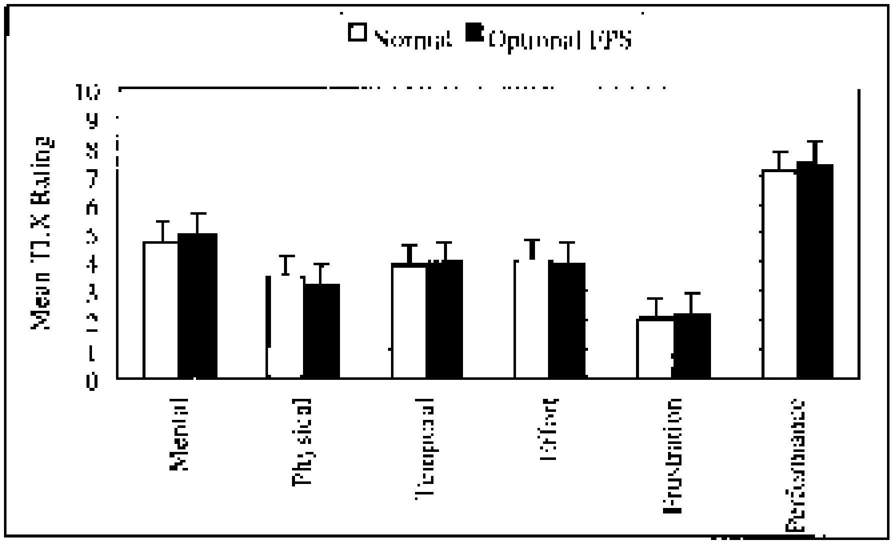

Figure 17. Mean TLX ratings by condition for Team R-side controllers in Low Altitude sectors.

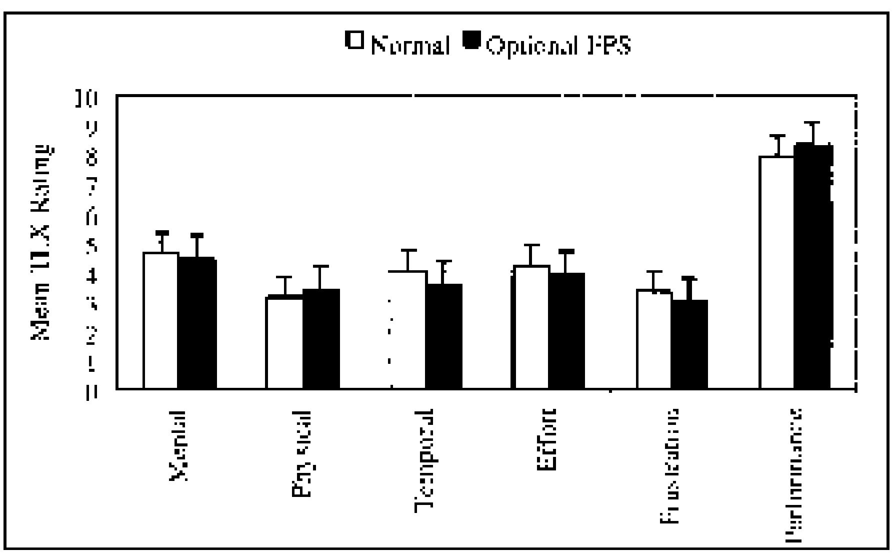

Figure 18. Mean TLX ratings by condition for Team R-side controllers in High Altitude sectors.

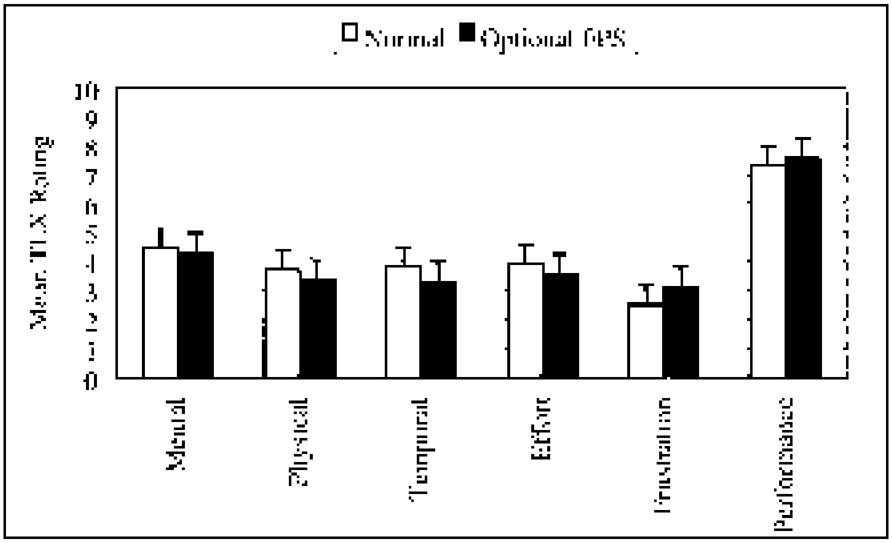

Figure 19. Mean TLX ratings by condition for Team D-side controllers in Low Altitude sectors.

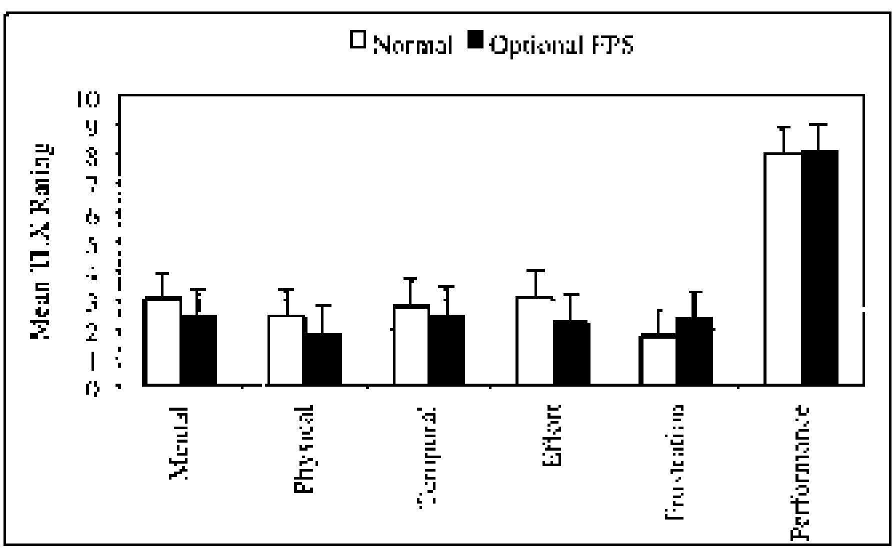

Figure 20. Mean TLX ratings by condition for Team D side controllers in High Altitude sectors.

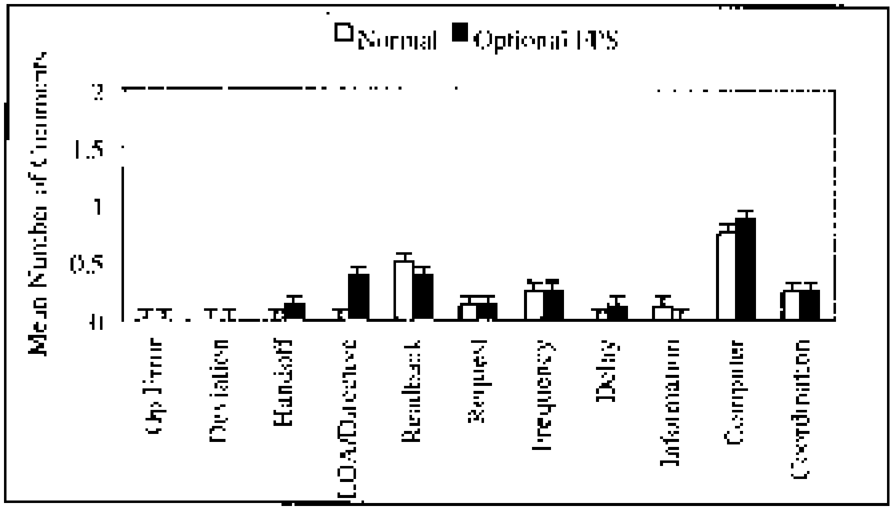

Figure 21. Mean number of event occurrences recorded by SME regarding Individual controller performance in Low Altitude sectors.

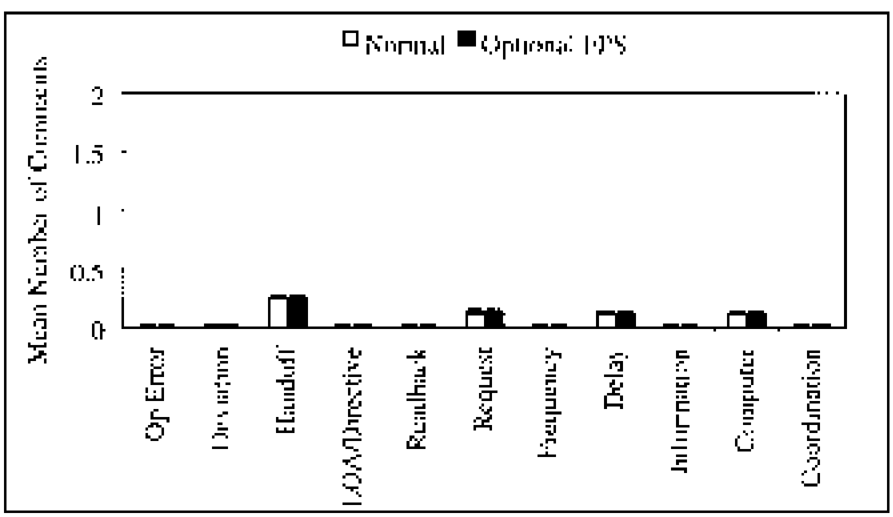

Figure 22. Mean number of event occurrences recorded by SME regarding Individual controller performance in High Altitude sectors.

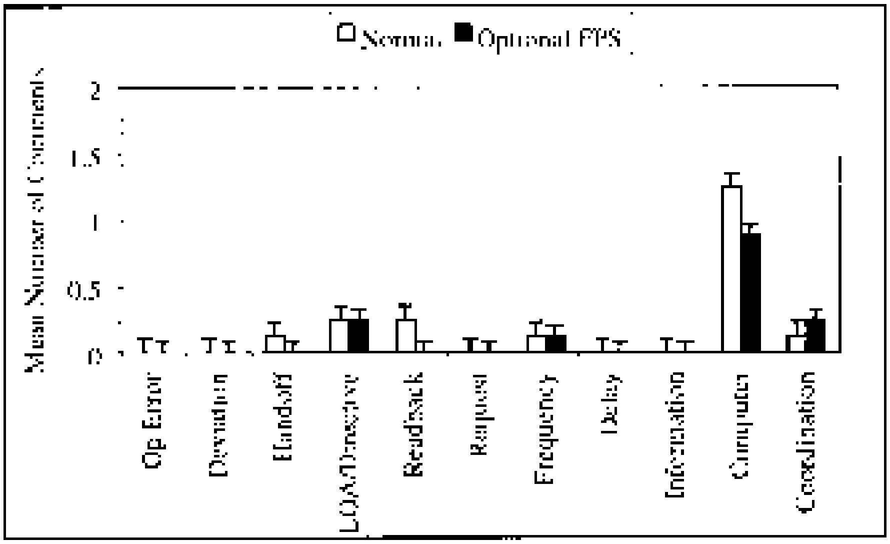

Figure 23. Mean number of event occurrences recorded by SME regarding controller Team performance in Low Altitude sectors.

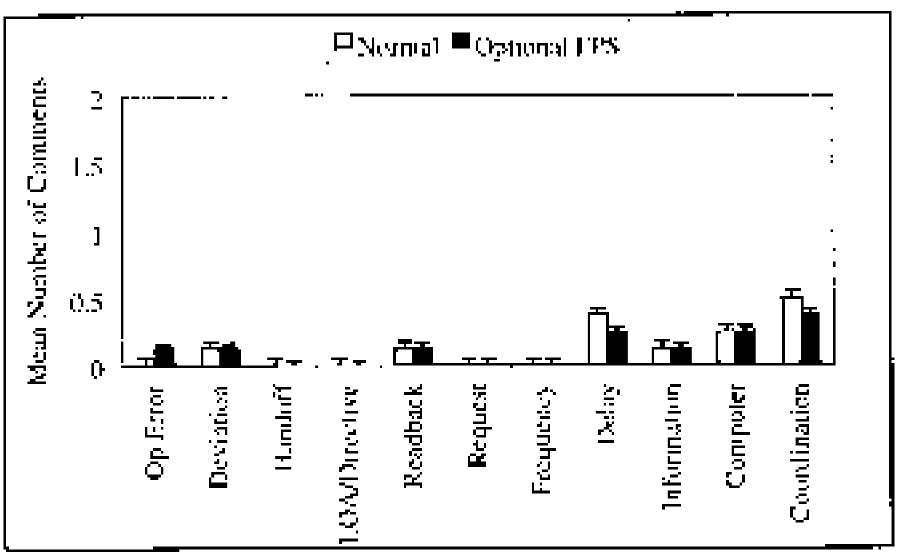

Figure 24. Mean number of event occurrences recorded by SME regarding controller Team performance in High Altitude sectors

Table 1. Means and standard deviations for biographical data by ARTCC.

Biographical Info	ZOB	ZJX
Number of ARTCCs worked	1.17 (0.38)	1.17 (0.38)
Years in current area	10.37 (7.01)	10.75 (7.04)
Years at current ARTCC	11.28 (6.73)	11.86 (6.56)
Years as FPL	8.94 (6.91)	11.15 (8.07)
Years as Controller	13.66 (6.49)	15.30 (6.84)
Time since recertification (yrs.)	4.91 (4.60)	7.89 (7.77)
Age	38.40 (6.38)	39.13 (6.65)

Table 2. Summary of steps in experimental procedure.

1	Participant, experimenters, SME, & simulation pilots meet in DYSIM
2	Participant completes informed consent statement & biographical questionnaire
3	Normal condition begins - Participant receives WAK instructions from experimenter
4	Participant instructed by experimenter to control traffic normally
5	Scenario is started & participant receives position relief briefing from SME
6	Data collection for 30 minutes
	Two experimenters record activity regarding PVD, CRD, and FPS
	SME records strip-critical & behavioral events & communication effectiveness for teams
	Participant controls air traffic & makes WAK rating every 5 minutes
7	Participant provides position relief briefing to SME
	SME evaluates completeness of briefing, noting missed items
8	Participant completes TLX
9	15-minute break
10	Participant, experimenters, SME, & simulation pilots return to DYSIM
11	Optional FPS condition begins - Participant receives WAK instructions from experimenter
12	Participant receives instructions on Optional FPS procedure from NATCA representative
13	Experimenter gives participant Optional FPS procedures summary sheet & reviews it
14	Repeat steps 6-8
15	Participant completes post-experimental questionnaire
16	Participant receives debriefing from experimenter

Table 3. Compensatory behavior. Means (standard deviations) for individual controllers by sector type and condition.

Sector	Condition	FPR	Rt. Readout	J-ring	All
Low	Normal	2.75 (3.58)	2.00 (1.31)	1.50 (2.07)	9.13 (4.49)
	Optional FPS	4.75 (8.03)	2.75 (1.83)	1.63 (1.60)	9.63 (3.85)
High	Normal	2.75 (4.40)	4.50 (1.60)	0.63 (0.92)	10.38 (9.24)
	Optional FPS	1.75 (1.58)	5.75 (3.06)	0.00 (0.00)	10.00 (7.31)

Table 4. Compensatory behavior: Means (standard deviations) for team r-side controllers by sector type and condition.

Sector	Condition	Point FPS	Point PVD	Request Info	FPR	Route Display	J-ring	All
Low	Normal	0.25 (0.46)	2.63 (1.85)	2.38 (1.30)	1.88 (2.30)	1.50 (1.07)	1.63 (1.60)	9.88 (4.97)
	Optional FPS	0.13 (0.35)	1.50 (1.31)	2.38 (2.77)	2.88 (3.09)	1.50 (1.41)	1.50 (1.51)	8.25 (4.46)
High	Normal	1.75 (2.19)	2.25 (1.91)	1.00 (1.20)	3.00 (1.51)	2.75 (1.28)	1.13 (1.89)	13.50 (5.04)
	Optional FPS	0.13 (0.35)	2.00 (1.96)	1.25 (1.04)	4.75 (4.43)	3.75 (2.49)	1.33 (2.26)	13.50 (6.02)

Table 5. Compensatory behavior: Means (standard deviations) for team d-side controllers by sector type and condition.

Sector	Condition	Point FPS	Point PVD	Request Info	FPR	Rt. Readout	All
Low	Normal	2.75 (1.83)	2.00 (1.41)	0.38 (1.06)	0.50 (0.76)	1.25 (1.16)	0.00 (0.00)
	Optional FPS	1.75 (2.67)	2.50 (2.98)	0.25 (0.46)	1.00 (1.31)	0.88 (1.36)	0.13 (0.35)
High	Normal	3.25 (2.31)	1.63 (0.92)	0.50 (1.07)	1.38 (0.74)	3.25 (3.11)	0.25 (0.71)
	Optional FPS	3.63 (2.67)	3.75 (2.35)	1.13 (1.25)	3.38 (2.92)	2.63 (3.46)	0.38 (1.06)

Table 6. Percentage of participants by group responding "yes" to items on the post-scenario questionnaire.

	Individual		R-side		D-side	
	Low	High	Low	High	Low	High
Did you notice anything unusual or unrealistic about either of the scenarios?	75.0%	25.0%	87.5%	25.0%	37.5%	37.5%
Were the scenarios similar in complexity?	50.0%	100.0%	87.5%	75.0%	50.0%	37.5%
Did the pilots or team member do anything strange?	25.0%	0.0%	0.0%	37.5%	25.0%	12.5%
Did responding to the workload rating hinder your ability to control traffic?	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Did you prefer the optional strip marking procedure?	75.0%	100.0%	75.0%	75.0%	87.5%	62.5%
Did you prefer the optional strip posting procedure?	87.5%	75.0%	62.5%	75.0%	87.5%	62.5%

APPENDIX A

Proposed change to Order 7210.3M Part 2. Chapter 8. Section 1. Paragraph 8-1-6. Flight progress strip usage/marking procedures.

a. Flight progress strips will continue to be posted, marked, and updated in accordance with the National directives until radar contact and communications are established and accepted.

b. Once this has been achieved, the radar controller (or, if so designated, the manual controller) may remove the strip from the board. If the radar controller (or, if so designated, the manual controller) elects to keep the strip at the sector, a check mark may be placed in box 21-24 to indicate that further strip marking is unnecessary.

c. The sector team is responsible for all information contained on the flight progress strip. Standard strip marking is optional for both controllers. However, if the radar controller chooses to utilize standard strip marking, the associate controller will support and comply with that request. If the radar controller does not choose to utilize standard strip marking, nothing in this procedure precludes the associate controller from utilizing standard strip marking.

d. Partial recording of control information deemed useful to the sector operation is permitted.

e. Strips on aircraft "pointed out" to the sector may be check marked even though communications are never established.

f. The following flight progress strips are to remain posted and standard strip marking used:
(1) Any aircraft you cannot reasonably expect to remain in radar contact.
(2) Aircraft transitioning from radar to non-radar environment.
(3) Aircraft requiring special handling, i.e., emergencies, radio failures, etc. (Note: Standard strip marking will begin when the need for special handling is identified.)
(4) All non-radar flights.
(5) All flights transitioning from automated to non-automated modes of operation.
(6) All flights that are issued holding instructions.

a. Departures and proposals are to be considered non-radar until radar contact has been established and accepted in accordance with FAAH 7110.65.

b. Any control action not recorded via landline, frequency, or computer entry must be marked on the appropriate strip to record the action.

c. In the event of a back-up system failure, the strips will be posted and marked in accordance with National and local directives. These systems would include any back-up radar or malfunctioning recording system and when operating in DARC only.

d. The controller will continue to be responsible for the control of the aircraft and coordination of information as prescribed in FAAH 7110.65.

e. Blank note pads will be available at every sector for the controller's use.

f. Standard strip marking must be accomplished when training is in progress. This may be discontinued with the consent of the training team.

APPENDIX B

Biography

1) At how many En Route Centers have you worked?
_________ (number of centers)

Please list the centers you have worked at beginning with the most recent:

1) ______________________________
2) ______________________________
3) ______________________________
4) ______________________________

2) How long have you worked in your current area?
______ years _______ months

3) How long have you worked at your current ARTCC?
______ years _______ months

4) How many years and months (total) have you worked at an En Route Center as an FPL? ______ years _______ months

5) Please indicate your total number of years as a controller.
______ years _______ months

6) Please indicate all operations in which you have been an FPL (check all that apply)

______ En Route
______ Terminal
______ Flight Service Station
______ Other (please list)

7) Please check below any area in which you served for six months or more. Please indicate whether you were a manager (M) or a specialist (S). (check all that apply)

______ Flow Control
______ Traffic Management Unit
______ Supervisor at En Route
______ Training Department
______ Automation Specialist
______ Quality Assurance Specialist
______ Area Officer
______ Regional Officer
______ National Headquarters

8) When were you last certified or re-certified?
______ month _______ year

OPTIONAL: Please provide the following:
1) Age _____
Gender _____

APPENDIX C

General descriptions for airspace sectors used.

Cleveland ARTCC (ZOB)

Lichtfield (LFD) Sector – low altitude (ZOB 7220.2B, Appendix 1)

The LFD Sector is a major feeder sector for arrival traffic to the DTW area. Most of this traffic comes in from the west, southwest, and the south. LFD Sector also works TOL arrivals and departures to or from the west and northwest.

Hudson (HUD) Sector – high altitude (ZOB 7220.2A, Appendix 2)

The HUD Sector is an intermediate high altitude sector that has two (2) main flows of traffic: One is primarily eastbound from the CRL VOR. The other flow is westbound via J36.FNT. There is additional eastbound traffic on J70. With the HUD Sector is an air refuel route, AR206H, which is located along J36.

Jacksonville ARTCC (ZJX)

Florence (FLO) Sector – low altitude (ZJX 7220.4H, Appendix 3)

This sector shall include all airspace from the surface up to but not including FL240.

Brewton Sector – high altitude (ZJX 7220.4H, Appendix 5)

This sector shall include all airspace from the surface up to but not including FL240.

APPENDIX D
TLX rating form and scale descriptors

TLX Instructions

We are interested in finding out your perception of how difficult the task is and how well you perform the task. Our objective is to measure your perceived "workload" level. The concept of workload is composed of several different factors. Therefore, we would like you to tell us about several individual factors rather than one overall workload score.

Here is an example of the rating scales. As you can see, there are six scales on which you will be asked to provide a rating score: *mental demand, physical demand, temporal demand, effort, frustration, and performance.*

Rating Scales

Mental demand refers to the level of mental activity like thinking, deciding, and looking that was required by the task. You will rate this scale from low to high.

Physical demand involves the amount of physical activity required of you, such as controlling or activating.

Temporal demand refers to the time pressure you experienced during the task. In other words, was the pace slow and leisurely or rapid and frantic? If the pace was rapid and frantic you are experiencing high temporal demand.

Effort refers to how hard you worked (both mentally and physically) in order to achieve your level of performance.

Frustration level refers to how secure and relaxed versus stressed and discouraged you felt during the task. If you feel secure and relaxed, you have low frustration.

Performance level refers to you perception of your own performance level. Your rating here should reflect your satisfaction with your performance in accomplishing the goals of the task.

Making your response

You should indicate your rating by placing an 'X' on the line adjacent to the item.

For example, if you want to give a high rating of stress factor, place an 'X' to the right of the half-way mark. The higher the stress rating, the closer the 'X' should be to "HIGH". In contrast, if your stress rating is low, you would place an 'X' closer toward the "LOW" end of the line. Likewise, if the stress rating is average, place an 'X' in the center of the line.

Please give your responses thoughtful consideration, but do not spend too much time deliberating over them. Your first response will probably accurately reflect your feelings and experiences.

APPENDIX E
SME rating form

Behavioral and Event Checklist

Event	**Aircraft identity**	**Totals**
Operational Errors (Describe briefly in this column)	(Write both call signs in one box)	
1.		
2.		
3.		
Operational Deviations/SUA violations (Describe briefly in this column)	(Write call sign in each box)	
1.		
2.		
3.		
4.		
Behavior	**Number of events**	**Totals**
Failed to accept, initiate handoff		
LOA/Directive Violations		
Readback/Hearback errors		
Failed to accommodate pilot request		
Made late frequency change		
Unnecessary delays		
Asked pilot for information available from computer or strip		
Incorrect information in computer		
Failed to pass headings, speeds or coordinate pointouts		

APPENDIX F
Team Communication Effectiveness Rating Form

Effectiveness of Team Communications

Sector type: High Low	SME ID:
Condition: Baseline Experimental	Scenario ID:
Facility: ZOB	Participant ID:

Activity	Effective	Ineffective	N/A
Each controller was aware of actions other had taken			
Communicated verbally with team member			
Pointed at PVD to communicate with team member			
Pointed at strips to communicate with team member			
Duplicated efforts—repeated actions already taken by other team member			
	True	Not true	N/A
Lack of communication affected safety of operations			
Lack of communication affected efficiency of operations			

Notes (comment on specific events):

APPENDIX G
Position Relief Briefing Rating Form

Position Relief Briefing Checklist
To be completed by SME or ATC Task Force Member

Individual / Team Sector type: High Low	SME ID:
Condition: Baseline Experimental	Scenario ID:
Facility: ZOB	Participant ID:

Please make a mark under the appropriate column if the participant did not cover the items along the left side of the form during the position relief briefing.

Items briefed	Individual	Team R-side	Team D-side
Navaids			
Equipment			
Radar			
Airports			
Weather			
Flow Control			
Special Use Airspace			
Traffic			

Please choose one of the following and comment below, if desired.

In your opinion, was the position relief briefing negatively affected by the absence of strips of the lack of strip marking?

a. No
b. Yes, it was affected by the absence of strips
c. Yes, it was affected by the lack of strip marking
d. Yes, it was affected by both b and c.

APPENDIX H
Procedures Summary Sheet

FPS Procedures

Post and mark FPS until radar contact and communications are established and accepted.

Must record on FPS any action not recorded elsewhere.

To indicate no further marking required, check box 21-24.

If FPS no longer needed, may remove from board.

Must post and mark FPS for aircraft if:

1) Radar contact may be lost
2) Transitioning from radar to non-radar
3) Special handling required
4) Non-radar flight
5) Transitioning from auto to non-auto mode
6) Holding instructions are issued