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Observing on-Demand Aircrew Transitioning From Paper to Electronic

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OBSERVING ON-DEMAND AIRCREW TRANSITIONING FROM PAPER TO ELECTRONIC FLIGHT BAGS: THE IMPACT ON WORKLOAD

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The introduction of electronic flight bags (EFBs) for flight crew use has reduced the overall workload, except in some situations if not designed properly or employed effectively. Researchers from the Civil Aerospace Medical Institute (CAMI) undertook an observational study combined with crew interviews to assess overall flight crew operations including flight demands, procedures, and the methods the crews used to integrate EFBs into all aspects of their flights from preflight planning to postflight debrief. The researchers also examined the EFB applications (apps) themselves for general usability and developed some recommendations for ways EFB use in operations could be improved. General recommendations and specific recommendations for each phase of flight are provided and include:1) adopting EFBs that are intuitive, 2) standardizing procedures for EFB usage, and 3) incorporating EFB usage best practices into training.

Electronic flight applications and the use of such applications began with the invention of the Electronic Flight Bag (EFB) meant to supplement and/or replace the conventional flight bag in the late 1990s. In 2002, the Federal Aviation Administration (FAA) approved the use of EFBs by publishing an Advisory Circular, (AC) 120-76. The AC defined EFB as an electronic display system intended for cockpit/flight deck use; displaying a variety of aviation data as well as calculations for basic performance in the aircraft. The EFB was originally designed to replace some of the paper products and tools used for flying, such as manuals, as well as serve as a supplemental device to paper documentation (FAA, 2020a). The FAA identifies an EFB as any portable electronic device (PED) a consumer could purchase off-the-shelf with functionality that replaces "conventional paper products and tools, traditionally carried in the pilot's flight bag" (AC) 120-76D.

The FAA created a requirement for Parts 91K, 121, 125, and 135 mandating the use of the approved EFBs in lieu of privately-owned devices to limit distraction from other apps (such as personal email, etc.) during the operation of aircraft (Federal Aviation Administration, 2020b). Part 91 operators (apart from 91K) are allowed to use privately-owned devices. Recent ACs (including the current AC 120-76D) published by the FAA, further defined the EFB as any device actively displaying dynamic and interactive applications such as weather, aircraft parts manuals, chart supplements, daily flight logs (DFLs), crew member qualification logs, weight and balance calculations, performance calculations, electronic checklists, and flight planning. This new designation means iPads and similar electronic devices can be considered replacement devices for flight bags, not merely as a supplement to paper-based flight bag documents. However, the AC requires the failure of an EFB to be a minor hazard when flying with minimal effect on safety if a failure of the EFB occurs. Thus, flight crews must be able to perform normal duties without a fully functioning EFB. Thus, EFBs are used in different ways during all phases of the flight. Reviewing airport configurations, approach plates, and other information pertaining to the flight occurs during preflight with crews at cruising altitude using the EFB to monitor flight progress, review future flights, and access information pertaining to the next airport.

Previous Research on Effects of EFB Use on Flight Crew Performance and Workload

There is some disparity within the literature as to whether EFBs increase or decrease workload. Some researchers state that EFBs increase workload, distractions, and head-down time (Chase & Hiltunen, 2014; Sweet, et al., 2017) while other studies suggest the EFBs decreases workload, increases situational awareness, and improves performance (Haddock & Beckman, 2015; Solgård & Oppheim, 2019). Additional studies suggest there are no statistically significant differences in workload between operations using an EFB and those using paper charts and materials (Suppiah, 2019). A couple of possible explanations for this disparity include variability in the relation between EFBs and workload due to organizational differences (Solgård & Oppheim, 2019), software application or system differences (Sweet et al., 2017), or Human Factors (HF) design differences (Laursen & Ludvigsson, 2017). Other possibilities include differences in study methodology and/or sample type. Many of the studies show a decrease in workload with EFBs when student pilots are participants in the research (Haddock & Beckman, 2015; Suppiah, 2019).

Previous research has shown EFBs increase risk of errors if designed poorly (Chase & Hiltunen, 2014). Risk increases if the EFB's interface is complicated, presents data in a way that is difficult to read, or is ambiguous. Identifying these issues to find the most appropriate tool(s), providing training on the tool(s), and limiting the total number of applications available can decrease errors using the EFB (Haddock & Beckman, 2015).

Providing flight crews with too much information or information that is difficult to access, requiring numerous applications can lead to HF issues such as information overload, increased distractions during flight operations, and the necessity to flip back and forth between applications during critical flying maneuvers (Sweet, et. al., 2017). Flight crews have noted the need to be more "heads down" during flight. However, with the increase in electronic information many aircrew members stated the tendency to fixate inside the aircraft can lead to more safety mishaps. Training must emphasize attention control strategies including proper scans of the instrument panel, EFB, and outside environment (Haddock & Beckman, 2015; Lylte, 2015).

Researchers have noted transferring skills from paper-based flight bags to EFBs for pilots well-versed in the features and functions available show significant increases in pilot performance (Sweet et al., 2017). Tasks such as monitoring other traffic (traffic alerting), accessing paper charts, following checklists, receiving weather updates, standard manuals, and performance calculations became easier when using the EFB (Haddock & Beckman, 2015).

Current Research

Most research on EFBs has been conducted in simulators, where scenarios were presented to pilots and EFB usage was documented (Haddock & Beckman, 2015; Sweet et al., 2017). Research in simulators is common because access to pilots in flight is difficult. However, for this study, Civil Aerospace Medical Institute (CAMI) researchers had access to flight crews, being able to conduct an observational study of flight operations during week-long trips. Prior to the observations, researchers conducted interviews and observed flight crews from planning to flight completion, including the flight debrief, in order to gain a better understanding of the impact of the EFBs on workload, operations, and safety. Researchers recorded real-time workload information, usage of EFBs during flights, and crew interaction to provide recommendations regarding EFB usage, training requirements, and safety challenges when using EFBs.

The overarching scientific question examined was the impact of the EFB on flight crew workload when switching from paper to electronic flight bag materials. More specific questions included: 1) What information on the EFB is important during flight? 2) What is difference between the information presented on EFB vs presented on paper? 3) Is there a difference in workload between EFB and paper-based materials? 4) Does the workload-related risk increase at any specific time during the flight, and if so, how do EFBs change that risk? 5) In what ways are distractions increased or decreased when using EFBs (compared to paper) during flight?

Methods

Participants included pilots and crewmembers from various locations. Data were de-identified and demographic information was separated and not stored with participant responses in an electronic or physical data file. In addition to Informed Consent and Demographics, flight crews were asked a set of prepared interview questions. The study was reviewed and approved by the CAMI Institutional Review Board (IRB) for the protection of research participants.

A sample of 30 pilots and 11 additional crewmembers participated in the study. Flight crews consisted of two pilots and an additional crewmember for each itinerary. The pilots were either the Pilot in Command (PIC) or Second in Command (SIC) during each flight. The PIC was responsible for the flight, while the SIC was often the flying pilot. Most crews switched responsibilities (PIC or SIC) every other day of the itinerary. However, trainees (regardless of years of experience as a pilot) were not eligible to be certified as the PIC, thus they were primarily the flying pilot for the week-ling trip. The additional crewmember collected data during the flight.

Demographic information was collected from crewmembers including position, location, and total flight time to ensure a representative sample of the target population was reached. Flight hours ranged from 5,200 to 27,000. Primarily, pilots fell into one of three categories: 1) 5,000 – 9,999, 2) 10,000 – 19,999, or 3) 20,000 hours. Seven pilots are in category 1, three pilots are in category 2, and one pilot is in category 3. Supervisor pilots' years of flying ranged from 24 to 35 years with the average being 29 years while the flight hours ranged from 7,500 to 14,500. The additional crew members did not provide flight time, ranging from 2 to 30 years in their current position.

Procedures

The procedures consisted of researcher observation of crew interactions with EFBs during flights and in-person interviews at field locations. The typical itinerary consists of a planning day and four flying days, with two flight periods each day. The CAMI researchers took the role of non-participant observer, seated in a jump seat behind the pilots and observed the crew for an entire workweek (40+ hours). The observations included preflight through postflight operations and additional informal meetings in the evenings.

Interview protocol. In-depth, semi-structured interviews allow researchers to explore and reconstruct meanings from events without personally experiencing them (Rubin & Rubin, 1995). Interviews are extensions of ordinary conversations and can be described as conversations with a purpose. The primary difference between interviews and conversations is the intentional listening for verbal and nonverbal cues to better understand the phenomenon (Long, 2006). The interview questions were created following a topical approach with probing questions added for clarification. Steering probes were employed to keep the participants on target and restrict the information being collected (Rubin & Rubin 1995). Interviews were conducted for 30-60 minutes per individual. Interviews were conducted with 41 participants.

Interviews conducted with flight crews covered topics including flight complexities, workload, and use of tools (EFBs, paper, etc.). Questions included, 1) what available information on the EFB is important during flight, 2) what is different between the information presented on EFB vs presented on paper, 3) are distractions increased or decreased when using EFBs (compared to paper) during flight? Questions were not provided to the flight crews prior to conducting the interviews. This allowed the researchers to take notes during the interviews and allowed for more reliable data collection to occur. Individual comments and statements were noted, but no identifying information was included in the note-taking process.

Observation Protocol. Non-participant observations were conducted at each facility after the interviews to provide a nuanced and dynamic approach to situations not easily captured through other methods (Lui, & Maitlis, 2010). In addition, observations were conducted to document any site-specific nuances vs consistent and widespread organizational issues, e.g., workload differences based on region (Lui, & Maitlis, 2010).

Researchers used a three-stage technique described by Lui & Maitlis (2010) in order to observe and document preparation and planning at each facility and during flight in the aircraft. The first stage involved descriptive observation, broadly defining the setting of the observation. The second stage, focused observation, helps researchers narrow the focus by observing the activities directly related to research questions. Finally, selected observation, allows the researcher to investigate the relationship and make connections to ensure a comprehensive understanding of the phenomenon documented.

Observations began with the planning phase of the flight where the researcher took notes by hand or computer, focusing on the use of the EFB vs paper to plan and brief the flight requirements. The researcher observed at least one flight planning session, prior to joining the flight crew. During flight operations, the researcher observed crew interactions and radio communications. Each flight consisted of 2 legs (approximately 3.5 hours in the airplane) breaking for lunch and fuel. After landing, observation continued both formally (end-of-day debriefing) and informally (after 8 hour workday).

Results

Based on observations, interview responses, and discussions with the flight crews, workload using the EFB was noted as moderate to high during all phases of the flight, including planning, preflight, and flying. Minimal impact on workload was noted postflight. Data were analyzed using qualitative techniques discussed below.

Flight Planning

Flight planning was noted by 80% of the crews as a moderate workload phase. Pilots noted the EFB was a positive tool decreasing workload during this stage due to the access to weather briefings, NOTAMs, updated airport information, and the ability to file flight plans quickly and efficiently. The crews stated the ability to import information from numerous sources and share among crewmembers, as well, the capability of overlaying information from one application onto the next, made the flight planning easier. However, 83% of aircrew members stated EFB sources did not always match, requiring further research prior to finalization, impacting workload at times.

Preflight

Flight crews go through a series of procedures to ensure the aircraft and flight plans are still achievable prior to each flight. Preflight checklists were often accessed through the EFB. The PIC reviews the itinerary and informs the crew of changes to the schedule completed each time a full stop occurs. The preflight procedures are considered a moderate workload phase by 64% of the crews if no major obstacles (e.g., weather, maintenance, late clearance) occur. Flight crews find these procedures routine and predictable. The challenge to the crews is being diligent during this stage to assess and record changes. When the routine becomes mundane, errors can occur. Catching errors prior to flying is critical to the success of the flight and organization.

Flying

Approach and landing are considered the highest workload phases by 100% of the crews. While most pilots fly from point A to B with general predictability, the observed pilots work on-demand operations, requiring flights to infrequently-visited or unfamiliar airports. Researchers observed 95% of the crews using the EFB as the primary tool used in flight. Aircrew members reviewed procedures, charts, NOTAMs, monitored weather conditions, and completed checklists using the EFB. The EFB increased situational awareness for the crews during flight when managed properly. However, when system changes (e.g. FMS) occurred during flight, the EFB became more difficult as multiple touches were used to update the procedure, charts, etc. according to 73% of the crews.

Depending on the complexity and requirements of the procedure, the pilot who is flying (in the left seat) is likely to be head-up, remaining vigilant to look for traffic. The PIC who is in the right seat may be head-down or head-up depending on the point in the flight. Since the PIC is responsible for planning and performing the runs, they will look at the approach plates, procedures, policies, and/or notes during the flight using the EFB. Researchers observed this methodology occurring approximately 98% of the time. However, observations were made where both the PIC and SIC were head-down reviewing a procedure, policy, or chart on the EFB during in-flight maneuvers, affecting situational awareness. This occurred more with pilots who were in training as on-demand aircrew member than those with more years in the current position. The impact of the EFB was noted as challenging by 73% of the pilots who were less familiar with the tools and applications used for this job, requiring more touches and head-down time to find information. Workload increased for the PIC when trainees were on board as the trainee was the flying pilot who was focused on flying and less on planning or procedures.

Discussion

Many factors affect the workload of flight crews including the need to complete itinerary planning, and conduct various preflight and in-flight procedures. Adding the complexity of an EFB with various avionics which perform differently can prove challenging. However, the crews stated, and the researchers observed, the addition of an EFB actually decreased workload and made missions safer. However, when trainees were part of the week-long missions, the EFB became more difficult and cumbersome at times. Thus, the following recommendations should be considered to help with workload.

The highest workload occurs during approach and landing (Haddock & Beckman, 2015). Depending on the tasks performed, additional traffic, the airspace, the communication required, and outside forces, workload complexity increases. Additionally, the capability of the tools available and the total number of touches required to access information can impact workload. Standardized training should be created using micro-learning videos for required and supported Avionics applications to minimize the impact of the EFB on workload. The majority of the crews stated learning the functionality in most applications occurred through “trial” and “error”, not through training increasing workload and safety risk during flight. Training should be developed on how to limit the total number of touches, reducing the need to pan/zoom in-out during flight, identify appropriate information required for each mission using a HF approach.

Evaluation and refinement of resource and cockpit organization can further reduce workload. Crews identified the need to find more efficient ways to collect and organize information (paper, EFB applications open prior to run, etc.). Highly experienced crews generally have tailored methods for cockpit organization. However, there may be gains made by reevaluating those methods, suggesting SOPs, and passing on lessons learned to new hires.

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