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Near-Term Nextgen and Class 2 EFBS

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This study is based on data collected at the Electronic Flight Bag (EFB) Advanced Software and Authorization Workshop for US operators currently involved in EFB software evaluation or implementation for their own fleets. With most US operators not taking delivery of new, larger aircraft in the next few years, they are considering ways of displaying near-term NextGen data on board existing aircraft through systems such as the EFB. The workshop collected operator near-term needs in the areas of EFB user interface and standardization and EFB advanced software applications. The analysis of the data collected during the workshop provided a prioritized list of operator needs over the next few years with an emphasis on runway safety and related NextGen systems. The study reports on those needs in the context of near-term NextGen systems and Class 2 EFBs.

The NASA/FAA Operating Documents Group held the Electronic Flight Bag (EFB) Advanced Software and Authorization Workshop jointly sponsored by NASA Ames Human Systems Integration Division and FAA ATO-P Research and Development during the last quarter of 2008. The primary audience for this workshop was North American operators currently involved in EFB advanced software evaluation or implementation. Topics for the workshop included implementation of EFB software applications such as moving maps, satellite weather, and data overlays. This workshop emphasized operator needs rather than manufacturer or vendor capabilities and provided operators with an opportunity to identify key EFB issues with a focus on EFB advanced software applications. Operators had an opportunity to hear about and discuss their EFB challenges, lessons learned, and how the EFB authorization process should be streamlined. The researchers, who have focused on the effects of EFB on crew performance (Kanki & Seamster, 2007) took the opportunity to collect data on operator EFB advanced software needs and issues and then had the operators rate each of those items with regard to how important they were in the context of their operations. The most important EFB issues identified through this workshop point the way to several near-term safety and efficiency improvements especially in surface operations that can be developed and implemented while the aviation industry is working toward full NextGen implementation.

Background

NextGen incorporates several significant advancements to air traffic control to meet the substantial increase in traffic anticipated between now and 2025. NextGen concentrates on the main technological shifts from ground based to satellite navigation, from voice communication to digital data, from disparate to centralized weather with the ability to operate in a fuller range of adverse weather and terrain conditions. NextGen is being planned and designed top down and its full implementation will require the implementation of a number of operational improvements that will not be available until the longer term. Looking at the near-term, NextGen is conceived from the bottom up starting with specific research and development activities, some of them leading to enabling technologies which in turn combine to provide more accurate navigation, weather and real-time broadcasting of related information necessary for the more accurate and tightly spaced management of air traffic. The research and development activities cover many areas including trajectory and performance-based operations, safety management, security, weather information services and a net-centric infrastructure.

Although these research and development areas are interrelated, it helps to focus on one area, in this case Trajectory-Based Operations (TBO). A full implementation of TBO requires near real-time and highly accurate navigation, surveillance and weather information that is accessed over a secure national integrated network. Prior to that full implementation, there are several enabling technologies that will, by themselves, improve operational performance, with an emphasis on crew performance on the flight deck. Starting with the research and development, TBO will require the technical development of critical data exchange of flight clearances, algorithms for real-time trajectory management that incorporate multiple user preferences, separation standards and automated en-route flight plan negotiation that accommodates changing weather and other operational conditions (JPDO, 2008). There are also several research and development areas that look at pilots and the allocation of roles, responsibilities and tasks between controllers and flight crews as well as between computers and their operators. Although crew performance using the EFB (Seamster & Kanki, 2007) is not a driving force across NextGen research, it was a key concern for the workshop participants who represented the operators and who, in most cases, were active pilots.

Near-Term NextGen

The timeframe being addressed in this study is from 2009 through 2012 which coincides primarily with the near-term NextGen work plan. One of the near-term operational enhancements for TBO is improved surface traffic management. This operational enhancement is based on a set of interrelated enhancement with an emphasis of controller data and decision aids. These enhancements are designed to increase both safety and efficiency of the surface movements of not only aircraft but in the long run, also of other ground vehicles. Specifically, it will improve the safety of active runway crossings and reduce aircraft departure wait times (JPDO, 2008). From a top-down perspective, improved surface traffic management requires advanced surface management systems to reduce the time aircraft spend on the surface as well as to optimize the use of gates, taxiways, and runways under a full range of operating conditions. NextGen plans to improve surface movement through the combination of automation, transmission of data instead of just voice communications as well as improved surveillance and displays. The full implementation of improved surface traffic management will require systems integration between surface and aircraft automation. The plan is also to include a runway incursion alerting system that provides controllers and pilots notification of potential incursions. This has been identified as an area needing additional research to determine key alert characteristics including the form, context and other human factors issues (JPDO, 2008). A related area for technology that will extend these surface capabilities will provide aircraft with the ability to taxi in near-zero visibility through a combination of Automatic Dependent Surveillance-Broadcast (ADS-B) OUT along with airport moving map and flight deck traffic displays. From a top-down view of NextGen, improved surface traffic management requires a complex of research and technology developments to achieve full implementation. By shifting the perspective away from a top-down, controller-centric view to a set of near-term operator and pilot needs, it is possible to obtain a clearer view of some less complex innovations that can lead to improved surface safety and efficiency in the next few year.

The NextGen work and implementation plans emphasize the Air Navigation Service Provider (ANSP) as it tracks the delegation of separation responsibilities ensuring that the responsibility is clearly communicated. The long-term plan leads to what NextGen calls, cooperative surveillance, based on ADS-B IN and ADS-B OUT where data is available about all aircraft in the area. Devices and displays will be needed for both the controller and flight deck side of operations to support receiving and understanding flight and traffic information. The air or pilot side can be enhanced through the use of flight deck displays in the graphic representation of surface clearances, conditions and changes. Some of the enabling technologies that will require flight deck display of airport and surface data include electronic maps and charts with own-ship position on airport ramps, taxiways, and runways with the eventual representation of other surface vehicles. Additionally, there will be the cockpit display of nearby surface traffic. This will be followed by a more advanced display of traffic information that includes both surface and airborne aircraft. A further capability will be a device to allow aircraft to expedite the crossings of active runway and perform delegated separation procedures at high-density airports as well as under low-visibility conditions. This complex of technologies may take a decade or more to develop, but there is an important tool that is being implemented by a number of operators that can provide pilots access to some of the capabilities that will improve surface safety and efficiency.

NextGen and the EFB

The EFB has the potential to display near-term NextGen capabilities in a cost effective manner on existing aircraft. This coincides with NextGen implementation plans to leverage existing aircraft systems and capabilities throughout the near-term. The EFB is being used by an increasing number of operators to display charts, manuals, and weather data. Recently, the FAA has allowed portable EFBs to display own-ship position on airport moving map displays. The FAA further authorizes installed EFBs that are certified to be integrated with other avionics, such as the Flight Management System (FMS), to support some of the implementations of the advanced NextGen capabilities. The EFB could play a significant role in the NextGen scenario where pilots will receive the final flight plan data, which could be in both a text and graphic format. Own-ship position would also be displayed on the flight deck showing it as it taxies along with the position of other aircraft in the vicinity and other surface vehicles. Rather than having a number of separate devices and displays, the EFB could also be considered as a way to provide runway incursion alerts integrated with the moving map and own-ship position.

EFBs have different certification requirements depending on their classification. Class 1 EFBs are portable computing devices that are not mounted to the aircraft. Class 2 EFBs are computing devices that are attached to the aircraft during normal operations while Class 3 EFBs are installed on the aircraft allowing for a wider range of applications. The name, electronic flight bag, describes the initial concept of the device which was to replace the pilot's bag of operational charts and documents with a computer and display that would provide full access to that information in a more usable form. As the pilot's EFB has evolved and has been networked not only with the other pilot's EFB but also with other flight deck systems, it is being viewed by pilots and operators as an innovative display and control device that can be used well beyond its initial intent providing a number of NextGen functions.

A candidate control and display of near-term NextGen data on the flight deck for US operators is the Class 2 EFB. This is due in part because major carriers will not be taking delivery of substantial numbers of new aircraft in the near-term with the overall estimates of new aircraft deliveries to the domestic operators being revised downward. This will affect the availability of Class 3 EFBs that are generally obtained through new aircraft purchases by the major operators. With approximately 17% of aircraft being stored by the major US operators, and three of those operators with more than a quarter of their aircraft stored (see Figure 1), the demand for near-term deliveries of new aircraft with Class 3 EFBs is has been reduced.

Methods

The workshop was designed to provide participants with an opportunity to present, discuss and rate EFB advanced software experiences and needs. There were 25 participants at the workshop involved in identifying the key EFB advanced software issues. They included representatives from the main operators evaluating or implementing EFBs as well as other industry members including regulators. All participants were given the opportunity to specify EFB issues, and then 16 of the participants performed the actual rating of those issues. The raters had an average of eight years of EFB experience and an average of 4,300 hours of total flight time. The range of total flight time was between 0 hours for the three engineers and 15,000 hours, with the raters having substantial operational experience.

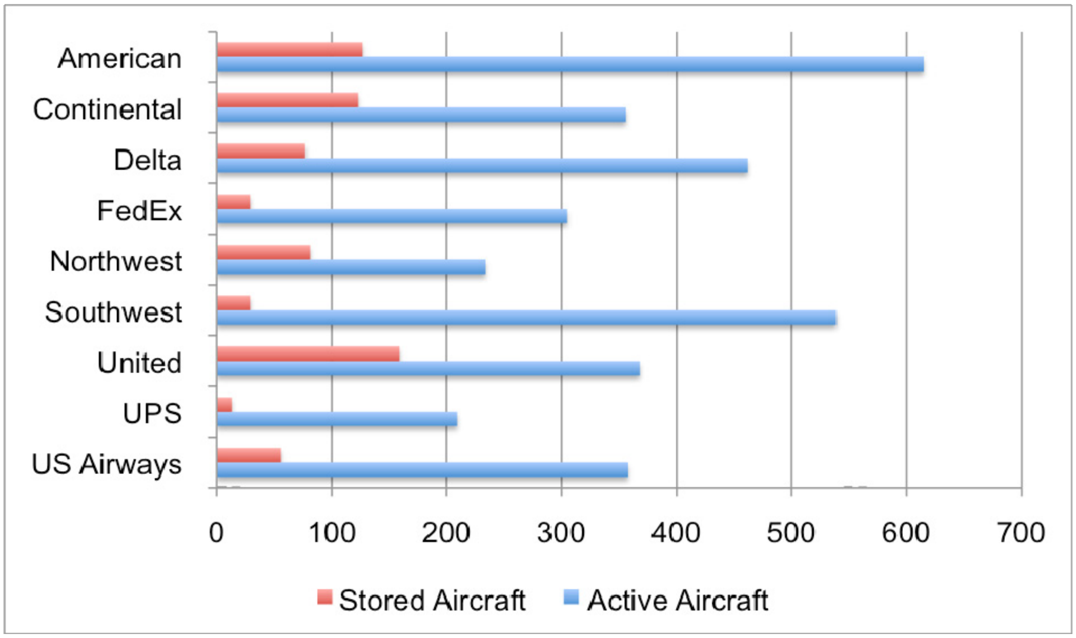

Figure 1. Major US operators with approximate numbers of active and stored aircraft (data source Planesregister.com).

Leading up to the workshop, participants were asked to submit topics that they wanted to present and also those they were interested in hearing about. During the workshop, participants, working as a group were encouraged to identify EFB issues in the following four areas plus any additional EFB issues:

1. EFB User Interface and Standardization to include Multi-Tasking, Color Coding and Symbols
2. EFB Advanced Software Applications including MET/WX, Charts Graphical Overlays.
3. Integrating EFB with SOP, Training, Best Practices and Flows
4. Improving Crew Performance with EFB to Include Situation Awareness, Workload Management and Runway Safety.

After all the EFB issues were identified and discussed, participants were provided with a ratings form listing the 25 issues organized by the above areas. They were asked to rate each issue as to its importance using a six-point scale where 6 represented 'Extremely Important,' and 1 represented 'Extremely Unimportant."

Results and Discussion

Although some of the issues proposed by the participants pertained to more than one category, the issue was placed in the area where it was first identified. The participants specified six issues related to the EFB touch screen functions, standardization of information organization, high level EFB functions, lower level chart and map details as well as standards applied to key features of the ground-based and flight deck EFBs. They also identified issues specifically related to advanced software including the display of own-ship position, airport moving maps, other traffic, and weather. In the area of EFB SOP and training, the group specified issues of crew coordination, company procedures and best practices, and integration with existing training and crew assessment. In the area of improving crew performance, participants were concerned with managing multiple applications on the EFB, integrating applications and standard usage of some of the advanced applications.

Table 1. *Top 10 rated EFB issues based on 16 raters with 6 representing Extremely Important.*

EFB Advanced Software Issues	**Mean Rating**
Top Five Most Important Issues	
Display of aircraft position	5.47
Runway and taxiway safety	5.43
Airport moving map plus traffic and advisories	5.20
How many and which applications degrade crew performance	5.19
Managing multiple applications	5.13
Next Five Most Important Issues	
Coordination across pilots	5.06
Multi-tasking issues, minimize button pushes	4.93
Select Function: touch/select/drag/scroll interface design and training terminology	4.87
Company-specific standard callouts, EFB use	4.81
Integration with training, qualification standards	4.81

The top ten EFB issues rated as most important are shown in Table 1 along with their mean ratings. The top five important issues, with an average rating between Extremely to Very Important group into an integrated set of EFB research and development activities that should be considered as a way to make available some NextGen data in the near-term. Airport moving map with own-ship position is just now being approved for operational use on Class 2 EFBs. Operators see the importance of extending that functionality to further enhance safety by determining ways to add traffic and advisories plus other available NextGen data. This combines with the issues of integrating, what are currently, separate applications into a form that will improve pilot information management without degrading crew performance. The next five important issues group into a set related to crew coordination, SOP, training and the EFB input interface research activities. Based on these two groupings of issues, operators are most concerned with the integration of additional surface data and advisories into an easy to use EFB display. They have a secondary concern on how to ensure that this advanced technology can be used to improve crew coordination through procedures and training as well as how to improve the EFB interface, with an emphasis on inputs via the touch screen.

Class 2 EFBs provide operators with an economical way of displaying and controlling some of the important near-term NextGen data on existing aircraft. Interpreting the ratings data, one of the research and development challenges is to provide that data in ways that will improve, rather than potentially degrade, crew performance. From a research perspective, there are several key challenges for providing the display and control of this NextGen data in an integrated manner, especially on Class 2 EFBs. One research area involves evaluating the different user interface metaphors as the EFB transitions from being just a flight bag that displays documents and charts to becoming a flexible display of both static and dynamic information to improve decision making and situational awareness while reducing crew workload. The industry is working with a number of distinct metaphors that are either under development or that have been implemented (see Figure 2 for some examples). Some of the metaphors are based on the FMS controls with either hard or soft buttons around the edges of the display for user input. Other metaphors have been derived from paper document trip books or clips that pilots have used traditionally to organize their charts before and during flights. Still other metaphors under development have utilized a browser for accessing and displaying information. The browser metaphor shows potential for transitioning the EFB from a flight bag to a more display and control device, but developers will have to address the challenges and limitations of using a browser interface for critical applications on a flight deck rather than at a desktop.

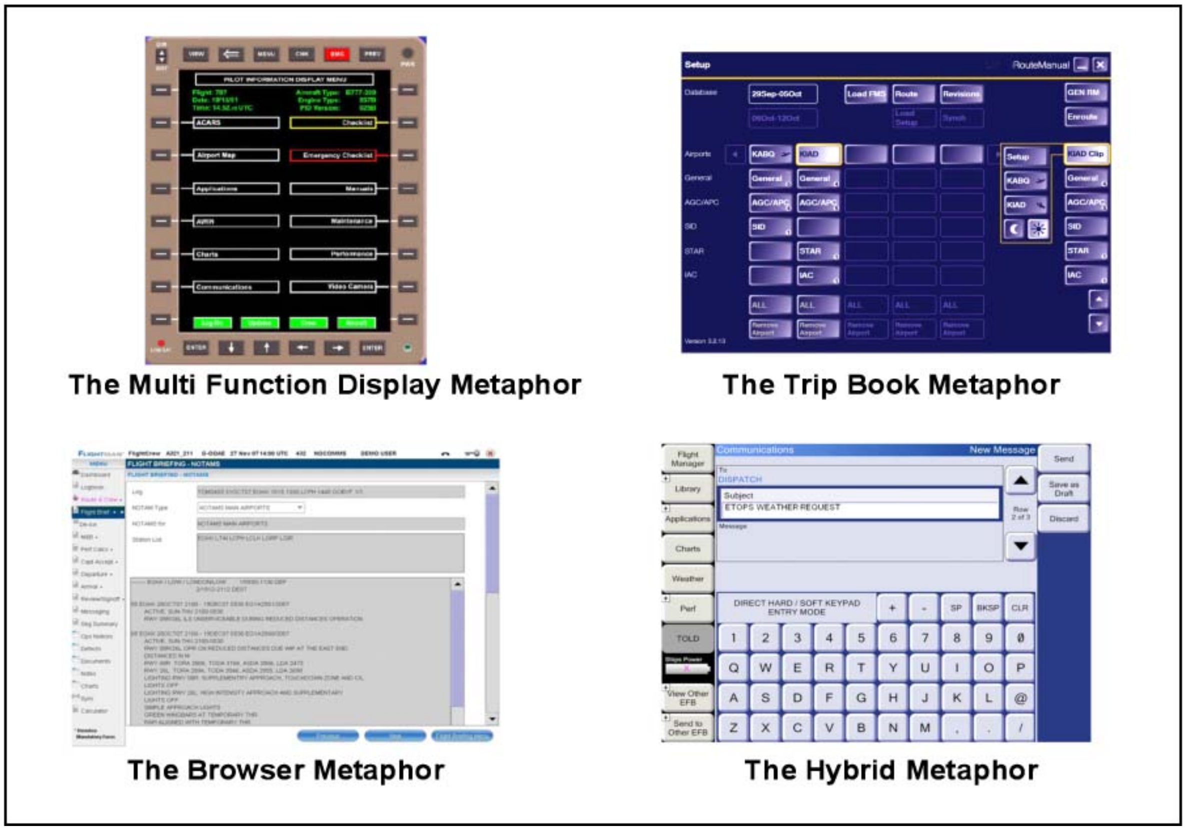

Figure 2. Examples of EFB User Interface Metaphors under development or in current use.

In order to incorporate NextGen capability, the current trip book metaphor needs to be extended and the browser interface would have to be refined before it can be used as a way to access information on the flight deck. In addition, the EFB Class 2 small screen size presents substantial limitations for data display. On most flight decks, the EFB screen size cannot be increased substantially in part because of the limited space and potential for blocking existing displays and controls. Even with these limitations, the Class 2 EFB should be evaluated as a way of graphically displaying additional airport data such as traffic, taxi clearances, closed runways, construction and other temporary obstacles normally made available to pilots through text messages. With operationally relevant research and development, EFB constraints can be overcome allowing the display of safety critical near-term NextGen data.

References

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