

Spatial Knowledge and Information CANADA: New Technologies in Air Navigation of the Czech Air Force

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Abstract

It is obvious that in the 21st century electronic maps have the sophistication to replace paper. This happens even in aircraft avionics. A device called electronic flight bag (EFB) can display digital aeronautical charts and other necessary navigation data. This article briefly describes the EFB and its advantages and application in the Czech Air Force (CZAF). Digital aeronautical charts and navigation data are useful for pilots of military airplanes and helicopters for the fulfillment of combat and special missions. Analysis and survey methods were used. The aim of the research is to demonstrate the need for the integration of new technologies to increase the efficiency of navigation and guidance of the CZAF aircraft. For this purpose, currently used devices in the CZAF were analyzed. In addition, experiences and opinions of the pilots obtained from a survey conducted by the authors are presented. Finally, a discussion on this topic is offered. It is expected that the research will help to increase the quality level of navigation equipment of the Czech Air Force aircraft. Further research on this topic will follow.

Background and Relevance

Pilots use aeronautical charts as both a planning tool and as a source of specific, detailed reference data (Wright and Barlow, 1995). As a planning tool, charts help the pilot envision the procedure to be flown by providing information, such as which navigation aids will be used, and/or altitudes and headings to follow for approach and landing procedures (Chandra, 2003). Paper charts have been used for decades in aviation. With advances in technology, more and more attention is paid to electronic solutions for aeronautical charts. An electronic device can hold many charts, reducing space and fuel needs associated with bulky paper charts. Digital aeronautical charts and other navigation data are displayed on devices called Electronic Flight Bags (EFB). Military digital charts displayed on these devices are the main point of interest in this research. The introduction of computers into the flight desk allows operators to work in a paperless environment through the elimination of physical charts on the flight desk (Johnstone, 2013).

Motivation

Among other things, this research was initiated in order to determine the effectiveness of the paper and digital maps in the cockpit. From a geographic perspective, we are trying to find out what products are most in demand for further improvement. Views of the target product users are highly important for specialists who create these materials. However, it is not possible or efficient to create maps that suit the needs of each individual. Creating an internal web service that would reflect the requirements of the target groups appears to be desirable. Another idea is to create an interactive legend for special maps that allows pilots to control the maps and perform analysis needed to fulfill

the tasks. Requirements for displaying of elements in the maps vary according to the type of aircraft. For example, the shape of villages with a population of less than 2,000 is important for fighter pilots. On the contrary, such detail is unimportant for transport pilots. The Czech Army Geographic Service is committed to comply with NATO standards in the map production, but also seeks to provide the highest quality products.

There are many factors for using EFB applications, including: 1. replacing production and distribution costs of paper products, 2. weight and space savings with the elimination of paper in libraries, aircraft, and on the pilot, and 3. providing real time updates such as current weather, electronic NOTAMs, tactical environment, etc. (Fitzsimmons, 2002). The Geographic Service of the Czech Army provides high quality NATO certified digital charts. The Service is a part of the Military Geography and Hydrometeorology Office in Dobruska. The military's progress toward the development and implementation of EFBs is advanced.

Electronic Flight Bags

A transition to Electronic Flight Bags is a technological leap in cockpit avionics design. Instead of using weighty packages of paper, using electronic equipment with almost infinite storage space for images and text-based information would be an innovation. There is also a demand for the display of various data that are essential for piloting an aircraft, these include airport moving maps (AMMs), satellite weather updates, and electronic charting (McHale, J. 2010).

Classification of the EFB

According to the Federal Aviation Administration (FAA) guideline, there exist three classes of electronic flight bags:

Class 1 EFB contains portable electronic devices (PED) that are not mounted to the aircraft. It does not have dedicated power connectivity (except for temporary connection for battery recharging) or data connectivity with aircraft systems. It can be used during critical phases of flight (taxi, takeoff, landing) only if it has the appropriate software, if it is appropriately secured and viewable, and if it doesn't interfere with the pilot's movement.

Class 2 EFB (also considered PEDs) contains devices that are typically mounted to the aircraft and may be connected to the aircraft data and power system. It is approved for all phases of flight and typically has more software functionality. However, in order to be considered portable it has to be removable from the flight deck without tools and a crewmember must be able to perform the task.

Class 3 EFB devices are installed equipment and the competent aviation authority must approve the installation.

Methods and Data

In this research, the current state of EFB in CZAF was analyzed. We also used a part of results of a survey we conducted among pilots of the CZAF to assess their attitude and experience with EFBs.

Analysis

To understand the current situation and to gain information about digital map systems in CZAF aircraft it was necessary to visit four Czech air bases. Based on consultation with engineers and pilots and according to the technical manuals, a list of EFB devices was compiled. The list contains information about maps displayed and the method for updating each system.

Survey

64 CZAF pilots completed an anonymous survey addressing use of aeronautical charts. Participants are male and female pilots of fighter jets, transport planes, and helicopters of four CZAF air bases. The age ranges between 26 and 52 yr. The 28-item questionnaire was designed to obtain demographic data, information about flight background, attitudes and experiences with digital maps, EFB devices, and system of updates.

Procedure

Participants received questionnaires from their commanders. The deadline for submission was 14 days. The participation was voluntary, but a minimum of 14 participants from each air base was ordered. The questionnaires were distributed in paper and electronic form.

Results

Digital map vs. paper

An important question for us was what kind of map is the best for them; it can be seen in figure 1.

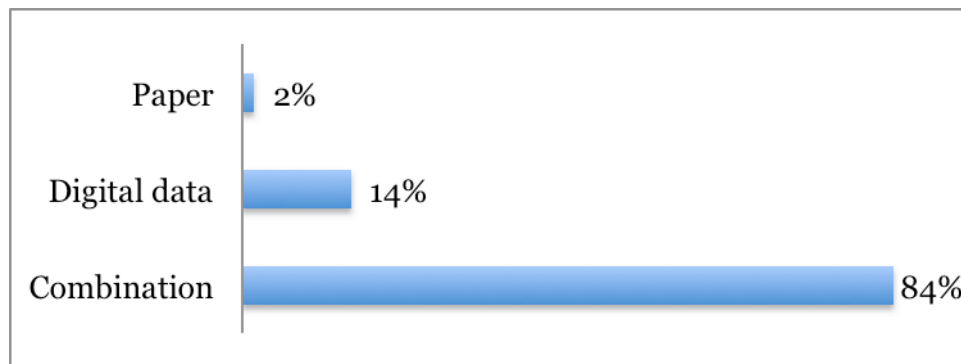


Fig. 1: What kind of map is the best form for your work?

Only 2% of pilots prefer paper form, 14% would prefer a digital map, and 84% choose a combination. Another expected result can be seen in chart 2. Participants were asked whether digital charts could fully replace paper charts. 27% of the respondents believe that it can, while 70% of them believe that it cannot. Pilots of fighter aircraft are more responsive to change and are more open-minded than others. Pilots of transport aircraft have rather conservative attitudes and believe that paper maps will never disappear. Also, the relative amount of space in each plane's cockpit might play a role in these responses.

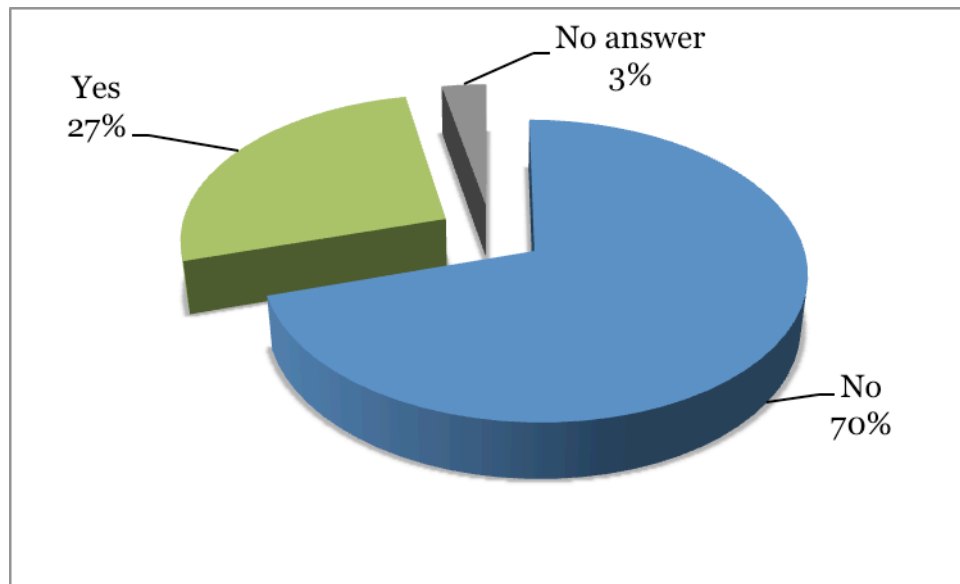


Fig. 2: Could digital charts fully replace paper charts?

These results lead us to believe that we are still not ready to fully replace paper charts with electronic. It is therefore desirable to create such digital material that will be sufficient enough so that the pilot does not have to use the paper. The investigated preferences of paper and electronic maps are indeed strong topic for further research.

On the other hand, there are some cases when the pilots consider the digital maps necessary for the performance of certain tasks (see the chart below). 42% of the pilots think that digital maps are necessary for tactical tasks, such as NVG¹ operations, low altitude operations, joint or combined air operations, air to ground operations, air reconnaissance. 30% of the pilots mention a necessity of the digital maps for the instrument flights (IFR²) on the civil ATS³ routes, especially abroad. This type of flying has its specifics and is based on a navigation system guidance, such as satellite navigation. Some of these devices (FMS⁴ equipped) are able to navigate the aircraft using navigation schemes, to lead the aircraft using data from international navigational databases, to display and navigate the aircraft on arrival, approach, departure aerodrome charts, and also to guide the aircraft on the airport map during the taxiing. Some of these devices are able to combine the navigational data with map layers and therefore the pilot can see the current geographical position of the aircraft. (However, the map layers are not so important for this type of flying.) 13% of the pilots think the digital map is necessary for every flight. 8% of them mention cases where there is no time to prepare and also some special tasks, such as SAR⁵ missions, photogrammetric scanning, etc. 33% of the respondents claim that the digital map is not necessary for any flight.

¹ Night Vision Goggles

² Instrument Flight Rules

³ Air Traffic Services

⁴ Flight Management System

⁵ Search and Rescue

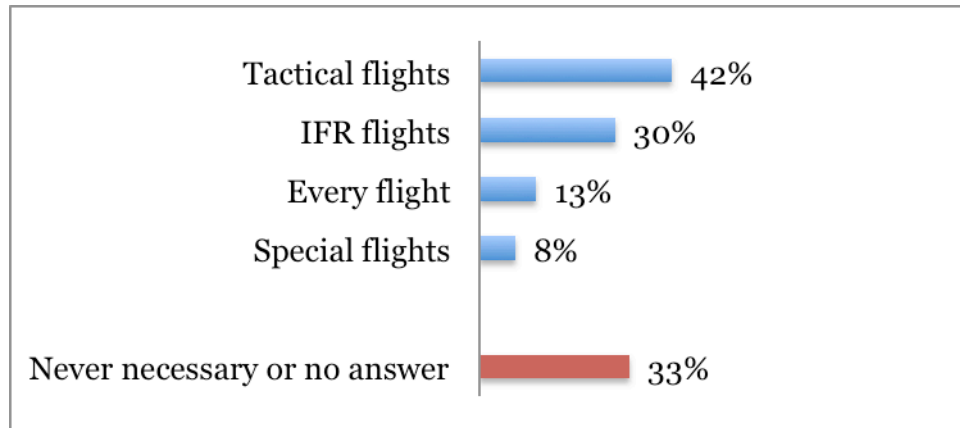


Fig. 3: For what tasks are the digital maps necessary?

EFB in the Czech Air Force

36% of CZAF aircraft are equipped with a device that can be considered an EFB. 29% are equipped with a device capable displaying maps. 29% of the aircraft have no such device.

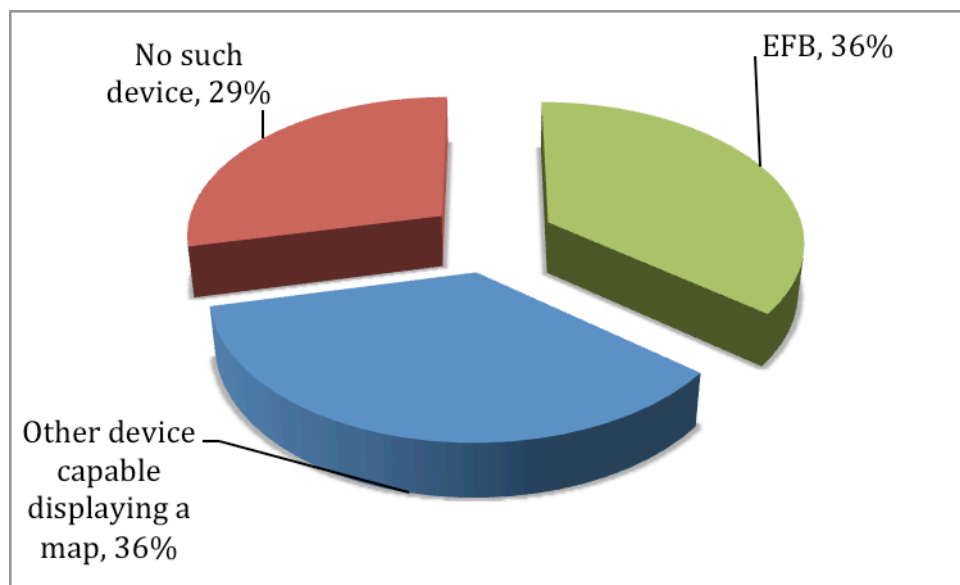


Fig. 4: Current state of the CZAF aircraft equipment

64% of EFB or similar devices in the Czech Air Force aircraft use commercial data instead of military charts. Only 27% of devices use military data issued by the Czech Army Geographic Service. The military charts are important for the fulfillment of military tasks, so the pilots without electronic maps are still dependent on paper. This problem can be partially solved with the implementation of a portable EFB with a dedicated application for military data, although it has limitations. The CZAF Transport Air Force Base is currently the only base where the iPad is being tested. The installed application is Jeppesen Mobile FliteDeck. The test use is allowed in the cockpit of C-295M transport airplane. The device is simultaneously undergoing the certification process at the Ministry of Defence. Pilots of the C-295M are mostly satisfied with the

iPad and the Jeppesen app. The only noticeable problem is the mounting position of the device. The cockpit allows mounting the device only on the sides. This reduces usability for a pilot flying in demanding situations.

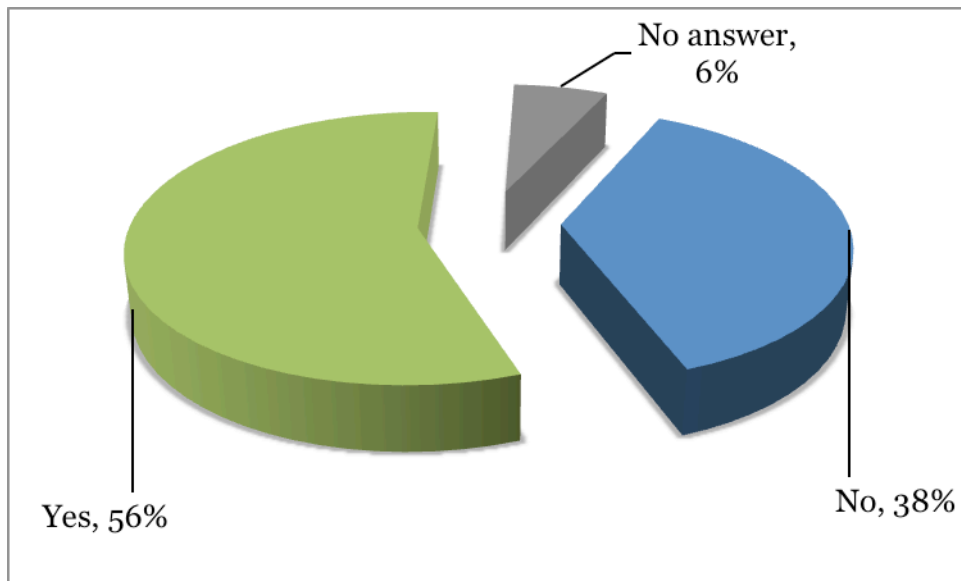


Fig. 5: Do you have a personal experience with a portable EFB or a similar device?

56% of pilots have a personal experience with a portable EFB or a similar device. Most of the respondents (77%) stated that they would welcome such a device for use on their aircraft. This is a clear impetus to the integration of portable EFB devices in the CZAF.

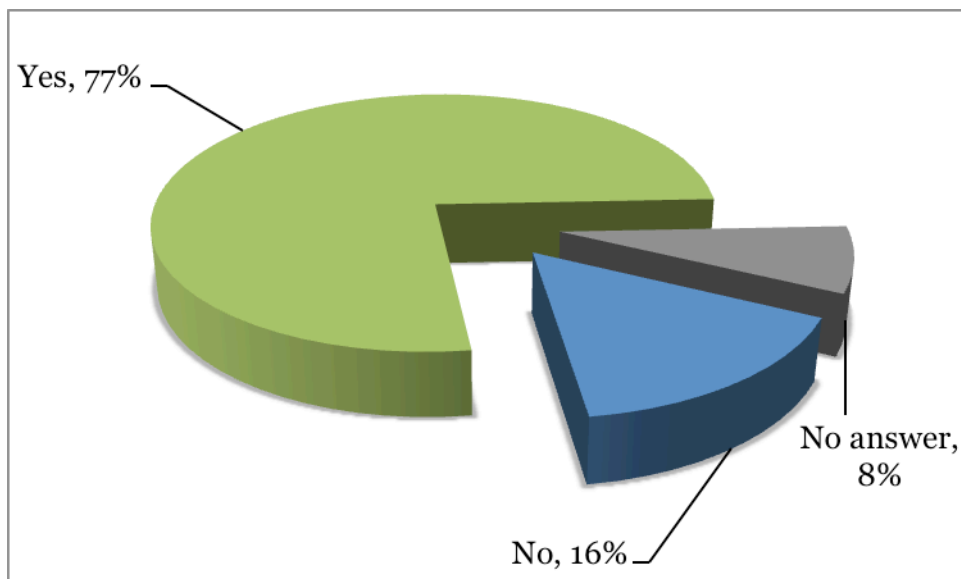


Fig. 6: Would you appreciate a portable EFB device on your aircraft?

Reported benefits were the following - better UI⁶; faster and easier to update; possible function as an "electronic kneeboard"; good tool for the IFR flights under the civil air traffic control; flight training facilitation; simple plan changes during the flight. Possible problems reported were - a difficult placement in the cockpit; software would have to be modified according to the needs of each aircraft type; an external GPS module is needed; power supplies differ across aircraft.

Possibility of using iPad as Electronic Flight Bag in the Czech Air Force

Without a doubt, a portable EFB such as the iPad would be in many ways a great step forward. However, before such a transition, several factors must be considered. First is safety. This has been discussed above briefly. Certification of such device is at the sole discretion of the authorized representatives of the Czech Army. In this section, we focus explicitly on the user experience and whether it would be an asset to the Czech Air Force (CZAF) crew. As with all EFBs, the iPad shares several comparative advantages to paper charts including its weight and the ability to scan text for information. Another factor is display equipment – the iPad has very high resolution (at least with the 3rd and later generation) and with the IPS panel colors and contrast stay unchanged regardless of the viewing angle. However, glare is a problem that might decrease usability in specific situations. Using a protective case or anti-glare display films could solve this problem. The size of the display must be considered as well. Screen size should be sufficient for clarity of information displayed and shall not increase the space requirements. Another issue is battery capacity and the recharging system. Power supplies differ across aircraft. Standard battery duration is around 10 hours but it naturally depends on many factors. The 3G versions of the iPad contain a GPS receiver. Wi-Fi only models use Wi-Fi hot-spot location services to determine your location. Either locating system is not designed for professional use, therefore an external GPS sensor is recommended. The iPad and other iOS devices use Assisted GPS (A-GPS) that relies on additional network information to supplement autonomous GPS positioning. The balance of processing power and battery life could be easily affected by malfunctioning applications or other hazards. Not only would it affect battery life but it could also lead to overheating.

The survey uncovered a number of shortcomings of the current EFBs and digital maps used in CZAF aircraft. For example, there is no database of vector maps available for pilots, only raster data. The reason is simple. The range of information is strictly set and any change is subject to an approval process. Therefore, it is necessary for pilots to have precise products that include their requirements. The challenge for the next period is a choice of the most suitable EFBs along with software that would meet the requirements of transport, helicopter and fighter aircraft. Distribution of data would be faster; updates could take place more frequently than once a year and pilots would no longer have to manually edit the paper maps.

To sum up, there might be problems with using the iPad as an electronic flight bag but many drawbacks could be minimized if it is implemented with thought and care. An important concern will be whether complete reliance on such a system is possible; if so,

⁶ User Interface

the elimination of paper charts would be possible. If complete reliance is not possible there might still be substantial benefit in adopting it as the primary charting system, with a paper back-up.

Conclusions

There is no doubt that the EFBs can enhance the efficiency of certain flight deck procedures. But paper is not just an independent resource that somehow has continued to survive despite attempts to remove it; rather it is an integral feature of using new technologies (Luff, 2004). In the survey, 84% chose the combination of digital and paper maps. Only 27% of the pilots believe that digital charts can fully replace paper charts. This suggests that while the EFB is desired, there is reluctance to abandon what is known and the quality of digital data and related equipment are not at a satisfactory level yet. On the other hand, many pilots consider the digital maps necessary for the performance of certain tasks, such as tactical missions (42%) and instrument flights (30%). 29% of the CZAF aircraft have no electronic device capable of displaying maps and from the others only 27% of devices use military data issued by the Czech Army Geographical Service. A portable EFB such as the iPad could be a partial solution of the problem. Approximately half (56%) of the pilot's have experience with a portable EFB or similar device. Most of them (77%) stated that they would welcome such device for use on their aircraft. The Geographic Service of the Czech Army provides high quality NATO certified digital charts and choosing the best form of their display would be the great step forward. The pilots are mostly satisfied with the iPad and the Jeppesen application. It is necessary to find a way to install an EFB in front the pilot's field of view of each aircraft to enable effective use during stressful situations. This represents an initial study that assesses the current situation in the field and offers possible solutions. It also provides the basis for further research in this area.

References

- FEDERAL AVIATION ADMINISTRATION (2011): The Apple iPad and Other Suitable Tablet Computing Devices as Electronic Flight Bags (EFB). AFS-200 Guidelines for the Certification, Airworthiness, and Operational Use of Portable Electronic Flight Bags
- FITZSIMMONS F.S., (2002). The electronic flight bag: a multi-function tool for the modern cockpit. IITA Research Publication 2 information Series., 66 pp.
- CHANDRA, D. (2002). Human Factors Considerations in the Design and Evaluation of Electronic Flight Bags (EFBs). National Technical Information Service, Springfield, Virginia, 22161, 206pp.
- JOHNSTONE N.: (2013) Air Safety Group Report Nr.104: The Electronic Flight Bag Friend or Foe? 50 pp.
- LUFF, P., HEATH, C.; NORRIE, M.; SIGNER, B. and HERSMAN, P. (2004). Only touching the surface: Creating affinities between digital content and paper. In Proc. of CSCW '04, pp.523-532.
- MCHALE, J. Future looks brighter for electronic flight bags (EFBs). Military & Aerospace Electronics. April 2010, Vol. 21 Issue 4, p13-19. 5p., ISSN: 10469079
- U.S DEPARTMENT OF TRANSPORTATION. Federal Aviation Administration. Advisory Circular 120-76B.
- WRIGHT, M. W. and BARLOW, T. (1995) Resource Document for the Design of Electronic Instrument Approach Procedure Displays. DOT/FAA/RD-95/2.