Future Investigations and Paperless Flight Deck

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Evolving flight deck environment

We say that the world has changed a lot over the last two decades, with the arrival of smartphones, tablets, the internet, artificial intelligence and drones, mobility is more present than ever. Practically everything has changed, our way of doing things, of playing, of communicating in groups, among ourselves and at work, we no longer do our routines the same way we did 20 years ago.

We have to readjust to the new environment and the way we work. This readjustment is not a smooth one, we have no choice but to think differently, change the way we do things if we want to succeed. How do you conduct an accident investigation in a paperless environment? The impact is enormous.

This paper is a reflection on this reality and how it will affect the way we do things.

Let's start with a not so distant era of the paper environment. A time when we shared notes, also known as aides-memoires, scribbled by hand or typed on the computer (or even typewritten) to remind us of certain procedures too complex to be memorized or simply notes from colleagues who, through experience, learned many tricks of the trade and that we wanted to know in order to make our lives easier, which we kept preciously in our notebook.

And let's not forget our flight manuals, our navigation charts, our approach procedure books, our pilot's license as well as our medical license, our pilot's logbook, our ruler affectionately called "WizWheel" and also our headphones. Remember, when it was time to update our approach plates? We were in despair just knowing that we would have to do it all again 28 days later...

We were always amazed at the weight of our flight bag when it was time to fly. The estimated average weight according to United Airlines is just over 17 kilos [1] per pilot, imagine.

Thanks to the rapid and constant improvement of technology, our lives, both personal and professional, have changed considerably. Today we have gone from just over 17 kilos to only 3 kilos of material in our flight bags. I think we can thank progress and miniaturization.

We have seen the same thing in our flight decks. We went from having steam instruments that gave us 2-dimensional information where we had to have a terrific scan throughout the flight to make sure we were flying safely and keep the blue sky up; pilots must deal with dozens and dozens of instruments during a flight. Traditionally, these instruments were displayed as gauges located throughout the cockpit. With the advent of Electronic Flight Instrument Systems (EFIS) and more robust international standards and better monitoring by manufacturers, pilots' scanning has greatly improved and simplified.

The biggest advantage of an EFIS system is the fact that all instruments are condensed into a much more efficient display, the automation systems are more accurate, the information more precise and all data is displayed in a more ergonomic manner.

Despite all these advantages, the system also has its share of disadvantages. It can be very easy to become over-saturated with information during emergencies or high precision approaches in bad weather. Humans

must readjust to the constant influx of information from the display. In the end, the advantages of EFIS easily outweigh the disadvantages.

The question we investigators must ask ourselves is what impact this technology will have on our accident investigations.

Paperless — The First Step

To better understand the evolution and impact of technology on our work, let's start with those early days. The arrival of digital versions did not come without a hitch. How do you digitize tons and tons of documents into electronic versions and also in what format?

Most organizations have turned to the increasingly popular Adobe PDF. PDF stands for "portable document format." This format is primarily used when you need to save files that cannot be modified but still need to be easily shared and printed. Today, almost everyone has a version of Adobe Reader [2] or another compatible program on their computer, tablet or mobile that can read a PDF file.

Everything, absolutely everything had to go through it, if we were to accomplish the ultimate goal of zero paper on board. First step, company operations manuals, aircraft operations manuals, standard operations manuals, flight plans, instrument approach and navigation charts. All this in PDF format. The second step is to find a work instrument that is powerful enough to reproduce all these PDF images when required and in no time. Let's not forget to consider the computer security of the material and also the protection of these data. The task was still titanic.

But again, the advantages outweigh the disadvantages by far. Remember the 17 kilos?

The ability to have everything at hand is fantastic and very useful. No more fumbling around in the aircraft or your flight bag to find the right information. You just have to turn on your tablet and click on the desired app to show the PDF document. It seems very simple but to say that it is super easy is … an exaggeration. Ah, the paperless office. Remember that buzzword that never seems to go away completely, even though history has proven that the use of computers has so far only led to an increase in paper use? The challenge is to have an excellent and robust classification system that will help pilots find the required information easily and at the right time.

The world of mobile technology may seem very easy to the younger generation, but the older generation is not necessarily so easy. Therefore, we often overestimate the intuitiveness of the instrument, in this case the tablet, and wrongly believe that pilots will find their way around easily. In fact, companies later realized that they may have neglected the training aspect of the initial equation. It takes time and practice to fully understand the intricacies of computer systems, especially mobile systems, it is not and never will be innate.

Simple questions to ask yourself. How to display 2 PDF sheets simultaneously and how to switch from one app to the other without losing our page or information we want to keep.

Training helps us to understand our electronic instruments as training helps us to better identify an emergency in flight.

Paperless — The Next Step

The second phase of the evolution of the paperless environment has brought us some great improvements and speed of access. Let's take a few examples.

- Fully evolved autonomous digital information that does not exist in paper form.
  - We have gone from raster graphics to vector graphics, giving the ability to enlarge the image without losing too much quality. If you have trouble seeing the name of the road correctly, just enlarge the image and you're done.
- The content displayed depends on the user's selection.
  - The user sees only what he or she has selected. So, no more unwanted information and can be out of sight of the user at his discretion.
- Complete annotation capabilities in the visualized content.
  - You can annotate only what you need. For example, you annotate closed construction lanes directly on the app to give you an overall view of what the place will look like when you arrive. You are done and don't need this info anymore, zap it and delete it without damaging the master file.
- Manipulating the Layout to Suit the Circumstances
  - You plot your route from the runway, from the taxiway to your maintenance hangar. You can enlarge the image and focus only on what is relevant to you, without worrying about the rest of the airport.
- Lighting at Night
  - No need for a flashlight or map light anymore. It's too bright, dim it down, not bright enough, bring it up.
  - But also, it could be too bright at night and not bright enough during the day?
  - The lighting of mobile devices has always been a problem, either too bright or too dim and often the reflection of the outside light on the screen makes it difficult to use the mobile device.
- uX—User Xperience [3]
  - Is the hardware easy to use? Can you have access to what you need within 2 clicks?
  - Often, uX is neglected compared to platform realization, for reasons of speed and production efficiency.
- App design?
  - Producing a good interface is not given to just anyone. The human being is so much towards ease. It is easier to program software than to make it usable.

All of this brings great benefits to aviation safety and significantly increases your situational awareness and decision-making.

Advantages of Digital Data Delivery Methods

- Total number of publications and data available at your fingertips
  - As I mentioned before, everything is available at your fingertips. You need to see this or that, you press and there it is. But you have to prepare yourself in advance. A good organization will assure you a greater flexibility and ease.

- Current Status of Amendments Search Functions
  - The updates are done either automatically or in a very simple way. A last amendment has just appeared, you download it and here it is. However, the danger here is exactly the ease of issuing too many updates. We have experienced the same thing at home where the flow of information was much too great and too fast.

- Better control of documentation by the company.
  - Controls its distribution and updates.
  - Once again, the planning of updates is necessary to ensure that pilots are not overloaded/overwhelm with information and amendments because you will discourage reading of these documents. For example emails.

- Digital Flight Plan with Annotation Capabilities
  - Big improvement here. Being able to access your flight plan well in advance of your arrival at the aircraft helps with flight planning.
  - Logbook of the aircraft and even pilot logbook.

- Aircraft position on maps and charts
  - Again, significantly increases your situational awareness.

- Apps
  - Tailor-made app to meet the needs of the company.
    - The big challenge here is the speed at which your organization can update its app in the event of an operating system upgrade.
  - Communication app between operator and crew
  - Exchange of information between operator, crew or even within the crew itself
  - Via WIFI
  - Via Bluetooth
  - Via satellite

- Weather app—Provider of real-time weather data.
  - Via WIFI
  - Via satellite
    - Allows you to see the position of the aircraft in relation to storm cells. So you can better plan your route and stay proactive.

Implications and Considerations for Investigators

Today's new environment brings its own set of challenges for the investigator. Not all aircraft have Digital Flight Data Recording (DFDR) systems. The investigator will have to surround himself with computer experts in order to better understand the subtleties of these systems but also in order to get the maximum of information relevant to the investigation without getting lost in the pool of data that these same instruments can provide.

- EFIS vs. analog gauges
    - Remember the needle slap effect [4]
        - As you know, from the laws of physics, with the force of the impact, the needle will leave traces on the background of the instrument. Giving you good clues as you investigate the impact speed and also the rate of descent.
        - What to do with black screens on aircraft with digital displays? Airliners and more modern aircraft all have data recorders, but most recreational aircraft do not.

- What information was available to the crew?
    - First, is it up to date?
    - Was there an update published or pushed to the device between the time of the event and when you took possession of the device?
    - Did they have access to all the required documentation?

- What were they looking at and acting on at any given time?
    - Several apps may be open at the same time, but which ones were they looking at?

- Were they looking at the same thing, same app, same page?

- Was the information available, understood, and used in a way that became a factor in an event, incident, or accident?
    - Available and more importantly understood.
    - Let's take the NOTAMS pages, for example. If you have 20 pages of NOTAMS and you have to go through them, would you retain all the info that was presented to you?

- How do you know?
    - Is it possible to still have access to the mobile device?
    - Is it destroyed?
    - Can the information be retrieved from the personal or company cloud?
    - Privacy dilemma, what is the limit? Data protection?

- What evidence do you have?
    - Again, access to data through the cloud?

Classic Cockpit Instrument Laid Out vs. New EFIS Flight Deck

Let's compare the classic cockpit instruments and the new digital instruments.

Classic

- Traditional data presentation
  - The presentation of instruments in a basic T shape
  - I can ask you to draw a flight instrument panel and you will be pretty close to the real thing.
  - We know that the altimeter will be on the right, the VSI below the altimeter, etc.

- Paper—flight libraries, charts, maps, flight plans
  - There are duplicates as well as a record of changes that companies have.
  - The operations manual is very specific about what a pilot must have in his flight bag in order to comply with all aviation laws.

- Advantages of traditional methods of disseminating information
  - It leaves a trail

- Limitations of traditional methods of information dissemination
  - Many updates, maybe too many or too often.

New EFIS

- One of the advantages of EFIS instruments is that they present information in a much more efficient manner and help pilots with their situational awareness, decision-making and workload management.

- But once the screens are turned off…
  - Where to find information?
    - What if it's the only thing you have?

It becomes a real challenge to get the information and retrieve as much as possible when we are in front of black screens … pretty useless.

- What to do? Does the electronic component have a memory card? If yes, is it still readable?

- Available information could be only the navigation database and inform you only that it is up to date.
  - Are there any basic instruments with the needle still intact?

These are all questions you need to ask yourself during the investigation.

Considerations for Fact-Finding Phase

- Securing any digital device—corporate, personal, part of investigative equipment.
  - Legal considerations for securing data and data sources.
  - The challenge will be to recover all this material. But this also brings its own set of issues regarding privacy, data protection, etc.

- Timely—perishable information/intervention/deletion—intentional or not
  - It all question of timing
  - What happens if there is an update between the time of the event and the interview.
  - What version were they using? Can these versions still be accessed?

- SOP— You will need subject matter expertise to understand what digital tools were available, what policies and standard operating procedures were documented to use them.
  - What language these versions are in, for example.
  - Compare these documented SOPs to current practices.

The Forgetting Curve [5]. Interviews are essential during this phase and should be conducted very early in the investigation. The longer you wait the fuzzier or biased the information becomes.

Be Prepared to Consider…

- Unexpected ways in which crews or individuals may miss or misunderstand important operational information.
    - There are several good communication exercises on understanding. One sentence can be interpreted in many ways.
    - As we know, when you are very familiar with the area, you will tend to take the route you always take and not the authorized one. An example of a clearance where pilots were told to cross 15 Right, Left, and Bravo to the gap at AK.
        - Is it left on Bravo or 15 Left?

- Unexpected ways that crews or individuals use digital devices may be factors in the investigation.

- CRJ accident at YYZ—crew filming—A07O0124 [6]—Loss of situational awareness of a crew member.

    - When the captain began to engage in non-pilot-related activities during the final stage of the approach, he left almost all decision-making and control of the aircraft to the first officer.
    - The captain did not notice that the first officer left the autopilot engaged well below the recommended minimum altitude.

- A photo taken just before a fatal midair collision in May 2019 between two passenger seaplanes near Ketchikan has become central to the NTSB investigation [7].

- During the approach—parasitic call to the cockpit late in the approach.
    - It could also be an alert from the ECAM/EICAS, this could be very distracting while making an approach in bad weather, at night especially.

- Class 3 EFB—video surveillance of the office—CRM concern.
    - The crew might see movement in the galley while they are conducting a briefing before the top of descent. When resuming the briefing, because they were distracted, they might have skipped some really crucial information for the approach, temperature correction needed to be applied, for example.

Considerations During the Analysis Phase— It goes beyond of what you see…

- With the factual information in hand, what items and issues were factors in the event

- Integration or lack of integration with aircraft systems—mounts.
    - Lack of integration example: iPads mount using suction cups to hold in place in the cockpit side windows.
        - Were they properly installed and in position before the event?
        - On impact, potential to injure the crew

- Human factors
    - Ergonomics of data—how accessible—SHELL model [8]
        - Software, Hardware, Environment, Liveware
    - Human Factors Analysis and Classification System (HFACS)
    - Crew Resource Management
    - Human Performance

- Did the digital information or activities create distractions?
    - Push notifications from the iPad
    - As you are getting close to the ground, if the iPad is not in Airplane Mode, you will have notifications popping on your screen. That can be very distracting, especially at night.

- If recording was occurring—did this affect individual conduct and the event itself?

By using existing tools such as the HFACS system, you will answer many of these questions. But you still need to be familiar with the technology in order to understand the subtleties that it may entail.

Summary

- The digital cockpit landscape is evolving and is not static.
    - From the 747 to the A220, from the U.S. Space Shuttle to SpaceX's Dragon capsule, we are operating in an extremely dynamic environment where technological change is moving at a rapid pace.

- But we must remember that the digital environment will vary significantly from operators to operators and also from pilot to pilot.

- To that end, self-disclosure and disclosure remain essential, under just culture principle. The importance of having a safe and healthy environment to encourage discussion is crucial.

- Crew interviews remain as important, if not more so, than in the past.

- Protections for safety disclosures remain as or more important than ever.

- Emerging issues?
    - Civilian space flights with passengers
    - Supersonic flights with new technologies
    - Aviation law vs. Space law
    - Etc.

My intention was to make you think about the effects of technology, not only in our personal lives but also during an accident investigation. Indeed, the world has changed a lot over the last two decades, with the arrival of mobile technology, mobility is more present than ever.

We have to readjust to the new environment and the way we work. This readjustment is not a smooth one, we have no choice but to think differently, change the way we do things if we want to succeed.

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