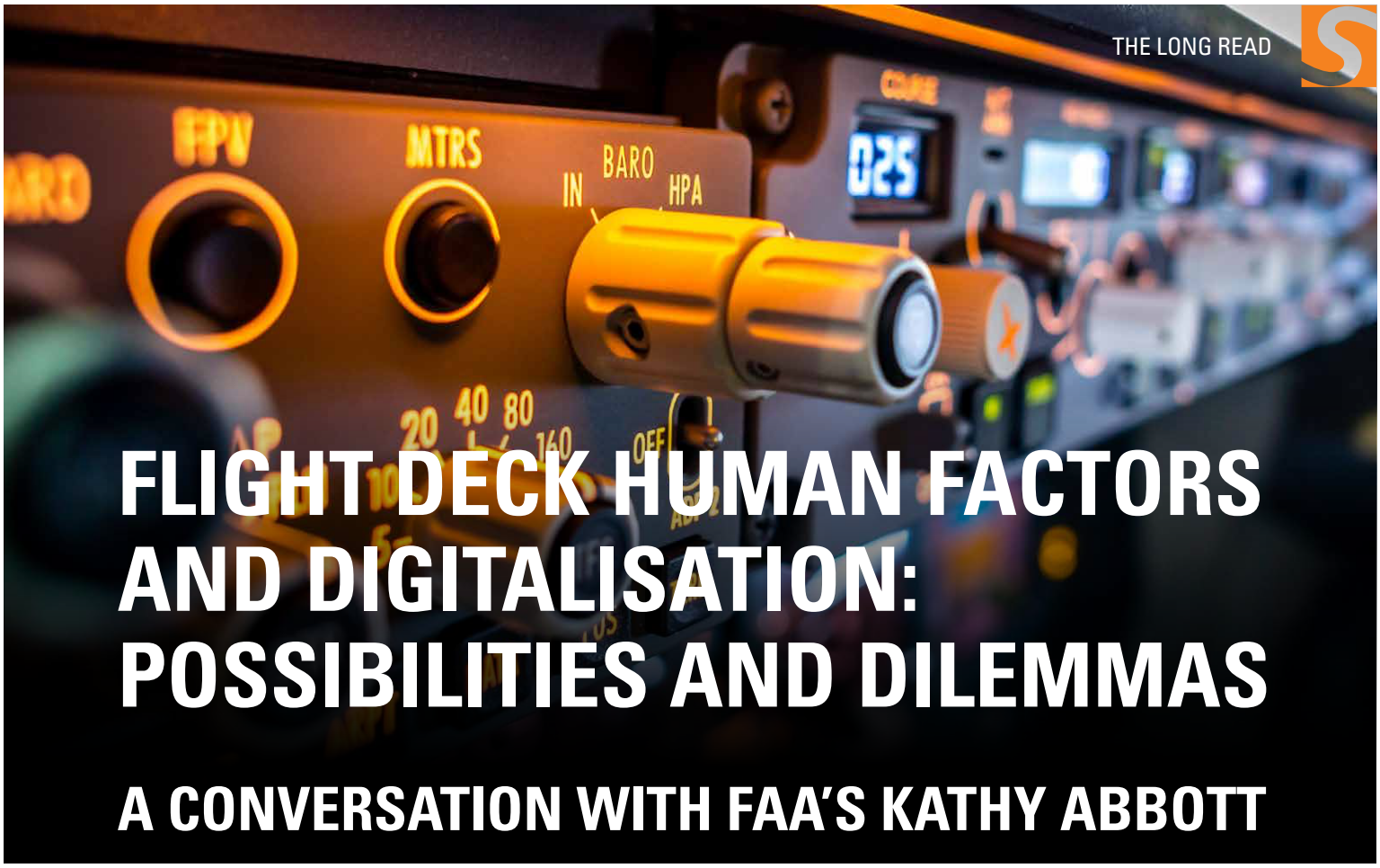


FLIGHT DECK HUMAN FACTORS AND DIGITALISATION: POSSIBILITIES AND DILEMMAS

A CONVERSATION WITH FAA'S KATHY ABBOTT

While there have been several decades of research on automated systems and human performance on the flight deck, developments in technology are accelerating the potential for change. **Steven Shorrock** talked to **Kathy Abbott**, one of the FAA's Chief Scientific and Technical Advisors, about the possibilities for digitalisation, some of the dilemmas we still have to address.

KEY POINTS

- **Digitalisation is enabled by availability of big data, and improvements in sensors and data storage. There are many possibilities to improve NOTAMS, CPDLC, safety data, and many other applications.**
- **'Reduced crew' long-haul operations are attracting industry attention, but issues of information, control, and responsibility remain critical. Introduction of automated systems may change the kind of staff needed, without necessarily reducing staffing.**
- **The safety continuum helps the FAA's Aviation Safety organisation to determine the appropriate level of rigour in standards, policies, and processes.**
- **As well as technical expertise, there is a need for more expertise in operations and the operational environment, human factors, complexity, and systems thinking. Lessons learned from experience, including unintended consequences of the introduction of automated systems, must not be forgotten.**
- **Pilots, controllers, and other frontline staff can have more of a say in the drive for digitalisation through participation, working through the staff associations and labour unions.**

In the world of flight deck human factors, few names are better known than that of Dr. Kathy Abbott. Dr. Abbott is the Chief Scientific and Technical Advisor for Flight Deck Human Factors in the Federal Aviation Administration. Along with the FAA's other Scientific and Technical Advisors, she applies her expertise to the promotion of safety-enhancing innovation, policies, and practices in the FAA's regulatory, certification, and oversight programmes. In short, Dr. Abbott is the most senior technical person in the FAA when it comes to flight deck human factors.

Dr. Abbott's expertise spans aircraft certification, equipment design, and flight standards, through operations, pilot training, safety investigation, and data analysis. In other words, *"anything that touches the pilot"*. Starting her education in mathematics and information science, she went on to

study computer science up to doctoral level, before spending 16 years at NASA as a research engineer. With over 26 years at FAA since then, there are probably few in the world more qualified to talk about digitalisation and human performance in the flight deck.

Enhanced capabilities

Digitalisation is nothing new, either in the flight deck or on aviation more generally. There are thousands of research articles and reports in human factors, and many applications already. So I was curious about why it is a trending topic now. Why are we hearing more about automated systems, autonomy, and artificial intelligence? Dr. Abbott reflected that several enablers that may be fostering this. *"One key enabler is the availability of big data, with improvements in sensors and data storage."* Developments in these technologies bring a realisation that we can get more value from these enhanced capabilities, that we can do more than we could do before, via technological applications.

One example is what Dr. Abbott described as *"a perennial problem"*: NOTAMs, or notices to airmen. *"Hopefully, digitalisation will help us do a better job of putting NOTAMs in a usable form for pilots and for other people that need to use those data."*

A second example application is controller pilot data link communication (CPDLC). *"This is changing the way that pilots and controllers communicate. And there are consequences because we're not eliminating voice – it's a mix of digitalisation and the way that we've done it by voice."*

Then there are applications for safety data, and the ability to process big data to take advantage of the data that we have. *"We have more data than we can really process right now from different data sources. And of course, the interest in the safety side of things is to use that. Can we find the risks and mitigate them before they become an accident?"* Dr. Abbott noted the potential to use data also to analyse what people do well, though in some ways this can be more difficult in practice.

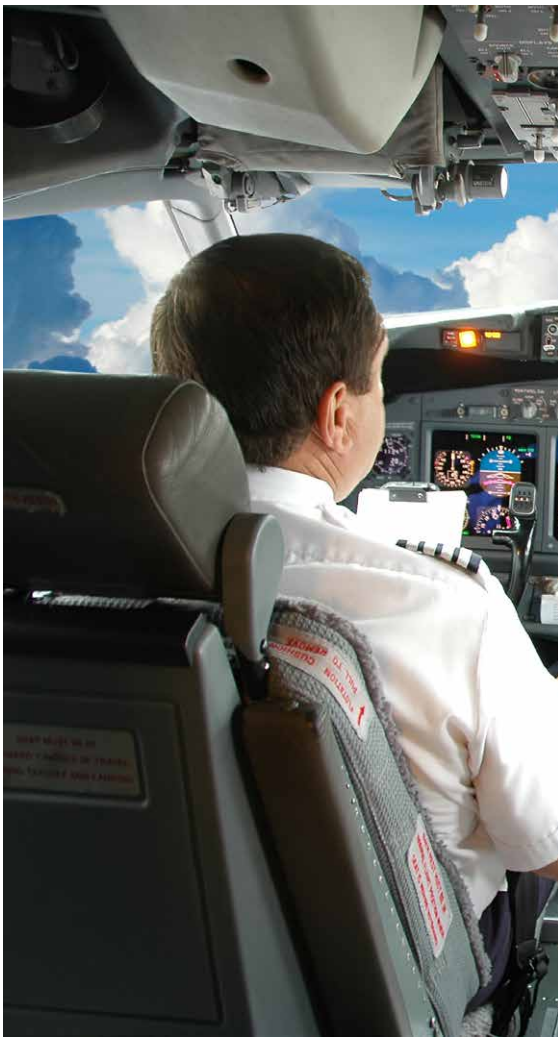
Single pilot operations and the pilot role

Such applications are significant, but with burgeoning digitalisation come new concepts of operation that are even more fundamental, and controversial. There has been some interest from airlines, as well as airframe manufacturers, in 'reduced crew' long-haul operations, where a sole pilot is in the flight deck for much of the time. A primary motivation is cost saving, along with airline flexibility, partly achieved via reduced staffing. The topic has been subject to intense commentary and increasing research over recent years. I was curious about the key issues for human performance, but also for safety more generally.

We began with the most fundamental consideration: that the pilot in command is responsible for the safety of flight, and as long as you hold that person responsible, you have to enable them to do the job. With increasing automation and autonomy, issues of information, control, and responsibility become inseparable. *"At what point can the pilot no longer be held responsible?"*

Issues of liability are also likely to become much more complicated. *"You can't hold a piece of equipment responsible from a legal point or regulatory point of view. I think we need to have fundamental considerations of how responsibility and liability get distributed in some of these new concepts."* This could be complicated further by differences between legal jurisdictions that pilots may enter.

Another issue concerns the safety contribution of the second crew member. Without that crew member, *"how do we know that we have fully mitigated the risks that may be involved?"*, asked Dr. Abbott, *"and what assumptions were made and how would those have to be changed?"* An 'obvious' topic concerns pilot incapacitation. *"If you only have one pilot, are you essentially requiring a pilotless aircraft capability?"* Then there are licensing implications, such as the potential effects on medical requirements because of the risks of incapacitation. There are many other fundamental questions and concerns, also depending on whether one is considering the modification of existing aircraft or the design of new aircraft.



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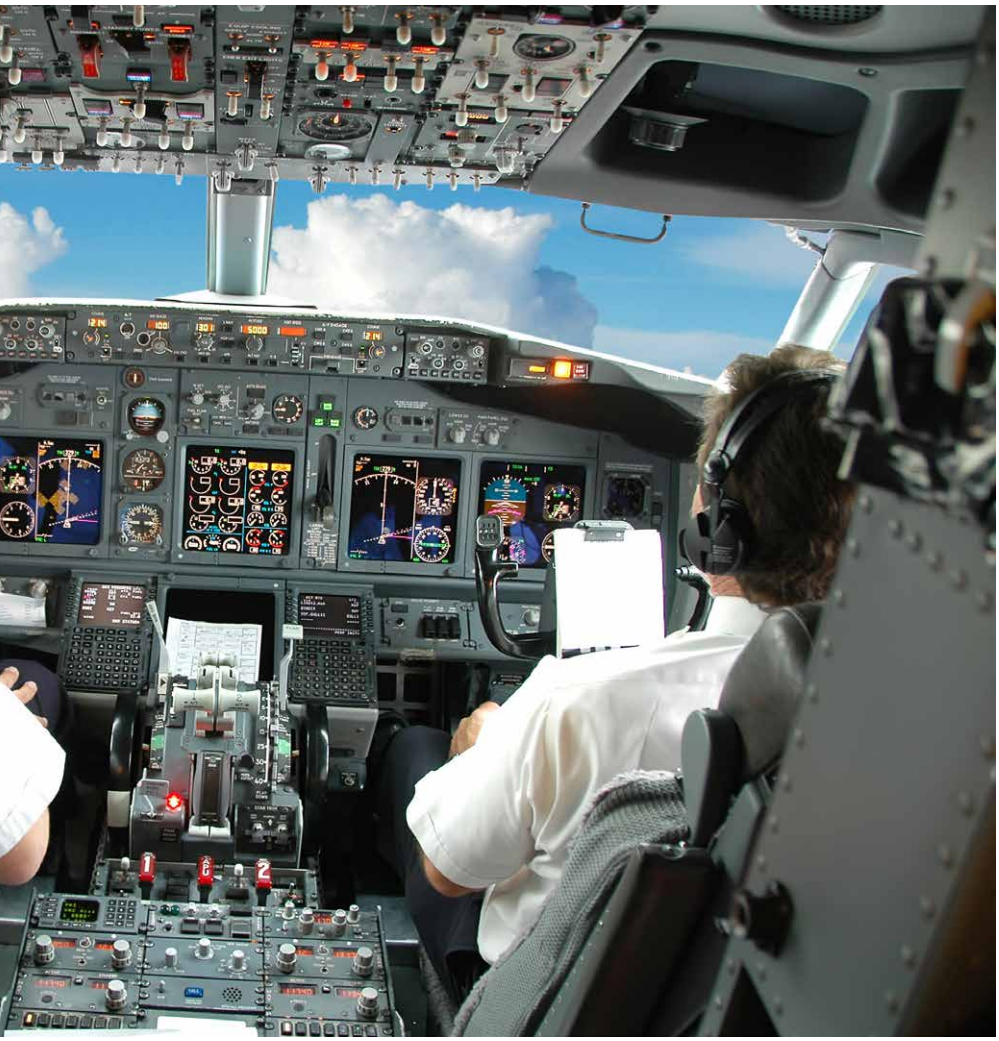
These are some of the considerations that affect whether it is possible to achieve the level of safety required with a single pilot for public acceptability. The FAA 'safety continuum' can help to focus its safety resources in line with the public's expectations. *"We refer to the safety continuum as a way of characterising that acceptable levels of safety and certitude differ for different groups or categories of aviation, and different levels of risk. Public transportation has to have a higher level of safety than private transportation."*



The safety continuum is integral to the FAA's standards and oversight. It helps the FAA's Aviation Safety organisation to determine the appropriate level of rigour in standards, policies, and processes. For newer concepts such as advanced air mobility, this raises questions such as 'What is the risk that's acceptable for that operation?' and 'How does it interact with others in the aviation system?'

Returning to reduced staffing, in many cases, even this is not so straightforward. Referring to work by the United States Air Force, Dr. Abbott revealed a counter-intuitive finding: with unmanned aircraft systems, staffing needs increased. Experience in other parts of the military has found that the introduction of automated systems changes the kind of staff that you need, without necessarily reducing staffing. *"If you're not reducing staffing, are you really reducing costs or are you just shifting cost around? And how do you assure that you've achieved the same level of safety or better?"*

Dr. Abbott sees opportunities, but also risks if we don't manage those opportunities properly. *"We want to leverage the benefits of new technology, but just because it's new technology doesn't necessarily mean it's an improvement, or that the cost benefit from a safety point of view is as imagined. It's important to be realistic."* There can be crucial differences between claims and operational reality.

Digitalisation and the varieties of human expertise

With the drive for more digitalisation, there is an obvious need for technical expertise. This finding mirrors experience in air traffic management, where the need for technical expertise is outpacing other forms of expertise. Often, the expertise is highly specialised, concerning specific technologies. There is much human factors research and practice in the design and engineering of aviation systems, especially in terms of aircraft certification. But the lion's share of attention is on operational actors such as air traffic controllers, with very few studies on engineers responsible for software development (and engineers in air traffic management generally).

Dr. Abbott noted that engineers who are designing systems often don't have extensive knowledge of operational work and the operational environment, and how technology is (or will be used) in reality. *"I personally have heard design engineers say that they don't understand why it's a problem, that it works exactly as designed. So that's one of the challenges. It does work exactly as designed."* Technology may work from the point of view of doing what the designers intended it to do. But from operational perspectives, there are often considerations that the designers either didn't or couldn't know about, concerning the variability and complexity of operations.

While this is familiar territory in human factors engineering, it is often not 'part of the curriculum' for those many engineering roles, such as software engineering, who do not always require specific formal qualifications, even in aviation. *"It doesn't mean that every single person has to have all that knowledge, but they certainly need to be working as part of a multidisciplinary team so that it gets addressed."* Now and over the coming years, there is a pressing need for more expertise in operations, human factors, complexity, and systems thinking, when it comes to technical development.

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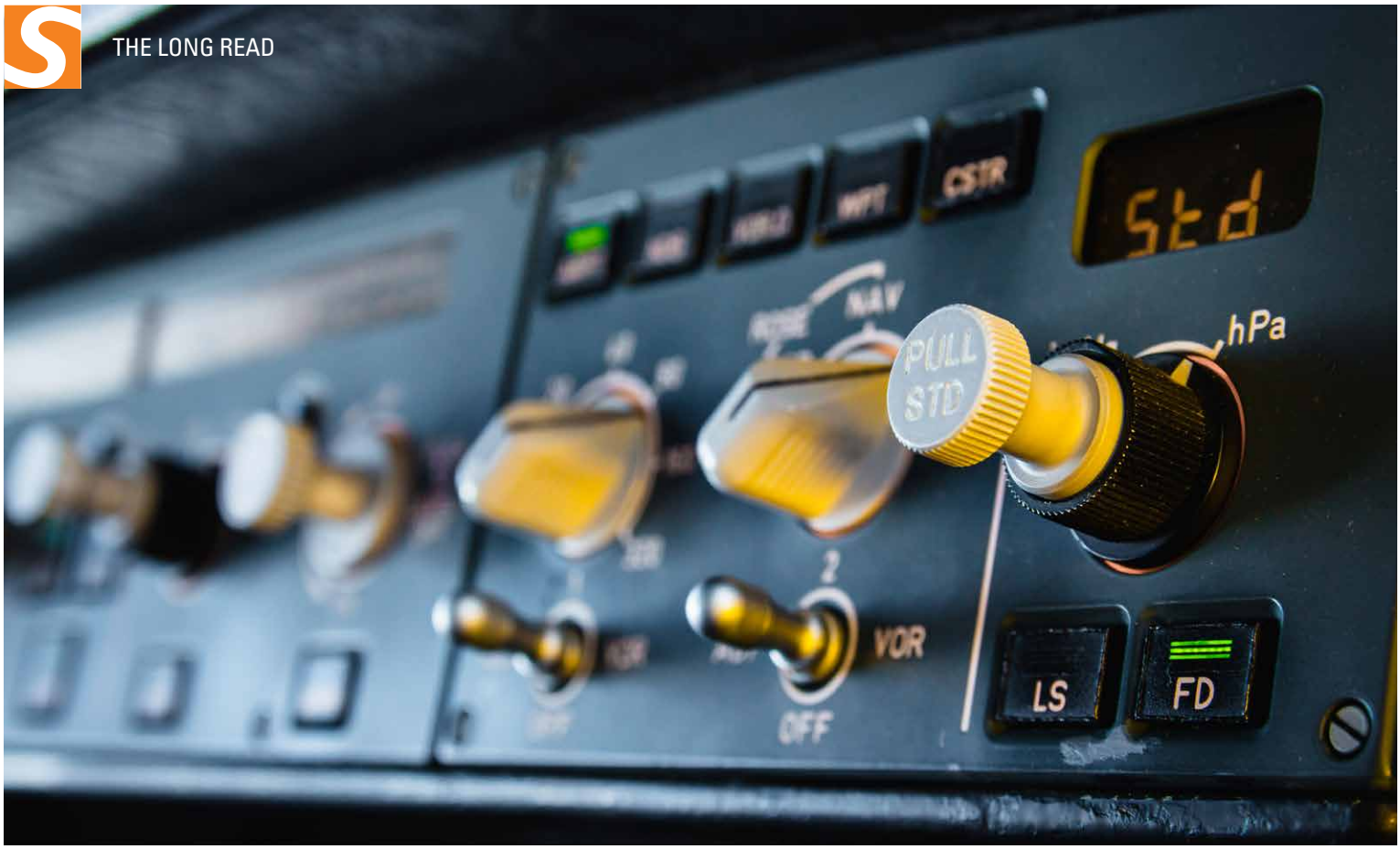

Unintended consequences

One of the concerns about digitalisation, automation and autonomy concerns the understanding of engineers – especially those who are relatively new to aviation – who may be unaware of the findings of human factors research, and the lessons learned from experience. *"It's important for the human factors community to make sure that those lessons get communicated so that we don't have some of the same mistakes because we have systems now that are going to be even more capable."*

One of the lessons learned is that new technology often introduces unintended consequences. *"All of that needs to be looked at from a broad and integrated perspective, not just in isolation for the one specific kind of system. We've seen so many cases where there are side effects that were not expected."*

The problem, said Dr. Abbott, is not a lack of willingness to consider unintended consequences, but that people in technical roles lack of the knowledge of how to do it, or haven't brought in the people who can help do it. Predicting so-called 'emergent properties' of new technology is notoriously difficult, and even more so when expertise in individual technical systems, or even technical system architecture, is not matched by expertise in systems thinking (including systems engineering), complexity science, and human factors.

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Integrating human factors expertise

The need for human factors research and practice in the context of digitalisation and automated systems has been known for decades. But the issue has more recently come into sharp focus via the recommendations of reports on the B737 Max accidents by the National Transportation Safety Board (NTSB), the FAA's Joint Authorities Technical Review (JATR), the US Department of Transportation Special Committee, and Indonesia's Komite Nasional Keselamatan Transportasi (KNKT). These recommendations refer to many aspects of the integration of human factors in design and certification, including system safety analysis. Some of the legislation since has also highlighted these points. One of the critical points is ensuring that assumptions about pilot responses are reasonable, so that there's not a mismatch between design and line operations.

Assisting human work

I wondered what developments in digitalisation with significant positive potential are of most interest to Dr. Abbott at the moment. Looking back at the history of some of the big improvements in aviation safety since digitalisation, Terrain Awareness and Warning Systems (TAWS) and the Airborne Collision Avoidance System (ACAS), she noted that we can take it to the next step to enhance the way that people in operational roles contribute, *"not just stopping them from doing things wrong"*.

But once again, we must be mindful of complexity. *"One of the things that digitalisation enables is flexibility, but one of the potential side effects, is that complexity can increase with flexibility. Sometimes flexibility for one player in the system makes it more complex for the pilot and vice versa."* Managing in the face of complexity requires systems thinking.

What can front line staff do?

Throughout the conversation, operational staff were at the front of our minds, but pilots, controllers, and other front line actors may well feel that decisions are being taken by people – whether manufacturers or regulators – who may be far from the operational environment. So what can pilots, controllers, and other frontline staff do to have more of a say in the drive for digitalisation? One answer is through participation. *"Working through the staff associations and labour unions, front-line staff can have a voice in a number of groups that are making some of these kinds of decisions, such as standards groups, regulatory groups, and research projects. Front-line actors can have a stronger voice than any individual would have."*

Dr. Kathy Abbott is the FAA's Chief Scientific and Technical Advisor (CSTA) for Flight Deck Human Factors, with over 40 years of work on human performance and human error. Dr. Abbott has led the integration of human engineering into FAA/international regulatory material and policies for flight guidance systems, avionics, all-weather operations, Required Navigation Performance, crew qualification, data communication, instrument procedure design criteria, electronic flight bags, electronic displays, organisational culture, design-related pilot error, flight crew alerting, manual flight operations, and other areas. She has been involved extensively in accident, incident, and other safety data analysis.

Dr. Abbott came to the FAA from the National Aeronautics and Space Administration (NASA), where she was responsible for leading analytical, simulation, and flight studies with the specific objective of improving aviation safety and operational efficiency. She is a Fellow of the Royal Aeronautical Society, an Associate Fellow of the American Institute of Aeronautics and Astronautics, and a Member of the Livery of the Honourable Company of Air Pilots. She is a certificated private pilot, with familiarisation training in several large transport aircraft. Dr. Abbott earned her B.S. in Mathematics and Information Science from Christopher Newport College, an M.S. in Computer Science from George Washington University, and a Ph.D. in Computer Science from Rutgers University.

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https://www.faa.gov/aircraft/air_cert/design_approvals/human_factors/

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