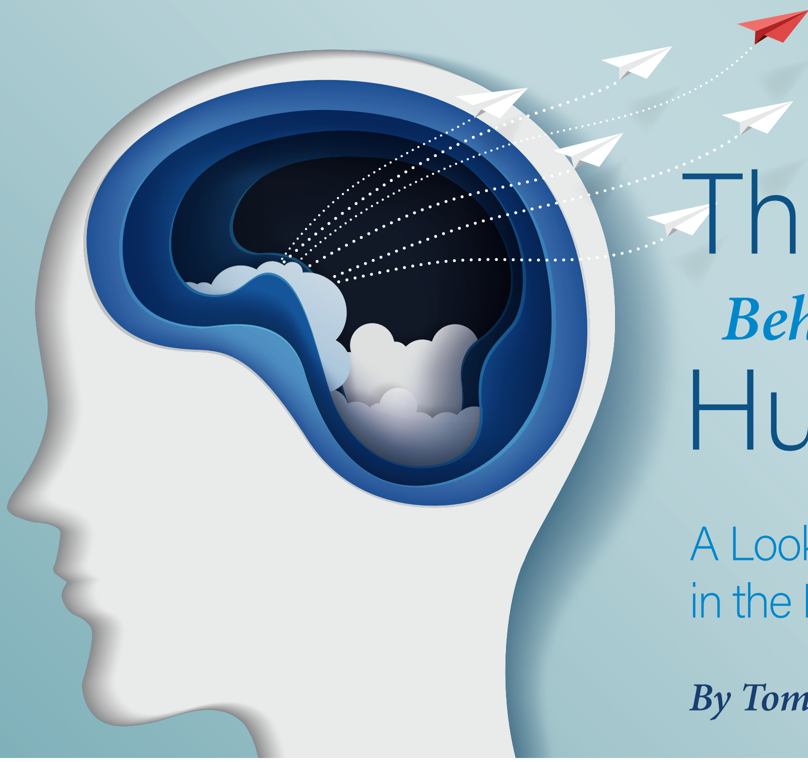

The Humans *Behind* Human Factors

A Look at the People and Resources in the FAA's Human Factors Team

By Tom Hoffmann and James Williams

Since the earliest days of aviation, scientists have labored over how to successfully factor the human into the vast world of aeronautical parts and procedures. From cockpit ergonomics, to maintenance procedures, to air traffic workloads, all have critical "human in the loop" components that must be considered for optimum performance, efficiency, and safety. As science and technology have matured over the years, so too has our ability to measure, analyze, and enhance the human condition in aviation; whether it's related to pilots, maintenance technicians, controllers, or the whole host of supporting roles in this ever-evolving industry.

> **For decades, the FAA has been at the forefront of aviation human factors research, development, and practical application.**

For decades, the FAA has championed efforts in this field and has been at the forefront of aviation human factors research, development, and practical application. While not always obvious to the average aviation consumer, this work is absolutely critical to preventing human-induced error and improving the safety of the NAS. For example, you may not readily think about why a particular cockpit control or indicator is colored, shaped, or placed where it is, or why certain checklist items are sequenced the way they are. But more often than not, there are human factors at play in determining how these things are deliberately designed or planned.

In this multi-part review, we aim to shed some light on the FAA men and women who work diligently to advance aviation human factors. Thanks to their efforts, stemming from multiple disciplines and areas within the agency, we've been able to peel back the curtain on the human condition — exploring what makes us tick, what makes us react in unexpected ways, and what helps us to perform at our best. That knowledge allows the FAA to implement standards, policies, and procedures that better account for the human condition across all aviation domains and advance safety in the NAS, both domestically and globally.

A Home for Human Factors

FAA human factors personnel currently reside in several organizations including the FAA's Office of Aviation Safety (AVS), the Air Traffic Organization (ATO), and the Office of NextGen (ANG). These organizations maintain sponsorship, collaboration, and oversight relationships depending on the requirements, resources, and expertise needed to complete projects and activities. This article will focus on the AVS-oriented human factors efforts as this area is more directly involved with projects that affect aircraft and airmen certification.

A particularly useful approach to leveraging the collective brainpower within AVS has been with the formation of an AVS Human Factors Coordination Team (HFCT). Triannual HFCT meetings bring together all the pertinent parties to discuss ongoing projects and requests, and to see where assistance and/or resources may be reallocated or where they could overlap. Chief Scientific and Technical Advisor for Flight Deck Human Factors, Dr. Kathy Abbott, chairs the AVS HFCT. *You can read more on Dr. Abbott in this issue's FAA Faces department.*

Let's take a closer look at what the people in each area of AVS bring to the table and how they contribute collectively to advancing human factors application within Aviation Safety.

Aircraft Certification (AIR)

One of the larger groups of human factors support is in the FAA's Aircraft Certification Service (AIR). The primary role of AIR human factors specialists is to develop human factors regulations and guidance on aircraft systems and to support certification projects. Also, they serve as subject matter experts on projects involving human factors issues with a new flight deck system, a new aircraft, or an alteration to an existing aircraft. Human factors specialists often focus on flight deck systems, but may also address other aspects of an aircraft, such as identifying human factors issues with flight controls and aircraft handling characteristics. A key reference is the *Human Factors Considerations in the Design and Evaluation of Flight Deck Displays and Controls V 2.0* (bit.ly/HFCFDD), a one-stop-shop for human factors-related regulatory and guidance material for aircraft certification.

Complementing some of this technology and certification-driven research is AIR's current focus on leveraging data, specifically how certain data sources can shed light on many of the more positive aspects of pilot behavior. "When we look at safety data, we often focus on pilot error or what went wrong with the flight," says Human Factors Scientific and Technical Advisor Michelle Yeh. "The truth is, there are a lot of incidents that have been avoided due to pilots doing the right thing." Yeh and her human factors colleagues look forward to finding ways to better describe what pilots do well and leveraging sources that provide data on this pilot behavior. This will help inform decision making that involves automation integration, another important human factors focus area for AIR.

"There are many human factors issues related to certification projects and automation technology," says flight test pilot David Sizoo. "These issues are sometimes subjective and relate to pilot workload in accomplishing a task." Sizoo, who specializes in helping bring advanced technology to the general aviation (GA) market, uses an example of a prototype touchscreen navigation system to make this case. "Part of our job is to determine how intuitive the design is and whether or not a pilot can properly interact with it during turbulence. We then work with other test pilots to quantitatively assess the workload of tasks and the usability of the system with respect to its intended function," he continues. AIR conducts these human factors assessments both on the ground and in the air in order to assess the suitability of a system, whether it's a component, or a whole aircraft.

Flight Level Engineering, LLC.

The EZ Fly concept being tested in a Navion airplane.

Sizoo's current project portfolio includes something along those very lines — the EZ Fly for GA. The concept entails integrating an automation platform that reduces pilot workload through a smartphone-like interface, while also providing full and seamless envelope protection. Sizoo partnered with industry and academia to develop and fly this system in a Navion airplane, which incidentally was not certifiable to fly with existing regulations. Sizoo acknowledges how that is a major part of the project — to identify gaps in the regulations so the agency can update the standards to enable this safety-improving technology.

AIR human factors specialists are also working together with scientists at the FAA Civil Aerospace Medical Institute (CAMI), NASA, industry, and universities on a number of research projects, including how to integrate control interface technologies that improve the human-machine team concept in other novel ways. One example is exploring autopilot system technology that does not require the pilot to take corrective action during a failure, but rather uses run-time assurance algorithms that "step in" to help the pilot. Another study aims to research the human factors of reduced crew operations (i.e., using a digital co-pilot).

Flight Standards (FS)

While human factors specialists in AIR are involved with aircraft certification issues, Flight Standards (FS) focuses more on the operational side of things. Among other things, FS human factors specialists:

- Develop and update FAA regulations, policy, and guidance about human factors issues for aircraft operations and procedures, aircraft maintenance, pilot training, and other functions;
- Support projects that involve human factors assessments of aircraft operations, procedures, and maintenance;
- Develop decision-making tools to assist the FAA Flight Standards Service; and
- Sponsor and supervise human factors research to support Flight Standards.

An FS employee on the frontline of human factors research is Engineering Psychologist Mark Reisweber, who

FAA Engineering Psychologist Mark Reisweber stands in front of an End-Around Taxiway masking screen at DFW.

works in the Flight Research and Analysis Group in Oklahoma City. His research is specifically geared towards testing and analyzing information that enables others to make decisions that affect the NAS. "I deal in new or re-designed procedures, including those that involve the integration of new equipment and designs," says Reisweber. "Based on our testing, we can then say, under these certain conditions, pilots can't deal with this situation, or if they can, here are the thresholds to do it safely."

> **It's our job to test all the elements of human-machine/system interaction, whether under good, bad, hard, or stressful scenarios, to ensure humans are safely up to the task.**

An important part of FS' human factors research capabilities are two highly configurable Level-D full motion flight simulators located at the FAA's Mike Monroney Aeronautical Center. "A lot of times we get tasked with testing procedures or configurations that don't yet exist, so our engineers, technicians, and pilots have to create them and/or modify our cockpits in the simulators," says Reisweber. This flexibility makes these devices a tremendous asset to the FAA, which can provide 150-200 lines of data, including such indices as vertical descent rate, aileron deflection, airspeed, etc. The simulators proved helpful in a recent angle of attack study that measured the efficacy of a new AOA display gauge and how pilots might interpret its indications under varying flight conditions.

Human factors testing and research for FS goes beyond the simulator. An example of a more "in-the-field" study occurred when Reisweber teamed up with a diverse group of researchers from Flight Standards, Bell Helicopter, the University of Oklahoma, and a Des Moines-based emergency medical services operator to test a unique flight procedure in a Bell 429 helicopter. The project tested whether air ambulance helicopters could alter their routine and safely fly to specific nodes around the city instead of higher-risk areas when responding to an emergency.

Another example is the End Around Taxiway (EAT) Project. This study aimed to address a phenomena which would occur at Dallas Fort Worth Airport when using proposed taxiways that extended beyond the pre-existing runway/taxiway structure. In simulation, pilots experienced some unorthodox reactions when landing or taking off with aircraft on the "new" end-around taxiways, which appeared to be incurring in front of them. "This was very much a human perception issue that required a human factors solution," says Reisweber. "When you're seeing an aircraft crossing in front of you, large or small, it's hard to judge its distance because the retinal image on your eyeball says it's the same size." The study determined that pilots did some "pretty strange things" about 25-percent of the time while observing what appeared to be an aircraft obstructing their flight path. The rather simple solution was to erect a 20-foot tall by several hundred foot wide barrier with standard orange and white markings that masks the taxiing aircraft. The FAA later determined this solution has the potential to apply to similar situations at other airports, even GA airports.

Reisweber is proud of the work he and his human factors colleagues have done and how much their testing capabilities have evolved. He's also a firm believer that more is not always better when it comes to technology and automation. "You have to test the human in the loop, whether it's a controller sitting in front of a scope, a single pilot flying a 172, or the flight crew of a 787. It's our job to test all the elements of human-machine/system interaction, whether under good, bad, hard, or stressful scenarios, to ensure humans are safely up to the task."

UAS Integration Office (AUS)

It's not uncommon to think of an unmanned aircraft system (UAS) — by virtue of being "unmanned" — as not requiring much attention in terms of human factors issues. However, human factors are very much at play with UAS operations. They just may not be as obvious as you might expect. For example, a UAS pilot works without the normal visual, auditory, or sensual cues that a pilot would experience during flight, and that can be challenging. "You don't think about these more subtle factors, but they are important feedback channels your body uses during flight," says human factors specialist Stephen Plishka. "If you increase power but don't experience a corresponding vibration and noise, it's easy to think something's not right."

An example of a flight deck style control station with multiple displays that would be operated with a menu structure.

It's these limitations that have Plishka's research focused heavily on UAS control station design, in particular, screen size limitations. "What critical information do we want displayed at all times and that cannot be masked or minimized? How do we factor in the remaining information with reconfigurable windows that make sense to the operator?" When it comes to menu design, Plishka stresses having a "shallow, but wide" approach. "You never want to be more than two button presses away from anything you need," he states. "Beyond that, it's difficult to remember where that function resides." This is also an area of research that can be leveraged for both UAS and more traditional manned aircraft designs.

Mission duration is another integral human factors component for UAS. Some operations last minutes or hours; others could "drone on" for days, weeks, or even months. Fatigue becomes a real issue in extended operations and raises questions about duty day limitations, breaks, relief crews, and shift change protocols. There's also a need to give pilots a sufficient level of stimulation throughout a long flight. A unique aspect of UAS operations that can help is the ability to stagger time zones for control stations. This helps UAS pilots avoid the dreaded night shift when the body wants to be sleeping.

Another unique challenge for UAS is the lack of aviation expertise among some manufacturers. Plishka makes it a priority to help educate and inform these companies about the standards and resources that apply to aid in their design process. "For example, we want to make sure they're using the color red [for emergencies] appropriately before they bring a system to certify with the FAA," says Plishka. One document he likes to share is the *Human Factors Considerations in the Design and Evaluation of Flight Deck Displays and Controls V 2.0* (noted in the AIR section) since much of it applies to UAS.

Aviation Maintenance

The goal of Aviation Maintenance human factors research is to identify and optimize the factors that affect human performance in maintenance and inspection. Example areas of attention include training, motivation, fitness for duty, worker/workplace safety, tool and system design for maintainability, and more. From a broad perspective maintenance human factors pays attention to the people who do the work, the environment in which they work, the actions they perform, and the resources to complete safe work.

"For the last 15 years, we've tried hard to capitalize on good solid scientific research to create practical guidance" says Chief Scientific and Technical Advisor for Maintenance Human Factors Dr. Bill Johnson, who leads research in this area for the FAA. "Our human factors work has evolved to stress demonstrated actions and attitudes rather than just pure science on the human condition." What Dr. Johnson dubs Maintenance Human Factors 2.0 emphasizes programs and concepts that lean more towards the application of prior research, e.g., safety culture, safety management systems, and information-sharing. "Going forward, we need to focus more on organizational psychology," says Dr. Johnson.

The "The Buck Stops with Me" course helps aviation maintenance personnel understand that 100-percent procedural compliance relies on a healthy safety culture.

Some recent projects that support that effort are the development of a new safety culture assessment tool and updated tools and methods for reducing failure to follow procedure (FFP) events, both discussed further in this issue. Dr. Johnson also helped develop an FAA Safety Team course on FFP entitled "The Buck Stops with Me" at bit.ly/FFPTheBuck. This course helps aviation maintenance personnel better understand and appreciate how an organization's culture affects safety with respect to FFP. The course has logged an estimated 14,000 completions to date, evidence of Dr. Johnson's flair for creating high quality and engaging products for the maintenance community. "It's less of a training program and more of a way to get maintenance technicians to think culturally about taking responsibility for their actions."

Dr. Johnson also works closely with the DOT Transportation Safety Institute to deliver a three-day maintenance human factors course to all Airworthiness Aviation Safety Inspectors (ASI). According to Dr. Johnson, "Our ASIs receive more HF training than any other inspector workforce in the world. They are able to understand and add value to any HF initiatives that they oversee."

You can find more maintenance-related human factors content at HumanFactorsInfo.com as well as dozens of courses on FAASafety.gov. Dr. Johnson stresses both sites as important resources for brushing up on the fundamentals, especially as workers transition back to a more routine work schedule in the coming weeks/months.

Office of Accident Investigation and Prevention (AVP)

"Data are just summaries of thousands of stories — tell a few of those stories to help make the data meaningful."

— Chip and Dan Heath, authors of "Made to Stick"

As part of his investigation duties, Air Safety Investigator Patrick Lusch looks for how human performance may contribute to aviation accidents.

Although vastly understated, the Heath quote does provide a fairly accurate account of the Office of Accident Investigation and Prevention's role in aviation safety and human factors research. AVP's overall mission: make air travel safer through investigation, data collection, risk analysis, and information sharing. They essentially tell the story of what the data is indicating to better inform how and where both the agency and industry make improvements. This includes identifying any potential human factors issues. More specifically in this regard, AVP investigators:

- Determine how breakdowns in human performance may have caused or contributed to an occurrence.
- Identify safety hazards related to limitations in human performance.
- Identify ways to eliminate or reduce the consequences of faulty human actions or decisions.

As part of these efforts, AVP investigators and analysts work closely with other divisions and offices within the FAA, as well as with groups like the Commercial Aviation Safety Team and the General Aviation Joint Steering Committee to inform them on what accident data is saying. Depending on how severe or pervasive the issue may be, requests for further support or research can be made, typically via the AVS HFCT. See this issue's Checklist department for more information on AVP's role in human factors investigations.

Office of Aerospace Medicine (AAM)

Tucked neatly into the windswept Great Plains is Will Rogers International Airport (OKC) in Oklahoma City. On the grounds of OKC sits the previously mentioned Mike Monroney Aeronautical Center, a federal campus that houses CAMI among other various offices.

Under CAMI is the Aerospace Human Factors Division of the Office of Aerospace Medicine managed by Dr. Carla Hackworth. The division is the home of two labs: the Flight Deck Human Factors Research Lab managed by Dr. Katrina Avers, and the NAS Human Factors Safety Research Lab managed by Dr. Jennifer Myers. The division is staffed by 37 employees comprised of research psychologists, research technicians, statisticians, engineers, and computer specialists. Let's take a closer look.

Flight Deck Human Factors Research Laboratory

The Flight Deck Human Factors laboratory conducts a broad-based program of applied human factors research on causal factors associated with aviation accidents and issues involving the design, operation, and maintenance of flight deck equipment in the NAS.

One employee behind this research is Dr. Dennis Beringer, a research engineering psychologist with over 45 years of aviation psychology/human factors experience and more than 25 years with the Flight Deck Human Factors Research Lab. "When I arrived we had no flight sims, but within two years, with the help of other principal investigators in the branch, we had two," explained Beringer. "I got my private pilot certificate in 1969 while I was a psych/math major at UCLA," he added. "So that got me interested in seeing if I could apply some of the psychology I was learning to aviation related issues." After a decade and a half in the university environment teaching graduate and undergraduate students and conducting applied research in Human Factors, Beringer eventually found his way to CAMI where he was brought on to help write a specification for the new general aviation flight simulator.

When asked which projects give him the greatest pride, Beringer recalls a study conducted in response to several otherwise inexplicable Piper Malibu accidents. "On one of the accidents, they were able to reconstruct some parts of the terminal phase through radar data. The aircraft had entered a steep and rapid descent and had broken up in the air," said Beringer. "We started looking at possible explanations. Through experimentation with pilots, we determined that the probable cause was pilots misunderstanding what the 'big red autopilot disconnect button' really did ... it disconnects the autopilot, but it only interrupts the electric elevator trim," he further explains. "In a runaway-pitch-trim incident with autopilot engaged, you can't just press the button and release it; the autopilot will disengage, but the trim will continue to run."

Beringer later presented his findings at the annual Malibu Mirage Owners and Pilots Association meeting. "They were very grateful to hear about it," recalls Beringer, "and I was thrilled that we had uncovered something that would help them remain safe."

When asked about the future of human factors research, Beringer reflects on some of the new, or in some cases, "revisited" control schemes that make it easier for the pilot to control the aircraft with less training, and more intuitive displays. The key is the ability to leverage an average person's talents to see and understand the information being displayed, and then use it to fly/navigate an aircraft. Beringer adds that this can be done with the addition of reliable "helper" systems onboard to take care of some of the tasks, whether they be autopilots, envelope-protection systems, or software-enabled sensors/displays. "This, I think, is where the most interesting parts of future human factors efforts in the aerospace field will be."

National Airspace System (NAS) Human Factors Safety Research Laboratory

Another important facet of the human factors research at the FAA is the air traffic control (ATC) workforce. Enter Dr. Jerry Crutchfield, an engineering research psychologist in the NAS Human Factors Safety Research Lab, a facility where research is focused on improving the person-job fit through hiring, training, and technology. "I have been interested in science my whole life," says Crutchfield, "but it wasn't until I started working as a graduate student at the FAA's Aerospace Human Factors division that I learned how meaningful and rewarding the applied side of psychology could be."

Crutchfield's primary focus is managing the ATC Advanced Research Radar Simulator and ATC Advanced Research Tower Simulator labs. He uses these simulators, sometimes in concert with other tools like electroencephalography (EEG) and eye tracking, to measure human performance and conduct research in the ATC world. With these tools, Crutchfield's team was able to develop a large (and free) set of standardized ATC simulation scenarios to assess new technologies and procedures for either en route or terminal area applications. Crutchfield's research also extends to the tower. "We have a Tower Simulation Based Performance Measure (TSBPM) that we have validated against over 300 tower controllers," he continues. The TSBPM could be used to rate controllers and for training or selection purposes."

Dr. Dennis Beringer tests out some eye tracking equipment in a simulator.

Looking forward, Crutchfield's research is having some interesting applications. "Four years ago I started a line of research about how controllers visually scan the air traffic environment, in order to teach novice controllers as well as experts to scan," he explains. "The scanning research led to my recent involvement in identifying visual requirements for remote tower systems." Crutchfield is excited about the prospect for this work to improve both the design of remote tower systems and the training of controllers in all types of air traffic environments.

We only scratched the surface here of what CAMI has to offer in the realm of human factors research. Some of the other facilities include the altitude chamber, the biodynamics impact sled, and the spatial disorientation simulators. For a more detailed look at the CAMI team and research lab facilities, go to bit.ly/FAACAMI.

Tom Hoffmann is the managing editor of *FAA Safety Briefing*. He is a commercial pilot and holds an A&P certificate.

James Williams is *FAA Safety Briefing*'s associate editor and photo editor. He is also a pilot and ground instructor.

LEARN MORE

AVS Human Factors
www.faa.gov/aircraft/air_cert/design_approvals/human_factors