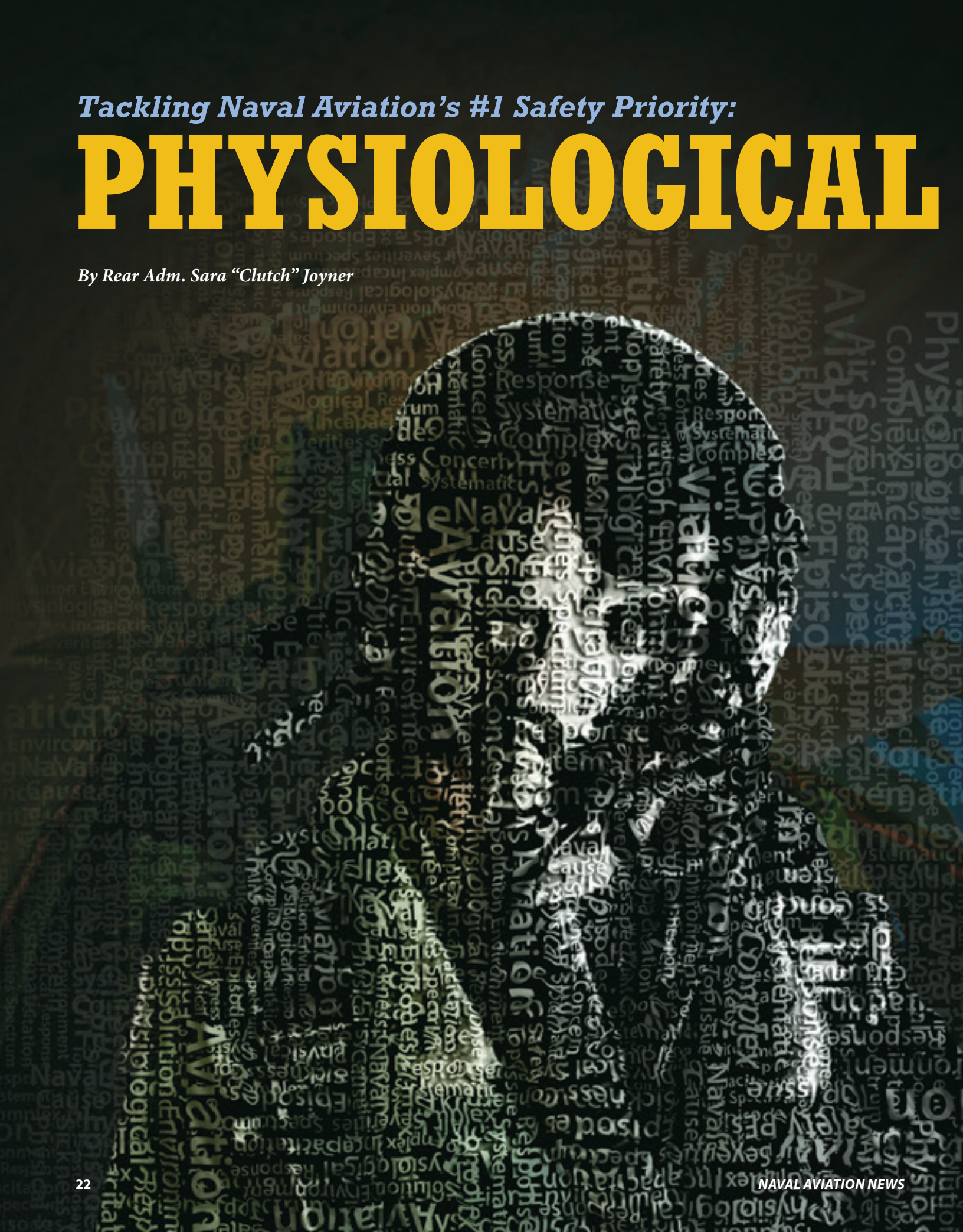
Tackling Naval Aviation's #1 Safety Priority:

PHYSIOLOGICAL

By Rear Adm. Sara "Clutch" Joyner



EPISODES

Editor's Note: Rear Adm. Sara Joyner has served as the lead for the Physiological Episodes Action Team (PEAT) since its inception in August. As she transitions to her new role on the Joint Staff, she provides the Naval Aviation community with an update of the team's progress.

I thought I noticed movement in the mirror while taking off for an early morning functional check flight (FCF) in an A-4 Skyhawk out of Naval Station Roosevelt Roads in Ceiba, Puerto Rico. A short time later, I again caught movement and realized something with a large wingspan was alive in the back cockpit. A bat was hanging from the aft clock, flexing its wings in irritation at its rude awakening. In my time as a pilot, I have angered my share of naval flight officers and weapon systems officers, but never as much as I did this back-seater.

Passing through 8,000 feet, I made a plan. With the bat becoming increasingly agitated, I knew that attempting to land might encourage it to take flight. Part of the FCF profile involved climbing to a high altitude to check the cockpit pressurization and dump sequence. So I climbed to 40,000 feet, priming myself on oxygen, and dumped pressurization. As the pressure climbed in the cockpit, the bat slowly folded its wings and went still.

Waiting an extra minute just for good measure, I re-pressurized the cockpit, finished my profile and returned to the flight line with a now-rigid bat. The air crewman gave him a place of honor for years in the office preserved in a pickle jar. But if I had known then what I know today, I would have kept him nearby to remind me that my solution was a bad idea. While I hadn't experienced a physiological episode during the flight, I had nevertheless set myself up for one with the altitudes and depressurization my solution involved.

Today, physiological episodes (PEs) are the top safety concern for Naval Aviation, and I know far more about pressure than I ever knew for any Naval Air Training and Operating Procedures Standardization (NATOPS) check. Last August, on recommendations from the Comprehensive Review (CR), I undertook my assignment to lead the Physiological Episodes Action Team (PEAT), with a clear understanding that resolving the issue for our aircrew would take nonstop focus.

The engineering details and interfaces between our bleed air and oxygen systems, and the incredibly complex environmental control system (ECS) that manages the high-pressure air essential for F/A-18 critical life support systems and aircraft avionics—all have become my 24-hour-a-day obsession.

My position requires a rapidly expanding knowledge of all Navy and Marine Corps aircraft that employ a pressurized cockpit and oxygen system. Our portfolio includes the F/A-18 Super Hornet, T-45 Goshawk, F-35B/C Lighting II and T-6 Texan II, and we also assist with the AV-8B Harrier and small number of EA-6B Prowlers that experience PEs.

My team includes representatives from multiple organizations such as Naval Air Systems Command (NAVAIR), the Bureau of Medicine and Surgery (BUMED), and our Navy laboratories and aeromedical communities. Our operational branch under the Air Boss and our public affairs efforts allow us to engage with civilian leadership and request the resources we need to research and correct these issues.

It is my goal that every effort under my purview be squarely focused, from start to finish, on those individuals who brief and execute the mission, so they can always return safely to the flight line.

Today, we are addressing PEs by monitoring both the aircraft and the aviator. While collecting data directly from the aviator may seem a logical starting point, providing real-time monitoring equipment that performs well in the cockpit has proved challenging. For example, systems that measure breathing gas delivered to the pilot are still being tested and matured. Physiological monitoring systems—such as the Aircrew Mounted Physiological Sensor Suite (AMPSS)—attempt to accurately measure human performance in a way

Photo illustration by Fred Flerlage

that would be familiar to anyone who participates in the "Quantified Self" movement, which involves using biometric technology to gain insights into one's daily life. However, challenges abound due to the environmental factors experienced in naval aircraft.

We are nonetheless making progress with systems such as the CRU-123 solid-state oxygen monitor, which measures the Onboard Oxygen Generation System (OBOGS) pressure and oxygen percentage in the T-45. This equipment proved revolutionary in helping us understand the T-45 breathing system and has allowed us to make data-driven corrections to the aircraft. This fall, we will field an F/A-18 system called the Cabin Pressure OBOGS Monitoring System, phase one of which will allow data logging as well as provide indications and warnings of pressure anomalies in the cockpit. Phase two will automatically actuate emergency oxygen for the aircrew.

As an example of commercial-off-the-shelf (COTS) procurement, the Aircrew Systems Program Office has provided all F/A-18 aircrew with Garmin watches, which provide the air crew real-time haptic warnings of pressure fluctuations in the cockpit.

The "art" of data science may sound like a contradiction, but that art has been critical to our understanding of the problem and our development of the holistic solutions we need. Indeed, its application has been among the most challenging but also most rewarding of our efforts. Our small but talented team of data scientists continue to explore how we can best use data, big and small, to gain insight into both the human and systems aspects of the PE problem.

Last spring, a NAVAIR engineer discovered a COTS device called a SlamStick that was capable of measuring pressure changes with time, rate and amplitude. Knowing the Hornet's analog pressure gauge doesn't record data, the engineer pushed the SlamSticks out to the fleet as a potential data collection tool. That technology, which began as a potential new data source, has since turned into one of our most promising devices for measuring, predicting and correcting the pressure performance of our aircraft. With it, we can determine "good acting" and "bad acting" aircraft as measured by the amplitude of fluctuations in various flight regimes.

When paired with memory unit data, the data we collect from the SlamStick provide insight into the ECS stability of our systems and allow us to detect whether a system is deteriorating in performance. While the SlamStick doesn't serve as a real-time warning device, it does indicate to pilots post-flight whether pressure exceedances have occurred. These indications allow the pilot to self-evaluate and report to a flight surgeon if he or she experiences symptoms. In the near future, we expect this device to help us develop a prognostic cockpit health tool for the aircraft. This is just one example of the promising data efforts we are pursuing.

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U.S. Navy photo by MC2 Rebecca Sunderland

Pushing the Limits

Our best military laboratories, such as the Naval Medical Research Unit and the Air Force's 711th Human Performance Wing, are conducting cutting-edge research into pressure and breathing gas events to enhance our understanding of the effects our aircraft systems have on aviators in the cockpit.

Physiological Episodes (PEs) are a physical response to the aviation environment and cover a broad spectrum of severity, from air sickness to incapacitation.

Due to our joint platforms and the opportunity they present for leveraging our research efforts, we work closely with the Air Force and have developed a unified path for both services. This relationship has already enabled us to develop joint solutions and achieve a better understanding of the cockpit environment and our oxygen systems.

The Physiological Episodes Action Team charter is definitive—the resolution of PEs across multiple platforms. My immediate team has been constructed from a wide range of talent. Working out of the NAVAIR Washington Liaison Office, it has been assembled from aerospace engineers, fleet operators, instructor pilots, medical professionals and fleet maintainers. Our daily focus is on how we can accelerate the research and procurement process, enabling rapid deployment of solutions to the warfighter and development of holistic and enduring solutions. Unlike legacy commands, it is our goal to find new ways to work ourselves out of a job.

—Rear Adm. Joyner

When I first began this assignment, I assumed we already had an understanding similar to that of the dive community regarding human requirements for pressure and breathing gas. Films like "The Right Stuff" and "Apollo 13" portray how our understanding of human physiology matured during the space program. In the decades since, we have built upon knowledge from that era and adapted it to fit the modern combat aircraft we fly today.

But even though our aviators of today aren't that different from the astronauts of the 1960s, that knowledge has proved incomplete—our aircraft have continued to push the limits of speed, endurance and altitude. Today, our research is surpassing the bounds of our knowledge of oxygen concentration and pressure fluctuations, and what we had once considered "cutting edge" in the 1960s has, understandably, become outdated.

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U.S. Navy photo by MC3 J. Alexander Delgado

In close coordination with NAVAIR, our aeromedical laboratories, the dive community and academia, we are increasing our levels of understanding of the optimal human requirements for our life-support systems. Cross comparisons of OBOGS-delivered pressures and oxygen levels are showing us where the boundaries of human performance lie with our breathing gas systems, while also accelerating our understanding of existing system deficiencies, and guiding designs for our next-generation OBOGS.

For each type/model/series aircraft, we are using a methodology called root cause corrective action analysis to trace fault trees, allowing a thorough, data-driven and methodical approach to identifying causes of PE events. Because PEs happen to aircrew and not the aircraft, all root cause analysis efforts begin and end with the aircrew. To understand the interactions we take for granted as operators, we must understand this man-machine interfacing and its contribution to physiological events.

For the T-45, we are already well down the road toward a corrective action that will remedy the low bleed-air flow to the OBOGS system. The F/A-18 ECS is far more complex and is dynamic in nature, but we are making strides in cockpit characterization and steadily working toward a material solution. We owe it to the warfighter to ensure that we perform an end-to-end analysis of this system and apply corrections as fast as they are identified.

The F/A-18 has served as the backbone of the fleet for nearly two decades of sustained combat operations. While even the best designed systems can degrade and eventually fail over time, we're not content to accept this outcome. We have begun to show we can slow this trend, and strong data-driven analysis suggests we can reverse course and develop a better system that might serve as the model for all future combat platforms.

Underpinning all of these efforts are the infrastructure and people that we rely on to support our aircraft. Restoring the manpower, equipment and parts that were hit hardest by years of restricted budgets is a priority. To adequately support the warfighter, we must resuscitate a supply system and subcontractors that have been kept on life support. It will take time to reverse the mindset of Sailors who have been consistently told there are no resources or assistance. Meanwhile, we are restoring a holistic, system-level understanding of the ECS to our schools, training pipelines and flight lines, which is making a real difference in the PE rate and turning trends downward.

We can't expect our warriors on the front lines, our maintainers and aviators, to accept systems that perform sub-optimally, which means that PEAT, NAVAIR and Commander, Naval Air Forces must guarantee the tools and resources are on hand to ensure "good enough" is never the correct answer. By assisting us in identifying shortfalls on the flight line and in our supply system and our depots, our warriors will help us return these critical systems to their historically, highly reliable performance.

In time, we will reach a point when PEs have become history and aviators will man their aircraft with other important matters on their mind, such as how to avoid getting gunned during their next basic fighter maneuvers sortie, or how best to employ nine Joint Direct Attack Munition bombs on an Islamic State compound, or how not to look bad behind the boat.

Active duty and Reserve aircrew who wish to subscribe to the weekly PE IPT newsletter should contact Cmdr. Mike Burks, PE IPT lead, F/A-18 and EA-18G Program Office, at michael.j.burks@navy.mil.

For other physiological episode questions or issues, contact PEAT@navy.mil.