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Photo Illustration by Dan Harman

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FSM notams

RIGHT SPOT, BAD TIMING

Courtesy ASRS *Callback* #267, Nov 01
NASA's Aviation Safety Reporting System

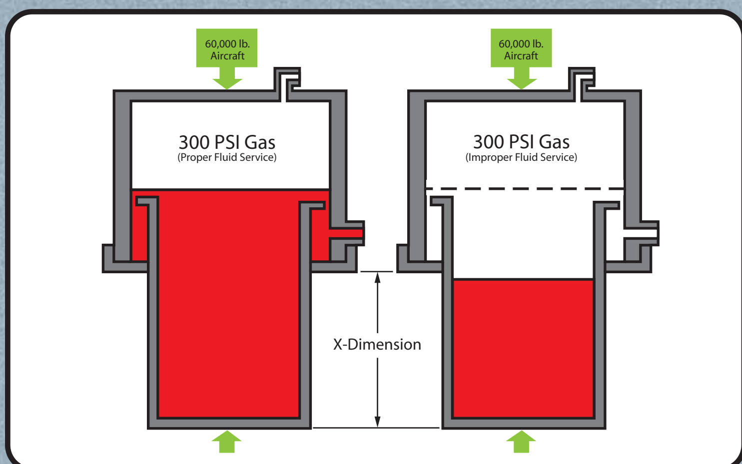
When fuelers and maintenance technicians are servicing the same aircraft, positive communications are needed to safely coordinate the work. A B727 flight crew report to ASRS explains:

During the first flight of the day cockpit setup, I observed that work was being done on the flight controls. All placards were normal. Ten minutes into ground operations, a ground personnel [employee] attracted my attention from outside the First Officer's window making gestures interpreted as "raise the flaps." After verbally confirming his intentions and verbally clearing the area with ground personnel, he again made the upward gestures and I took steps to raise the flaps. Maintenance technicians then intervened and informed us that they were still at work on the wings.

In reality, the signaling ground person was a fueler that was not aware of the work being done on the other side of the aircraft. Nor was he aware of the potentially dangerous condition that existed.

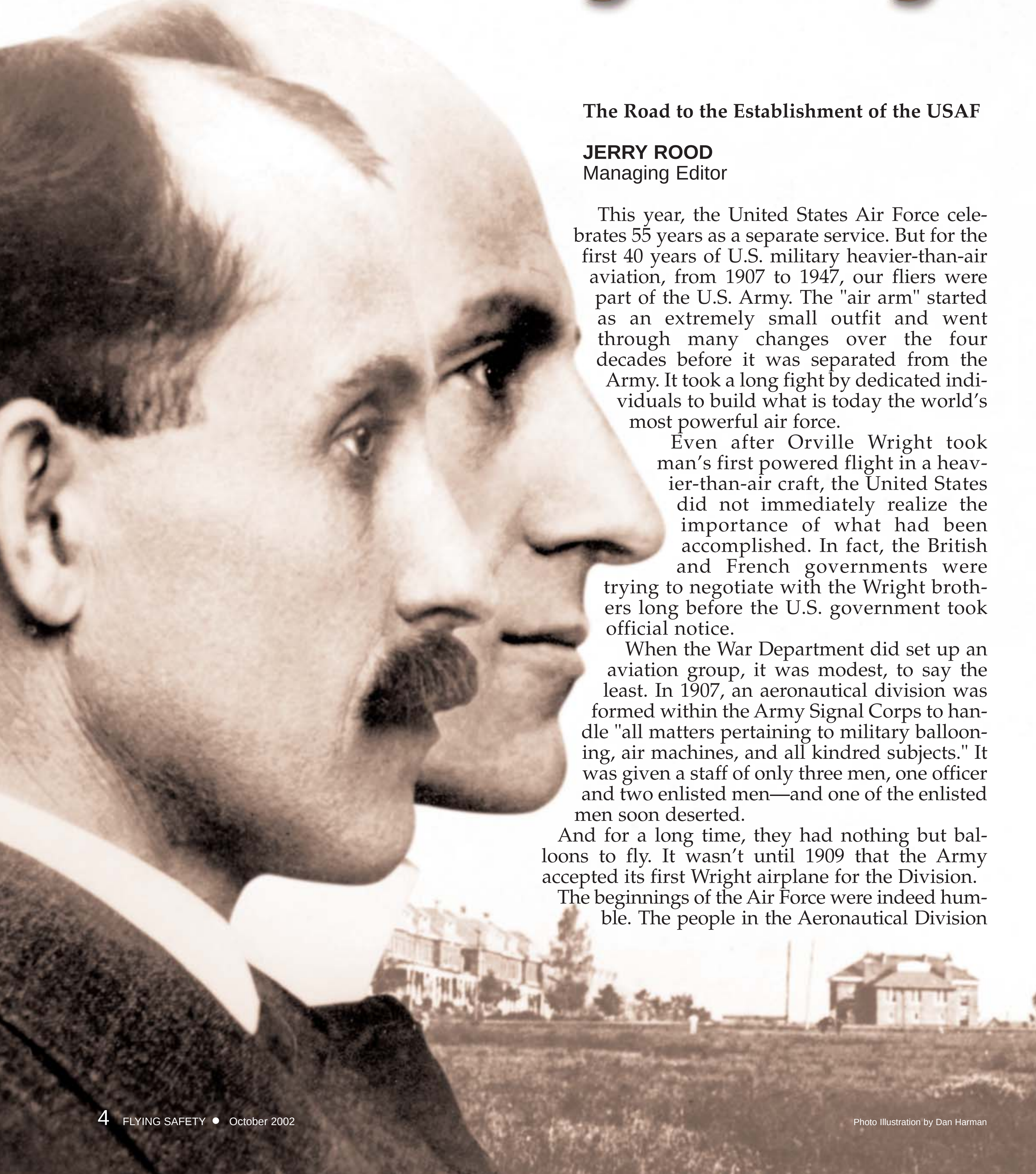
Unfortunately, his proximity, gestures, and timing all fit the circumstances and his actions were mistaken [by the flight crew] for those of a maintenance technician summoning assistance from the cockpit, which is a common scenario. It is obvious, in hindsight, that more positive communication was needed.

It's hard to know what the reporter meant by "normal" placards. In this situation, maintenance technicians should have pulled the circuit breakers on the flaps and hydraulics, and placarded the breakers and flap handle to prevent activation of the flight controls.



Errata: In the August 2002 issue, "The Mysterious X Dimension," page 19, Figure 2, we incorrectly reported the strut pressure. The correct pressure in both struts should be 300 psi gas, not the different pressures represented, which would be physically impossible. We apologize for any confusion this may have caused.

Humble Beginnings



The Road to the Establishment of the USAF

JERRY ROOD
Managing Editor

This year, the United States Air Force celebrates 55 years as a separate service. But for the first 40 years of U.S. military heavier-than-air aviation, from 1907 to 1947, our fliers were part of the U.S. Army. The "air arm" started as an extremely small outfit and went through many changes over the four decades before it was separated from the Army. It took a long fight by dedicated individuals to build what is today the world's most powerful air force.

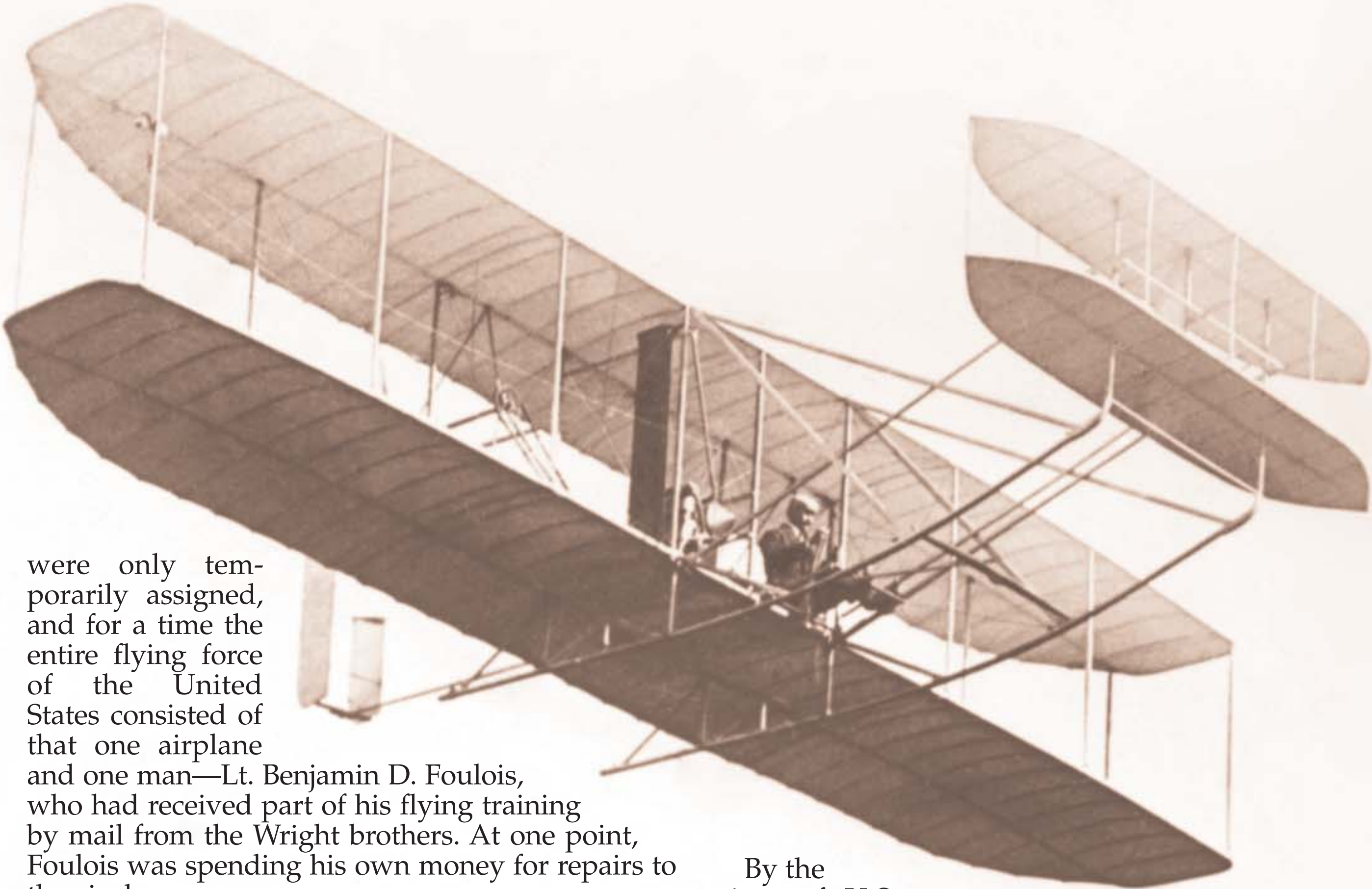
Even after Orville Wright took man's first powered flight in a heavier-than-air craft, the United States did not immediately realize the importance of what had been accomplished. In fact, the British and French governments were trying to negotiate with the Wright brothers long before the U.S. government took official notice.

When the War Department did set up an aviation group, it was modest, to say the least. In 1907, an aeronautical division was formed within the Army Signal Corps to handle "all matters pertaining to military ballooning, air machines, and all kindred subjects." It was given a staff of only three men, one officer and two enlisted men—and one of the enlisted men soon deserted.

And for a long time, they had nothing but balloons to fly. It wasn't until 1909 that the Army accepted its first Wright airplane for the Division.

The beginnings of the Air Force were indeed humble. The people in the Aeronautical Division

Photo Illustration by Dan Harman



were only temporarily assigned, and for a time the entire flying force of the United States consisted of that one airplane and one man—Lt. Benjamin D. Foulois, who had received part of his flying training by mail from the Wright brothers. At one point, Foulois was spending his own money for repairs to the airplane.

The War Department put a little more emphasis on aviation as the Army assigned more officers to flying duty and bought more planes. The Department's budget had a specific amount for aviation for the first time in 1911—the huge sum of $125,000.

By 1914, the Division had over 100 men and 15 aircraft. That year, the Aviation Section of the Signal Corps replaced the Aeronautical Division. It was set up with 60 officers and 160 enlisted men, the first people permanently assigned to aviation.

In 1916, the Section got a test of combat when it was involved in the Punitive Expedition into Mexico against Pancho Villa. By the end of six weeks, all eight aircraft were either worn out, in need of major repairs or had crashed. This action, plus the possibility of U.S. involvement in the war in Europe, convinced Congress to greatly increase the budget for the Aviation Section.

Foulois, working in the Aviation Section in Washington, developed a plan for a buildup of the air arm to support the three-million-man army. He was able to convince Congress to allocate $640 million for his plan.

By the time of U.S. entry into the First World War, the Air Service consisted of over 100 officers and 1000 enlisted men. However, there were few airplanes. Between the purchase of the first plane in 1909 and U.S. entry into the war, 224 planes had been purchased, but by then few were still flying. In April 1917, the Army had 55 planes—all of which were trainers. Fifty-one of these, according to General John J. Pershing, were obsolete and the others were nearly so.

The growth of the air arm of the Army continued. The Air Service, Allied Expeditionary Forces, was created in 1917 after U.S. entry into the war. The next year, a Director of Air Service was appointed, and military aviation was separated from the Signal Corps.

During the war, the Army Air Service flew mostly in a supporting role to the huge ground armies, including reconnaissance of enemy troop movements, artillery spotting and close air support. In the view of most of the Army command, interruption of enemy communications and bombardment of enemy war production by Air

Service fliers was secondary to their support of ground troops. Still, there were opportunities to demonstrate the effectiveness of air power.

Two battles late in the war, at St. Mihiel and the Meuse-Argonne, provided such a chance. Fifteen hundred aircraft of French, Italian, British and American units were put under the control of Brig. Gen. William ("Billy") Mitchell, Commander of the Air Service, First Army. Mitchell used the majority of them to fight for air supremacy, destroying enemy planes and attacking ground targets.

By the end of the war, Air Service aviators had flown 20,000 combat missions and shot down 800 enemy planes, at a loss of 300 U.S. aircraft. Further, they had dropped 275,000 pounds of bombs—negligible by World War II standards, but still an example of things to come.

Following the war when the Army was demobilized, Air Service officer strength dropped from 20,000 at war's end to around 200 in 1919. This disturbed many who wanted to see the growth of military aviation. Most of the Air Service wanted it to be separate from the Army, while Army officials were against losing control of an important function. The Army Reorganization Act of 1920 formally gave the Air Service the role it had filled during the war, that of a combat arm of the Army.

The difference of opinion was between those who saw a larger and more important mission for the air arm, including offensive bombing, and those who believed the effectiveness of aircraft was limited to support of infantry. Those against were unconvinced of the value of offensive air operations, and they were horrified at the possibility of action against civilian targets. They included Army officers up through the General Staff, and civilians up to the Secretary of War.

Those in favor of expanded emphasis on the Army's air arm tried to convince their superiors that aircraft could be used to attack the means of producing war, and thereby destroy the will to fight. They ranged from moderate advocates such as the Air Service Chief, Maj. Gen. Mason M. Patrick, and fliers like Maj. Foulois and Maj. Henry H. ("Hap") Arnold to the very vocal (and sometimes intemperate) Gen. Mitchell.

Mitchell, now the Assistant Chief of the Air Service, staged demonstrations of the strategic power of aircraft in the early 1920s. He had Air Service bombers sink several old battleships, including the heavily armored German battleship *Ostfriesland*, and he professed that the day of such ships was past. He continually defended the need for air power in speeches and in books like "Winged Defense." His outspoken manner attracted both public attention and official disapproval. He was eventually court-martialed for insubordination after some extremely critical remarks about superiors. He subsequently resigned from the Army rather than remain silent about air power.

Gen. Patrick, then Chief of the Air Service, was a more moderate advocate. His interest was in advancing the growth of military aviation rather than infighting for complete separation from the Army. Gen. Patrick wanted the Army's relationship to the air arm to be much like the relation of the Navy and the Marine Corps. He wanted the Air Service to be directly under the Secretary of War rather than the General Staff, to increase the influence of flying officers over those without air experience.

In the 15 years following the war, Congress had about 14 different boards and committees study the question of the role aviation should play in the nation's defense. The conclusion was that the air arm should remain part of the Army.

For instance, in 1925 the Lambert Committee in Congress recommended the establishment of a Department of National Defense with separate Army, Navy and aviation departments. At about the same time, the Morrow Board came to different conclusions based on some of the same testimony. It rejected the Defense Department idea and instead backed an air arm remaining under the War Department—although with increased power in the Department hierarchy, including representation on the General Staff.

Public and official interest was focused on air power at the end of 1925, when the reports of the Lambert Committee and the Morrow Board, along with the court-martial conviction of Billy Mitchell, all occurred within a period of less than a month.

BGen "Billy" Mitchell

Bombing tests,1923

The result of all these studies was the 1926 Air Corps Act, which followed most closely the recommendations of the Morrow Board. The Act turned the Air Service into the Army Air Corps. This increased the numerical strength of the air arm and further increased its prestige as an offensive force, as opposed to an auxiliary service of the Army. It left the air arm under the War Department's General Staff, and thus the Air Corps had to compete with the rest of the Department for its share of the limited funds appropriated by Congress for a peacetime War Department.

The level of growth in the aircraft inventory provided for by the Air Corps Act did not occur, but the fewer than 900 planes in the Air Corps in 1926 had risen to 1650 by 1931.

Following the Air Corps Act, the differences of opinion concerning aviation continued, as did the studies of the need for an independent air force. The conventional wisdom was that the United States was too far away from potential enemies to worry about attack from the air, and therefore a service charged with air defense of the nation was unnecessary. Further, the Navy and War Departments had a vested interest in keeping air operations within their control, and they proved powerful opponents to any drive for an autonomous air force.

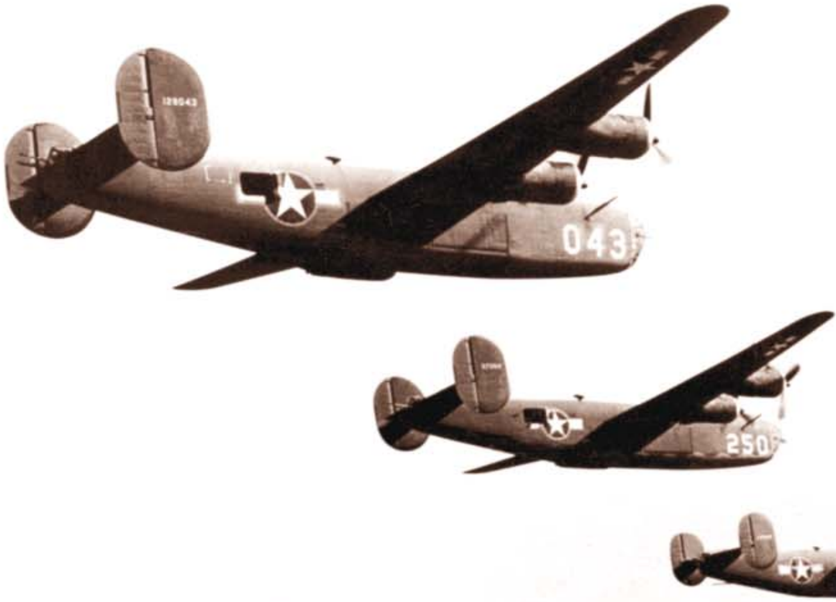
However, in the 1920s, aviation was moving ahead faster than the conservatives realized. Record-breaking flights—including the Air Service round-the-world flight in 1924 and Charles A. Lindbergh's solo transatlantic flight in 1927—demonstrated the possibilities of aviation.

Another wave of commissions in the early 1930s, by both the War Department and the newly established Federal Aviation Commission, studied the need for an independent aviation service. Once again they supported the status quo, but also recommended setting up a General Headquarters Air Force, composed of all air combat units, trained as a unified force and able to perform both close support and independent action.

The War Department moved on these recommendations in 1935 when it created the General Headquarters (GHQ) Air Force. The GHQ Air Force was a coordinate component with the Air Corps, with its own commanding general who reported directly to the Chief of Staff in peacetime, and to the theater commander in wartime. It was a step in the right direction, but military aviation was split between the two organizations, with training and employment under the GHQ Air Force and supply and individual training under the Air Corps.

It took an emergency situation to further strengthen the air arm and to give it more autonomy. Reacting to the worsening situation in Europe at the end of the 1930s, President Franklin Roosevelt called for U.S. production of 10,000 planes a year for the protection of the Western Hemisphere. After the German invasion of France in 1940, he called for an Air Force of 50,000 to meet the mounting threat.

The Army Air Forces were created by order of the Secretary of War in 1941. The Deputy Chief of Staff for Air was also the chief of the new organization, and he commanded both the Chief of the Air Corps and the Commanding General of the Air Force Combat Command (formerly the GHQ Air Force).



This is the organization with which the United States went into World War II. Early in the war, the Army Air Forces was recognized as one of the three major Army commands, and the Office of the Chief of the Air Corps and the Air Force Combat Command were abolished.

Further moves toward autonomy came in the course of the war. During the fighting in North Africa, the tactical air forces were at first under control of ground commanders. The British, who had had a separate air force since World War I, brought the idea of coequal ground commanders and air commanders reporting to the theater commander. The effectiveness of this arrangement became evident when Allied planes took control of the air away from the Germans.

The eventual victory in Africa led to the Army Air Forces field manual in 1943, which stated "Land power and air power are coequal and interdependent forces; neither is an auxiliary to the other."

All those changes of organization, policy and practice over four decades brought about the establishment of the Air Force as a separate service on 18 September 1947. It was a long road for military aviation, from a tiny three-man operation to an equal partner in global conflict. But the Air Force—under whatever name and whatever hierarchy—had proved itself equal to all tasks set before it. And great achievements were ahead.

Gen “Hap” Arnold

Are Vibrations Dangerous?

USAF Photo by SSgt Dave Nolan

MR. JOSEPH J. NEVINS
58 SOW, Lead AFETS/Vibration Program Manager

In 1995 a USAF MH-53J helicopter crashed while flying a gun mission over South Korea, destroying the $45 million helicopter. It was only because of the aircrew's expert airmanship that no lives were lost. The culprit: a broken engine-drive-shaft-to-coupling bolt. No one knows how long this faulty component was installed, but one thing was certain, we could not afford to let a $77.56 bolt destroy a $45 million helicopter, ultimately costing lives.

Retired USAF CMSgt Jimmy Ramsey spent 20 years in helicopter maintenance and two tours in Vietnam as a flying crew chief and was the first to decide something had to be done. It was Mr. Ramsey who in 1980 established the 58th Special Operations Wing vibration management program office.

Over the years, the vibration office has rewritten the way we perform maintenance, not only on our helicopter fleet, but also on our C-130s. As many oldtimers can tell you, we used to track the main rotor blades using a metal pole with a bungee cord attached. We covered the bungee cord with masking tape and applied different color grease pencils to the tips of the main rotor blades. Once the pilot had the main rotor turning at 100%, the very brave maintenance types would slowly and carefully move the bungee cord slightly into the path of the whirling main rotor blades. Once they felt a little twinge in the pole they would withdraw the pole from the blades and lay it down. If they could cover all the different colors on the masking tape with one finger, the main rotor was considered in track. You see why we always picked the guy with fat fingers.

Not only was this a long and hazardous way of performing rotor maintenance, it did nothing for the in-flight track of the rotor blades. This process would take days to complete, and then they could start the blade balancing process, which meant wrapping masking tape on the tip of one of the main rotor blades. If, in the pilot's judgment, the vibration got worse, they went to another blade until the pilot was satisfied with the resulting ride. Once it was to the pilot's satisfaction, maintenance would convert the wraps of tape to permanently mounted lead weights. Of course, it wasn't unusual for the helicopter to have several repeat write-ups from different crews that all had a different feel for vibrations.

We used to track the main rotor blades using a metal pole with a bungee cord attached.

To track the tail rotor blades maintenance would cover the tip of a teacher's pointer with a grease pencil, and once the pilot had the tail rotor spinning at 100%, maintenance would again slowly move the pointer into the path of the tail rotors. Many tail rotor blades were damaged due to an over- aggressive maintainer.

Many tail rotor blades were damaged due to an over-aggressive maintainer.

Today, thanks in large part to technology and pioneers like Mr. Ramsey, we now use Fast Fourier Transform (FFT) analyzers to track and balance a main rotor. We currently use two Chadwick-Helmuth systems. The 8500C Balancer/Analyzer is a portable FFT analyzer that can perform vibration trend analysis, track and balance helicopter main and tail rotors, balance turboprop propellers and balance drive shafts. The second system, currently in use on our MH-53J aircraft, is the Vibration Monitoring System (VMS). The VMS system is an on-board continuous vibration monitoring system. It uses transducers to monitor vibrations on an ongoing basis and to perform main and tail rotor balance. It can also integrate with flight data and cockpit voice recorders for health and usage monitoring. What once took weeks, is now safely accomplished in two to three flights with a much smoother result.

Turboprop aircraft and helicopters, as a matter of fact all machinery, are inherently built with some form of vibration. Some we humans feel, some we do not. Some vibrations are harmless, while others are very harmful and even dan-

HQ AFSC Photo by TSgt Michael Featherston
Photo Illustration by Dan Harman

gerous. It's not the vibration you feel that you have to worry about, it's the one you don't feel. Why? Because vibrations that are left unmonitored result in fatigue and component damage. Being able to determine what components are safe and unsafe has now become a reality. Because of men like retired CMSgt Mike Klickovich, the USAF has been able to take advantage of their strong maintenance expertise in applying this technology to aging aircraft.

The C-130 T-56 engines are expensive to operate due to their high recurring maintenance costs brought about through harsh usage and the inability to know when and under what conditions key components are deteriorating to failure. The replacement of components is required by tech orders to ensure safe operation, even in the absence of knowledge of the true condition of critical systems and subsystems. This means that preventative maintenance is performed and healthy components are replaced needlessly in an attempt to prevent unexpected or catastrophic failures.

The current maintenance practice is time- and conditioned-based, i.e., removing engines at a select time schedule or when a failure occurs. Failure of an internal engine component historically causes extensive collateral damage, resulting in higher repair or replacement costs. In addition, military aircraft and their subsystems are notoriously prone to the effects of vibration, and these effects require periodic replacement of compo-

All vibration on turboprop aircraft has a deteriorating and cumulative effect.

nents (i.e., fuel systems, avionics, radar, propeller and engine systems) to ensure safe operation. The last definitive study conducted by the United States Government was by the Naval Air Warfare Center in the late 1980s. The study showed that the average mean time between failure for all major systems on board T-56-powered aircraft doubled with the control of vibration levels on studied aircraft, raising average mean time to failure from 125 hours to over 300 hours. The bottom line is that all vibration on turboprop aircraft, even at relatively low levels, has a deteriorating and cumulative effect on engine and propeller components, as well as the aircraft and all of its components.

Maintenance personnel can safely operate the vibration equipment from the comfort of the aircraft cabin.

A USAF PRAM project will implement and install the Chadwick-Helmuth on-board Vibration Expert System (VXP) on six C-130 aircraft. The VXP will support USAF's engine trending and diagnostics (ET&D) and reliability-centered maintenance (RCM) vision. This will implement a proactive engine health monitoring philosophy or predictive maintenance philosophy rather than the more costly reactive maintenance practices currently followed. The VXP will reduce the frequency of unscheduled maintenance actions and costs by detecting impending failures early in the deteriorating process before systemic damage occurs to ancillary systems, and by providing the ability to schedule maintenance actions well in advance of need. Drawing on empirical data obtained from actual flight trials of multi-transducer arrays on flying C-130H aircraft and high resolution cost projection models, the predicted fully amortized five-year savings will be $101,092,589, in year-2000 dollars.

So, what have we done for the H-53 engine drive shaft bolt? We now have an on-board Vibration Monitoring System on the MH-53J/M. With this system, maintenance can monitor the vibration levels of certain flight-critical components, like the engine drive shaft. We can see, and have seen, high vibration levels of these components long before they became a flight hazard. This allows maintenance to make the necessary repairs without the flight crews ever realizing there was a problem. Since we installed VMS on the MH-53, the USAF has seen a 66% reduction in vibration-related aborts. This in turn means greater aircraft availability for accomplishing our mission. With our high deployment rate, maintenance has another tool to help determine which aircraft should be deployed and which aircraft require extra maintenance.

HQ AFSC Photo by TSgt Michael Featherston

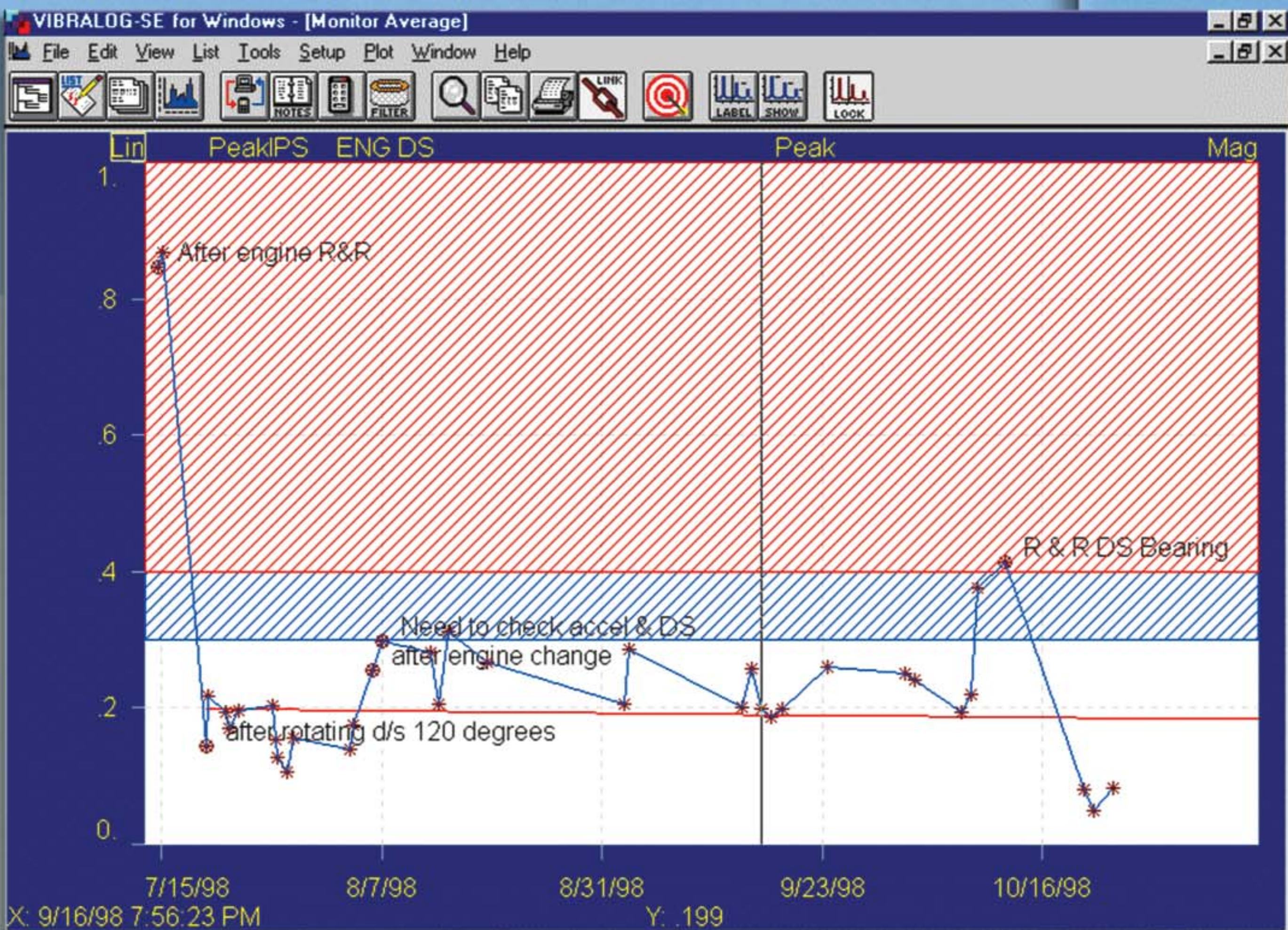
But one of the biggest benefits of this new technology is safety! We no longer expose our maintainers to very high-risk activities, like working in close proximity to rotating main or tail rotor blades. Maintenance personnel can safely operate the vibration equipment from the comfort of the aircraft cabin. Using optical blade trackers, we can safely and accurately determine the blade track adjustments necessary for a smooth flight.

Every 10 flight hours, maintenance downloads the on-board VMS system into a ground-based computer. The following figure depicts spectrums from the Vibralog ground-based software. Two alarm levels are used to aide the maintainer. The first, blue alarm level is an advisory level, meaning 68-95% of the fleet are less than this value. The second, red alarm level dictates an investigation is required; 95% of the fleet are less than this value. The MH-53J engine drive shaft operates at 6023 rpm, when the aircraft is operating at 100% rotor speed. (Figure 1) The spectrum shows the engine drive shaft operating over time, first in the second "red" alarm level shortly after an engine change. As maintenance rotates the drive shaft to find the optimum balance level, you can see the vibration level bounce between no alarm and the first blue alarm level. Then maintenance replaces the engine drive shaft hanger bearing, thus reducing the vibration level below both alarm levels.

Bottom line for all this? A proactive vibration monitoring system, along with using technology to predict a failure, reduces maintenance downtime and expense, while increasing aircraft productivity and safety. If you would like more information on the vibration systems please contact the Kirtland vibration office at Joe.Nevins@kirtland.af.mil.

Two alarm levels are used to aide the maintainer.

Figure 1. Engine Drive Shaft Coupling Vibration Signature



Silent Flight?

USAF Photo by TSgt Dave

MAJ NOEL BRADFORD
18 WG/SEF
Kadena AB, Japan

The entire instrument panel went blank.

The mission was going great. The crew had finished air refueling, and I was excited because it was my turn to get an approach and landing from the left seat of the KC-135R—my very first time in the pilot's seat! The pressure was on to prove I was ready. If I could fly the High ILS approach with its holding pattern and arcs, I would surely be able to handle any of the other, much simpler radar vectors to the FAF.

After I strapped into the left seat, I briefed the approach in the MOA before heading home. The IP called Center and requested an IFR clearance back. Center cleared us direct to the home station TACAN at 10,000 feet. I reminded the IP that I wanted to do the High ILS, which starts at 15,000 feet, and we needed clearance direct to the holding fix for the approach, not direct to the airfield TACAN.

In the process of Center handing us over to approach control, we had passed 15,000 feet, and the IP suggested that we just start the approach at 10,000 feet and drop the holding: non-standard, but doable. I quickly set up the MFD and radios for the 22-DME arc that was now approaching. Since we had deleted the holding, I called for the Approach and Landing checklist.

The IP was running through the checklist and we kept descending. At my lead radial, we were cleared out of 4000 feet for 2000 feet, and I rolled the airplane to 30 degrees of bank with the autopilot while the IP started to call approach to let them know we had traffic in sight. Not wanting the gear warning horn to blare while the IP was talking on the radio, I reached down and crossed over with my left hand to pull up on the horn cutout switch while I pulled the throttles back to idle.

What happened next is something that I hope no one else ever has to experience. The entire instrument panel went blank, and we heard the familiar clicks from the relays on the autopilot, clueing us that the autopilot had just disengaged. I grabbed the yoke to maintain pitch and bank while I scanned the panel for some indication as to what had just happened.

Thankfully, it was day VFR outside, so I used visual references for my attitude. I knew I would not stall the plane if I did not raise the nose but, at our altitude, I did not want to let the nose fall any lower. The only inside light I saw was the battery power light. I reached up and switched it to emergency to extinguish the light. As I scanned the panel again, the airspeed indicator and altimeter (my two main concerns) came back into view.

By this time, the IP noticed there was no fuel flow to any of the engines. We both looked down at the throttles, and that was when I realized that what had felt like the idle stop was actually the throttle cut-off position. I had accidentally shut down all four engines on the power pull!

The IP immediately pushed all four throttles up to "start." Another scan showed N2 on all four to be around 65% and still falling. I heard the IP yelling "Throw the ignition switches to start," but I was thinking that they were above 63% and they would be damaged. Before I could say anything, he yelled it again. Who was I to argue? I had just shut down all four engines!

I turned on all four ignition switches; we lifted the throttles into idle position and still heard nothing! The IP now had control of the jet and was looking outside for options as to where to put down. We were coming up on 2000 feet AGL, but we were 18 miles from the airport. To make matters worse, there was nothing below but ocean. The nearest land remained over 14 miles away. In these last few moments, I heard a thumping sound and concluded it was my heart, and it made me realize how deathly quiet this 200,000-pound aircraft can truly be. All noise that you hear in the tanker is derived from the engines in some form or fashion—trust me!

The slowest 10 to 15 seconds of my life passed before Number 3 and 4 engine fuel flow needles bounced to life and a faint rumble of life surged through the plane. Three seconds later, the Engine 1 and 2 fuel flow needles also flickered and then came online. The IP leveled off the plane at 2000 feet and let the airspeed bleed back from 250 KIAS, giving the engines time to stabilize in hopes they would provide the thrust we so desperately needed. As the airplane passed through 200 KIAS, the engines looked stable and the IP pushed up the throttles. The engines roared to life and stabilized at 2500 pounds of fuel flow. The entire crew breathed a sigh of relief. We had lost a total of 2200 feet during this event, but we were still on the approach and we had four good engines, so the IP continued the approach to a somber but uneventful full-stop landing.

As soon as we landed, my commander impounded the jet and directed fuel/oil sampling. Aircraft and crew records went over to Wing Safety, while I and the rest of the crew went over to the Clinic for toxological testing. The Wing investigated the incident as a High Accident Potential incident (HAP). We conducted interviews, prepared a report for release and briefed the Wing on lessons learned. I ended up with an "Unqualified" Form 8 and a stint in Supervised Status. It could have been far, far worse.

Looking back on the incident, I realize the importance of pre-briefing on the ground anything new that you are going to attempt in the air—not because a regulation requires you to, but because techniques and procedures can be dangerous, if not downright fatal, if not executed in the proper manner and sequence. Briefing on the ground allows you to point out potential pitfalls before you are airborne. I attribute my mistake in part to a negative transfer habit from the right seat. I had always silenced the warning horn with my left hand, and in the heat of the moment, that's where that left hand went. Unfortunately, my right hand came up in concert with the left, and "poof," the fires went out! We filed a HAP report, and the Dash One may be changed to warn pilots to "exercise extreme caution" when reducing power to idle during descent and not pre-empt the warning horn when retarding the throttles.

Another point to emphasize is that I happen to always fly the high approach clean, without flaps or gear. Had we been at flaps 20, I am not sure we would have had the 200 KIAS airspeed required to assure an air start. With all four engines out, that was our only option to start. By the time we were 3000 feet above the ocean, we may not have had the altitude to trade for the needed airspeed.

Never believe that you've "seen it all" in aviation. The next time you are preflighting in the jet, before you reach for the battery power switch or start up the APU to apply power, take a moment to stop and listen to just how quiet a KC-135R really can be. Then be thankful that this is the only time you ever do hear "nothing"!

To make matters worse, there was nothing below but ocean.

Napping: Power or Poison?

Illustration by Dan Harman

J. LYNN CALDWELL, PH.D.
Air Force Research Laboratory
Brooks AFB TX

During times when aviators are working around the clock trying to meet deployment deadlines and trying to accomplish the mission, sleep becomes difficult to obtain. The will to work is strong, but the body's ability to follow that will weakens with each hour spent awake. Ultimately, the fatigue from lack of sleep can become so powerful that concentration, motivation and performance are seriously impaired. How important is it to get enough sleep, and how much sleep does it take to really make a difference? Is it enough to take naps when long sleep periods aren't possible or is this just a waste of time?

Unfortunately, information about the importance of sleep may be confusing at best, and contradictory at worst. This is especially true of napping. Some people say, "If you can't sleep at least two hours, then don't sleep at all," and others say, "I feel worse after waking from a nap, so naps just don't work for me." Still others insist, "All sleep is important, so get as much as possible." Which, if any, of these statements is correct? There may be some truth to each, but as they say, "The devil is in the details," so issues surrounding sleep and especially naps deserve explanation. Here is a summary of what researchers know about napping during otherwise continuous hours of prolonged wakefulness.

The Power Of Naps

There is an abundance of evidence that a nap taken during long periods of otherwise continuous wakefulness (such as during shift rotations) is extremely beneficial for improving alertness and performance. Switching from a day shift to a night shift commonly causes sleep deprivation in a lot of people. For various reasons, many workers choose to stay awake throughout the day before reporting for a night shift, leading to at least 24 hours of wakefulness and all the ill effects of sleep deprivation. If a full sleep period is not possible before making this transition, a two- to three-hour nap before the night shift will definitely improve nighttime performance over what would occur without the nap. Although the usual circadian trough will still be noticeable in the early morning hours—the symptoms are excessive sleepiness, poor attention, etc.—the nap will attenuate these decrements compared to remaining awake continuously.

There are times other than transitioning to night shift when long hours of continuous wakefulness are experienced, preparing for deployment, participating in training exercises, and responding to emergencies, to name a few. In situations where a normal eight hours of sleep isn't possible, a nap can make a noticeable difference in performance, mood, and alertness. A nap taken *before* long periods of continuous wakefulness, called a "prophylactic nap," is beneficial for preventing decreases in performance and alertness compared to not taking a nap. If a significant sleep dept is not allowed to accumulate before getting some sleep, the positive effect from the nap will be readily apparent. However, a prophylactic nap's beneficial effects will wear off if a second night of continuous wakefulness occurs without additional sleep.

Sometimes a continuous work period is not expected and a prophylactic nap cannot be planned. In such situations, taking a nap whenever

it is convenient is better than trying to stay alert and productive for hours on end without sleep. During long periods of sleep deprivation (more than 36 hours), a nap of any duration, but preferably one that is as long as possible, is very beneficial. This nap, called a "replacement nap," will reduce the decline in performance during the subsequent work period. Of course, it is best to take a nap before significant sleep loss has occurred, but when this is not possible, a nap any time during the continuous wakefulness period will improve alertness, performance and mood compared to what would have occurred without any sleep
.

The Poison Of Naps

It is well established that practically everyone experiences post-nap sleepiness, termed "sleep inertia," immediately upon awakening from a nap. This is why many people think naps aren't helpful, because they remember the immediate discomfort they feel right after they wake up rather than the long-term benefits from the extra sleep. Performance and mood generally are lowest during the first five minutes after awakening, but usually recover after 15 to 30 minutes. Generally, sleep inertia will be extended when naps are taken during the temperature minimum or trough (usually in the early morning hours) and/or the amount of sleep deprivation is extensive before the nap occurs. If sleep inertia is a major consideration (such as it would be if you didn't have time to become fully awake before performing a task), naps during the temperature trough should be avoided; however, it may be difficult to actually fall asleep during "non-trough" times. Sleep inertia also can be minimized by ensuring that naps are taken before 36 hours of continuous wakefulness. The easiest way to avoid sleep inertia and reap the greatest benefits from napping is to allow about an hour between nap-wake-up and work.

So What Do I Do?

Sleep is important and cannot be avoided indefinitely. At some point, the body will shut down and sleep, regardless of the situation. So, making sure personnel can sleep at least a short while should be a high priority for the sake of performance, safety, and morale. However, scheduling naps is not a simple matter. In order to make napping an asset rather than a problem, several factors should be considered.

Nap timing. One important factor in scheduling naps is placing them at optimal times with regard to the amount of sleep loss. A nap taken during the day before an all-night work shift (a prophylactic nap), with no sleep loss prior to the shift will result in improved performance over the night compared to performance without the nap. Although naps taken later in the sleep-deprivation period also are beneficial, these naps probably should be longer than prophylactic naps in order to derive the same performance benefit.

Nap length. Another factor to consider when scheduling naps during continuous operations is nap length. Most studies indicate that naps of at least one hour will improve performance and alertness, but there is a relationship between nap length and performance — the longer the nap, the longer the beneficial effects on performance and mood. The conclusion from research is that a nap should be as long as possible to produce maximum performance benefits. However, any sleep obtained during a long work period is better than no sleep at all, especially if time can be given to recover from sleep inertia.

Nap placement. Another factor to consider when planning a napping strategy for use during continuous operations is where the nap should be placed in the 24-hour day. Nap timing should take into account the ease of falling asleep at various times, the quality of sleep as a function of the body's internal clock, and the effects on performance both immediately after awakening and later in the work period. Sleep tendency is highest when core body temperature is in its trough (in the early morning hours) and lowest when core body temperature is in its peak (in the early evening hours). Thus, there may be significant problems initiating and/or maintaining naps during times when core temperature is high, termed the "forbidden zone" for sleep. Naps placed at times when body temperature is low are the easiest to maintain, and they show beneficial effects on later performance. However, sleep inertia is highest following these naps. While both naps have been shown to improve performance measured later in the day compared to after no sleep at all, the nap taken in the temperature trough offered the most benefit. But remember, a nap taken *anywhere* in the 24-hour cycle before sleep deprivation is better than no nap at all.

The Bottom Line

In summary, naps of any length are beneficial for reducing sleepiness and performance decrements during sleep-deprivation periods. The longer the nap, the longer the benefit will be. A nap is most beneficial if taken before significant sleep loss occurs, if it is as long as possible, and if it is placed in the temperature trough (provided there is time to recover from sleep inertia). If choosing between no sleep at all and a nap of any length, generally the choice should be a nap, but remember to allow time for sleep inertia to dissipate before returning to the job. 2

Disclaimer: The opinions, interpretations, conclusions, and recommendations are those of the author and are not necessarily endorsed by the USAF or the Department of Defense.

A Maintenance "There I Was"

USAF Photo by TSgt Fernando Serna

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In the Wing Commander's office (again) trying desperately to convince this grizzled Vietnam veteran that I did indeed have family members that stood upright. He did not look totally convinced, especially in light of the fact that I had just helped totally demolish an RF-4C centerline fuel tank, as well as the stand I was supposed to put it on.

Let me set the way-back machine to 72 hours prior to being in the Wing King's office. We were deployed to Shaw AFB from Eglin AFB with the 3246th Test Wing (part of the now defunct Armament Division) and two RF-4Cs. On the last day of the testing program, one of our prized, exceptionally modernized (for 1983) birds had taxied out from parking, and then right back into the parking spot. It seems that nasty old constant speed drive (CSD) had cracked wide open, letting all that good oil lubricate the taxiway, ramp and parking spot instead of the innards of the J-79 engine. Needless to say, we had to fix that, and to replace the CSD the centerline fuel tank had to come off.

The "real" aircraft crew chief had to call home station and tell them the bad news, so he told me (the highly qualified 3-level avionics guy and now assistant crew chief) to take the centerline tank off. "It's all in the book," he says. So, I looked in the book and the crew chief was right. It looked darn easy.

- Empty the fuel tank
- Unhook that L-shaped thingy
- Disconnect the fuel pipe thingy
- Ratchet the tank onto the tank stand.

Off I went, determined to make the crew chief proud of his young protégé.

In short order, the line chief delivered a tank dolly, which I positioned under the tank just like the picture in the book. Off came the L-shaped thingy and the fuel pipe. "Hah," I thought to myself, "This crew chief stuff is no sweat." (A lie, if you have ever been to Shaw AFB in the summer.) One more ratchet and I could lower this tank onto the dolly and wheel it away. BUT WAIT: Step 1, I recalled, was to empty the tank. This made total sense to me, since the dolly appeared to be made from rolled tin foil. Not wanting to break my rhythm, I didn't go into the cockpit to check the fuel level, I just snapped off the old fuel tank filler cap and looked inside. Didn't see a drop of fuel in there. (Some of you may know that JP-4 is a very clear liquid.) Can you see what's next? Pop the fuel cap back on, and off I go to ratchet the tank off. Dang, that is a hard ratchet bolt to turn.

Weight, momentum and position are with me, and with one last mighty heave—THUNK. Uh-oh! *There I was*, staring at a ruptured fuel tank, a flat tank dolly and a lot of amused onlookers. Amused, until the smell of the newly-freed jet fuel began to waft their way. Then we all began that time-honored ritual: *"Run away from the plane until you smell nothing, stop, turn and await orders from the fire chief."*

The moral?

(1) Don't even try to do a job you're not at all familiar with, without a T.O.

(2) Never assume that you know everything about what you're doing.

(3) Never assume the Wing Commander will have a sense of humor if you neglect 1 or 2.

USAF Photo by SSgt P.J. Farlin
Photo Illustration by Dan Harman

Pay-Back Time: Respect and Professionalism

J.S.T. RAGMAN

Pay-back time. Thirty-eight years ago, he ran alongside me as I attempted my first ride without training wheels. Twenty-eight years ago, he sat alongside me as I attempted my first drive with manual transmission. Two days ago, he sat alongside me as I guided him through a hand-flown ILS to minimums in the Boeing 777 simulator. Pay-back time.

My father's last simulator ride had been in 1943, a Link Trainer at Mitchell Field, Long Island: an artificial horizon, and a gentleman outside moving the simulator this way and that. His most recent ride, courtesy of my airline training department, was in a $40 million simulator, equipped with full visuals, auto-flight, variable winds, visibility, ceiling, turbulence and shear. We had a database at our fingertips from which we could select virtually any approach to any runway to any of the major international airports worldwide. Phenomenal technology. Phenomenal expense. A phenomenal experience.

My father broke out at minimums, with the flight director centered, the airspeed within limits, and smoothly flared. Touchdown. He had spent four hours in the simulator with me, my training partner and our instructor. He ran out the door to catch his flight home; I headed to the debrief. We shook hands.

The next day I took a moment to share my father's observations with my training partner, and with our instructor. My father had said nothing about the phenomenal technology, nor the phenomenal expense, nor the phenomenal experience. My father had shared but one comment: "Never in my entire lifetime have I ever witnessed three people treat each other with such a high and consistent level of professionalism and respect." As I type the words, they resonate as deeply as they did when he first shared them. I could think of no finer comment. I could not have scripted it any better.

Respect. Professionalism. High and consistent level thereof. I had been flying for twenty-two years. It had become so much a part of my manner of dealing with others that it had become a "non-item." It had become so much a part of my aviation experience that I had come to take it for granted.

My father's comment suggested a re-visit with the two concepts might be a worthy journey. Respect and professionalism are what keep us alive in the aviation business. Checklists, standard operating procedures, cross-checks, situational awareness, along with any number of other flight safety elements, gain their value only through our high and consistent level of respect and professionalism. The degree to which we show each other respect, the degree to which we exercise professionalism, dictates the value of every other flight safety element. High respect and high professionalism equals high value. Low respect and low professionalism equals no value.

There is no escaping this reality. Examine the evidence. Examine the instances in which crew resource management was compromised: Was each and every crewmember respected for his/her inputs, concerns, reservations? Examine the instances in which standard operating procedures were willfully compromised, the instances in which checklists were short-circuited: Was professionalism present at a high and consistent level?

Conversely, how is it that some aviators manage thirty or forty years of incident-free flying? Do they respect the inputs, concerns, and reservations of every member of the "team"? Do they display a high and consistent level of professionalism, adhere to standard operating procedures and practice checklist discipline? Examine the evidence.

How had I come to view respect and professionalism as a "non-item"? How had I come to take it for granted? The answer resided in the conscious, willful effort on the part of an organization, from the top managers through every level of supervision, to make respect and professionalism a non-negotiable requirement. The twin values form the bedrock of any flight safety program. Compromise the two values, and you undermine the program. Live the two values, from Commander through Section Chief to individual crewmember, and you build a flight safety program your father would surely comment upon. More importantly, you build a culture in which you would put your father on any aircraft, on any day, with any crewmember.

Thanks for the words, Dad. Nice landing.

("J.S.T. Ragman" is the pen name of a C-130 pilot and unit commander in the Air Force Reserve. He is also a Boeing 777 pilot for a major airline.)

Fatigue Factors For Aviators ...And Everybody Else!

HQ AFSC Photo by TSgt Michael Featherston
Photo Illustration by Dan Harman

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Flying Safety, Sep 98

Editor's Note: Although written with the aviator in mind, the precepts in this article apply to all personnel, regardless of AFSC.

Fatigue impairs alertness and performance, often without your awareness. In fact, sleepiness/fatigue can be as dangerous as intoxication. Just 18 hours without sleep causes mental and motor skills to deteriorate as much as they do when blood alcohol concentration (BAC) reaches 0.05 percent. Twenty-four hours of sustained wakefulness equates to a BAC of 0.10 percent, the legal intoxication limit in most states. Fatigue is a significant risk factor in aviation as well as ground operations, but the consequences of being tired are too often underestimated or ignored.

What Is Fatigue?

The terms "fatigue" and "sleepiness" are often used interchangeably. One definition of fatigue describes it as a subjective state of tiredness associated with prolonged work and/or prolonged wakefulness (or sleep loss). This may be experienced differently by different people. One of the reasons the risks associated with fatigue or sleepiness are underestimated is that no biological markers or "Breathalyzers™" for fatigue exist. Thus, it's difficult to determine how many accidents and other problems are associated with fatigue. Fatigue-related impairments are underreported because sleepy pilots, drivers and workers are reluctant to admit they fell asleep (or even became inattentive) on the job, especially if an accident results.

Is Fatigue a Big Problem?

Despite the fact fatigue is difficult to measure, there's plenty of evidence that fatigue-related problems have reached almost epidemic proportions. As a society, we sleep too little and ignore our biological clocks. The demands of everyday life have reached the point where slumber is routinely sacrificed for work, family and recreation. As a result, approximately 63 million Americans chronically suffer from moderate or severe daytime sleepiness. And because of this, on-the-job concentration, decision making, problem solving and performance are adversely affected.

Forty percent of adults now say their daily sleep is inadequate. Much of this is simply due to the fact people go to bed too late and get up too early or don't sleep well due to stress or other factors. Also, the requirement to work rotating shifts leads to disrupted or insufficient sleep. There are over 25 million shift workers in the United States, many of whom find it impossible to stay alert during their night jobs because sleeping during the day is contrary to the body's internal biological clock. Thus, there are a lot of sleep-deprived people in America, and many of them are in the military.

Interestingly, however, most of us see our sleepiness as a badge of honor rather than as a condition to be remedied. Twenty-six percent of career-minded adults feel sleepiness is part of the price to be paid for being successful. In the military, commanders place a high value on troops who "tough it out" despite the fact these individuals are increasing accident risks because they are suffering from dangerous alertness deficits.

Is Fatigue Worse at Some Times of the Day Than at Others?

The simple answer to this question is yes. Human beings have a number of biological rhythms (for hormone secretions, temperature, etc.) which are synchronized to 24-hour cycles by exposure to daylight, knowledge of clock time, meal intervals and activity schedules. Because of these rhythms, alertness is greater during the day than the night, and research has shown people not only feel sleepier at nighttime, but perform less skillfully as well.

For instance, it's been found that truck drivers fall asleep behind the wheel more frequently at night (after midnight) than during the day. Also, they are seven times more likely to be involved in a drowsy driving accident between midnight and 0800 than at other times. Studies of truckers have shown that time of day is more likely to impact driving performance than the amount of time on duty or the number of consecutive trips.

In a variety of other occupations, errors and accidents have been shown to increase at night. Thus, time of day is as important a determinant of fatigue as is the amount of wakefulness since the last sleep period. However, both of these factors work together to influence alertness levels, and because of this, both must be considered when attempting to minimize sleepiness on the job.

What Are the Costs Associated With Fatigue?

Unfortunately, sleep deprivation affects almost every aspect of daily functioning, but attention, complex thinking, judgment, decision making and motivation are the most vulnerable. As a result, it's estimated $18 billion in U.S. industrial productivity is lost every year because of sleepiness on the job.

On the highways, drowsiness costs more than $12 billion a year in lost productivity and property damage. About 1500 deaths and 76,000 injuries occur annually because drivers fall asleep while traveling.

Besides these costs at work and on the highways, many of the over 50 percent of aviation mishaps chalked up to human errors are directly related to fatigue and sleepiness in the cockpit. Some have described flying as "long periods of boredom interspersed with seconds of sheer terror," and it's now known this boredom (associated with flying routine, uneventful missions) places pilots at greatest risk for falling asleep at the controls. Passive monitoring tasks (such as navigating at altitude) are the most susceptible to being botched as a result of sleep deprivation.

Why Are We So Tired?

Two of the major causes of fatigue are (1) inadequate sleep prior to work and/or (2) extended periods of wakefulness (as in sustained operations). Although the military, the trucking and railway sectors, and commercial aviation have sought to combat fatigue by restricting the amount of time spent working, there's little clear evidence that hours of work, per se, adversely affect performance as long as adequate daily sleep is obtained. Instead, the most readily identifiable cause of fatigue is sleep loss. This is alarming since chronic sleep deprivation in America is on the rise.

At the turn of the century, before the advent of electric lights, people slept 9.5 hours per day, most of which was at night (since artificial lighting was inadequate for working during hours of darkness). However, many of us now sleep less than seven hours per day, and some segments of the population (i.e., shift workers) sleep even less. As a result, sleep deprivation is taking a heavy toll on job productivity, personal safety and well being.

What Are the Warning Signs of Inadequate Nightly Sleep?

In general terms, excessive sleepiness at work indicates insufficient sleep while off duty. Sleepiness (fatigue) can result either from acute periods of deprivation ("pulling an all-nighter") or from chronically shortened sleep periods across several days (leading to cumulative sleep debt). Indicators of inadequate sleep include:

- Difficulty waking up without the aid of an alarm clock.
- Repeatedly pressing the snooze button to sneak in a few extra minutes of sleep.
- A strong desire to take naps during the day.
- Difficulty staying awake while in meetings, riding in a car or watching TV.
- Falling asleep rapidly after going to bed at night (usually in less than five minutes).

• Looking forward to weekends when one can "catch up on sleep."

• Sleeping two or more hours than usual on days off.

Many fatigued people blame their sleepiness on boredom or on inactivity. However, in well-rested individuals, boredom causes a feeling of irritation or agitation and not the irresistible urge to nod off which results from sleep deprivation.

How Much Sleep is Necessary to Be Fully Alert?

There are substantial variations in sleep needs from one person to another, but on average, adults need about seven to nine hours of nightly sleep to be fully alert during the day. Although there are some people who can get by on much less sleep, it's not possible to accurately predict which individuals are "short sleepers" and which are "long sleepers." Age, fitness level, intelligence, motivation and personality appear to have no reliable relationship to sleep needs. In fact, the only way to determine sleep requirement is by trial and error. However, learning how much sleep is necessary (and ensuring this much is obtained) is essential to remain fully awake on the job. Studies have shown the loss of even two hours of sleep during a single night is enough to significantly degrade next-day alertness.

Sleep-deprived individuals are often unaware of their own impairment.

How Can I Determine How Much Sleep Is Right For Me?

Individual sleep needs can be determined in two ways. The best way is by studying your own behavior while on your next vacation, particularly if the vacation is a couple of weeks long. However, it's possible to determine sleep needs during non-vacation times as well.

While on vacation, sleep until you wake up without an alarm for several days and record the amount of nightly sleep. The average is how much sleep you naturally need. When trying this, start keeping records on the third day after you've overcome any preexisting sleep debt.

While on a regular work schedule, add one hour to your usual nightly sleep and maintain this for a week. At the end of the week, evaluate how alert you felt at work each day. If more sleep is needed, add an hour the next week, and so on.

Once your natural sleep requirement is established, carefully evaluate factors that may be preventing adequate daily sleep. Usually, reprioritizing or simply rearranging the course of a normal day will help to ensure enough sleep to maximize on-the-job alertness.

Can I Train Myself to Need Less Sleep?

It's a fact some people need more sleep than others. If you're one of those people, there's unfortunately no way to train yourself to get by on less than your biologically determined amount of slumber. Some people think repeated exposure to sleep deprivation improves their functioning during sustained wakefulness. This, however, is not the case. Simple tasks can be made resistant to the effects of sleep loss by overpracticing them to the point they become automatic. *But this won't work with tasks requiring thought and judgment.*

People who think they have made themselves immune to the effects of sleep deprivation through practice have actually just learned to reprioritize work tasks so sleep loss seems to have less of an impact. But their higher mental processes continue to decline while their chances of involuntarily falling asleep increase.

Furthermore, *sleep-deprived individuals are often unaware of their own impairment since sleepiness interferes with accurate self-evaluations.* Just like the drunk who boasts of being able to drive better after several drinks (and actually believes it), the reality is his performance is seriously impaired, but he is simply incapable of realizing it.

How Can I Improve My Nightly Sleep?

If you are allowing yourself a sufficient amount of time to sleep every day but feel your sleep is less than optimal, you may be suffering from bad sleep habits. Everyone struggles with occasional sleep problems, and one or two nights of trouble are not a major cause for concern. However, if you have insomnia for several days, weeks or months, something is wrong. One possible cause of chronic insomnia is a medically recognized sleep disorder, but since most aviators are reasonably young and healthy, they are unlikely to be suffering from one of these (such as sleep apnea or nocturnal myoclonus).

On the contrary, the sleep problems of most adults stem from behavioral or environmental factors. If you repeatedly are unable to fall asleep at night, make sure you do the following:

- Stick to a consistent bedtime and wake-up time, even on the weekends.
- Use the bedroom for sleep only and not for watching TV, reading or working.
- Develop a soothing nighttime routine (take a warm bath, read for a few minutes, etc.).
- If you are a bedtime worrier, set aside an earlier time to resolve daily dilemmas.
- Include aerobic exercise in your daily routine, but not within three hours of bedtime.
- Don't take naps during the day.
- Don't consume caffeine (in coffee, tea, chocolate or medications) within four hours of bedtime.
- Don't drink alcohol within three hours of bedtime.
- Don't smoke cigarettes within an hour before going to bed.
- If you can't fall asleep, don't lie in bed awake. Instead, engage in a quiet activity until sleepy.

Adhering to these principles will help overcome chronic sleep problems because they break mental associations that prevent sleep and avoid substances known to delay or disrupt sleep. However, it may take several days or weeks for these new habits to repair the damage done by months or years of poor sleep practices.

Is It Possible That Shift Work (or Reverse Cycle) Is Making Me Sleepy?

If you usually sleep well and feel alert but suffer from fatigue when rotating to a new work/rest schedule, you are experiencing the normal problems associated with disruptions in your body's internal rhythms (referred to as shift lag). Shift lag is similar to jet lag in terms of its effects. The primary problem is that restful sleep during daylight hours is contrary to our normal circadian rhythms. As a result, night workers often become chronically sleep deprived because they sleep two to four hours less per day than day workers.

Although shifting the biological clock improves daytime sleep (and enhances nighttime alertness), the process is slow, often taking more than a week. Also, the readjustment is hampered by the fact external timing cues (such as sunrise and sunset) conflict with the new sleep schedule. Anyone who has ever traveled from the U.S. to Europe can appreciate the difficulties associated with reprogramming the biological clock.

Even when everything (i.e., sunrise, sunset, meal times, activity, etc.) in the new time zone is fully synchronized with the new sleep schedule, fatigue, gastrointestinal discomfort, concentration problems and insomnia persist for eight to ten days (or one day for each time zone crossed). Needless to say, shift workers suffer chronically from such problems because they rarely work the same shift for very long and, therefore, are in a constant state of readjustment. However, there are strategies that can speed adjustment to new work/rest schedules.

What Strategies Promote Adjustment to a New Work Cycle?

Although transitioning from one shift to another will invariably cause feelings of fatigue and discomfort, certain strategies can facilitate readjustment and minimize how long the discomfort will last. These are especially important when changing from day to night shift.

- Maintain the new work/rest schedule even when off duty.
- Rapidly adjust meal times (breakfast, lunch and dinner) to agree with the new schedule.
- Talk to friends and family about your need to sleep at a different time than they do and gain their cooperation.
- Unplug the phone, disconnect the doorbell, put blackout shades on the windows and turn on a fan and/or use earplugs to mask out noise.
- When a solid eight hours of sleep is unobtainable, use napping to get as much as possible.
- If possible, use a sleeping medication *under medical supervision* during the first three days of the new rotation.
- Judiciously use caffeine in the middle of the night shift to enhance alert-

Night workers often become chronically sleep deprived.

ness, but avoid caffeine within three to four hours of the next sleep period.

• If sleeping during the day, wear dark glasses and limit time outside before bedtime, then take a walk in the sunshine after awakening later in the day.

• If planning a night cycle, (1) try to end the mission well prior to daylight so personnel can get to bed before sunrise, (2) make sure night crews are not required to attend meetings or other activities which will interfere with sleep, and (3) in field scenarios, make meals available at reasonable times so that no one has to make a choice between eating and sleeping.

Consistent rest/activity cycles and "bright light discipline" are the most important factors when adjusting to a new schedule. Circadian rhythms are very sensitive to being reset (or to resisting resetting) by exposure to bright light.

Sleep-deprived people cannot will themselves to say awake no matter how hard they try.

How Can I Safeguard My Alertness Even When I Can't Readjust to a New Shift or When the Long Missions Just Have to Be Done?

Avoiding fatigue during night flights is difficult because few people are able to fully adapt to night duty beforehand. However, even day flights can be challenging, especially when the flights are long and are sandwiched in between additional duties. Obviously, it's best to avoid flying at night if this is your normal sleep time. Day flights are much safer because of improved alertness. However, if there's no flexibility in establishing when a flight will take place, the following strategies should be implemented:

• Obtain plenty of sleep before the flight (or the duty day when the flight is planned).

• If the flight is late in the day or at night, take a 45-minute nap before takeoff.

• Avoid alcohol consumption within 24 hours prior to night flights because alcohol increases fatigue by interrupting pre-mission sleep and causing blood sugar changes.

• During the flight, swap tasks (navigation, radios, etc.) between pilot and copilot to minimize boredom.

• During the flight (or immediately prior), consume caffeine for the stimulant effect.

• If possible, avoid hot refueling in favor of shutting down and walking around for a few minutes (a break every two hours is very helpful).

• Note that increasing radio volume and exposure to cold air do not fight off sleepiness.

• Remember that after being awake for a long time, involuntary sleep episodes will occur despite your best efforts to the contrary.

What Are Some Warnings That Fatigue Is Becoming Too Great?

The dangers of fatigue from prolonged wakefulness, sleep deprivation or disruptions to the body's internal clock should be obvious at this point. However, optimum mission scheduling is often impossible. When there is no choice but to fly when tired, be attuned to these indicators that falling asleep at the controls may occur in the next few seconds:

• Your eyes go in and out of focus.
• Your head bobs involuntarily.
• You can't stop yawning.
• You seem to have wandering, disconnected thoughts.
• You don't remember things you did in the last few seconds.
• You missed a navigation checkpoint.
• You forgot to perform some routine procedure.
• Your control accuracy is degrading (altitude and airspeed fluctuate).

If you experience even one of these symptoms, the safest course of action is to end the flight as soon as possible and get some sleep. Despite popular opinion to the contrary, sleep-deprived people cannot will themselves to say awake no matter how hard they try. *Even personnel who think they are staying awake are susceptible to falling asleep for several seconds at a time without realizing it.* This is a serious problem given that an aircraft flying at only 90 knots can travel more than the length of a football field during a microsleep of only four seconds.

Can Napping Help?

Since one of the major contributors to fatigue is the lack of recent, restorative sleep, napping is the best countermeasure for drowsiness in prolonged missions. Several research studies have shown that long (four- to five-hour) naps during a period of sleep loss can restore performance to near-normal levels. Also, two- to three-hour naps taken shortly before a period of sleep deprivation can minimize the loss of alertness and performance that would have occurred without a nap.

How Long Should a Nap Be?

Generally, the longer the nap, the better its ability to lower the impact of fatigue. Although two-hour naps cannot erase the effects of sleep loss, they are very beneficial because they provide sufficient time to go to sleep and complete one full sleep cycle. It takes about 90 minutes to transition from light sleep to deep sleep and then into dream sleep. Even ten-minute naps appear to be better than nothing. Just remember—if napping is used in close proximity to the duty area, anyone who naps should be allowed at least 15 to 20 minutes to awaken before they fly or perform other complex tasks because everyone feels a little groggy when they wake up due to sleep inertia.

What Factors Are Important When Planning Naps As A Fatigue Countermeasure?

In situations where a full sleep period is not possible because of work demands, naps can substantially reduce fatigue. When implementing strategic naps:

- Establish a relatively quiet, dark and comfortable place for napping.
- Use sleep masks or earplugs if necessary to block out sunlight and noise.
- Place the nap when sleep is naturally easy (i.e., 1400 to 1600 or 0200 to 0600).
- Make the nap as long as possible under the circumstances.
- Consider implementing a nap in the afternoon prior to an all-night session.
- Plan the nap early in the sleep-deprivation period rather than later.
- Allow 15 to 20 minutes for sleep inertia to dissipate before resuming work tasks.

What If A Long Mission Is Necessary Despite No Opportunity For Sleep?

Missions that pop up without warning, those involving unanticipated night flight, and/or those requiring extended periods of sustained wakefulness are inherently risky because many of the normal fatigue countermeasures cannot be employed. Commanders and pilots should consider the following as risk reduction/risk management tools when flights must be completed despite fatigue or inadequate sleep (in an operational environment):

- Be sure to eat high protein foods like yogurt, cheese, nuts and meats.
- Avoid high fat foods (candy) and high carbohydrate foods (cereals, breads, etc.).
- Drink plenty of fluids since dehydration compounds fatigue.
- Converse with other crewmembers, and rotate tasks to minimize boredom.
- If possible, try to move around in the cockpit. Definitely exercise during refuels.
- Once fatigue becomes noticeable (but not before), take caffeine in some form.
- In combat situations, request a stimulant such as Dexedrine™ from the flight surgeon.

These strategies may provide some short-term enhancement of alertness, *but with the exception of caffeine and dextroamphetamine, they are only minimally effective*. During peacetime, the best countermeasure, other than adequate sleep, is the judicious use of caffeine, which is helpful primarily for people who ordinarily don't drink coffee, tea of caffeinated sodas. However, it's important to remember that regardless of which countermeasures are used, someone who has been awake for 18 hours or more is seriously impaired, particularly if the flight occurs from 0300 to 0900 with no prior sleep. Even the most powerful prescription amphetamines are no substitute for sleep!

Adequate, restful sleep is a biological need like hunger or thirst.

So What's the Bottom Line?

Fatigue is a serious threat to the military as an organization and the individuals who make up each unit, whether ground troops or aviators. Adequate, restful sleep is a biological need like hunger or thirst, and it's the only cure for fatigue—there is no substitute. Recognizing the threat posed by on-the-job sleepiness, identifying the causes or insufficient sleep, implementing countermeasures to ensure proper rest, and developing crew rest cycles that will ensure well-rested and alert crews are among the best force multipliers.

Editor's Note: The following accounts are from actual mishaps. They have been screened to prevent the release of privileged information.

One thing is certain about flying—you have to land sometime. Unfortunately, landing isn't always easy, as other aircraft and vehicles get in the way. Once in awhile we even land on the wrong runway.

Landing On The Closed Portion

At one of the civilian airports that we use on a routine basis, the airport manager closed the first 2500 feet of the runway for maintenance. He issued a NOTAM and the workers went to work. However, the NOTAM went out after some F-15 drivers and students had already gone flying. When they returned to the base they landed over the closed portion of the runway, planning touchdown at or beyond the displaced threshold. The airport manager filed the HATR when two aircraft landed short and endangered the maintenance crew.

The cause of this incident? The coordination between the fighter squadron and the airport manager was minimal. The NOTAM was issued on the day of the closure and not available for the first set of pilots. Supervision inadequately assessed the effect of the closure on their students, and the pilots themselves failed to touch down at or beyond the new threshold, which was not properly marked. So you see, it was a collection of errors by many different people. Haven't we talked about the safety chain before? Remember, be the strong link, look for ways to prevent incidents and never fail to communicate.

Are You Cleared To Land?

Weather in sunny Florida wasn't so sunny, so it was becoming difficult to find a nice place to land. Two F-18s couldn't land at their planned destinations, so they diverted to a local AFB and were being vectored by ATC to the new location. As they were coming in they were cleared to the approach, but not yet cleared to land. Why? There was an operations vehicle still on the runway. Unfortunately, the F-18s continued on and landed on the runway. To their surprise, they found the vehicle, which exited the runway rather quickly.

Another case of short-notice task saturation. There was bad weather, the transponders weren't working very well, and there was confusion on what type of approach was being flown. Do you see areas for improvement here? The pilots had minimum fuel and a short amount of time to divert, and they went from a visual approach to an instrument approach due to the rapidly deteriorating weather. Tower was busy with other aircraft, dealing with the weather and how they would be handling the aircraft. Several people get to share the blame on this one, pilots and controllers. We all need to make sure we talk and listen to each other and ensure we understand what is going on. Especially when the weather gets bad and the task saturation level rises.

Two Aircraft, Same Spot On The Runway?

At a very busy airport, an EA-6B was cleared to land and a C-141 was waiting to depart IFR. Shortly after the EA-6B landed, the C-141 was cleared for takeoff. As the C-141 entered the runway and applied power for takeoff, they saw the EA-6B still on the runway. They elected not to take off because they felt they would not have sufficient clearance from the EA-6B. A wise judgment?

In this case the tower felt that the EA-6B would be clear of the runway by the time the C-141 would take off and exercised their judgment. FAH 7110.65M Paragraph 3-9-5, "Anticipating Separation," specifies that "Takeoff clearance need not be withheld until prescribed separation exists if there is a reasonable assurance it will exist when the aircraft starts takeoff roll." In addition, Paragraph 3-9-6, "Same Runway Separation," states, "Separate a departing aircraft from a preceding departing or arriving aircraft using the same runway by ensuring that it does not begin takeoff roll until: A preceding aircraft is clear of the runway." In issuing the clearance the controller used his judgment that the EA-6B would be clear of the runway when the C-141 started their takeoff roll.

For the C-141 crew, who estimated that the EA-6B was in their viewfinder for 20-30 seconds, they had the potential for occupying the same spot on the runway as the EA-6B. They used their judgment to say, "I'll wait and take off later." In this case who was wrong? All parties involved used their judgment to do what they thought was right. The final responsibility always rests with the aircrew. Here, they used good common sense and delayed their takeoff until they were certain they had a clear runway. Make sure you are the strong link in the safety chain, and make that hard call to delay.

How Current Are Your FLIP Charts?

Here is a case of a crowed military training route (MTR) that almost caused a T-1 and two F-16s to join together at a closure of almost 900 knots. All aircraft involved thought they were in the clear, until they saw each other. The T-1 saw the F-16s. Then the lead F-16 saw the T-1 and called for the F-16s to climb. As the F-16 wingman climbed, he rolled inverted as they passed 600-800 feet above the T-1. Is this Top Gun or what?

How can two different flights on two different MTRs almost hit each other? Well, if you really want to know. These MTRs actually overlap in the area of the near-mid air, and the fact that each route is controlled by a different agency for scheduling gives the potential for people to be at the same spot in time and space. Actually there are two other routes that come close to the first two routes. Many pilots are under the mistaken assumption that they can rely on the "low charts" to deconflict their chosen instrument or visual routes. Bottom line of this near miss is to make sure you adequately plan the sortie and keep a lookout for other traffic. The charts you use may not show everything, and if you are close to another route it doesn't hurt to make a phone call to see if you will have visitors in the same spot in time and space.

Where Do I Land?

On a cloudy day, a flight of T-38s awaiting departure on runway 15R got a surprise as they were cleared to taxi into position and hold. Just before applying power to taxi, the pilots observed a civilian aircraft on short final for the runway. The pilot informed the tower and held position until the aircraft landed.

The civilian aircraft had been right of course on his approach and had been continually directed by the tower to turn left to the center of runway 15C. Do you see what is about to happen? When the pilot of the civilian aircraft broke out of the clouds, he evidently got confused about which runway to land on and chose the one in front of him, instead of the one he was cleared to land on. The best part is we have a great bunch of pilots who remember to look both ways before they enter the runway. Keep up the good work!

High Kite Strike

An HH-60G had taken off for a night tactical sortie, and weather was clear skies and great visibility with moon illumination at 99 percent. Unfortunately, they didn't see one object in their path as they went through 600 feet, and they had to return to the airfield unexpectedly. The post-flight inspection by maintenance found 25 feet of nylon string wrapped around the main rotor pitch change links, and another five feet of string in the sliding cowl wire strike protection system.

How did this crew get all wrapped up? No one knows for sure where the string came from, but their flight area is a popular area for high kite flying. Best part of this incident, the only damage was a groove in the aircraft commander's window, and the task of removing the string and cleaning the main rotor pitch links to ensure no damage. You never know what may be in the air in front of you.

Maintenance Matters

Editor's Note: The following accounts are from actual mishaps. They have been screened to prevent the release of privileged information.

You all have seen or heard of "The Right Stuff." How about The Right Part? We have too many incidents where using the wrong hardware resulted in aircraft damage. Never forget the few seconds you save will cost a whole lot more when you redo the work. Isn't "Excellence in all we do" one of our core values?

Lost Nut = Stuck Throttle

A T-38 was supposed to be flying a student-training sortie but unfortunately came home early with a throttle stuck at 95 percent. Once safely on the ground, the maintenance inspection found a 1/4-inch nut lodged between the throttle control box and the main fuel control input shaft. A 1/4-inch "body-bound" bolt was also found loose in the engine bay. The cause of the stuck throttle was found, but how did it get there?

In this case, the engine had undergone maintenance 26 flight hours prior to the event for an ice ingestion engine stall. The technicians had to split the compressor case to inspect for compressor damage. On engine reconstruction, the compressor case was reattached and the self-locking nuts torqued to 44-48 inch pounds IAW T.O. 2J-J85-116-6. The nut that attached itself to the fuel control had no self-locking ability. Do you know how to tell if a nuts self-locking capability is still there? Evidently the technician in this case didn't, or the story wouldn't be printed here. If you are curious about or unaware of the rules for self-locking hardware, see T.O. 1-1A-8 for the full story.

Flight Controls Split

A KC-135 maintenance crew had started their post flight inspection when the aircraft flaps suffered a split flap problem and damage that wasn't flight related. Initial investigation by the maintenance impoundment team focused on a failed flap gearbox. The team removed the damaged flap and aileron, and as they removed the outboard torque tube from the gearbox they found the torque tube separated from the center splined shaft. This little problem would have caused the initial split flap problem. Further investigation revealed that the self-locking nut and washer that was supposed to hold things together were missing. Now how could that have happened? In this case we don't know and will never know. There was no documentation of any flap maintenance within the last 90 days. Self-locking nuts don't normally come off all by themselves, so make sure they actually are self-locking!

Which Way Does The Safety Wire Go?

At one time or another all of us can say we had to stop and think about which way the safety wire goes when securing multiple fasteners. In this case it caused a C-130 a little gear problem, it wouldn't come down. The crew was able to get the gear down and safely land at home station. What happened? Maintenance found the right forward main gear vertical torque shaft quick disconnect (QD) coupling nut disconnected. Not a good thing when flying, except maybe when ground flying. How can a safety wired QD come apart inflight?

When the QD came apart the strut wedged itself against other components. Causing the gear to stick. Now the QD itself was not damaged and the safety wire used to secure the QD was still present, but broken. The QD was safety wired by .032 safety wire using the single strand method. Another factor was that this was the first flight after an ISO inspection. The ISO inspection work cards require the vertical shaft to be disconnected, inspected, lubed and reconnected. The work cards even refer the technician to T.O. 1C-130H-2-32JG-10-1 for proper procedures. Now pages 2-199/2-206 specify that the QD coupling nut should be applied hand tight and "then install two strands of safety wire." How many were actually installed on the mishap aircraft?

The T.O. even has a picture that shows the exact safety wire routing for the QD. Immediately below the procedure for the QD is a procedure for those struts with a coupling that has four bolts and nuts instead of the QD. The procedure for safety wiring this type of connector…the single strand method. An inspection of the fleet found one other connector improperly safety wired.

Bottom line of all this? Make sure when you are doing maintenance and there are options on how to safety wire a connector, you utilize the right safety wire procedure. If you are ever in doubt, ask your supervisor for help.

Another Case Of Non Self–Locking

This time a KC-10 came home with a number 1 engine anti-ice valve problem. Upon landing the maintenance team found the over pressurization blowout door on the cowling opened and separated from the aircraft, one of the N1 fan blades bent 90 degrees outward and several large sections of abraidable seal material missing. In addition, the team found a section of the anti-ice duct unattached due to a broken clamp. The team removed the engine and sent the broken clamp off for analysis.

The abraidable material was within limits, but they fixed it anyway, and the fan blade was changed. The cause of the fun and games? The self-locking nut on the bleed air clamp was useless as far as self-locking goes. It had been loosened and tightened numerous times and had an immeasurable amount of running torque. That means the dang thing was stripped out. The clamp had broken at the U channel area where the clamp retains the duct, and had failed from fatigue.

How many times can you reuse a self-locking nut in a critical area of the aircraft? If you don't know, then go to your tool room, find T.O. 1-1A-8, section 5-29 and read the guidance on self-locking nuts and don't forget the caution. Maybe this is a topic for the next safety day?

What If The Right Part Isn't Available?

A KC-10 tried to take off but had to come back to parking due to an engine indication problem. Inspection revealed a rupture in the number three pneumatic heat exchanger and ducting. Further inspection revealed that the heat exchanger, plenum and gasket were all damaged beyond repair. These parts had all been recently changed, and the replacement ducts were the "new ones" required by a recent Boeing service bulletin. Now the new ducts are thicker and require a longer tension tie, and guess what was not available in supply? A caution in the T.O. states that the ties be installed until endplay is minimum, which would allow finger rotation of the tension ties. Be careful not to over-tighten. I wonder how tight these ties were?

If you are using a shorter tie than required do you think they were able to achieve the right tension on the ties? What would you do if you did not have the right part to fix the aircraft? Would you cheat and use the wrong part or talk to supervision? I wonder if supervision even knew the right part wasn't available? ✈

USAF Class A Flight Mishaps

FY02 Flight Mishaps (Oct 01-Aug 02)	FY01 Flight Mishaps (Oct 00-Aug 01)
33 Class A Mishaps	**21 Class A Mishaps**
21 Fatalities	**9 Fatalities**
16 Aircraft Destroyed	**19 Aircraft Destroyed**

14 Oct	♣	An HH-60 crashed into a river while flying a low-level training mission.
17 Oct		An F-16CG was severely damaged following an aborted takeoff.
25 Oct		An F-16C departed the runway after landing.
02 Nov	♣	An MH-53 crashed while performing a mission.
05 Nov	✶	An F101 engine undergoing Test Cell maintenance sustained severe fire damage.
12 Dec	♣	A B-1B crashed into the ocean shortly after takeoff.
21 Dec	♣✶	A C-141B sustained a collapsed wing during ground refueling operations.
30 Dec	♣✶	An RQ-4A Global Hawk unmanned aerial vehicle crashed while returning to base.
07 Jan		An MH-53M collided with a ground object (Upgraded to a Class A Aug 02).
08 Jan		A C-17 was damaged during landing.
10 Jan	♣	An F-16C crashed during a surface attack training mission.
10 Jan		An MH-53J crashed during a search and rescue mission.
17 Jan	♣♣	Two A-10As were involved in a mid-air collision. Only one pilot ejected safely.
24 Jan		An MH-53 crashed while performing a mission.
25 Jan	♣✶	An RQ-1 Predator crashed on landing.
31 Jan	♣	A T-37 crashed during a training mission. The two crewmembers suffered fatal injuries.
02 Feb	♣	A C-21 crashed while landing. The two crewmembers suffered fatal injuries.
12 Feb		An F-15 was severely damaged due to an engine fire.
13 Feb	♣	An MC-130P crashed during a mission.
18 Mar		An MH-53 crashed during landing.
20 Mar	♣	An F-16 crashed during a training mission and the pilot did not survive.
10 Apr		A KC-10 experienced FOD damage to an engine. (Upgraded to Class A 08 May 02.)
15 Apr	♣	An F-16 crashed into the sea during a training mission.
22 Apr	✶	An F-22 suffered a birdstrike that severely damaged the right engine.
30 Apr	♣	An F-15C crashed during a test mission. The pilot did not eject.
13 May		An E-4B experienced damage when the HF wire broke loose and struck the fuselage.
15 May	✶	A B-2 suffered major damage when a main landing gear collapsed.
18 May	✶	An RQ-1 Predator crashed returning from a routine mission.
25 May		An MH-53M main rotors struck the fuselage (Upgraded to Class AAug 02).
29 May	♣✶	An F-16CJ crashed during a training sortie.
30 May		An HH-60 crashed during a rescue mission.
12 Jun	♣	An MC-130H crashed shortly after takeoff. Three crewmembers suffered fatal injuries.
27 Jun	♣	An A-10A crashed during a training mission and the pilot did not survive.

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03 Jul		An F-15 experienced an engine failure. (Upgraded from a Class B Jul 02)
10 Jul	♣✶	An RQ-4A Global Hawk crashed during a mission.
21 Jul		A KC-135E had a Number 2 engine fire. (Upgraded from a Class B Jul 02)
24 Jul		A C-17 suffered a hard landing. (Upgraded from a Class B Jul 02)
07 Aug	♣	An MC-130H crashed during a proficiency sortie. All 10 crewmembers did not survive.
08 Aug		A UH-1N crashed during a student training mission.
09 Aug		A U-2S departed the runway during a touch-and-go landing.
13 Aug		An HH-60G crashed during a mission.
21 Aug	♣	An F-15C crashed into the ocean during a training mission.

- A Class A mishap is defined as one where there is loss of life, injury resulting in permanent total disability, destruction of an AF aircraft, and/or property damage/loss exceeding $1 million.
- These Class A mishap descriptions have been sanitized to protect privilege.
- Unless otherwise stated, all crewmembers successfully ejected/egressed from their aircraft.
- Reflects only USAF military fatalities.
- "♣" Denotes a destroyed aircraft.
- "✶" Denotes a Class A mishap that is of the "non-rate producer" variety. Per AFI 91-204 criteria, only those mishaps categorized as "Flight Mishaps" are used in determining overall Flight Mishap Rates. Non-rate producers include the Class A "Flight-Related," "Flight-Unmanned Vehicle," and "Ground" mishaps that are shown here for information purposes.
- Flight and ground safety statistics are updated frequently and may be viewed at the following web address: http://safety.kirtland.af.mil/AFSC/RDBMS/Flight/stats/statspage.html
- **Current as of 30 Aug 02.**

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