flying

SAFETY

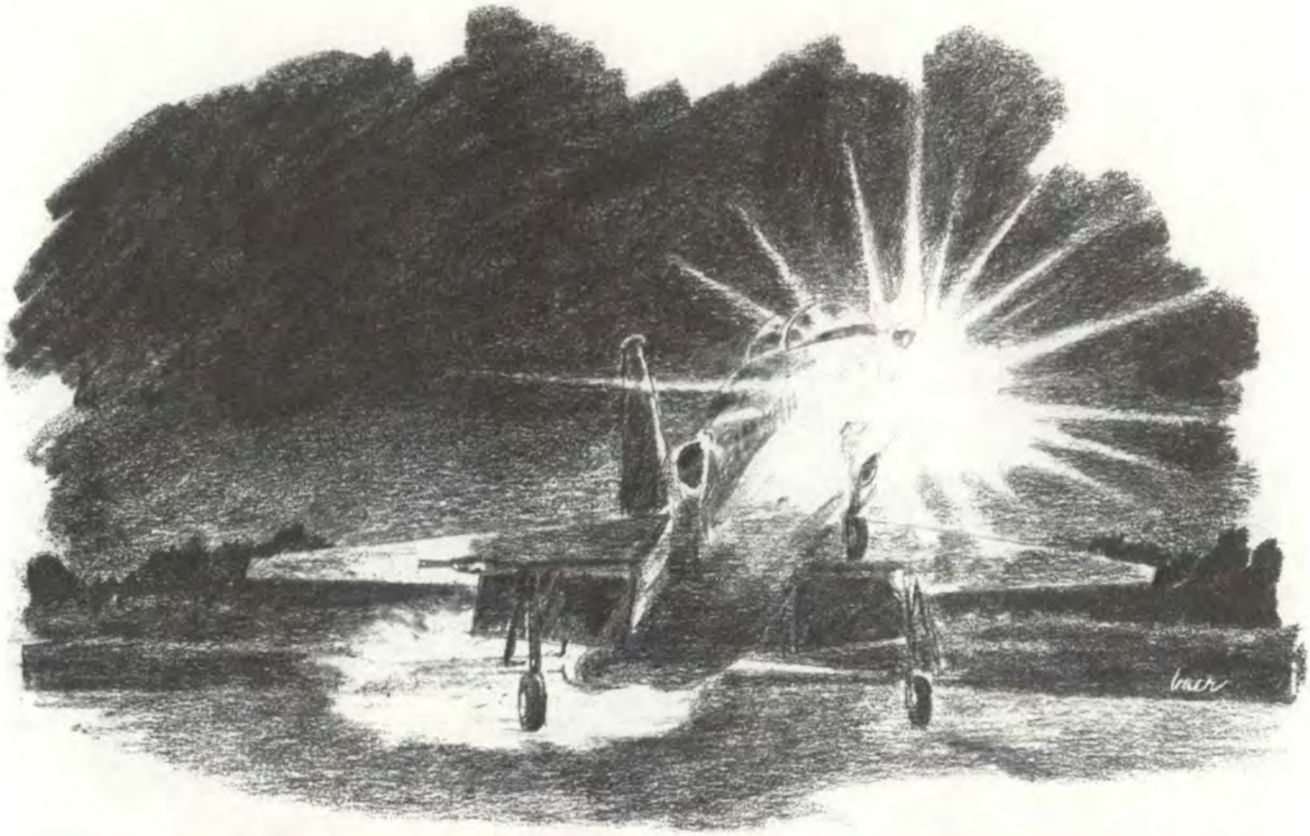
JUNE 1985

Human Factors and Computerized Visual Simulation

Aircraft Performance Planning

Skill Fatigue

WILDFIRE!



THERE I WAS

■ Allowing the student to go too far is something most IPs do now and then, but shouldn't. I did, and I learned a valuable lesson.

We had been to the area, and the maneuvers went well. The student hadn't been the best; in fact, he had been marginal for most of the programs. After doing several touch and goes with no noticeable improvement, I began to get concerned. The weather at our training base wasn't the best, and we needed to complete the night training.

About the "umpteenth" pattern, I felt he had to do one completely on his own. The pattern looked OK until we approached the flare. Time to flare — wait — he will. "Flare." "Flare." *"Flare!" "Flare!!! I got it!"*

After impacting the runway, anxiously waiting for the instantaneous burners to light (which took forever), we bounced. Boy did we bounce. Finally, the burners lit and hope increased. The "flight" down the runway in burners just above the runway is a trip I will *never* forget.

The next pattern, with the gear down (didn't know if they would still work), was relatively smooth since I was now doing all the flying. I made the full stop and let maintenance have the airplane at the end to pin it and tow it in.

The Flying Safety Officer picked us up and, once safely inside the truck, said, "Now that you're safely back, let me tell you this. I saw it all from the RSU and didn't think you were going to keep it flying." That really shook me up. The next day I got a call from the Chief of Stan/Eval. "Ray, understand you were drilling for oil at the end of 32 last night?" "Yes, sir." "Sounds like a classic case of letting your student go too far. That incident probably taught you more than a check from me could, so just be careful, OK?" "Yes, sir."

I now have several thousand more flying hours, many of which are more IP hours, but that incident rates very high in the lessons learned file. Students need to learn to handle their own mistakes, make their own decisions, and know how far is too far. Instructors need to learn (and remember) this too! ■

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ROBERT L. HANCOCK
USDA Forest Service
Ontario, California

■ The fire had only been burning for about three hours. As I started down into the steep walled canyon, I thought about the change from when I had first been dispatched to this fire. Then it had been small, little more than 20 acres. But the hot, dry winds from the desert had whipped up the flames into a monster, which by now had consumed over 1,500 acres of brush and timber. There were no predictions of when we would gain control. I flew down along the face of the fire, carefully staying clear of the smoke. As air tanker coordinator over the fire, I was responsible for directing the air tanker drops and ensuring the safe, efficient use of the air tankers.

As I flew along the raging face of the monster below me, I was thinking of the best place for the 3,000 gallons of fire retardant the tanker above me carried and was ready to deliver. "Tanker 190, this is the drop area. Just widen out your left turn, and I'll pick you up for the drop."

"Roger, I've got you in sight." The voice crackled in the earphones of my helmet. As I added power and started a steep climbing left turn out of the canyon, I saw the DC-7 in a wide, graceful left turn about three-quarters of a mile away and about 2,000 feet above me.

"Lead 7-4, how's the air down there?" asked the captain of Air Tanker 190. He was definitely not overjoyed about taking a large, heavily loaded aircraft into the bottom of that steep, narrow, and twisting canyon without knowing all the conditions.

"Some turbulence as we pass from base to final over the ridge, and some trace smoke in the canyon. Visibility is better than one mile, and the air is smooth. You will have a slight tailwind in the drop area, and your exit is down canyon." As I briefed, I thought about the run we were going to make. It would start by crossing a high ridge and dropping into a narrow canyon, leading to the main canyon. This auxiliary canyon was 30 degrees off the heading of the main canyon where we would drop. The run required a 30-degree course change to the left just prior to the drop area. Just then my radio crackled again.

"Lead 7-4, this is Air Attack 4. It looks like your additional air tankers are starting to arrive. I've just received a call from MAFFS* 3, ETA 3 minutes."

The air attack supervisor was in constant contact with the incident commander on the ground and relaying his orders for aerial suppression to me as I directed the air tankers to their targets. I had requested additional tankers, and they were now arriving. With all our other tankers committed to other fires, we were now using MAFFS C-130s, flown by Air National Guard crews. This one had been diverted from another fire.

I was now 500 feet from Tanker

*Modular Airborne Firefighting System

Photographs courtesy of US Forest Service

"As I flew along the raging face of the monster below me, I was thinking of the best place for the 3,000 gallons of fire retardant the tanker above me carried and was ready to deliver."

190 on a parallel course at 6,300 feet, indicating 130 knots. "190, are you ready?" I asked.

"We're ready," came the reply. I turned my Baron across the ridge and dropped down into the canyon. The tanker slid in behind me as we continued toward the drop zone. I kept my conversation to a minimum because the tanker crew was very busy now setting up for a drop and running checklists. Then we entered the long, narrow canyon.

As we approached the drop area, I called identifying terrain features and indicated the drop area, verbally and with a wing rock. As I pulled up, I saw that it was a good drop. I called for 190 to load and return, then started looking for my next tanker. It wasn't long in coming.

"Lead 7-4, this is Helicopter 7-10, we're three minutes out and need to land near your drop area."

"Roger, 7-10," I replied, "one DC-7 on departure from a drop, down canyon, and I'll be bringing in a C-130 in a couple of minutes."

"Any jets down there? I had a near miss with one lifting off the ridgetop heliport about five miles west of here."

"Standby, 7-10." This last query from the helicopter pilot set me thinking. I was concerned because the area we were working in was along a military low level training route and near a large military operating area. When I first arrived, I had checked to be sure that a NOTAM had been issued for our operation. Under FARs, the area of a fire can be designated as restricted airspace. The only aircraft allowed are those actually participating in the firefighting or have special permission to be there. I had also confirmed that the NOTAM would be transmitted to the military bases in the area. Still the helicopter incident had me worried. Our helicopters are very hard to see since they are various colors and often blend in with the hillsides. I checked again with the air attack supervisor who confirmed that the NOTAM was still valid. He asked if we were having a problem, to which I responded with the helicopter incident. I also said that I believed it was an isolated occurrence.

By now, I had climbed out of the canyon and was looking for my next tanker. I soon picked up the unmistakable silhouette of the C-130. I briefed the crew and marked the drop area prior to the run. Then after the marking pass and verbal description of the target area, I pulled up alongside the C-130, and we prepared for a live run. Our airspeeds were matched at 140 knots and the C-130, MAFFS 3, was 500 feet in trail matching me turn for turn as I made my left turn over the ridge and dropped back down into that narrow canyon which would lead us to the main canyon and the fire.

continued

"I turned my Baron across the ridge and dropped down into the long, narrow canyon."

"MAFFS 3, this is Lead 7-4 approaching the main canyon. Remember, stay to the right side and put retardant right next to the visible flames, half in and half out."

"MAFFS 3, Roger," came the reply.

As we turned into the main canyon, we were around 200-feet AGL, 140 knots. It looked like my small red-and-white Baron was being pursued by a huge olive-drab monster with orange dayglo wingtips and tail and two large pipes extending out of the open rear ramp.

"Approaching the drop area . . . drop here!" I glanced back to check the drop area, then turned my attention straight ahead to start the climb when I saw them — two aircraft head-on at our altitude! It was so fast that I still had the mic button depressed from my drop call.

"Aircraft straight ahead! Break off! Break off! Climb straight ahead!"

The throttles and prop levers went full forward asking for all the go power the Baron had as I pulled back into a max performance climb. As soon as my climb was established, I rolled to look for my C-130 tanker. My call was too late to prevent the drop, so when I looked back I saw a Herky bird about 30 degrees nose up clawing for altitude and spewing 3,000 gallons of retardant in a bright red stream in the sky. I saw the two aircraft flash past about 200 feet away. It all happened so fast that I wasn't even sure what kind they were. I knew that they were some kind of fighter, I thought F-4s.

"What the hell is happening, Lead?" The C-130 crew was understandably shook. But before I could answer, the radio came alive again.

"Lead 7-4, Helicopter 7-10. Are you guys all right?"

"Lead 7-4, Air Attack 4, what's happening? Is everybody OK?"

The C-130 and I continued to climb for safety as I began to sort things out. I obviously had a real problem — the helicopter near miss earlier and now this. . . . As much as I disliked the decision facing me, it was the only one possible under the circumstances.

"When I looked back, I saw a Herky bird clawing for altitude and spewing 3,000 gallons of retardant in a bright red stream in the sky."

"Air Attack 4, Lead 7-4, we just had a near miss with a couple of military jets. That's the second one in just a short time. It doesn't look like our restriction is holding. I'm going to shut down all air operations until we get a handle on this. It's just too dangerous down there now. I want the helicopters grounded, too. They are just too hard to see. I think you can safely stay on the scene, if you stay above 2,000 AGL."

I then returned to the air tanker base. As aviation safety officer, I had a lot of work to do. First, I had to call the Forest Dispatch Office to explain why I had just cut off all use of aerial firefighting support to a major fire. Next, I had to find out why our NOTAM restriction didn't work. I called NAS West Coast, the owner of the low level route. They were aware of the NOTAM and, in addition, had no aircraft in the area at the time of the near miss. They confirmed that after they had received the information about the fire, they had canceled all flights scheduled for the low level route until we released the airspace. Next, I called High Mountain AFB which controlled the MOA adjacent to the fire. They were just as concerned as the Navy, but at the time of the incident they had no known aircraft operating in the MOA. They also assured me that all their crews were aware of the NOTAM restriction.

After I hung up from that last call, I sat at my desk for awhile pondering the real problem. We were facing a major out-of-control fire that desperately needed air tanker and helicopter support, but I still had no clue to whom had been violating our airspace. After considering the reassurances of the military and the FAA that our airspace restrictions were still in effect, I decided to reinstitute air support to the fire. I gave all the aircrews a special briefing on our previous incidents and emphasized the need for an extra sharp lookout for other aircraft.

The air tankers and helicopters were quickly back in the air and attacking the fire. Unfortunately, the damage was already done. The loss of tanker and helicopter support after I was forced to shut down air operations allowed the fire to cross the canyon. It took four more days and cost another 11,500 acres before the fire was finally under control.

At the high point of air operations, the Forest Service, along with other cooperating agencies, were operating 12 regular contract air tankers with 3 additional MAFFS C-130s. We also had six helicopters assigned and two air attack ships. There were aircraft over the fire 24 hours a day, every day of the fire. At night, while the air tanker crews

The loss of timber, recreation areas, watershed, and personal property was estimated to cost $12,600,000.

were resting, the night flying helicopters were working. Two Bell 212s with crews using nightvision goggles delivered retardant from their 350-gallon tanks. Another aircraft periodically orbited over the fire at about 10,000 feet AGL transmitting infrared pictures to the incident commander on the ground.

The suppression costs for the fire were impressive. The air effort cost $1,321,475. The entire suppression costs were over $4,884,000. These are the figures for direct suppression only. The loss of timber, recreation areas, watershed, and personal property was estimated to cost another $12,600,000. Of the total costs, about 31 percent were directly attributable to the near miss and 4 hour shutdown of all air operations. That was all the time the fire needed to get completely out of control.

A Military Club — Many Miles And Some Days Away From the Fire

A group of pilots are sitting around a table, relaxing after a mission. A commentator on the TV over the bar is discussing the serious consequences of a major fire which had recently devastated a large area to the west.

"Hey, I bet that's the fire that we saw the other day," said one of the pilots.

"Probably," responded another, who then continued, "I wonder what those aircraft were doing down in that canyon next to the fire? We came pretty close out there."

A new voice interjected, "Those aircraft were part of the Forest Service aerial fire suppression operations." A young major, the unit safety officer, sat down at the table.

"There was a NOTAM issued for that area," the safety officer continued, "and if you had contacted NAS West Coast or High Mountain AFB, they would have told you about it."

"But that's VFR airspace, and we were at legal VFR altitudes. Besides, we got a briefing and there wasn't anything about a fire."

"That may be true. Your briefing may have occurred before the NOTAM was issued, but the important thing is that you ran a real risk of a midair out there by going to investigate some smoke. I was talking to the flight safety officer at High Mountain yesterday. He told me that one day during the fire, maybe the day you were there, military jets had near misses with a Forest Service helicopter and later with an Air Guard C-130 dropping retardant on the fire. The near miss caused the Forest Service to shut down the air suppression. That left the firefighters on the ground without any support. So they lost control of the fire."

"Hey, wait a minute," one of the pilots interjected, "all we did was take a look, one pass. We saw the Herk and we were clear of them."

The safety officer took a sip of his drink before answering. "What was your closure rate, about 500 knots? That Herk never saw you until the last second. And what about the helicopters and other aircraft that were operating in the area. Did you see any of them? The Forest Service uses a lot of air resources to fight fires. Even if you don't see any fixed wing aircraft, there are probably helicopters in the area. It doesn't matter how remote the area, assume there are aircraft there."

"The Forest Service tells me that the first few hours of a fire are critical. They must commit the maximum resources available then to keep the fire under control. Any delay can mean disaster. After the near misses the other day, the Forest Service pulled all air support out of the area. They couldn't afford the risk of a midair. That let the fire get out of control. You just saw the result on TV."

The pilot who had first commented on the fire set his glass down. "You know, that was pretty close the other day. I didn't know about those Forest Service air operations. I sure don't want to have a midair. From now on, if I see smoke, I'm giving it a wide berth."

The other pilots all agreed. The safety officer nodded in approval as he motioned to the waitress for another round.

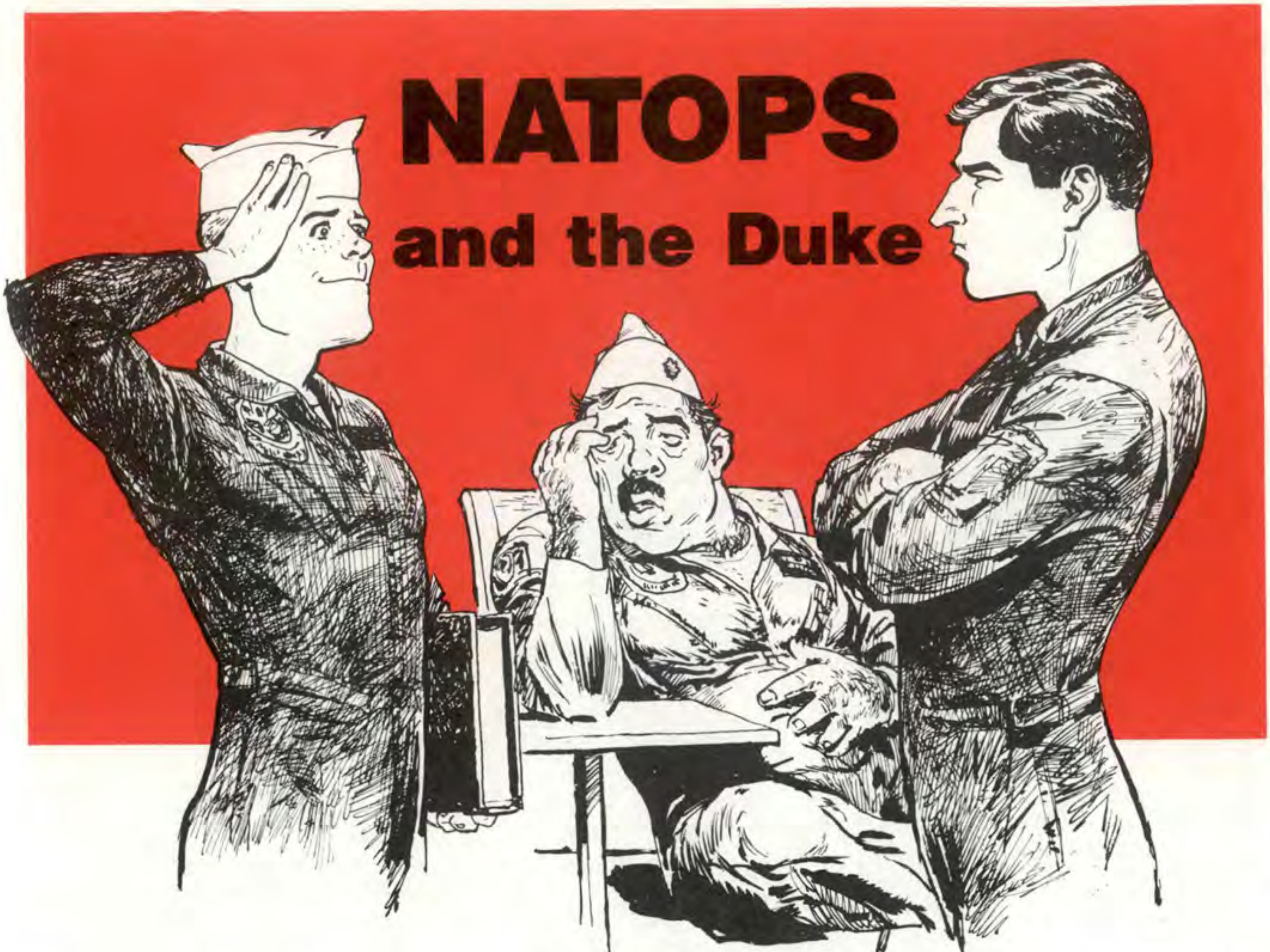
At About The Same Time

Above a steep-walled canyon, a small white-and-red aircraft banked sharply, the pilot sizing up the fire below. "Air Attack 7, before we start down, is our airspace restriction in effect?"

"Lead 7-1, affirmative."

"OK, break, Tanker 210, are you ready?" ■

NATOPS and the Duke



LT COMMANDER MARTY FOX

■ "Morning, sir. I'm the SDO and the XO said to be sure to wake you in time to get to the readyroom for today's safety standdown."

"I know where your room is, Puff. I'll remember this." Slam.

"Hey, Cougar Breath. Get up! The XO wants your armpits in the readyroom in 10 minutes! Safety Standdown Day."

"I can't move, Duke. I think I caught polio during the night. You'll just have to call and tell . . . safety standdown! Do you think that XO knows that I have Betsy Breathes-Easy, the CPR training device?"

"That, gentlemen, concludes the structured presentations for this safety review. I sincerely hope that each and every one of you enjoyed the surprise TACNOTES quiz and the flight surgeon's discussion of rare tropical ailments. Now, please break up into your normal crews to conduct an emergency procedures review. I regret that we couldn't present the scheduled CPR training, but I am confident that you gained some information that will enable you to better cope with the Sea King and its quirks. I, personally, have been most excited throughout. . . ."

"Hey, yo! Can we watch 'Man From Lox' again?"

"Uurp!"

"What was that?"

"That was Cougar, Sir. He ate seven rollers with onions at midrats last night, and his stomach is upset."*

"Thanks, Cougar. OK Buffy, let's sit down over here and go over some emergency procedures."

"Yes, sir. I'm sure that I can give the proper response to any emergency."

"Yeah? OK, let's say that we are motoring along one night and you see a wisp of smoke rise from near your feet. What are you going to do?"

"Uh, what kind of smoke? I think that I may need some more information."

"You do? What do you think is going to happen in a real aircraft not on a NATOPS check flight? Are you going to wait for a caution light to illuminate and say, 'Excuse me, you are experiencing aircraft malfunction number 38? Real problems start with a wisp, a shudder, an odor, a bump. The plan is to solve the emergency *before* the caution panel can be used as a night light. *What are you going to do?*"

"Well, I am going to assume it's a fuselage/cabin fire and break out the pocket checklist to see what procedures we should follow."

"Wonderful! Before you assume anything, how about *thinking first!*

* Seven hot dogs with onions at midnight. — Ed.

What's below your feet? Electronics?"

"Uh, that's right. It must be an electrical fire. I'll go to that emergency procedure in the checklist and . . . ."

"How about hydraulics? Any plumbing there? A pinhole in a hydraulic line might look like smoke."

"OK. Yeah, uh, we'll go to the checklist under hydraulic failures. We can . . . ."

"Which hydraulics system? Primary? Auxiliary? Utility? Any? Why don't you ask the crewman to look in the electronics compartment and tell you what he sees? Let's say it is electrical. What page is the proper procedure printed on? It's as dark as flying in a glass of Ovaltine, and we may lose our lights pretty quickly due to the fire. How much time do you think we have for you to thumb through the checklist, after you find it, if you can see it? You're betting your buns on your ability to successfully find and read the proper emergency procedure."

"But, sir, they said that I didn't have to memorize most of these procedures."

"Whoever told you that said it while he was sitting in a readyroom or a trainer, and *he* had already memorized his procedures."

"Yeah, maybe, but NATOPS says that it will denote memory items. These procedures are not marked as memory items."

"You are a *banana* if you believe that! OK, for your sake, let's not say 'memorize.' Let's say R-E-A-L-L-Y know the procedures. Remember, slick, we are never more than 400 feet from the water, and *we are in* the rescue vehicle."

"I may see your point, Duke."

"OK. Next, let's look at some other stuff. . . . What's the matter, kid? You look a little funny."

"I wish Cougar would go somewhere else."

"He's *Lcdr. Breath* to you, sailor! Let me tell you something about him. Do you know that he shoots *every* approach as if he were single-engine? That's in case he becomes single-engine on the way in. He reads and re-reads his emergency procedures *every* Tuesday. Then he bothers me with a whole bunch of "what if" scenarios to see what I would do in that case. Then he argues about my choices with me. The rest of the week he wanders around to all the shops and asks those guys questions about how the various systems really work in the aircraft. He spends just a few minutes a day, a couple of hours each month, learning his aircraft and worrying about how he'll handle that wisp of smoke, bump, or thump. He still has time to do some movie watching, letter writing, and paperwork procrastinating."

"Everybody knows he's a good stick, sir."

"Wrong. He's a good *aviator.* He knows his aircraft and all its systems. He is READY to take quick and correct steps to solve any emergency. Even the ones where NATOPS admits that it is not a substitute for sound judgment and modifications of its procedures may be necessary."

"Now get away from me and don't tell me you can give me the proper response to any emergency until you can."

"But I know my NATOPS, Duke. At least as well as any guy should."

"Yeah? One more chance. Late afternoon with the sun in your face. You're my copilot. You're in the left seat, and we are doing a pax transfer to a smallboy by hoist. As the Chaplain gets halfway to the deck, we start to lose an engine. I can't take this guy with me over the side — it will kill him. I yell, 'jettison the hoist then give me full power!' Got the picture?"

"Yes, but what is the question?"

"Knowing that *any* delay will cost us either the aircraft or the man on the hoist, probably both, which position on the jettison panel is the hoist?"

"What? No one knows that! I'd have to look at the panel, Duke."

"Fine. *You* don't know it now, but there is the place to learn it — not during the emergency in the aircraft? Really know NATOPS."

"Come on Cougar. Let's get you some chow. You're starting to show signs of one of those tropical diseases the quack was talking about."

— Courtesy *Approach* magazine, February 1984. ■

Human Factors And Computerized Visual Simulation

LT COL FREDERICK V. MALMSTROM,
WA ANG
and
BRIAN K. GAUGER,
Software Engineer

■ Aircrews familiar with flight simulator technology will appreciate the dramatic changes in the technology and configuration of flight simulators over the past 10 years. The garden-variety layman probably thinks of the computerized flight simulator as something at the video arcade, which allows him or her to go about happily zapping electronic space aliens. Few people, however, — lay or otherwise — realize the video arcade game is a pale shadow of the true power of the present-day computerized visual flight simulator.

Furthermore, the improvements in the technology of computer-generated imagery (CGI) have allowed the aviation sector a wide range of flexibility, which is not necessarily limited to visual flight simulation. (CGI — computer generated image — is the computerized product, and CIG — computer image generation — is the process of making computer images. The reasons for the confusing preference of acronyms are not always entirely logical.)

Why Did CGI Come To Flight Simulation?

If you believe the answer to that question was because of safety, you're only partially correct. As with any other innovation which is born of necessity, the real answer is that it is far cheaper than flying. The worldwide fuel shortages of 1974 and 1978 were probably the biggest boost to the development of CGI. While it is probably true that CGI has improved flying safety, it's anybody's guess as to how much; there aren't really any baseline statistics that allow direct comparisons of safety and visual simulation.

But there are plenty of comparisons that indicate the costs of running a flight simulator complete with CGI may be only one-tenth of the costs of flying an actual aircraft. Developing a "good" CIG program a few years ago took dozens of programmers several man-months to generate a few minutes of crude video presentation. Today's race to develop better and cheaper ways of making CGI is truly an exciting one, but the images you see on the flight simulator screen are only the final products of programmers, engineers, and mathematicians who fret over functions from fractals and fifo to Fortran and Fourier.

How Much "Realism" Is Necessary In CGI?

That's probably not even the question you should be asking. The correct questions is, what improvements should I add to CGI to ensure that "sufficient training" occurs? If our flight training instructors could determine that aircrews got sufficient training solely by watching the movie "12 O'clock High," then there would be no point in making CIG improvements. From a behavioral scientist's viewpoint, it remains a nagging and unanswered question whether CGI is "realistic" or even whether realism is necessary. We understand fully that aircrews *like* realism in CGI; whether "realism" offers the aircrew any improvement in training is an entirely different question.

Unwittingly or not, some of the many factors which give CGI its "realism" are the abilities of the scene to deliver simultaneous depth cues, abilities absent from most video arcade games but very present in many present-day flight simulators. Some of the standard monocular (one-eyed) depth cues the observer uses to judge distance are:

- Linear perspective. (As objects get more distant, they appear smaller.)
- Aerial perspective. (As objects get more distant, they appear hazier.)
- Superposition. (Objects nearer to you obstruct the view of distant ones; known in CIG as the "hidden surface problem.")
- Brightness. (Nearer objects are usually brighter than distant ones.)
- Shadows. (With respect to the light source, nearer objects usually cast shorter shadows than distant ones.)
- Texture. (Nearer objects appear "grainier" than distant ones; the level of detail increases in nearer objects.)

Although the eye-brain system normally processes these distance

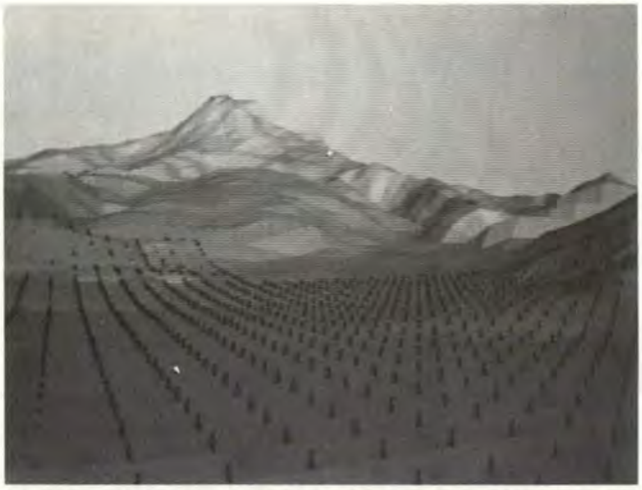


Figure 1. 1979 vintage computer generated image. Scene lacks brightness, texture, shadows, and aerial perspective as distance cues. Courtesy of Boeing.

Figure 2. 1983 vintage computer generated image. Although greatly improved from Figure 1, including the addition of color, scene still lacks brightness and texture as distance cues. Courtesy of Boeing.

cues instantly and unconsciously, it is no small feat to generate a CIG program which will obey and juggle all of the above six rules at once.

Figures 1 and 2 should point out some really startling changes which have occurred in CGI in only the past five years. The CGI presented in Figure 1 is from 1979 state-of-the-art vintage. Figure 2 shows 1983 state-of-the-art improvements, including the addition of color, variable luminance of the sky, and semirandom roughening of small surfaces into "fractals." The CGI quality of several years ago was a real target for complaints from both commercial and military aircrews. The low level daytime landscapes over which the crews "flew" were likened to a cartoonish atmosphere in which one-half expected to see a comic-strip coyote chasing a clever roadrunner.

Today, the crossover point has been reached. CIG can now produce a scene so finely detailed that it contains far more information than the eye can resolve. Oddly, some complaints from aircrews now indicate that the CGI is "too clean." Hence, programmers are now adding artifacts to the scenery like skid marks on the runway, glare on the windscreen, and carbon deposits on engine exhausts.

The CGI is flexible enough to call up several "generic" airports from which a pilot can taxi, take off, fly formation, perform in-flight refueling, and land, each scenario with "instant" weather conditions and time of day or night, including the proper sun angle and glare. Clearly, this is a case where information technology has again outstripped the ability of the human mind to use all that information. We have no doubt the day will soon arrive when programmers and mathematicians scoff at Figure 3 as a classic example of "primitive computer art."

Flight Simulators Aren't Limited To Flying

Fitting the cockpit to the person isn't always easy. This is because people come in such a variety of sizes and shapes, to say nothing of individual differences in ability. There is a very old discipline called anthropometry ("the measurement of man") which says there is physically no such thing as the average person.

For example, if I design a man's "universal" pair of pants with the "average" dimensions of a 34-inch waist, 32-inch inseam, and a 40-inch seat; those pants will, in fact, fit less than 5 percent of the male population. (Maybe this helps explain why

continued

Figure 3. 1984 computer generated image. Scene is a "generic" airport viewed during taxi and takeoff. Note the addition of a semi-transparent window. Courtesy of Boeing.

the clothing sales store never has your size.)

Try making a size of unisex pants which will fit both men and women, and you make the problem worse. The same reasoning applies when you make a "universal" cockpit seat. The reason for this additional problem is that men and women come from two statistically separate size distributions. Subsequently, most "average" seats are too large for women and too small for men.

The real catch is that in terms of anthropometry, the 50th percentile female is only the 5th percentile male. In practical terms, this says that if you design a seat for the average woman, it will fit only about the smallest five percent of the men. This usually is no big problem, *if* you limit your users to women; however, current service directives (MIL-STD-1472C) require that most equipment be designed for use from the 5th percentile female to the 95th percentile male; a very large range of sizes, indeed.

It's critical (and obvious) that pilots be able to reach and see the controls. To illustrate this point, studies of fatal military aircraft mishaps indicate that in some cases the rudder controls were not properly adjusted and thus the pilot may not have had full control capability. Failure to adjust those rudder pedals might seem like a boneheaded oversight, yet that length becomes even more critical as more women are added to the military aircrew force.

And Now, "The Man Who Never Was"

Computer modeling of the human form has been around for about 15 years, and, for the most part, can give surprisingly satisfactory results if you're trying to fit a cockpit to 90 percent of the population. In the most common instances, very rudimentary block and "wire basket" human forms are usually sufficient to ensure that most people can see or reach the controls. In other cases, such as attempts to model the human hand and all its intricate movement, we haven't been so successful. Computer modeling of such movement may be years or even decades away. Quite possibly, it may never be worth the effort or cost to simulate the human hand, although here in the dawn of high technology, we'll never say never again.

Some quite mathematically elegant women, men, and cockpits that never existed can now be simulated with CGI. Figure 4 is a good example of the state of the art in anthropometric modeling. What looks like The Man in the Wet Suit is actually one of a dozen sizes from the Fourth Human System by William Fetter of SIROCO, a non-profit research institution of Bellevue, Washington. This particular model evolved from the third system he developed at Southern Illinois University and the second and first systems he developed while investigating and developing the then infant field of computer graphics at the Boeing Company.

Many such detailed figures have already been generated, male and female, in about a dozen different percentiles of both body sizes and types. It will soon be possible to place these detailed figure models into any desired cockpit environment and field-of-view. These more detailed figures can be crashed, outfitted in different clothes, or bent any way you please — yet they never complain. (See Figures 5 and 6.) The prospects for jointly engaging both the human figure system

Figure 4. The basic 4th Man and Woman System. Courtesy of SIROCO.

Figure 5. A male variation of the 4th Man System, a computerized human form. Courtesy of SIROCO.

Figure 6. A female variation of the 4th Woman System, a computerized human form. Courtesy of SIROCO.

and advanced computer graphics capabilities offer much promise for future cockpit studies, many of them in some very nontraditional and creative ways.

Figure 7. A 67-inch pilot's left-eye view of a hypothetical cockpit arrangement.

Figure 8. The same 67-inch pilot's right-eye view. This view of the throttles obstructs the pilot's view of the copilot's multifunction panel. Photos courtesy of Boeing.

Viewing The Cockpit Through The Other Guy's Eyes

CGI isn't limited to configuring the person, either. In some instances, CIG allows the designer to bypass the human form altogether and put *you,* the observer, directly in the pilot's seat. Stan/Eval has always been notoriously rigid and unyielding when it comes to flyers who try to place "unauthorized" labels and equipment aboard an aircraft. Pilots and aircrews who felt personal equipment configurations wouldn't interfere with safe operation of the aircraft thought flight examiners just couldn't see the world through their eyes. Well, CGI has changed that, too.

Figures 7 and 8 illustrate the concept of "what if's" in placements of cockpit instrument controls for a large commercial transport. In both figures, we have placed a hypothetical speed brake lever in front of a proposed pilot-copilot oversized and shared electronic attitude indicator. (Of course, placing the attitude indicator away from a pilot's line-of-sight is probably a poor idea, but let's continue anyway.) Our question here is whether the lever blocks the view of the placement of that attitude indicator. And the answer is, for a typical 5'7" pilot, the speed brake lever does not block the view of either the right eye or the left eye to the attitude indicator.

However, the view also reveals another unexpected finding. The placement of the "block" model of the throttles *does* obstruct much of the view of the pilot's right eye to the copilot's multifunction panel! Since it is a known fact that pilots are notorious busybodies when it comes to the settings of their copilots' controls, we must now consider whether there is another more desirable placement for either the throttles, the multifunction panels, or even the seat position and sitting height of the pilot. And so the computer juggling of controls, indicators, and pilots could go on all week until a satisfactory solution is reached.

With CGI, We Can Anticipate Human Error

Had it been known at the time, CGI simulation of various instruments, controls, and their placements and settings might have avoided all of the confusion and panic which occurred during the 1979 near-disaster at the Three-Mile Island (TMI) nuclear power plant. Most analyses of that incident have rightfully placed the major cause of the mishap as unanticipated (and undiagnosed) human error. For better or worse, we can now say the TMI incident taught us a very expensive and valuable lesson in applications of human factors engineering.

Fortunately, we now have a relatively cheap method of both analyzing *and* synthesizing human error short of core meltdown; CGI is a tool which permits us either to experience or avoid crashes, thunderstorms, meltdowns, or nearly any other disaster. Nuclear reactors are currently being simulated with CIG, and the automobile industry has begun to simulate two-dimensional structural "crashes" with CGI on programs that assimilate and analyze the huge amounts of data which only the numbercrunching supercomputers can presently handle.

In anticipation of problems, the physical configuration of the United States' planned Space Station is already being modeled by CIG, years before the first hardware goes into orbit. As more efficient programs and algorithms are developed, we await other logical steps, including CGI simulation of three-dimensional aircraft "crashes" utilizing computer-generated anthropometric models such as the Fourth Human System. CGI is our ultimate vehicle which will allow us to, like the Starship Enterprise, "Boldly go where no man has gone before;" yet live to be debriefed. ■

IFC APPROACH

By the USAF Instrument Flight Center, Randolph AFB, TX 78150-5001

Helicopter Instrument Procedures

CAPTAIN BRUCE GUNN

■ The Air Force Instrument Flight Center (IFC) has recently added a helicopter specialist who will be the focal point for Air Force helicopter instrument operations. The pilot in this position is responsible for inputs to AFR 60-16, AFM 51-37, AFM 55-9 (Terminal Instrument Procedures), and all other publications which affect helicopter instrument flying. The most immediate positive impact will be seen as expanded helicopter instrument sections in soon to be published revisions to AFR 60-16 and AFM 51-37. Let's look now at some specific helicopter instrument concerns that have surfaced as these publications are being rewritten.

Copter Only Approaches

Helicopter only approaches are identified by a title which includes the term "COPTER," the type of facility producing final approach course guidance and a numerical identification of the final approach course; e.g., COPTER VOR 310 or COPTER TACAN 090. The obstacle clearance criteria for "copter only" approaches are based on the unique maneuvering capability of the helicopter at airspeeds *not exceeding* 90 knots.

Based on this criteria and airspeed, helicopters must be considered as approach Category A aircraft when flying these special helicopter only approaches. Currently, the nomenclature for these approaches in the minima block may be an H- (Army and Air Force), an S-, or an S L.A. (Navy). Also, you, the pilot, should consider all such approaches as "straight in" procedures, and you may use "visibility only" criteria when filing and flying them.

Low altitude approach procedures are normally designed using 500 feet per nautical mile (NM) as a maximum descent rate in the initial segment. In "copter only" approaches, this gradient may be as high as 800 feet per NM. The accompanying approach plate (COPTER VOR/DME or TACAN 359) is a

good example. From the IAF (ROTAR) to the FAF, the depiction shows a loss of 1,300 feet in 2 miles or 650 ft/NM. Flown at 90 kts with no winds, this equates to a a 975 foot per minute rate of descent. Rate of descent is the key here. Keep in mind that having a tailwind may result in a descent rate in excess of that allowed for some Air Force helicopters.

Another important point is that you review the published missed approach procedure to ensure your helicopter can comply with the published climb gradient. Then for "copter only" procedures, the missed approach is based on a climb gradient of at least 304 feet per mile, twice that used for other low altitude approaches.

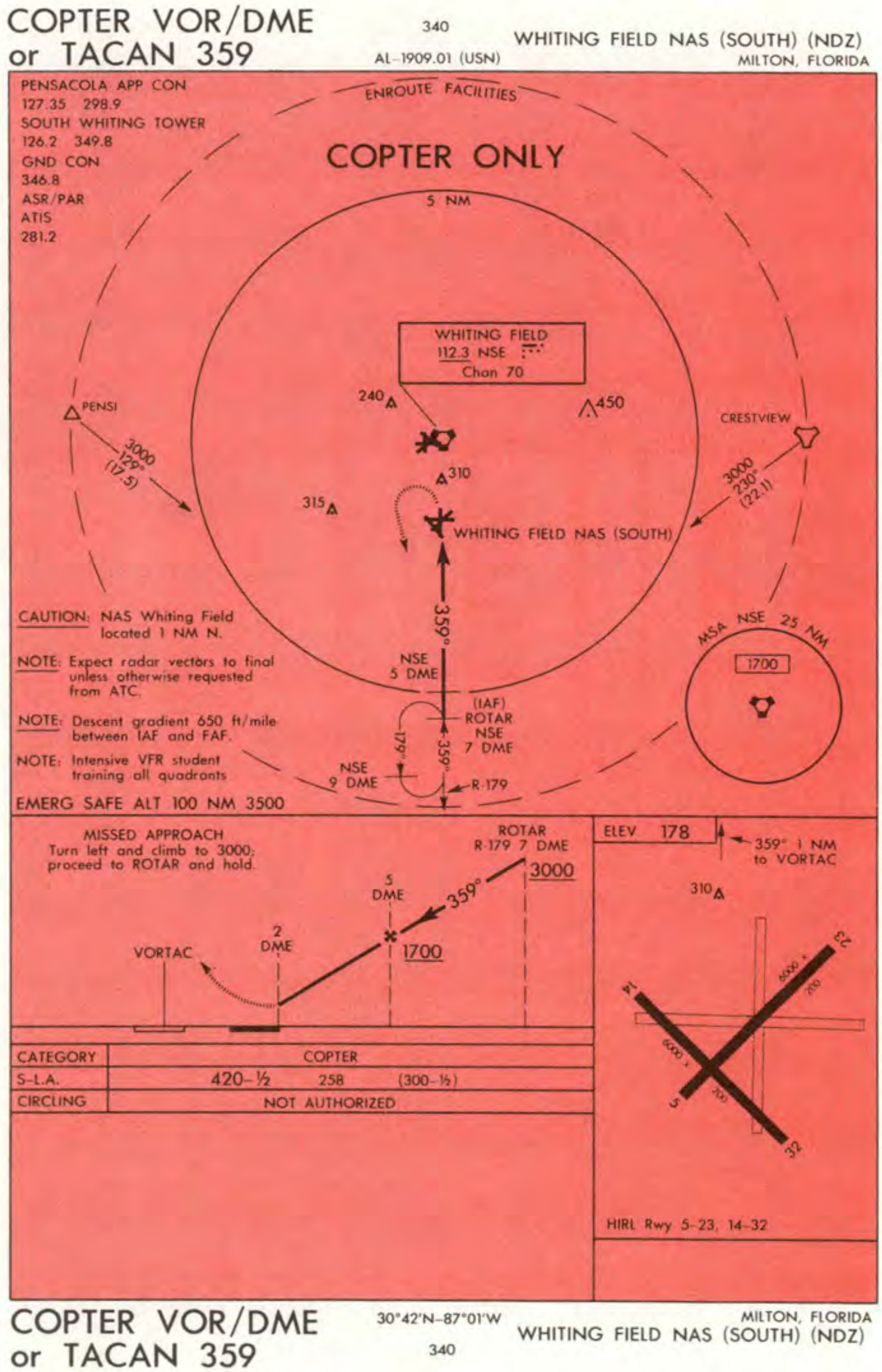
Approach Categories

When flying published instrument approaches (other than "copter only"), the helicopter pilot must determine the approach minima based on final approach speed. The statement in FLIP General Planning (GP), Chapter 9, "All US military helicopters may utilize Category A minima," applies to Air Force helicopters *only* when the approach speed is 90 kts or less. This statement of Air Force policy will be included in future FLIP GP editions. If the approach speed exceeds 90 kts, Air Force helicopter pilots will:

- Determine an approach category based on approach speed.
  - Cat A: Less than 91 kts
  - Cat B: 91 through 120 kts
  - Cat C: 121 through 140 kts
  - Cat D: 141 through 165 kts
  - Cat E: 166 kts or more
- Adhere to the minima published for that approach category.

For example, if you are flying an approach in an H-53 at 110 kts, you are considered a Category B aircraft and must use Category B minimums. Remember, except for "copter only" approaches, your category is based *solely* on approach speed. Plan your approaches accordingly.

These are only a few of the items that will be further clarified in upcoming regulation changes. As previously mentioned, the regulations concerning helicopter instrument operations will be substantially rewritten in the next few months. We are asking for, and will welcome, your inputs to these revisions. As your representatives at the Air Force level for helicopter instrument matters, we appreciate all comments and recommendations regarding helicopter operations in the instrument environment. Call or write to: Captain Bruce Gunn, USAF IFC/IP, Randolph AFB TX 78150-5001, AUTOVON 487-4674.



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We *will* get you an answer. ■

Aircraft Performance Planning

MAJOR STEVE SUMMERS
301 TFW/SE
Carswell AFB, TX

■ The loss of an RF-4C on short final not too long ago due to fuel starvation was the result of a long series of errors in planning and execution. The thing that stood out like a hand grenade in a haystack, in my opinion, was the number of opportunities to salvage the situation which fell through the cracks. At almost any point throughout the flight, operation at an optimum profile would have saved the jet. Was this an isolated case? Probably not — except, perhaps, for the result.

Personal experience leads me to believe that there is not a widespread understanding of how a jet airplane gets from Point A to Point B most efficiently. Fly with enough pilots, and you'll get more opinions than you'll find hairs on a Borneo monkey. F-4 jocks most often mention, and rely on, the "bug" as the answer. This is only an approximate answer though. Therefore, in the interest of more intelligent planning and operation when fuel may be a factor, I have attempted to develop a basic, uncomplicated guide to the complicated mechanical factors which affect jet airplanes in general, and the F-4 in particular.

Having attained a Master's Degree in Laziness, the information is presented in a manner that even a fighter pilot could understand by omitting the mathematical groundwork of a textbook. If you have doubts about anything presented here, YOU look it up. Remember, an expert is just a guy from out of town.

Jet Engines

In the process of converting JP-4 into smoke and noise, modern turbojet engines have several characteristics which are directly related to optimum aircraft performance. A jet engine is designed to operate at high RPM and consequently, when throttled back below approximately 95 percent, its efficiency decreases rapidly. The standard measure of efficiency for a jet engine is specific fuel consumption (C_t); the amount of fuel required to produce one pound of thrust.

$$C_t = \frac{\text{fuel flow}}{\text{THRUST}}$$

A typical plot of specific fuel consumption versus RPM is shown in Figure 1.

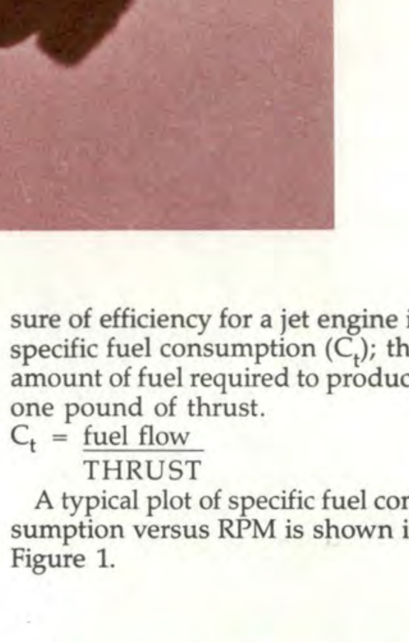

Figure 1. T-38 Specific Fuel Consumption Versus RPM.

For any given RPM, specific fuel consumption (SFC) increases as the airspeed/mach increases, but the important point to note is that for any given airspeed/mach, maximum efficiency, i.e., maximum thrust per pound of fuel burned (SFC_{min}), occurs between 95- and 100-percent RPM.

The other noteworthy characteristic of jet engines is the effect of increasing altitude on SFC. The beneficial effect of lower ambient temperature at altitude results in decreased SFC for a given RPM and mach as illustrated in Figure 2.

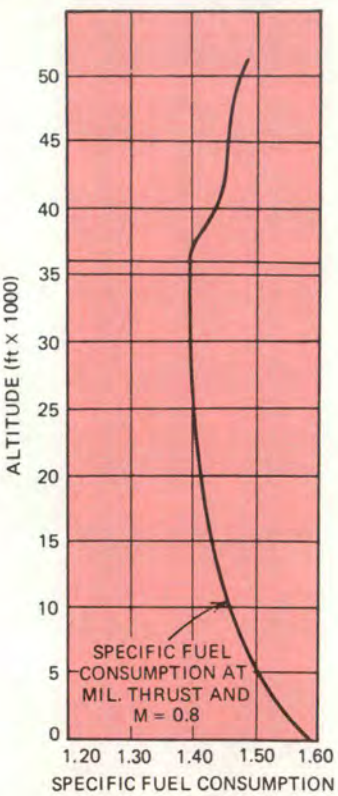

Figure 2. T-38 Specific Fuel Consumption Versus Altitude.

Above the tropopause, the temperature is constant, so no reduction in SFC will occur. In fact, the compressor will not operate efficiently because the air density is less and a slight increase in SFC will occur.

What the Captain means is this:

■ For any airspeed at which we operate, we get more thrust per pound of fuel burned at MIL power than at any other throttle setting. To use less than MIL power to climb is not desirable and will result in greater fuel consumption.

■ Cruise altitude should be the highest altitude (at or below the tropopause) attainable in the weight/drag configuration you have. This will result in less fuel burned per pound of thrust produced due to the beneficial effects of both higher RPM and lower ambient temperature.

Thrust and Drag

An airplane in-flight at some velocity has drag (an F-4 *is* drag). This drag opposes thrust, and for level, unaccelerated flight (i.e. cruise), they are equal and can be used interchangeably. This drag (thrust required) is the sum of two components:

■ Parasite drag is the resistance of the air to any body moving through it and increases progressively as the speed increases. The "dirtier" the configuration, the more rapidly parasite drag increases.

■ Induced drag is generated by the production of lift on a body and is at maximum at stall speed but decreases to practically nothing as speed increases.

The total drag curve is the sum of these components and, over the speed range of the aircraft, is roughly U-shaped with minimum drag occurring at the point where parasite and induced drag are equal, as shown in Figure 3.

The shape and location of this curve varies with gross weight (AOA/induced) and drag index (parasite). As weight increases, the curve shifts up and to the right due to the increased influence of induced drag to the total. As the drag index (DI) increases, the curve shifts up and to the left as the parasite drag becomes more prominent. This means, among other things, that at higher gross weights (DI constant), minimum drag and thrust required (T_r) will occur at higher true airspeed. Conversely, at a given gross weight, as the DI increases, minimum drag (T_r) will occur at a lower true air speed (TAS).

So what? We don't have a drag indicator, so how can we use it? Well, thrust is directly related to fuel flow, so if we substitute fuel flow as a function of velocity for any given condition of gross weight, DI, and altitude, we can determine TAS for optimum cruise. Since the F-4 has a digital TAS indicator, we have the *most precise* performance instrument available.

continued

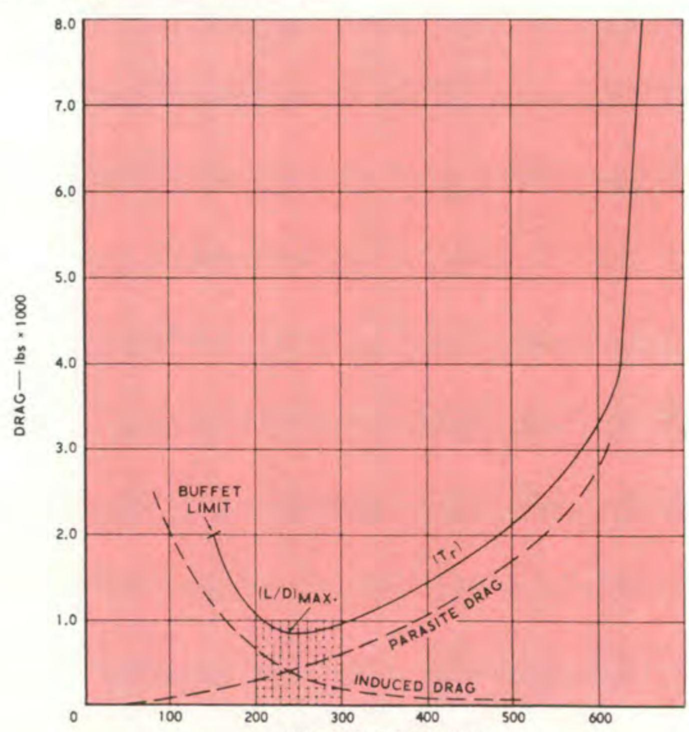

Figure 3. T-38 drag curve.

Max Endurance Versus Max Range

There are two important speeds a T_r curve can show us: The speed at which we can stay in the air longest without regard for getting anywhere, and the speed which will take us the greatest distance. The difference can be illustrated on a typical T_r curve as shown in Figure 4.

Any point on the curve represents a specific cruise condition. For any airspeed, there is an associated fuel flow (T_r) required to maintain that airspeed. For max endurance, it should be as obvious as a C-5 in a subway that to maximize flight time, we need only to minimize fuel flow. This occurs at Point A on the curve, which is the lowest T_r and corresponds to L/D_{max}, the minimum drag point. Although TAS will vary with altitude for this point, indicated air speed (IAS) for L/D_{max} will be the same at all altitudes.

Each point on the curve also represents a range for the aircraft at that airspeed. A ratio of velocity to fuel flow for any point on the curve is the range per pound of fuel burned, or specific range (SR).

$$\frac{\text{velocity}}{\text{fuel flow}} = \frac{\text{NM/hr}}{\text{Lb/hr}} = \frac{NM}{\text{Lb}} = \text{SR}$$

For maximum range, therefore, we need to find the speed which will give the most NM for each pound of fuel burned, or SR_{max}.

$$SR_{max} = (\text{Vel/FF})_{max} = (\text{FF/Vel})_{min}$$

If a triangle is drawn from the origin to any point on the curve, the FF/Vel ratio is a trig function of the pointy end of the triangle at the origin. For FF/Vel to be a minimum, this angle must also be a minimum. Only one point on the curve meets this requirement. That is the point where the line from the origin is tangent to the curve, Point B. Any point above or below gives a larger angle and, therefore, lower SR and less total range. This optimum cruise TAS is not L/D and will always be a higher TAS. It might be interesting to note that the SR and total range for the aircraft is exactly the same at Point A and Point C even though the fuel flow is considerably less at Point A.

As fuel is burned, weight is reduced, and the T_r curve moves down and to the left as shown in Figure 5. At this point, the cruise airspeed is no longer optimum. For max range, there are two possible options. First, if altitude remains constant, speed must be reduced by a reduction of thrust. The second possible option is to maintain or increase the thrust setting and allow the aircraft to climb to a higher altitude. As mentioned earlier, decreasing temperatures increase engine efficiency, and as thrust available (T_a) at higher altitudes decreases, higher RPM is required to produce it and SFC is further reduced. The net result is that fuel flow remains about the same, but the velocity is substantially higher as illustrated in Figure 6.

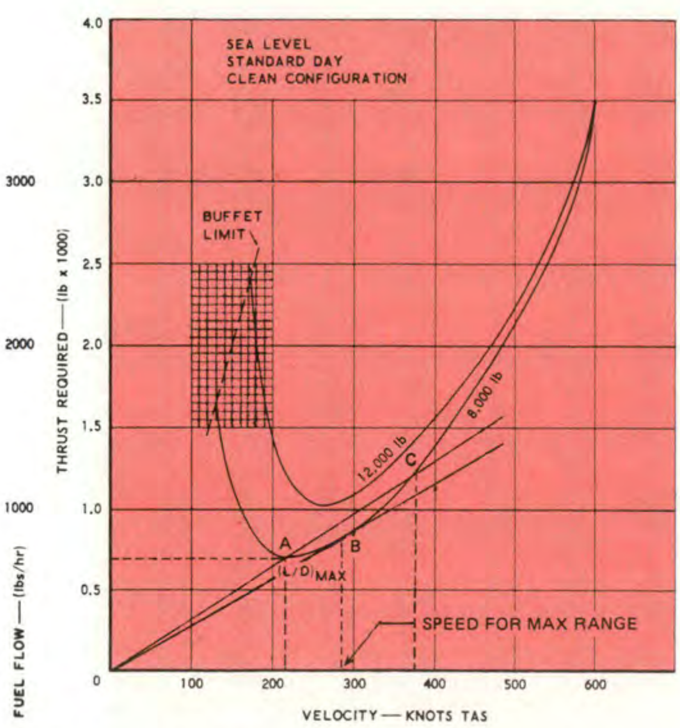

Figure 4. T-38 Effect of Weight Change on Thrust Required.

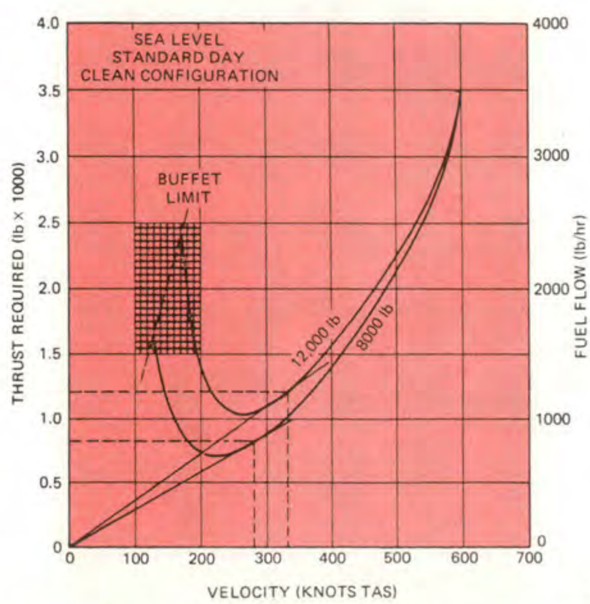

Figure 5. T-38 Effect of Weight Change on Range.

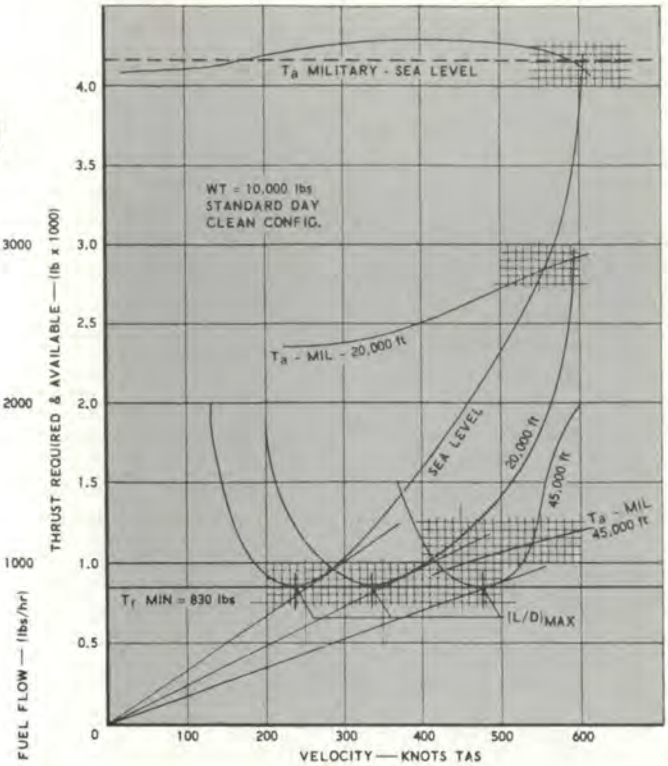

Figure 6. T-38 Effect of Altitude on Thrust Required and Thrust Available.

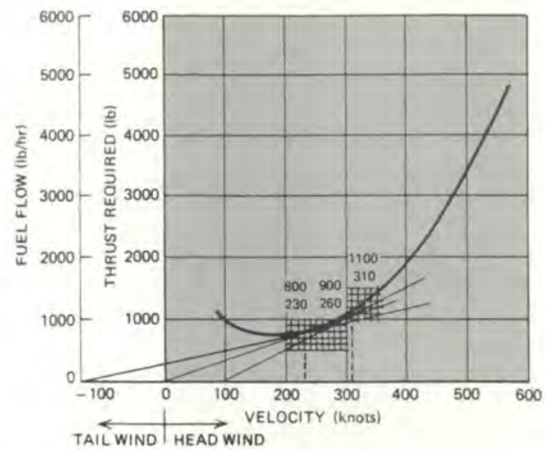

Figure 7. Effect of Wind on Specific Range.

One final "real world" consideration now that we've measured it with our micrometer is that we don't fly charts, we fly jets and theoretical precision is sometimes lost between textbook and throttle. As any Blue Four second lieutenant can tell you, the more you move the throttle fore and aft, the sooner you're BINGO and out of there. Lock the throttle if you can, and make only small adjustments (one-half percent) when necessary. Turns and bumps both upset the cruise equilibrium and require increased thrust to maintain airspeed. Speed excursions that fall below optimum may result in increased drag since max range TAS approaches L/D_{max} at high altitude, as illustrated by Figure 6. A large thrust increase may be required to correct back to optimum speed, so plan ahead and add a little thrust early to avoid falling behind. A slight error on the high side will cost less than correcting an excursion on the low side. An out-of-trim aircraft causes extra drag and increases fuel burn so it's desirable to retrim after establishing cruise speed. The proper technique for trimming is to first ensure symmetrical thrust (for us multi-engine pukes), then trim the pitch, then the rudder, then the ailerons. This method minimizes the possibility of cross-trim.

Wind

A headwind or tailwind has obvious effects on range, just as it does in dive bombing, you end up a "miss short" or "over on the fly." To maximize *ground* range, we must select a new cruise TAS based on *groundspeed* rather than our speed through the air. This will not be an optimum velocity from the design engineer's standpoint but *will* maximize our actual specific range, NM/Lb. Consider a headwind equal to our "optimum" TAS. It should be obvious that unless we sacrifice some gas to fly faster than planned, we'd never get anywhere. For a headwind condition, our range will never be as great as with no wind, but it will be the best possible under the circumstances.

To find the corrected TAS for a headwind, subtract the wind velocity from the TAS by moving the origin to the right by the amount of wind. This is the same as shifting the curve to the left to reflect fuel flow versus groundspeed. A new tangent to the curve, drawn from this point, will now give cruise TAS for best ground range. Similarly, a tailwind is handled by moving the origin to the left. This method is illustrated for a 100-knot headwind and tailwind in Figure 7. The speed for best range will always be higher with a headwind and slower for a tailwind. F-4 drivers can increase their cruise TAS by 15 percent of any headwind and decrease the normal cruise TAS by 10 percent of a tailwind.

Since wind is not constant at all altitudes, we are often faced with a decision between "optimum" altitude and a headwind we can live with. The break-even point comes when the tangents to the two curves for the different altitudes are parallel. Since your typical operator seldom has the necessary equipment in his G-suit pocket to make this little decision, the choice is usually based on experience. If you're still driving the Thunder Rhino, a 25-knot penalty at the next 5,000 feet* higher altitude seems to be an approximate break-even;

*ATC allows only a 4,000-foot increase.

continued

however, it varies with weight and drag. Heavyweight, the trade-off comes closer to 40 knots, while a high DI is less tolerant than a clean jet and would rather avoid a 10-15-knot headwind.

What's wrong with the "bug?" Just as there is an optimum TAS for each combination of weight, DI, altitude, and wind, there is also a corresponding AOA. The point to recognize is that for different configurations, the optimum AOA will vary with the DI. A higher DI will mean a higher AOA for optimum performance, along with slower cruise and climb speeds. The "bug" does a nifty job of compensating for weight changes, but it doesn't know anything about the wind or what's hanging on the belly. The difference can be as much as 10 percent of the indicated AOA for your semidirty Rhino. AOA is useful because it's an easy solution and puts you in the ballpark without a lot of brainwork; but to be close to an optimum solution, you should have a good idea of what you're looking for. Beyond these difficulties, the AOA system is just not very accurate. It will never be as good as TAS.

Climbs and Descents

In the context of max range, the objective of the climb is to get to cruise altitude as quickly as possible, i.e., maintain a maximum *rate* of climb. Climb performance is determined by thrust available (which varies with altitude, drag, and gross weight). Rate of climb (RC) can be calculated or determined experimentally for any altitude,

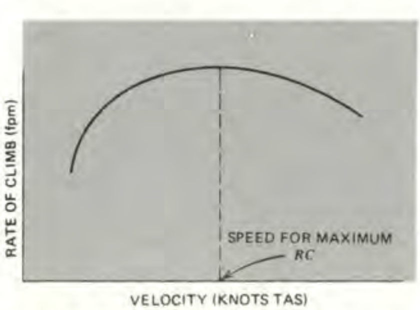

Figure 8. Finding Velocity for Maximum Rate of Climb.

configuration, and speed. Figure 8 illustrates a typical climb capability curve for an aircraft over its speed range. RC is a function of excess thrust times velocity, and the peak of this curve represents the speed for RC_{max}. At speeds near the stall or approaching maximum velocity, drag approaches thrust available (Figure 6), and RC will be nil (or negative). As you climb to altitude, T_a decreases up to the absolute ceiling, where RC is zero.

Wind isn't much of a player in the climb problem since our concern is with rate of climb, not angle of climb. Of course a headwind/tailwind condition will affect the distance traveled in the climb. But there are other more serious complications to our range problem. For example, the intermediate level-off that ATC always seems to need. To slow or not is the question, and the answer generally is to maintain climb speed unless the delay is indefinite. Accelerating back to climb speed will take more gas than you'll blow out the back holding a slightly higher intermediate cruise. In the climb, we only have control of one of the variables — T_a.

The charts in the Dash 1 show three options for climb: Mil power, 350 knots, and max power. If you trace out the differences, you see that the fuel savings for AB versus mil is about 150 lbs. On the other hand, you have only traveled about one-quarter the distance, so the question then becomes, is the cruise fuel flow for that extra mileage equal to or less than the climb savings? The numbers are so small that they are barely readable on the fuel gauges. So the argument for or against a burner climb does not relate to range or fuel savings.

The descent is one area where we almost get something for nothing. The ultimate descent profile would be to shut off the motor and coast all the way to touchdown. Electric jets even practice this. Unfortunately, this cuts down your options and wouldn't be compatible with your average TCA operation, so the best we can do is idle. Airspeed in the descent is less important for fuel conservation than throttle setting, and any thrust increase above idle will use fuel. If you'll buy that without proof, the rest is easy.

Unfortunately, once I've said that, I have to back off because there are other players in the game. If you pull the throttles on old double ugly to idle at altitude, you will very quickly get a sensation of pressure in your mask as the cabin pressure fails. In addition to being uncomfortable, pressure breathing makes it difficult to talk on the radio. There is another problem, too. Jet engines are not very efficient at idle. Remember our measure of jet engine efficiency is C_t, specific fuel consumption. The lowest figures for C_t occur between 95- and 100-percent RPM, and the increase is very rapid as RPM is decreased. As a result, the difference in actual savings between idle descent and an 80-percent descent are small and not worth the pain of loss of cabin pressure.

Our primary objective should be to maximize return on fuel used. There are two measures of this distance on time. When we want distance, we talk about max range descent, which is maximum travel over the ground per unit of altitude lost. Time is measured in terms of minimum sink or minimum altitude loss per unit time. Gliders achieve this beyond reasonable expectation through design for maximum lift at minimum drag. Most jet airplanes were designed for other purposes, but the principle still applies.

To avoid an in-basket full of nasty letters, I must acknowledge the one-half nozzle descent. The one-half nozzle technique uses a little less fuel than "full idle" because the fuel flow remains the same, but the overall drag is slightly reduced at the smaller nozzle opening so the time and distance covered in the descent is increased very slightly. If you use this technique, you're still ahead, but the difference would probably be hard to measure. A test done by students at the Test Pilot

School at Edwards AFB, California, using specially instrumented F-4s could not determine any usable difference between idle and one-half nozzle descents.

One situation that ties all these principles together is the short range flight segment such as a divert or "BINGO minus" RTB from the range. Regardless of how far you have to go, the only plan is to straighten out that left arm and strive for the highest feasible altitude. The amount of time spent at optimum cruise altitude is not important. A "John Glenn" flight profile, consisting of only MIL climb and idle descent, is more economical than a level cruise at less-than-optimum cruise altitude, regardless of the altitude attained in the climb.

Review and Summary

In the unlikely event that the nuggets of wisdom in the foregoing effort fail to stand out like a lighthouse in a bowling alley, here are a few basic guidelines:

- Use MIL power for all climbs and acceleration maneuvers if possible.
- Get to altitude as rapidly as possible by adhering to optimum climb speed schedules.
- Climb to as high an altitude as feasible and trim the aircraft.
- Maintain optimum cruise speeds (TAS) and reduce power or climb to a higher altitude as fuel burns off. Adjust speed/power each 2,000 lbs. Maintain symmetrical thrust — trim, trim, trim.
- Avoid airspeed excursions below optimum speed.
- Play the wind and adjust your cruise speed.
- Stay high as long as possible, then use an idle descent (if pressurization is not a problem).
- Max range is attained in the descent at the speed for L/D.
- Establish your speed prior to beginning descent and avoid undershooting the descent point.
- Avoid slowing down if you will have to speed up later.
- AB is fun but not fuel efficient.
- Guns and bombs? . . . Nah! Airplanes are for going places? ■

MAIL CALL

EDITOR
FLYING SAFETY MAGAZINE
AFISC/SEDF
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Human Factors Happenings

■ The discussion, "The Other End of the Spectrum," in the "Human Factors Happenings" section in your January issue was informative. The thrust of the discussion was that the opposite of pilot overload, or "task saturation," is "unsaturated time usage," which you characterized as pilot plus airplane without mission. In such cases, you pointed out, some pilots indulge in "recreational" rather than mission-related maneuvers, and wind up in, or looking down at, a "smoking hole." You suggested that supervisors minimize "nonloaded time available" to partly offset the potential problem.

I agree with your description of the problem and your suggestion for supervisors. I wish to point out why "recreational flying" might happen so that we, as pilots, may try to adopt the proper attitude and fight the problem ourselves. About 40 years of research concerning human "vigilance" or "monitoring" abilities has shown that many humans rapidly tire of performing repetitive tasks aimed at finding rare, but very important occurrences in their work environments. Preflights, checklists, and repeated training missions all fall into the category of repetitive tasks. The main symptom of our tiredness is a failure to consciously note a subtle discrepancy as we perform our by-now automatic preflight or checklist or instrument departure, etc.

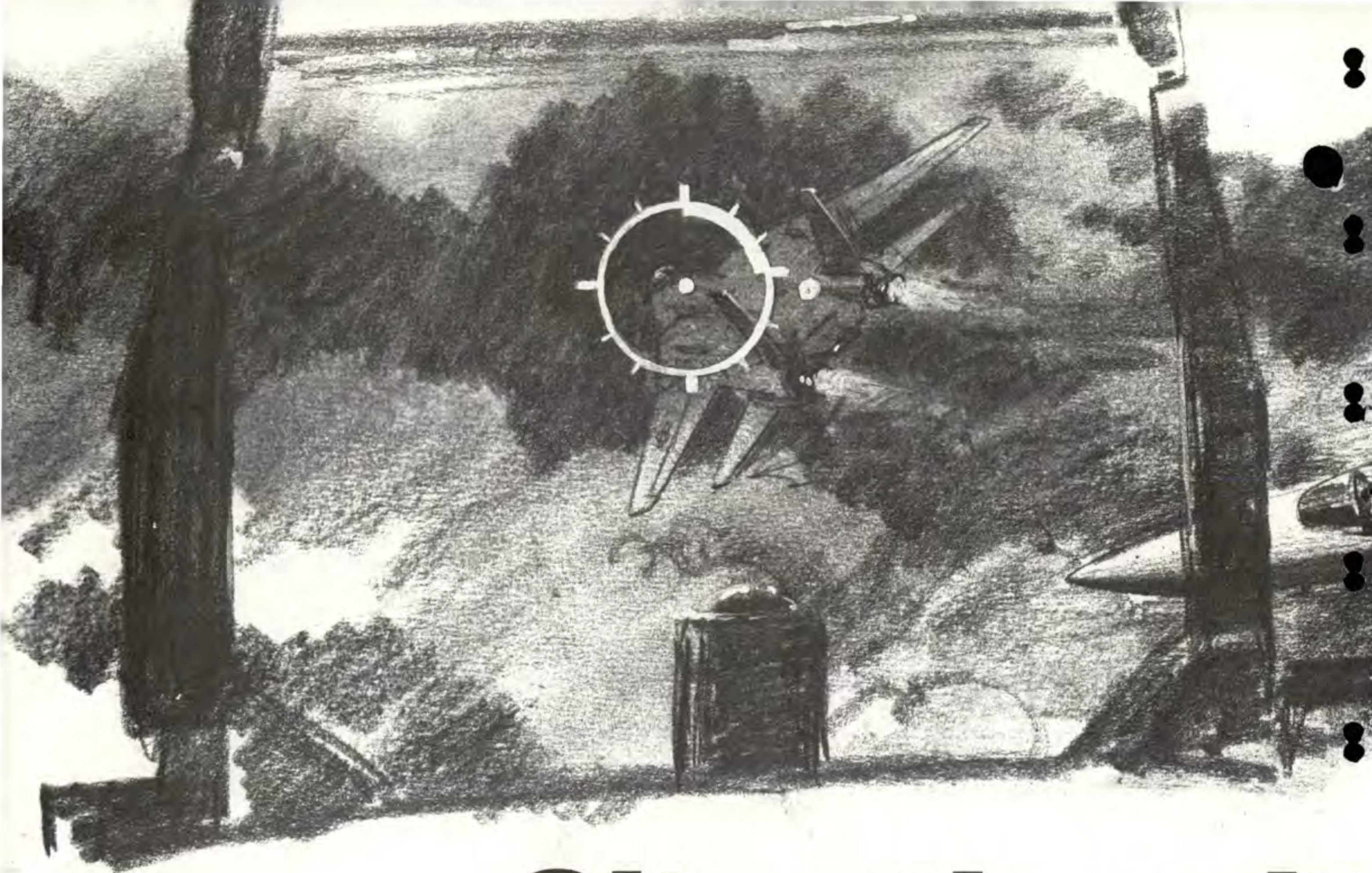
For example, the bent pitot tube, described in the "There I Was" section of the same January issue, was too subtle to alarm a pilot hurrying through an often-repeated checklist. In that case, the inadequacy of humans as "monitors" was revealed during task overload situation. During underload, when mission complexity is low (for example, no mission commitment, or long, overwater flights), the pilot cannot remain vigilant, and subtle cues of impending problems may not be perceived. This inability to sustain vigilance appears to be an innate human characteristic and may be unavoidable.

Thus, the poor vigilance ability of humans, in general, may underlie the problem we call "pilot complacency." "Recreational" flying may represent an attempt by the pilot to "stir up" the environment; that is to make the sortie more complex, as it would be with a mission. The pilot may be seeking relief from the boredom brought on by repetitive, flying-related tasks (instrument cross-check, radio calls, etc). The pilot may also be seeking the sensory stimulation needed to maintain an adequate level of vigilance. Pilots and supervisors must be aware of the human susceptibility to repetitive task-induced boredom and plan ahead to deal effectively with it. Such planning must include alternate missions to be flown if the original mission is scrubbed.

In our laboratory, we are seeking methods to determine when the pilot is not highly vigilant. We look at pilots' perceptions (subjective reports) of their level of fatigue; we examine the performance of flying related or simulated flying tasks; and we study the electrical signals coming from the brain, heart, eyes, etc. One day, perhaps, aircraft computer systems and pilots' brains will enjoy a symbiotic relationship with the strengths of both being used to best advantage in a dynamic arrangement. In such cases, the ability of the computer to remain "vigilant," without "tiring," and the elegant pattern recognition ability of the human visual perception system would be blended to best advantage.

James C. Miller, Ph.D.
Research Physiologist
Crew Performance Laboratory
USAFSAM
Brooks AFB, TX

Your observations are most appropriate. Our current medical investigators field guide contains a glossary which places this problem as a special anomaly of attention called "general inattention," which may be precipitated by either complacency or *boredom (defined exclusive of one another). You've just improved our definition of the latter! Thanks.* ■

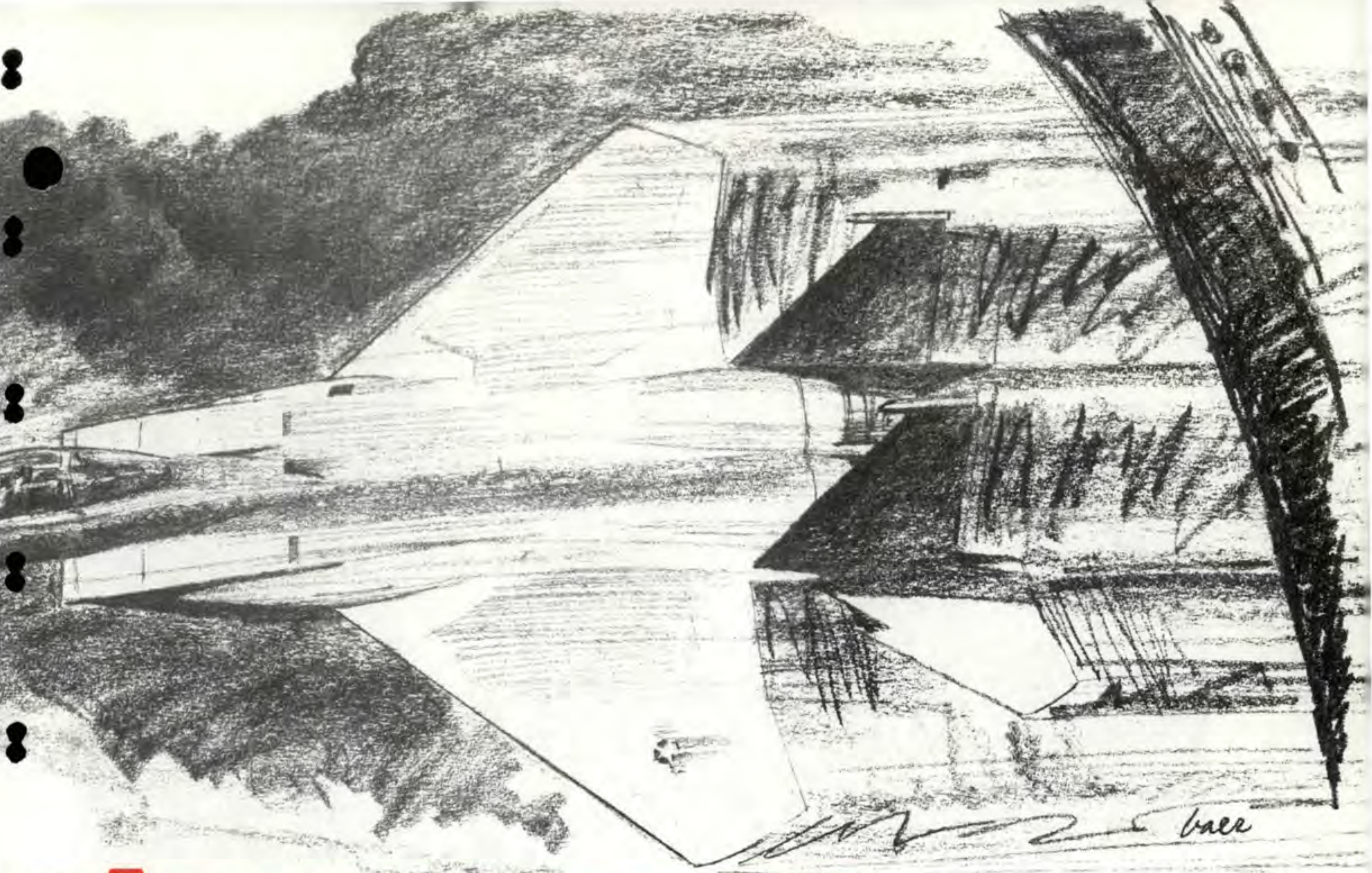


Situational

■ I was flying Jaguars from Bruggen. The squadron had invited the Lightnings from Binbrook over to act as "aggressors" and the week was progressing reasonably successfully, with each of us trying to get good guns-tracking film on the other — you know, the sort of film that you can get a print made from for the Squadron Diary! On one sortie, I was flying as Number 2 to one of the flight commanders; we were returning home having successfully evaded the "bounce," and having found — and hit — all of the targets. Spirits were high, and they rose even higher when we saw the two Lightnings in our one o'clock crossing from right to left. Well, the sortie was complete really, and we should have slipped past them quietly and unobtrusively — after all, that is what we would have done in war. But, we had plenty of fuel to spare; so, plug in the heaters — ease down a few feet so that we're skimming along the tree tops — they won't be able to skyline us now — you go for the one on the right — I'll go for the one on the left — Yahoo! — they still haven't seen us — should get some bona (oops!) tracking film.

Just before I ran out of film, they saw us and started to evade. Well, this made it a bit more sporting and, contrary to popular belief, the Jaguar can maneuver quite well when it's going fast. I wasn't about to get "spat out," so I hung on and finished off the film. As we approached our limit of 2 x 360° turns, I was tucked in nicely (well, hanging on by the skin of my teeth actually), positioned about 400 yards behind my Lightning. I'd lost my leader and the other Lightning by now, but he wasn't asking for help, so he was obviously happy with what was going on; after all, he was a very experienced flight commander. All of a sudden, the second Lightning crossed through my 12 o'clock, passing between me and the Lightning I was following; I went through his wake with a loud bang a split second later. The fight was called off and we went home; I was extremely frightened. I don't know how close we were when we crossed (I'd run out of film by then), but I do know that I never want to be that close to another aircraft again — other than in a pre-briefed close formation.

A couple of years later, I was on exchange in the USA and took part in a Red Flag exercise. It was terrific. "Lima shots down the throat," "Furball," "Set your hair on fire" — the vocabulary expansion was amazing. One day we were sitting through one of those interminable de-briefs, when everyone is claiming to have shot down everyone else first, when



Awareness

a bird colonel (group captain equivalent) stood up and spoke briefly and quietly about the need to retain "situational awareness" at all times. That was another piece of new vocabulary which meant always knowing where you were in relation to the ground and everyone else who was flying in your piece of sky; it's quite difficult when you're setting your hair on fire in the middle of a Furball! He reminded us of the importance of flight safety, and everyone settled back into their seats and started to think about which Casino should be helped with their mortgage payments that night. He told us about how he had been flying an F-15 that afternoon, and how he and his wingman had each been guns-tracking an F-14, and taking yards of head up display (HUD) film; it was only later that it became apparent to them that they were both tracking the same F-14. He then showed us the HUD recording from his aircraft. It was remarkable for two reasons.

First, you could actually see what was going on. Their qualified weapons instructors (QWIs) don't need to squint at grey scratched images for hours on end, trying to support the boss's contention that he ceased fire well outside "scrub" range and that the range safety officer (RSO) has a personal vendetta against him — and isn't your 1369 due soon? No white sticks and cock-bottle glasses by the age of 28 for their QWIs!

Second, it showed a very large F-14 twisting and turning in a vain attempt to evade the F-15. The pipper was firmly embedded in the cockpit of the F-14 when a very large light grey shape flashed across the screen. In slow motion, that light grey shape could be identified as the second F-15. The closest distance was measured at 70 feet; it took one-fourth second for the aircraft to cross the screen from right to left.

By now, nobody was slouching in their seats and the importance of retaining " situational awareness" had been well and truly brought home. The film reminded me vividly of my experiences with the Lightning some time before.

The colonel and I were lucky — we got away with it. Some of you who take the time to read this may have had similar experiences which spring to mind. What is sad is that some of you will read this and think "it'll never happen to me" — but it will. A midair collision is a messy business — costly in terms of human life, grief, and aircraft lost. Nothing in peace is worth dying for.

I hope that "I have learnt about flying from that." I hope that you can. — Courtesy *Air Clues,* Jul 84. ■

SKILL FATIGUE

■ Skill fatigue is defined as "the deterioration in performance caused by work that demands persistent concentration and a high degree of skill."

The dangers of this condition need to be understood by all pilots. Although the accidents described in this article concern very low level helicopter operations, the general thrust of the article applies to any pilot whose task can at times place great demands on him. Clearly, this encompasses the complete range of aviators, from the F-16 driver or KC-10 AC to the private pilot.

Skill fatigue is associated with failure of memory, judgment, integrating ability, and presence of mind. Its effects may occur in conjunction with, and be accentuated by, other fatigue-inducing factors such as sleep loss. The phenomena were first described in a classic series of experiments carried out in the UK and published in 1948. Subjects were tested for two-hour spells in a simulated aircraft cockpit under blind flying conditions during which they had to deal with a series of maneuvers. This was a very high workload task, designed to demand sustained concentration and skilled performance throughout the entire two-hour period. In these studies, it was found that skill-fatigued subjects accepted lower standards of performance and accuracy. At the commencement of the testing sessions, "fresh" pilots would scan and use all the instruments systematically, but with increasing fatigue, this integrative ability failed, and they would "chase" one instrument at a time. Memory also decreased, and the pilots would forget to monitor side instruments and neglect to reset instruments and controls. Eighty of the 140 pilots tested forgot to lower the undercarriage for at least one "landing."

Subjects in these experiments took longer to observe and interpret instruments as the tasks progressed. Performance under these conditions tends to suffer disruptions that build up in a vicious circle. Increases in times taken to observe and interpret instruments mean that the resulting errors tend to be greater before the pilot takes any corrective action. When this action is eventually taken, it may, so as to make up time lost, be poorly controlled and thus require additional subsidiary corrections, which in turn take up more time and require subsequent corrective actions to be even greater.

The characteristics of skill fatigue are as follows:

- Loss of accuracy and smoothness of control column and rudder movements.
- Unawareness of the accumulation of rather large errors in azimuth, elevation, and attitude.
- An increase in control movements involving greater fluctuation in order to produce the same effect.
- Under- and over-control movements.
- Forgetting of side tasks.
- Errors of inattention. Failure to scan sky; fixed vision.
- Preoccupation with one task component to the exclusion of others.
- Allowing various elements of operational sequence to appear out of place with respect to one another.
- Easy distraction by minor discomforts, aches, pains, noises, etc.
- Increasing unawareness of performance deficiencies and, in extremes, signs of physical breakdown such as fainting, cardiac arhythmias, etc.
- The requirement for larger-than-normal stimuli for evocation of appropriate responses.
- Errors in timing.
- Overlooking of important elements in a task series.

Research by the Bell Helicopter Company, among others, has demonstrated significant qualitative differences in the visual workload of pilots flying helicopters at low and very low altitudes. At 500 feet, pilots' average eye scan fixation time was 1.5 seconds, in comparison to approximately 4 seconds at 300 feet. Further, at the lower altitude, the pilots were operating at their maximum visual workload capacity in just flying the aircraft, even over familiar terrain.*

It must be emphasized that pilot skill level and task workload should not be considered in isolation. The two facts are interdependent. In other words, identical flying tasks may represent quite different workload levels to pilots with different individual levels of skill. In general, the greater the level of relevant and applicable skill of a pilot in a particular flying situation, the less is the task workload for that pilot. Consequently, when evaluating the level of workload for a particular pilot involved in an accident and the possible incidence of skill fatigue, the appropriate skill level of the pilot related to factors such as time-on-type, currency, experience of the specific task (e.g., night flying, mustering), total flying hours, etc., must be taken into account, remembering that certain kinds of flying represent high workload environments for even the most experienced and current pilots.

Research into stressors such as skill fatigue have typically found considerable differences in the onset and manifestation of fatigue effects, both between pilots and within a single pilot. Consequently, it is impossible to provide a simple "index" of fatigue, e.g., in terms of hours flown. The problem is a complex multi-factored one, but it can be dealt with. The essential point to remember is that when the observable effects of skill fatigue do become apparent in a pilot, these effects are either one, or a selection of those listed above.

Typical Accidents

The effects of skill fatigue on pilot performance are considered by research psychologists in the Bureau of Air Safety Invesigation to have been probable relevant factors in the following accidents:

The pilot of a Bell 47 was taking

continued

*The visual workload of the primary task of flying was measured in terms of changes in pilots' ability to perform simultaneously a secondary visual task. At maximum visual workload on the flying task, the pilots had no "spare capacity" to perform the secondary visual task. In flight situations where pilots were able to perform the secondary task to some degree, the primary flying task was not occupying all their available capacity.

Consequently, pilots' performance on the secondary task was a direct measure of the degree to which the task of flying the aircraft was occupying their available visual workload capacity. This dual task experimental method has been used in many studies of pilot workload because of the difficulty of measuring pilot workload levels on the flying tasks alone.

Skill Fatigue continued

a geologist and his assistant to selected points in order to collect mineral samples. The wind conditions were variable, but generally northerly at about five knots. The temperature was 36 degrees. The pilot had landed in a small clearing surrounded by trees 30-35 feet tall. While waiting for his passengers to return, he tied flagging to the trees in order to assess the wind velocity for takeoff; he determined the wind direction as varying from northwest to east. He also polished the aircraft and the rotor blades to maintain peak performance.

When the passengers returned, the pilot carried out a careful pretakeoff check, which included a hover to assess surplus engine power available for takeoff. He selected a takeoff path to the north to take advantage of the slight headwind. The helicopter cleared the first trees but was unable to outclimb rising terrain and started to sink. The pilot then attempted to gain lower ground by turning to the right but the aircraft continued to sink, struck a small tree, and then hit the ground. The subsequent investigation established that a more suitable takeoff direction existed towards the south-east where the trees were not so tall and the ground was level. Moreover, the helicopter's capability to achieve the steep gradient was marginal, and the pilot inadvertently overpitched the main rotor.

The pilot was obviously conscientious, but he lacked experience in helicopter operations under high ambient air temperatures. More significant from the standpoint of this article is the fact that he had been flying continuously for 22 days prior to the accident. The geosurvey work, on which he was engaged, was conducted at low level and involved numerous takeoff and landings. It is considered that the effects of accumulated fatigue and heat stress may have led to a deterioration in the pilot's capacity to process and integrate the information he was receiving.

The effects of accumulated fatigue and heat stress may have led to a deterioration in the pilot's capacity to process and integrate the information.

The second accident occurred during a low-level ferry flight, also in a Bell 47. Approximately 25 minutes after takeoff, while overflying a lake, the aircraft entered a descent and struck the water in controlled flight, slightly nosedown and with a slight bank to the left. Shortly after the aircraft entered the water, the pilot removed his helmet, released his harness, and left the helicopter.

Pilot mishandling and mechanical failure were discounted as factors in the accident. The pilot himself could offer no explanation. In his own words:

When I crossed the hills prior to the lake, I was about 1,000-feet AMSL or about 500-feet AGL. I wasn't contour flying. As I flew out over the lake, I remember sighting Mt X and checked that the track took me to the south-west of Mt X, and I looked back in an attempt to sight the dam wall just to confirm my position. The next thing I remember is being in the water.

It seems significant that there was evidence that the pilot had been

under stress from personal problems for some days, while at the time of the accident he had been working for 10½ hours. Although he had only been flying for 25 minutes of this time, the low level flight over changing terrain of hills and water would have been very demanding. In the opinion of an aviation psychologist, the pilot's action in looking back over his left shoulder to check the dam wall and thereby losing his forward visual reference may have led to an unperceived loss of height; that is, where the rate of angular acceleration of the aircraft was below the threshold level required to enable it to be detected by the pilot's organs of balance. The aircraft's configuration at the point of impact (slightly nose-down, slight left bank) was consistent with this low rate of descent and the pilot's actions in the cockpit just prior to the accident.

Comment

The intention of this article has been to make pilots and supervisors aware of the insidious nature and dangers of skill fatigue. In General Aviation, the onus is on the pilot to safeguard himself as far as possible from vulnerable circumstances. Skill fatigue feeds on dedication, ambition, greed, overconfidence, pressures from the employer and customer, not knowing your own limits, and a reluctance to say "enough" . . . .

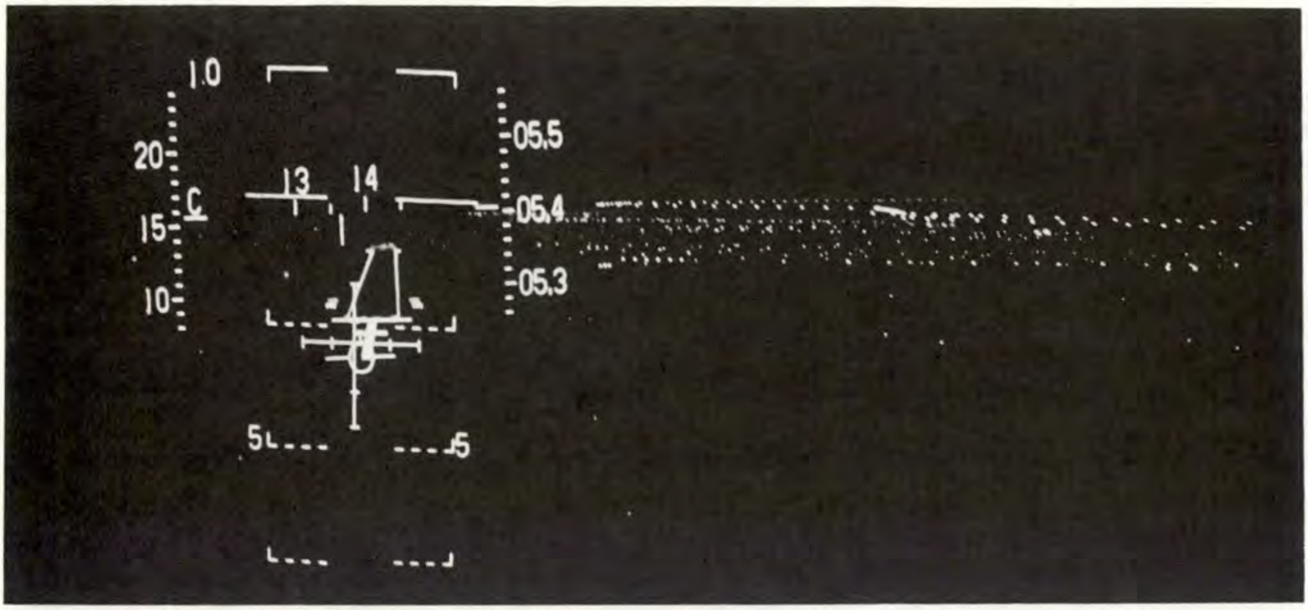
Prevention or Remedial Actions

Know what kinds of flying conditions for you as an individual will constitute high workloads.

Know what the behavioral effects characteristic of skill fatigue are (page 23), and try to be aware of them in yourself and others so that remedial action can be taken before it is too late. For example, if you find yourself making mistakes in procedures, errors in timing, taking longer than usual to carry out normal actions, overcontrolling, forgetting side tasks (e.g. ATC instructions), the chances are that these symptoms may indicate a fatigue state which could become dangerous, and cessation of flying for the day could save your life, and/or your aircraft. Fatigued pilots do not always have accidents, but their chances of doing so are increased — particularly if they have to cope with an unforeseen emergency.

Apart from restricting flying hours, personal discipline should include:

- A program of suitable exercise.
- Regular meals.
- Plenty of water intake to prevent dehydration (avoid caffeine which induces dehydration).
- Control of alcohol intake before flight and smoking during flight. (One cigarette raises the carbon monoxide in the blood to a level that equates to a state of hypoxia at 7,000 feet. Two cigarettes smoked consecutively raise the level to 10,000 feet, and these levels are further aggravated by actual cabin altitude.)
- Awareness that psychological and emotional problems are an insidious drain on energy reserves, a particularly important consideration in very high workload flying operations. — Adapted from *Aviation Safety Digest*.



IMC APPROACHES—IN THE DARK

CAPTAIN JONATHAN G. TOVANI
50th Tactical Fighter Wing

■ I was a new guy in the squadron, fresh out of RTU, and was ecstatic to be flying both air-to-air and air-to-ground tactical training missions led by guys who have "been there." The European flying arena, with its high traffic density and VMC flying, offers an excellent opportunity to keep a high level of realism in each mission, and this is supported by a set of ROE designed to keep it safe while keeping it realistic. And of course the European weather intervenes just enough to keep each mission slightly unpredictable. And was it ever fun. Each sortie would generate hours of talk at the bar. It was tactical training at its best.

But then, not three months after I had arrived, we lost a jet. Fortunately, the pilot made a timely decision to eject and got out OK. Just as the mishap board was handing in their paperwork on this incident, another very close call did some structural damage to an aircraft, but the pilot was able to make a safe landing. As you would expect, this got some high level people interested in the way we were doing business. But the business that was under the spotlight was not the tactical portion of the missions. These incidents happened during night IMC approaches.

The Challenge

Why did night IMC approaches prove to be so difficult? It's not a simple answer, but the problem lies in the fact that during every instrument approach (with the exception of a CAT III ILS), there is a point when the pilot must transition from instruments to a visual approach for the landing. I think this is the most challenging portion of an approach in poor conditions.

Transitioning from a nonprecision approach can be more difficult than from a precision approach because you have to put yourself on the glidepath. This is where VASIs and a VDP become important. Transitioning to land is even more difficult when your visibility is inhibited by something like haze or fog. Darkness also makes the transition tough because of the reduced visual cues available at night. Another factor entering into the transition to a visual landing at night is the early flying training we all receive in UPT.

Early Training

Our early experience with night flying can do us a disservice when we are later faced with flying night approaches in IMC. This is because during those phases of night flying in UPT, a student becomes very proficient at night flying, for about a week anyway. In the highly controlled ATC environment, student pilots think nothing of flying visual straight-ins as well as overhead patterns at night.

The sad fact is that when we later fly only enough night sorties to log our two per half, our proficiency goes way down. Add to this low proficiency some bad weather, and you now have a scenario that demands great respect.

Our early experience with night flying might lull us into a false sense of security. We might think that once we see the runway environment we can continue visually, and the rest of the approach is a piece of cake. This just isn't so due to the limited visual cues available in darkness.

As long as we're talking about lousy weather and night approaches, we might as well throw in a good stiff crosswind to complete the picture. When crosswinds are a player, and they are correctly anticipated, the first glimpse of the runway at your left 11 o'clock is something that was expected and is no cause for alarm. But if you planned on the runway appearing under your nose and it showed up somewhere else, the ensuing lateral PIO can be eyewatering and dangerous as your attention becomes channelized.

All this is to say that night approaches in IMC can be a formidable opponent which should never be underrated. The critical part of the approach is the transition to a visual landing, and it can be done successfully in even the worst conditions by correct anticipation and a good cross-check.

The Key To Success

The key to making a smooth transition from instruments to a visual landing at night is thinking ahead. Form a picture of what you expect to see when (if?) you break out of the weather. If the approach plate shows the alignment of the final approach course and the runway to resemble a geometry lesson rather than a nice straight flightpath, you need to be expecting that.

Runway lighting is another feature of the visual environment that should be anticipated. Take into account what the VASIs will be able to tell you when you break out. They can be great for a precision approach. They are very limited in what they tell the guy flying a nonprecision approach until he gets himself on the glidepath.

I've already mentioned what crosswinds can do to an approach if their effects have not been considered. How many of us have broken out, pointed the jet at the runway, drifted downwind, and spent nearly the rest of the approach getting back on course. The last thing you want to do at night is screw up something like this.

One more thing to anticipate is the picture you plan to see in the HUD, if your aircraft has one. Have a well devised plan for using the HUD and stick to it. I believe the HUD is great for fine tuning pitch attitude and heading on an approach. This is because the scales in the HUD are larger than the scales on the round gauges, hence deviations are easier to see. But I only use the HUD for making small corrections on the picture I've already set on the round gauges. Another advantage of the HUD is that it lets your eyes look out front at the same time you're checking your parameters. But don't get engrossed with the symbology and ignore the round gauges or the view out front.

A good technique (from AFM 51-37, Instrument Flying) to ensure you cross-check your round gauges throughout the approach (even after you can see the runway lights), is to start an outside/inside cross-check early in the approach, even before visual cues are available out front. By glancing outside then coming back inside as the approach is flown, you will find it easier to continue to come back inside to check the round gauges even after you're able to see the lights on the ground.

It's important to come back inside and confirm what your eyes are telling you from the limited visual environment of the runway at night. Once you get closer to the runway and visual cues begin to get better, then the cross-check should concentrate more on what's outside so a smooth flare and landing can be made.

The Old Rules To Fly By

The techniques I've tried to pass on in this article for making a safe transition to a visual landing in poor weather at night are not brandnew to the flying community. In fact, they are nothing more than specific applications of old proven rules about flying that we've heard many times. The old rules used here are:
(1) Stay ahead of the airplane, and
(2) Don't channelize your attention.

These rules are simple enough, and we all know their value. By forming a picture of what you expect to see when you break out from a night IMC approach and by keeping up a good cross-check throughout the transition from instruments to a visual landing, you can land safely from the most challenging approaches. ■

UNITED STATES AIR FORCE

Well Done Award

Presented for outstanding airmanship and professional performance during a hazardous situation and for a significant contribution to the United States Air Force Accident Prevention Program.

STAFF SERGEANT

Brian D. McCurdy

343d Tactical Fighter Wing
Eielson Air Force Base, Alaska

■ On 4 May 1984, an A-10 aircraft was undergoing a Number 2 engine change in conjunction with phase inspection. While disconnecting the main fuel line from the engine pylon, the fuel line was found to be severely chafed on top of the elbow. Sergeant McCurdy investigated the discrepancy and determined that the engine oil service door hinge had created the chafing condition. After receiving a replacement fuel line, Sergeant McCurdy repositioned the main fuel line clamps, allowing adequate clearance, to prevent recurrence of the chafing. On 16 May 1984, another severely chafed main fuel line was discovered on another A-10 while it was undergoing phase inspection. Again, Sergeant McCurdy investigated the discrepancy noting that the same factors were present as with the past aircraft. Recognizing the development of a trend, he immediately contacted quality assurance to initiate a one-time inspection of this item on all assigned aircraft. Quality assurance inspectors randomly inspected two aircraft 16 May 1984, finding one chafed fuel line. On 17 May 1984, a one-time inspection meeting was held, and all aircraft were inspected that day. A total of 14 main fuel lines were discovered chafed, requiring replacement. One line was chafed to the point of seeping fuel. A message was sent to all A-10 units to perform this one-time inspection. The number of main fuel lines requiring replacement was 71. The outstanding inspection procedures and the action taken by Sergeant McCurdy probably averted the loss of many aircraft along with the possible loss of lives. WELL DONE! ■

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UNITED STATES AIR FORCE

Well Done Award

Presented for outstanding airmanship and professional performance during a hazardous situation and for a significant contribution to the United States Air Force Accident Prevention Program.

CAPTAIN
Albert S. Wickel

49th Fighter Interceptor Squadron
Griffiss Air Force Base, New York

■ On 13 June 1984, Captain Wickel was returning to base in an F-106A following a practice scramble and intercept mission. The weather at the destination airfield was 500 feet overcast with 2 miles visibility and solid cloud cover up to 21,000 feet. On final, 3 miles from touchdown and in the weather, Captain Wickel noticed abnormal airframe vibrations accompanied by electrical surges and erratic instrument indications. Total failure soon followed. With only 2 miles to go, descending through 600 feet above ground level, he executed an immediate communications out go-around while transitioning to emergency instruments. The electrical failure also prevented the retraction of the landing gear and speed brakes, reducing maneuverability and further complicating his situation. With no outside references, Captain Wickel had only nine minutes of marginally reliable attitude information as the emergency standby gyros wound down. Faced with a probable bailout situation, Captain Wickel climbed the aircraft to the minimum safe altitude for the area and proceeded to an uninhabited area by dead reckoning. While en route, he accomplished the pre-ejection checklist procedures and managed to restore partial electrical power, enabling intermittent radio communication. Captain Wickel contacted approach control, declared an emergency, and was informed that his flight lead had landed and there were no other aircraft in his area to provide support. With his aircraft rapidly reaching a critical fuel state, he requested and received gyro-out vectors for a minimum fuel precision approach. In a severely time-compressed situation, with degraded communications, and less-than-reliable instrumentation, Captain Wickel flew his aircraft to a safe landing. WELL DONE! ■

SAFETY AWARDS

THE KOREN KOLLIGAN, JR., TROPHY FOR 1984

The Koren Kolligian, Jr., Trophy was established in 1957 in memory of First Lieutenant Koren Kolligian, Jr., declared missing in the line of duty off the coast of California on 14 September 1955. The Kolligian family established this memorial because of Lieutenant Kolligian's great feeling for the Air Force and love of flying. The award recognizes outstanding feats of airmanship by individual aircrew members. The trophy is awarded annually to the USAF aircrew member who most successfully coped with an in-flight emergency situation during the preceding calendar year.

CAPTAIN JOHN F. KELLY

20th Special Operations Squadron
Hurlburt Field, Florida

Captain Kelly was flying a joint service training exercise with a crew of seven and eight combat-configured troops in his HH-53H Pave Low III helicopter when the tail rotor fell off the aircraft.

Coincident with the loss of the tail rotor, the aircraft yawed violently to the left. Despite this unusual situation, Captain Kelly immediately took control of the aircraft, entered autorotation, called out the boldface emergency procedures, and prepared the aircraft for emergency landing.

Realizing he had very little altitude and time to react, Captain Kelly adeptly cross-controlled the main rotor tip path with cyclic to compensate for the lack of balance in the flight vector. This enabled him to fly the aircraft toward his selected landing site instead of it falling uncontrollably from the sky.

While at 500-feet altitude, Captain Kelly realized the proposed landing site had two houses on either side of the clearing. Since this type of recovery is nearly impossible to control with any degree of certainty, Captain Kelly turned the aircraft away, opting to recover in the trees rather than risking injury to those on the ground. In so doing, he spotted another small clearing.

By exceptional airmanship, he was able to gain control of the crippled aircraft, maneuvered it away from the houses towards the small clearing, and successfully crash landed. Captain Kelly's courageous actions under extreme stress resulted in the survival of all 15 people on board.

This is the first known catastrophic loss of a tail rotor in which everyone survived, and it is due solely to the outstanding flying skills of Captain Kelly.