flying SAFETY

JUNE 1984

THERE I WAS

■ . . . coming off the night gunnery range in the back seat of my F-4. No radar, no INS (good platform, of course, or we would have ground aborted!).

The last pass was a nuke lay down, so lead was 6 or 7 miles in front of us. We climbed out looking for lead (who's taillight was out) and heading for the filed fix enroute back.

The front seater picked up the visual first, and I could see the flashing red lights through his canopy. He called "visual" and lead acknowledged and sent us to center freq.

As we approached the fix, we started to close on lead very fast — too fast. Before we could react, a flight of two passed just above us about 500 feet to the right. We were rejoining head on to an incoming flight!

After we calmed down and called "blind," we picked up lead's flasher, slightly high and one-half NM to our left.

Nobody did anything wrong procedurally, but it sure was close. ■

"Visual" rejoins on lights alone have been a problem before. Not all the lights pilots have joined on belonged to lead. Some were airliners, other flights, or even trains. It's really a time to be a little extra careful.

UNITED STATES AIR FORCE **flying** SAFETY MAGAZINE

AIR FORCE RECURRING PUBLICATION 127-2 JUNE 1984 VOLUME 40, NUMBER 6

AFRP 127-2
Entered as a publication at the Second-Class rate (USPS No. 586-410) at San Bernardino Postal Service, 1331 South E Street, San Bernardino, CA 92403

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SPECIAL FEATURES

REGULAR FEATURES

DEPARTMENT OF THE AIR FORCE • THE INSPECTOR GENERAL, USAF

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An Analysis of PILOT EXPERIENCE and MISSION CHANGES in Aircraft Mishaps

LT COL JAMES I. MIHOLICK
Directorate of Aerospace Safety

■ There recently has been some feeling expressed that the Air Force has experienced "numerous" operator error Class A flight mishaps involving high time or highly experienced pilots. There has also been reference to "several cases" in which briefed missions changed for various reasons at the last minute. AFISC was asked for an analysis of "any correlation in incidence of mishap operator errors and changes in mission plans." We therefore looked at both cases, those involving pilot experience and those involving mission changes.

Previous AFISC studies and analyses such as Change Pace, Quick Look, and Broad Look have corroborated the widely held opinion that increased "experience" by itself reduces the potential for pilot error mishaps, and pilot experience was one of the major issues addressed by Broad Look. This analysis also verifies the general validity of the opinion. It is important to note that

Analysis shows that while increased pilot experience does reduce mishap potential, the chance of a mishap is never eliminated. There is also evidence which shows that UE experience, not total time, is the governing factor. The risk of a mishap goes up whenever a pilot changes to a new aircraft regardless of that pilot's total time or experience.

Approximately one out of four operations-related mishaps which destroyed the aircraft involved a mission change (alternate mission, alternate crew, or a delay). Mission changes increase susceptibility to mishap-causing conditions like distraction and should not be taken lightly by aircrews.

while increased experience reduces mishap potential, it is never eliminated, and we attempted to document any observable changes in the relationships between experience and operations mishaps in the mishap data available at AFISC. We also attempted to analyze the impact of unscheduled mission changes on mishaps, however, the data available in this area are limited.

The analysis included all mishaps in which USAF aircraft were destroyed from 1 January 1979 through 31 December 1983, and further mention of the word "mishap" implies destroyed aircraft. In 1984, mishap data through 8 March were also evaluated, but most 1984 data were still preliminary and therefore not validated. Also used were automated AFISC mishap data, aircraft utilization data (flying hours/sorties/landings), and data from the AFISC Individual Flight Record file. The mishap data base for this time period included 348 destroyed aircraft, 204 of which were destroyed in "operations" (pilot error) mishaps. One hundred and forty-seven of the 204 operations destroyed were fighter/attack aircraft. The analysis is in two parts: the first, a general look at pilot experience as it related to the mishaps, and second, a look at those mishaps where mission changes were identified, including the pilot experience levels of those mishaps.

The second part of the analysis was limited to mission change data that were in the mishap data files, as overall Air Force mission change data were not available. The lack of mission change data on flights *not* involving mishaps precluded a comparative analysis of the impact of mission changes on mishap potential, however, a descriptive analysis of those mishaps is provided.

The assumption was made throughout the study that neither pilot experience nor mission changes singly or together significantly influenced the likelihood of a logistics (materiel failure) mishap, and although the logistics mishaps were examined, we concentrated on the 204 operations mishaps. We also concentrated on fighter/attack aircraft due to their numbers and the inherent experience differences between fighter/attack pilots and those flying other aircraft. While we intuitively believe that mission changes adversely affect mishap potential, we tried neither to prove nor disprove this opinion and ultimately found that proof in either direction was impossible with only mishap data.

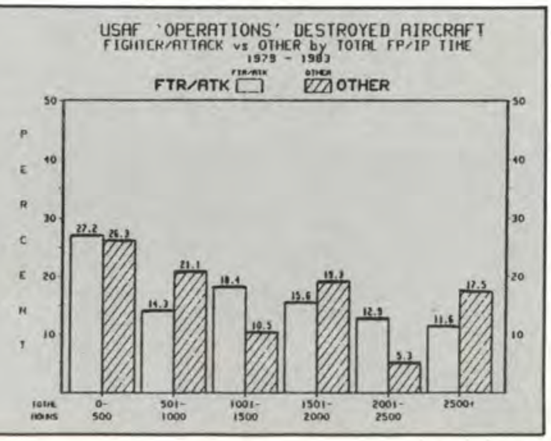
Throughout the analysis, observed differences between the variables investigated were tested for significance using a Normal distribution test (Z statistic) for trend line slopes and 95 percent confidence intervals.

Pilot Experience Levels

Operations mishap pilot distribution by 500-hour total FP/IP flying-hour increments (Figure 1) revealed the expected general "learning curve" applying to both fighter/attack and other pilots, with the fighter/attack curve improving at a slightly greater rate. Mishap data cannot

continued

Fig. 1



Analysis of Pilot Experience continued

Fig. 2

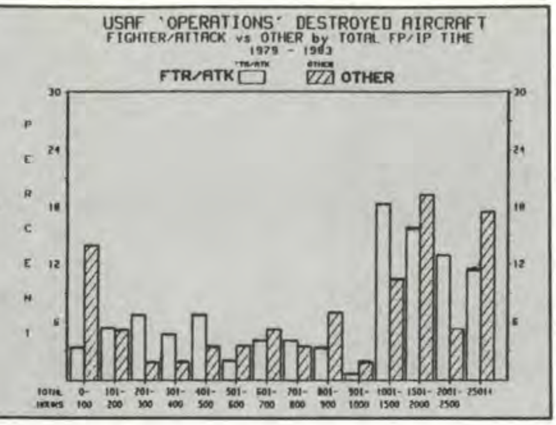
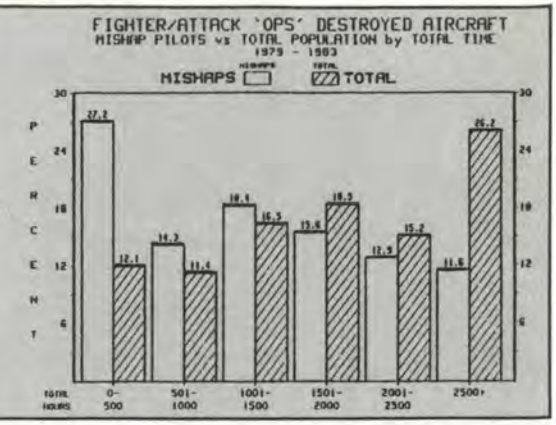


Fig. 3



explain the anomaly of the 500-1,000-hour fighter/attack pilots' contribution of only 14.3 percent, however, AFISC project officer conjecture is that fighter pilots at this point begin to realize their limitations and exercise increased caution until they reach the 1,000-hour mark. The two anomalies of other pilots between 1,000-1,500 hours and 2,000-2,500 hours are believed to be the result of increased supervision during aircraft commander upgrade and IP/FE upgrade. The same data broken out by 100-hour increments below 1,000 hours are shown on Figure 2. The "other" 0-100-hour group consists exclusively of trainers, seven ATC T-37s/T-38s and one AAC T-33.

A comparison of fighter/attack operations mishap pilots to the total Air Force fighter/attack pilot population (Figure 3) reveals that inexperience is a major factor in operations mishaps. If experience were not a factor, each population group would be expected to have "their share" of the mishaps. However, as seen on this figure, pilots with less than 1,500 hours total flying time constitute 40 percent of the fighter/attack population, yet they are involved in 59.9 percent of the operations mishaps. More significantly, while pilots with less than 500 hours total time constitute only 12.1 percent of the total population, they are involved in 27.2 percent of the operations mishaps. As total experience is gained, each group is involved in a smaller percentage of the mishaps, and pilots with over 2,500 total hours have significantly fewer than their share of the mishaps based on their percentage of the total population. Although a reversal appears at the 1,500-hour point, differences between any set of the two groups from 500 to 2,500 hours are not statistically significant. The same data broken out by 100-hour increments below 1,000 hours reveal that the pilots with less than 500 hours total FP/IP time are relatively evenly distributed, with no one group driving the total.

In order to evaluate the contention that recent mishaps involve "high time or highly experienced pilots," a 5-year comparison was made between mishap pilots using 1,000 total FP/IP hours as the dividing line (Figure 4). Except for 1981, pilots with less than 1,000 hours were involved in approximately one-third of the operations mishaps, and pilots with over 1,000 hours were involved in the other two-thirds. Reasons for the reversal between groups in 1981 could not be determined from mishap data, however, neither of the group's overall 5-year trend is significantly increasing or decreasing.

The fact that two-thirds of the mishaps involve pilots with more than 1,000 total FP/IP hours is not unusual in that they represent 75 percent of the total population. Figure 5 compares the percentage of mishap pilots with over 1,000 hours to the percentage of total Air Force pilots with over 1,000 hours by year. While the hashed bars show an in-

Fig. 4

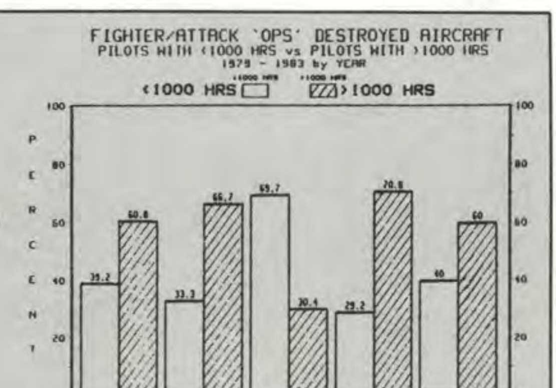


Fig. 5

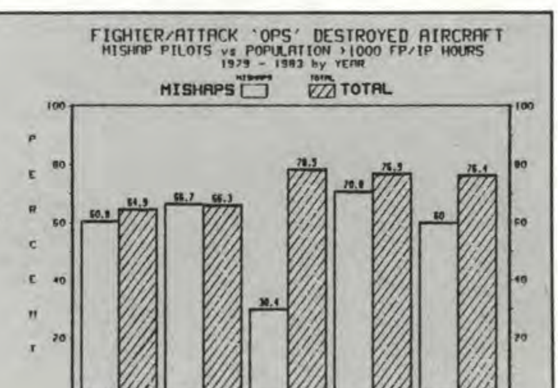


Fig. 6

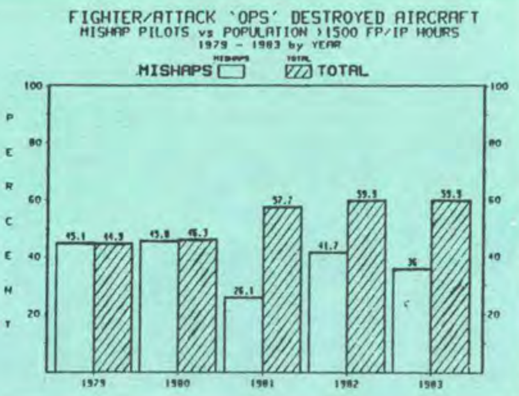
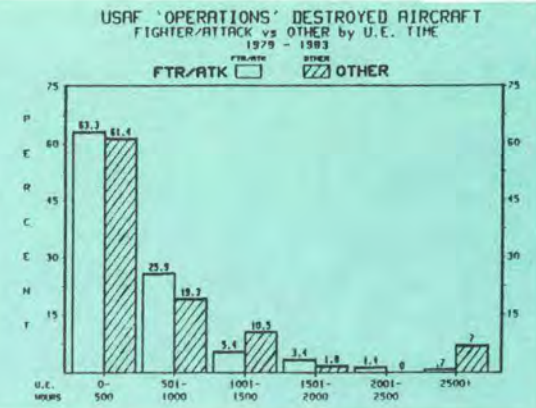


Fig. 7



creasing percentage of total pilots with over 1,000 hours, the percentage of mishap pilots is remaining relatively constant. Again, the 1981 anomaly could not be explained by mishap data. A similar look was taken at pilots with more than 1,500 hours (Figure 6). In their case, the total population is increasing while their percentage of the mishap population in fact decreased. The decrease in mishap pilots with 1,500+ hours since 1980 was not driven by any specific MAJCOM or aircraft, but is an Air Force-wide phenomenon. It appears that if "high time, highly experienced" is defined as pilots with over 1,000 hours FP/IP time, the answer to the original proposition on "numerous" operator error mishaps involving high time or highly experienced pilots might be yes; if it is defined as pilots with over 1,500 hours, the answer is definitely no. In neither case are any differences over the past 5 years significant, therefore, any concern over a recent increase in mishaps involving pilots who are "experienced" in total FP/IP time is unwarranted.

Mishap pilot distribution by U.E. (PAA) time (Figure 7) for the 5-year period revealed a steeper learning curve than that for total FP/IP time, again with the fighter/attack curve the steeper of the two. It also showed that time in the aircraft being flown is more important than total time, in that more than half of the total mishap pilots had more than 1,000 hours total time, while only 10.9 percent of the fighter/attack pilots and only 19.3 percent of the other aircraft mishap pilots had more than 1,000 hours U.E. time. The same data broken out by 100-hour increments below 1,000 hours revealed that fighter/attack pilots with less than 400 hours and other pilots with less than 300 hours drive each group's contribution of the mishaps.

A comparison of fighter/attack operations mishap pilots to total Air Force fighter/attack population (Figure 8) again reveals a steeper learning curve, with pilots with over 1,000 U.E. hours representing 25.2 percent of the total population but only 10.9 percent of the mishap population. While the total population of pilots with less than 500 hours U.E. time has decreased slightly compared to earlier studies (47.7 percent in 1983 vs 49.8 percent during Broad Look), their portion of the mishap population has increased slightly (63.3 percent vs 61.5 percent during Broad Look). The same data broken out by 100-hour increments below 1,000 hours again shows pilots with less than 400 hours U.E. time accounting for almost all of the 0-500-hour group's mishap contribution.

Fighter/attack operations mishap pilots with less than 500 hours U.E. time and those with over 500 hours (Figure 9) showed the opposite picture that total FP/IP time did, i.e., the pilots with less than 500 hours had two-thirds of the mishaps and those with over 500 hours had the

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Fig. 8

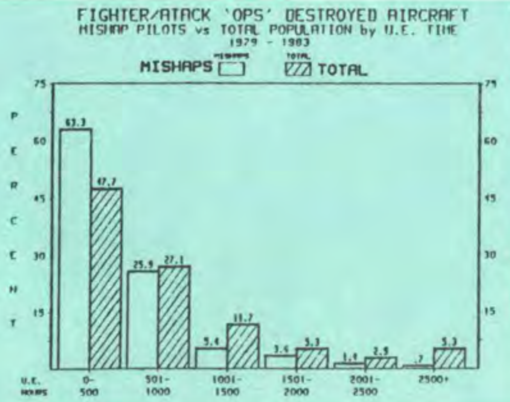
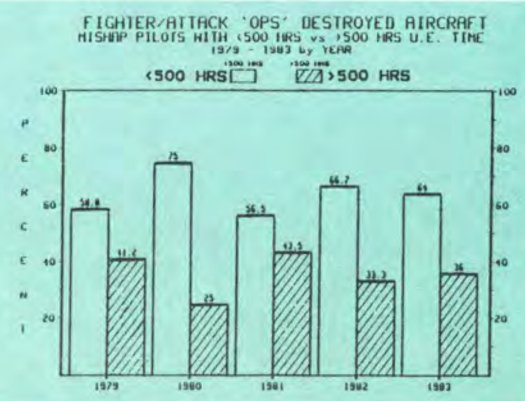


Fig. 9



Analysis of Pilot Experience continued

Fig. 10

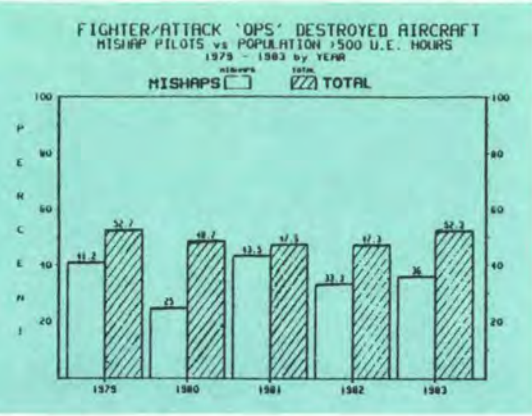
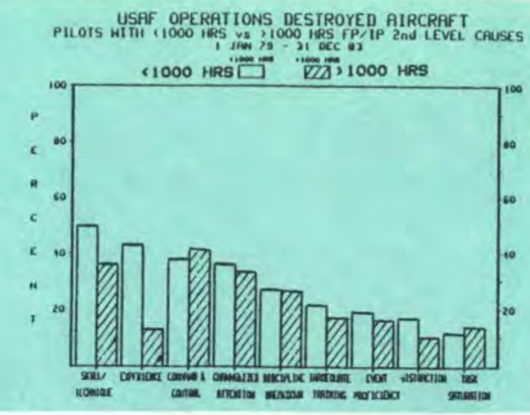


Fig. 11



remaining one-third. Again, unlike the total time comparison, there were no anomalies or reversals for any year. However, any differences between years were not statistically significant, and trends were neither increasing nor decreasing.

When mishap pilots with over 500 hours U.E. time are compared to total Air Force pilots with over 500 U.E. hours (Figure 10), it appears, as it did for total time, that they have fewer than their share of the mishaps. The percentage of the population each group represents by year is not significantly changing for either group. While pilots with over 500 U.E. hours represent approximately half the total population and one-third of the mishap population, pilots with over 1,000 U.E. hours represent one-fourth of the total and only one-tenth of the mishap population. This supports the earlier contention that U.E. experience has a greater effect on reducing mishap potential than does total experience.

A comparison of second-level causes between operations mishap pilots with less than 1,000 total FP/IP hours and pilots with more than 1,000 hours (Figure 11) revealed significant differences in experience (which is to be expected), skill/technique, and distraction. The second-level causes shown are the top nine ranked for pilots with less than 1,000 total hours and those that exceeded 10 percent of the total. The same second-level cause comparison for pilots with less than and more than 500 U.E. hours (Figure 12) showed the same difference in experience, an increase in command and control, and the same difference in distraction. It is important to note, however, that 53.3 percent of the mishap pilots with less than 500 U.E. hours also had more than 1,000 total FP/IP hours and therefore comprise more than half of the pilots on both charts. The increase in command and control was due to IP/flight lead involvement in 46.1 percent of the mishaps experienced by those pilots. A comparison of pilots with less than or more than 1,000 U.E. hours (Figure 13) showed an even greater increase in command and control (55.6 percent) and significant decreases in skill/technique experience, discipline breakdowns, and inadequate training.

Other areas investigated and found not to contribute to any valid conclusions were pilot total and U.E. experience by aircraft, MAJCOM, wing, type mishap, and activity.

Mission Changes

Of the 204 operations destroyed aircraft, 53 (26 percent) involved an alternate mission, an alternate crew, or were delayed (took off more than 15 minutes late). The annual percentage varied between 20 and 34.2 percent, and the overall totals have decreased slightly over the last 5 years (Figure 14). The 5-year percentage of mishaps involving these mission changes is decreasing (Fig-

Fig. 12

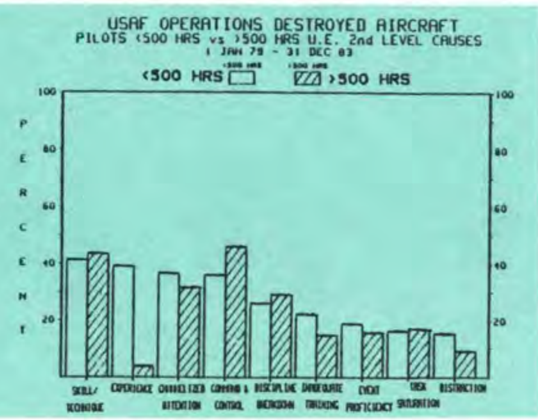


Fig. 13

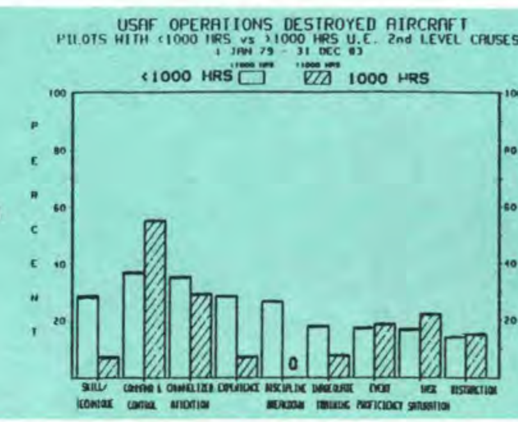


Fig. 14

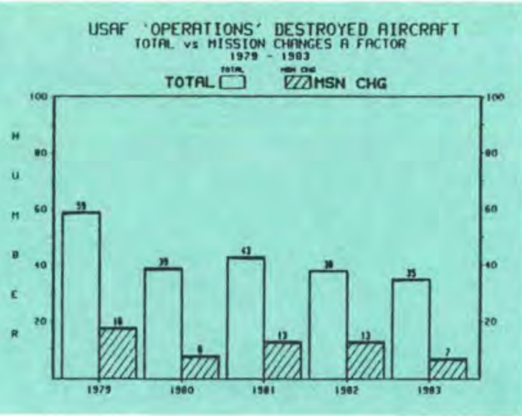
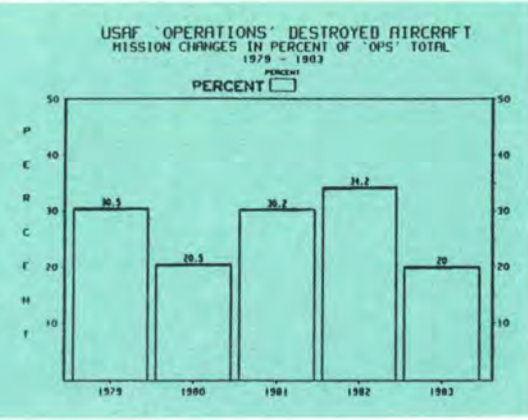


Fig. 15



ure 15), but not significantly. It is not known whether or not the percent of mishaps involving mission changes compares favorably with the percent of total missions flown involving these changes as these data were not available. We therefore performed a descriptive analysis of those mishap data with the hope that MAJCOMs may be able to make comparisons with other MAJCOM-unique data.

The F/RF-4 with 13 and F-111 with 8 accounted for 39.6 percent of the 53 total mishaps involving mission changes (Figure 16). These mishaps represented 27.1 percent and 61.5 percent of each aircraft's total operations mishaps. If less than 27 percent of the F/RF-4's total sorties or less than 61 percent of the F-111's total sorties involve mission changes, this may be an area worthy of increased education and emphasis.

TAC and USAFE (Figure 17) together experienced 60.4 percent of the total mission change mishaps with 16 mishaps or 30.2 percent each. These numbers represent 20.5 percent of TAC's and 36.4 percent of USAFE's total operations mishaps (Figure 18). While SAC had the largest percentage of their operations mishaps involving mission changes, three of the four mishaps were delayed takeoffs but did not involve alternate missions or alternate crews. PACAF's seven mishaps involved six alternate missions, five of which were also delayed. If less than 47 percent of PACAF's total sorties involve mission changes, this may be another area worthy of investigation.

Mission change mishap sortie rates (Figure 19) were calculated by MAJCOM and are the cumulative rate per 100,000 sorties for the 5-year period.

A mishap comparison by MAJCOM by year shows that, for those MAJCOMs with numbers large enough to be significant, all but TAC show a decreasing trend in mission change mishaps.

Mission change mishap pilot experience by total FP/IP time indicates a distribution similar to that for all operations mishaps, with pilots over 1,000 hours accounting for 54.8 percent of the total. Within each individual time group, variables such as the specific mission change involved, the MAJCOMs, and the aircraft were randomly distributed with no one factor driving any group's contribution to the total.

Mission change mishap pilot U.E. time distribution also remained similar to that for all operations mishaps, and again within each group, no significant differences between variables could be found.

A mission change mishap comparison by U.E. time for PACAF and ANG revealed numbers too small to be significant, but nevertheless a scattered distribution. The same comparison between TAC and USAFE, however, shows that TAC pilots at virtually all U.E. experience levels are susceptible to mission change mishaps, while all of USAFE's mission change mishaps

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Fig. 16

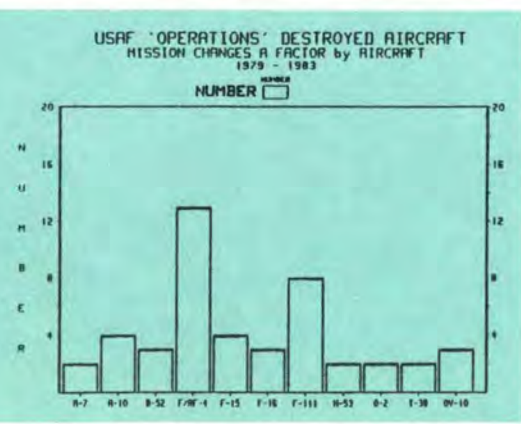
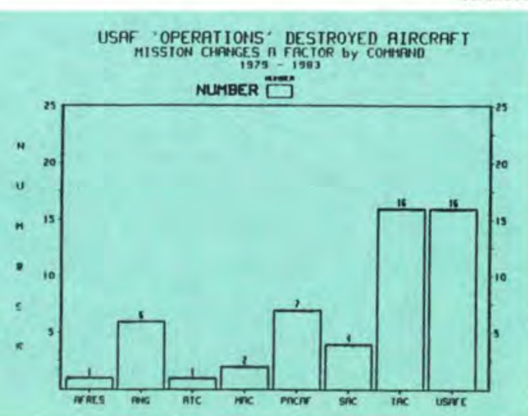


Fig. 17



Analysis of Pilot Experience continued

Fig. 18

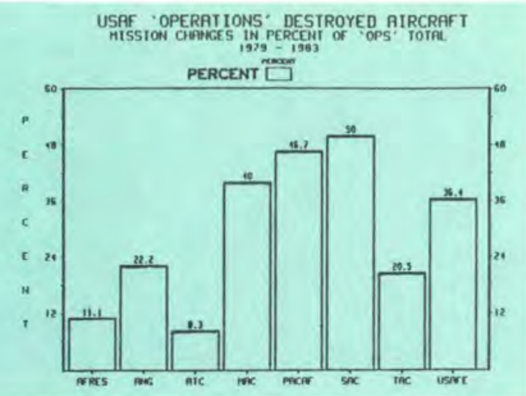
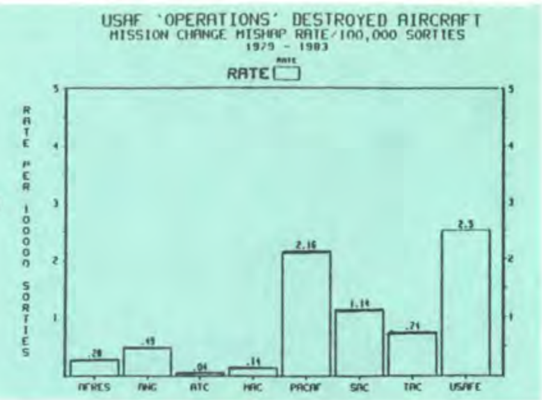


Fig. 19



involved pilots with less than 800 hours in their aircraft. While this may be simply a reflection of USAFE's overall U.E. experience levels due to conversions to new aircraft, it may also be worthy of further investigation.

A second-level cause comparison between mishaps involving mission changes and other mishaps (Figure 20) showed increases in lack of experience, event proficiency, inadequate training, and distraction. These reflect the fact that alternate missions involved events for which the pilots were neither proficient nor adequately trained, and the resultant degree of difficulty of these events made the pilots more susceptible to distractions which precipitated the mishaps.

Conclusions

Pilot experience levels:

■ The historically wide-spread belief that increased pilot experience reduces the potential for operations mishaps is true. How much it is reduced is a function of many variables, one of which is the amount of experience itself. U.E. experience is a more valid measure of mishap potential than total experience, and mishap potential reduces far more quickly with increased U.E. time than with increased total time.

■ As in previous studies, pilots with less than 500 total FP/IP hours (and therefore by definition less than 500 hours U.E. in any aircraft) and pilots with less than 400 U.E. hours, regardless of their total FP/IP time, experience a disporportionately greater share of the operations mishaps based on population than any other group of pilots.

■ While a pilot's mishap potential is reduced as he gains total experience, this reduction is negated to some degree whenever he changes aircraft resulting in significantly higher mishap potential during the first 400 hours in the new aircraft. Not until he becomes experienced in the new aircraft does his mishap potential again lower to reflect his total experience.

Mission changes:

■ Approximately one out of four operations destroyed mishaps involved an alternate mission, alternate crew, or a delayed mission. There were two conditions in the mishaps that resulted from a change in plans. The first, due to alternate missions or crews, resulted in unbriefed mission tasks which caused a mental condition of being rushed, and in some cases, confused, which in turn led to increased susceptibility to distraction or channelized attention. The second was due to delays and resulted in unfamiliar shortcuts on low level nav legs and eventually doing a mission task such as ACBT or weapons deliveries with a much heavier than planned aircraft. It appears that mission changes should not be taken lightly and that pilots should be made aware of their increased susceptibility to mishap causing conditions when such changes occur. ■

Fig. 20

A Nice Day To Fly

MAJOR JOHN E. RICHARDSON
Editor

■ As he stepped out of his car, Mike Smith took a deep breath of the crisp fresh air of this bright April morning. The air held a hint of the sweetness of spring and a promise of a fine day to follow. As he closed the door to his car, Mike scanned the early morning sky, noting the absence of any clouds. "The weatherman was right for a change," he thought, "This should be a really nice day to fly." Just then, his two passengers pulled into the parking space beside him. After the customary greetings and comments on the weather and the prospective flight, the three friends proceeded into the Aero Club office.

Once inside, Mike directed his passengers to the lounge and coffee machine while he went to complete the final steps in the flight planning. A recheck of the weather confirmed his earlier conclusion — it was going to be a very nice day for flying, VFR over almost all of the upper Mid West. Then, with weather and flight plan in hand, Mike sought out the club president and IP. "Hello, Bill, can you sign my clearance, please?"

"Hello, Mike, sure. Where are you going?"

"Over to Haverston and back. I'm taking a couple of friends and we'll be gone about 6 hours."

"OK, I don't see any problem with that. Which airplane do you want?"

"How about the Mooney?"

"Sorry, the battery's dead. You're qualified in the Cessna 172, why don't you take it?"

"OK, I'll fill in the numbers and go file."

"Have a good trip, Mike."

His clearance filed, Mike picked up his passengers and they all walked out to the aircraft. By now the sun had taken the last of the chill from the air. While his passengers boarded, Mike completed a careful preflight. Then he climbed in and started the engine. A short time later, the airport tower controller watched as the Cessna took the active, accelerated and climbed into the morning sky.

After clearing the traffic area, Mike turned south and headed for Haverston. His passengers were fascinated by the beautiful spring green of the countryside. Mike was more than happy to play the part of tour guide and the hour's flight passed quickly. Soon it was time to contact Haverston Unicom and after receiving landing instructions, Mike

continued

A Nice Day To Fly continued

smoothly and professionally completed both the pattern and landing. Once they were parked, Mike made arrangements for servicing while the passengers went to see about a rental car.

Arrangements completed, Mike joined his friends and they drove off to their appointment in the nearby town.

Time seemed to fly while they were gone and almost before they knew it, the planned four-hour ground time had stretched to 6 hours. It was getting close to dusk when Mike and his friends returned to Haverston. Mike was especially concerned for he had an important meeting that night back in his home town. If they hurried, he could still just make it.

When they arrived at the airport, Mike could find none of the servicing personnel. He also could not find any record of the servicing. But since he had paid earlier he assumed that everything was OK. Since the office was closed, Mike couldn't use the telephone to call Flight Service to file a flight plan or get a weather briefing. He thought about walking over to the car rental agency to use the phone but just then he saw his two passengers walking up and decided to go ahead and take off and check after he was airborne.

It was getting later and later and Mike was in a hurry so he talked himself into believing that a preflight wasn't necessary. After all, he had done a good, thorough one that morning and no one else had flown the aircraft so it should be OK. So a quick engine start and the aircraft was taxiing for take off. Since Haverston was an uncontrolled airport there was no delay and the aircraft climbed for cruise altitude and headed home.

Right after they were airborne, the two passengers started an animated discussion of the business deal they had just completed. Mike was very interested and involved in the discussion and was flying mechanically. He had forgotten about his plans to air file and check the weather. Soon however, the environment outside brought Mike's attention back to more active consideration of the situation. It seems that the fine weather of earlier had turned sour. The aircraft was now flying above a solid undercast. Although Mike was not instrument rated he knew enough to do some basic instrument navigation. Turning on the VOR receiver he tuned in the home field VOR and started to home in on the signal. Once established, Mike then did what he should have done much earlier — he contacted the local FSS for weather for his destination. The news was not good. A fog bank had moved in and the field was below even instrument minimums.

Mike was just considering his options when one of the passengers asked, "Aren't those fuel gauges a lot lower than when we took off this morning?" A quick glance told Mike the bad news. Obviously, the attendant at Haverston had not fueled the aircraft as Mike had asked. Caught on preflight this would have been irritating and inconvenient, but now, with a solid undercast and their destination below minimums, the situation was serious.

At this point Mike was smart enough to swallow his pride and contact the air traffic control for that area. The controller was very professional but because Mike was so low he had difficulty picking him up on radar. Mike wasn't sure how to work the transponder and had some difficulty getting the proper codes set. Finally, the radar picked the aircraft up some 30 miles south of their destination. Unfortunately, it and every other field close by were below minimums. The closest open field was almost 200 miles away.

Mike was becoming seriously concerned. There didn't appear to be enough fuel to make it all the way to that alternate. In fact, there didn't seem to be enough fuel to do much of anything. Mike considered turning back to Haverston but by now it was getting dark and the prospect of landing on that short unlighted grass strip at night was not very appetizing. Nonetheless, it appeared to be the only solution left, so Mike advised ATC and asked for vectors back to the airport. There was no navaid for the field but the controller knew where it was and was able to give Mike a heading for a vector. It was quite dark as the little aircraft swung back to the south and began to retrace its route. The cockpit was very quiet. The excitement of a few hours before was gone — replaced by growing apprehension. Mike tried to remain calm and unconcerned, but he couldn't help glancing at those fuel gauges. You would almost think that there was a fuel leak, the way they were decreasing. It was rapidly becoming clear to Mike that they would never make it to Haverston. He only hoped that he could make it back to VMC before he had to make a forced landing.

The calm voice of the controller broke in on Mike's thoughts to advise him that Haverston was at 12 o'clock and 20 miles. The controller had alerted the owner and he was trying to light the field with lights from his pickup truck. Mike was just keying the microphone to acknowledge when the engine of the Cessna sputtered and coughed. Mike tried leaning the mixture even further but it was no use. The engine coughed again and then died. Mike was surprisingly calm as he declared an emergency and reported his position to ATC. He then set up a glide and began looking for a place to land.

It was about 9 p.m. when the president of the Aero Club got the call that one of the club's aircraft had crashed. The police dispatcher had no information on the pilot or passengers other than that there had been injuries — probably serious. The aircraft had crash-landed in a small field. There would not have been much damage except for the two small trees in the middle of the field. The aircraft struck the trees ripping off the left wing and flipping the aircraft over. The dispatcher commented that the passengers were lucky; there was no fire.

After he hung up, the Aero Club president stood staring at the phone for a few minutes. He was thinking of the message he had read just that day from AFMPC. The subject of that message was pilot responsibility. The really ironic part was that the message told of an aircraft accident at another club under circumstances almost exactly the same as Mike's. The president shook his head and, wondering what he could say to Mike's wife, picked up the phone and began to dial. ■

The photographs of composite components in Figures 2, 3, and 4 were provided through the courtesy of EDO Corporation (Fiber Science Division) and Lars & Associates, Inc.

The What and Why of FIBER COMPOSITE MATERIALS*

*Apologies to materials specialists for my scientifically imprecise explanations and analogies.

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■ "To arms, to arms, the composites are coming." Quick folks, snatch your beloved bulky, gas-guzzling, corroding, and wrinkled aircraft from their parking spaces or they will be grabbed up and changed by the composite people. Once that happens, they will never look or behave the same.

In the confusion of the rapidly changing aerospace industry, the term composite material keeps appearing and is the source of several misconceptions. Many people are asking what it is. Their impressions range everywhere from a form of plastic to some far out space material such as marvelinium. In reality, it is simply a combination of two or more distinctly different materials which exist together in separate phases. Concrete with reinforcing steel might be considered a composite. If you added chopped fiber particles to a molten plastic mix, you would have a composite once the plastic cured and took a rigid set. Perhaps, if you substitute the words composed of for composite, it will assist in your understanding.

Anyone who reads aviation trade publications or is a serious follower of experimental aircraft builders has become aware that there is a revolution taking place. The revolution is in the use of composite materials for aircraft construction. Sometimes we hear a reference to some new "plastic" airplane that is extremely light and strong. Many of the experimental homebuilt aircraft made today are mostly composite materials. A common form of composite you may be familiar with is fiber glass. It consists of several layers of a woven glass cloth laid into a mold with alternating layers of an epoxy resin. When the layup is complete, the pliable cloth and wet resin are pressed firmly into the mold and heated. After a few hours, the molded part becomes very rigid and can be drilled and cut to fit. This technique is used to form parts such as wheel covers, engine cowlings, flaps, control surfaces, and even wings.

Fiber glass is inexpensive and comparatively easy to work with; however, there are other materials which are stronger, lighter, and possess other more desirable qualities. Unfortunately, they are also far more difficult to manufacture, but the long-term rewards appear to justify their use. Three of the most commonly used materials are boron, graphite, and kevlar fiber. These were first used in the manufacture of golf clubs, skis, tennis racquets, racing bicycles, and automobile tire reinforcement cord. In time, it was found that with proper quality control these materials offered great promise for aircraft structure. At first, their use was limited to aircraft secondary structure, such as wheel doors, spoilers, speed brakes, fairings, etc., the types of components which, if failed in flight, would not seriously threaten the safety of the aircraft. Test and usage data, along with many improvements in manufacturing processes, have convinced the aircraft builders that these materials can now be safely used in primary airframe structure such as wings, fuselage, empennage, and control surfaces.

The F-15 and F-16 are presently the largest users of composites in the United States Air Force. The skins of the horizontal and vertical tail surfaces are boron epoxy and graphite epoxy for the F-15 and F-16, respectively. The F-15 speed brake is also graphite epoxy. The Navy F-18 and AV-8B are additional heavy users. The Space Shuttle cargo bay doors (Figure 1) are the largest single operational structure in use today. A savings of over 1,000 pounds was realized in that design. Since it costs approximately $15,000 to place each pound of weight into a low earth orbit, then there is a net savings of $15 million on each shuttle flight. Other areas of the Shuttle shown in Figure 1 also take advantage of the low weight and high strength of composites.

Several other applications are being evaluated. Tests indicate that the fatigue life of composite helicopter rotor blades (Figure 2) may be 60 times greater than a conventional metal blade. Figure 3 is a typical I-beam which may be used as a floor support for large aircraft or even form the basic wing spar in both large and small aircraft. Figure 4 is a door spring for a Boeing 767 which has three times the fatigue life, half the cost, and one-third the weight of a comparable metal spring.

Let's digress here to look at some simple analogies to show how composites work and the various forms you may encounter. Each of three principal types (boron, graphite, and kevlar) start out as a fine threadlike fiber. If you wished to bind someone's hands together, you could do it with only a few wraps of nylon thread. If you wished to make it even stronger, you could lay each strand tight alongside the previous one. Further, you could cover the wrap with a plastic glue and then add additional alternating wraps of thread and glue. When the glue has dried sufficiently, you have a very lightweight but formidable binding. Another form of the same procedure might be weaving the thread into a cloth and then wrapping the hands with alternating strips of cloth and glue. The thread and glue are separate and distinct

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Fig. 2
Section of UH-1D multi-tubular rotor blade.

Fig. 3
Lightweight composite graphite "I" beam.

Fig. 1

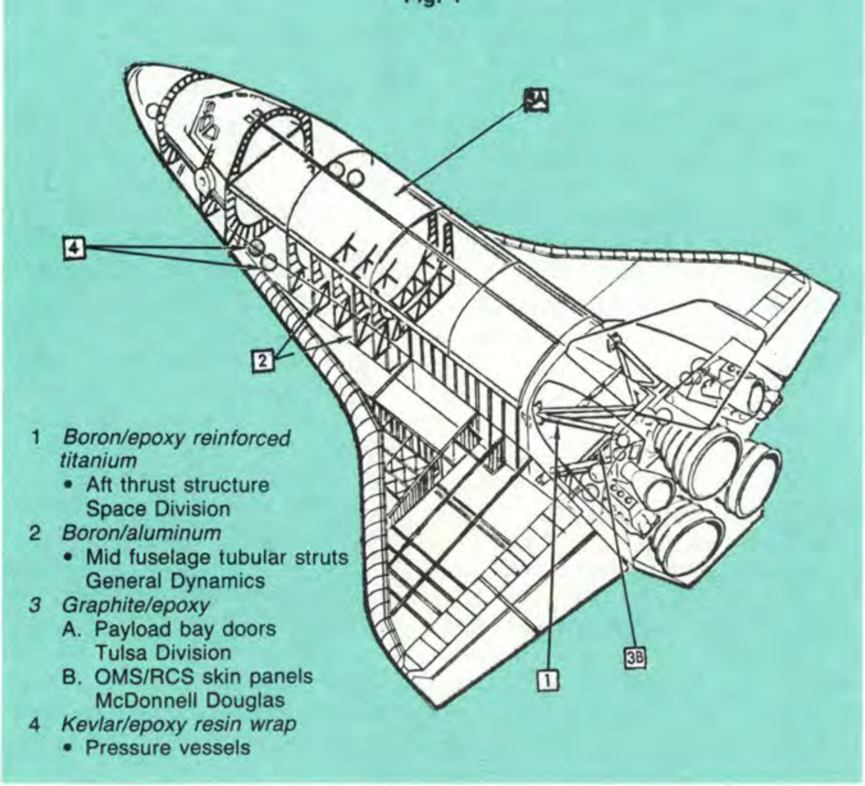

Fig. 4
Composite graphite spring designed for the doors of the Boeing 767.

The What and Why of FIBER COMPOSITE MATERIALS

continued

from each other but, when dried, jointly form a "composite" material. Now, if you replace the nylon thread with either boron, graphite, or kevlar fiber and replace the glue with an epoxy resin, you are very close to a typical aerospace composite material.

Since gluing and wrapping can become troublesome, the fiber manufacturers have found better ways to package their material. Usually, it is delivered to the airplane builder in large rolls of cloth-like material, ranging in width from ½ inch to 4 feet. To get rid of the gluing problem, these rolls, known as "prepreg," come preimpregnated with a controlled amount of epoxy resin which will remain soft and pliable as long as it is not exposed to heat which causes the resin to "cure" and set up rigid. The prepreg material is kept refrigerated when not in use. This pliable cloth is unrolled and stacked several layers deep on a flat table and cut into many patterns at one time by a computer-driven cutter, the same way a garment manufacturer cuts out 200 suits at one time. These patterns are then laid up one-by-one into a mold of the part you wish to make. The opposite mating half of the mold is put into place. The parts are forced together and heated to 250-350°F in a vacuum furnace. The heat and pressure cause the resin to flow and cure. When the rigid part is removed, it may be three times the strength of steel at one-third of the weight. High strength and low weight are "hog heaven" for the aircraft designer. Other great payoffs looming on the horizon are a 25 percent cost reduction in manufacturing and considerable reduction in maintenance.

The Lear Fan Company is currently undergoing flight certification of their Lear Fan commercial executive aircraft. Boeing Vertol is expecting to fly the model 360 advanced composite helicopter in November 1984, and a West German company is developing a two-seat aircraft known as Grob G 110. The automobile industry is pursuing this technology furiously. One well known sports car now uses a rear spring which reduced the weight from 42 pounds to 7 pounds, and the manufacturing costs by 70 percent. The composite flood has started and now we all have to learn how to stay afloat. New technology brings us wondrous things; it also brings its own new problems of which we must be aware and learn to respect. The following tables present a brief list of advantages and disadvantages of graphite epoxy material.

Advantages of Graphite Epoxy

- Very high strength; low weight.
- Very high stiffness (good for thin surfaces exposed to flutter environment).
- Less costly to manufacture.
- Considerably less susceptible to fatigue damage.
- 75 percent reduction in number of fasteners.
- 60 percent reduction in number of parts for typical assembly.
- Reduced maintenance.
- Near zero expansion/contraction with temperature changes.

Disadvantages of Graphite Epoxy

- Impact sensitive (dropped tools can cause hidden subsurface damage).
- Brittleness (cracking of the interlaminar epoxy).
- Difficult to inspect in service.
- Difficult to perform failure analysis.
- Requires drastic changes in design/manufacturing methods.
- Susceptible to causing galvanic corrosion with aluminum.
- Vulnerable to lightning strike damage (it's a nonconductor, so you must provide an electrical path).
- Questionable repair process/procedures.
- Very difficult to cut and drill in cured state (requires lasers, water jet, or carbide tools).

"With all these unknowns, should we really risk going to these materials?" This can be answered with an additional analogy. The auto industry has doubled the gas mileage of the automobile in the last 10 years. Most of this improvement has come through weight reductions of 20 to 30 percent of the typical car. Now, if someone offered you further weight reductions of 30 percent and at the same time promised to lower your manufacturing cost by 25 percent, would you be interested? There is little doubt that we will curse the problems attendant to composite materials for many years to come, but the potential rewards are too great to ignore. In the near future, you will see a reduction in the use of boron and an increase in the use of graphite and kevlar. One area where maintenance personnel can do themselves a world of good is to assure that the design development offices which are proposing to introduce these materials in fleet hardware also devote sufficient funding and design attention to maintenance, repair procedures, inspection criteria, and training. ■

HUMAN FACTORS
Information Needed

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■ Periodically, the cold hard facts associated with mishap experience force any critical analyst to the conclusion that the real problem in prevention lies in understanding and controlling human factors. It makes little difference whether mishaps evaluated are in the ground or flight arenas, the analyses which have been done demonstrate that the most common concomitant associated variables are errors of commission or omission, or the role of some human characteristic in the sequence which ultimately was a factor in the mishap.

This all pervasive factor encourages an increased interest in this area, but frustration associated with trying to become more definitive usually results in a decrease in interest and increased emphasis on the more tangible hardware areas. The variables associated with this area are so much easier to see, measure, and control that it is only natural that the hope persists that improvements in hardware will serve to solve the human problems. Unfortunately, this rarely happens. The result is a cyclical waxing and waning of interest in human factor considerations with not too much real progress in the area.

This cycle is currently being repeated with the observation that the cost of mishaps is increasing almost astronomically and the projection which shows that these costs will be even higher during the next few years. The 1982 cost of Class A mishaps approximated almost one-half billion dollars.

There is a sound business axiom which states that resources should be directed toward the problem which causes increased cost or failure. On this basis, it is apparent that if the cost of mishaps is to be reduced that there must once again be an attempt to come to grips with the human factor elements. It is not as though any great amount of resources have been expended in the past.

One has only to consider the integrated systematic and extensive amount of effort directed toward the hardware in a man/machine relationship and to compare this to the amounts directed toward the solution of human factor problems to see the gross disproportion in the amounts involved. This observation in itself is somewhat heartening. It means that easy hardware problems have most probably been solved and that major improvements in this area will probably be at greater cost. In the human factors area, by contrast, there is every reason to believe that a modest, consistent effort will, in fact, yield results in the form of both increased effectiveness and very substantial savings in mishaps experienced.

If then, a serious attempt is to be directed toward a human factor problem, the immediate question is, which human factor? From an accident prevention standpoint, safety boards are sometimes prone, having once isolated the problem as one associated with human

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Hardware fixes, no matter how elaborate, cannot solve human factors problems.

variables, to dismiss the matter from further consideration. Unlike hardware investigators who pursue the cause behind the cause to the ultimate source, the human factor assessment frequently stops at a very superficial level. It is apparent then that the first step needs to be a much more meticulous definition and documentation of the actual related factors on a much more precise basis.

This need for human factors information and its relative unavailability can be seen through an analysis of the critical problems of any period. At the moment, some areas of concern are low level flying, the introduction of new complements of crewmembers into the system, and improvements in the man/machine interface. In all of these areas, questions have been asked which either past mishaps experience or some basic information about human behavior should have answered but has not.

In the low level realm, for example, there are many questions regarding the best method of training to assure maximum effectiveness with the minimum potential for mishaps. To date, this program has been only minimally engaged, with the greatest effort perhaps having been exerted by the Air National Guard. In considering the introduction of a modified crew force, the actual role of size and strength has been most inadequately documented in past mishap experience.

The changing approach to instrument presentations including the use of color brings into clear focus the deficiencies in knowledge about exactly what kind and amount of information do crewmembers need to perform their tasks most efficiently and safely. And further, what is the best method of presenting this information. The role which stress and personal problems have as causative factors in mishaps is also an area which needs attention.

Another current concern is crew selection. With the probability of a track system in UPT, it would be highly desirable if the characteristics of crewmembers best suited for various kinds of equipment could be determined. In actual fact, the profile of a good pilot for any kind of aircraft which then might in turn be used for selection has been very inadequately developed.

It is certainly not unreasonable to expect, however, that past mishap experience should have provided information in all of these areas as well as in others. The facts are that there is insufficient information available to provide clear cut guidance to those making decisions in any of these problem areas.

In reality, decisionmakers will be forced to come to grips with all of the problems mentioned, and others, with or without the information which could have been provided from mishap experience. Decisions will be made which could

The message is simple. To improve long term mishap prevention and operational effectiveness, improve the quality of human factors investigations.

have been done better if the information had been available. It is apparent then that some steps must be taken to assure that the next generation of decisionmakers have more definitive human factor information to use in making the choices required of them.

The long suffering flight surgeon who has struggled through the multiple pages of the Air Force's 711gA or some comparable form may think that the requirement for additional effort is the straw that broke the camel's back and be inclined to add the minimum of additional information in some narrative form. In actual fact, in spite of the great quantity of information currently collected, one reviewing the reports often finds that the basic answer to what caused the mishap or the injury in meaningful terms has not been included.

One difficulty arises from the fact that if it were precisely known which questions should be asked, there would be little need for asking them. The importance of these items would already be established. Because what to ask is not known, it then becomes necessary to develop a general summary covering a variety of broad areas in some sequential form in the hope the analysis of accumulations of these data will provide insights not previously developed.

To repeat, the major cause of aircraft mishaps is some human failure. This failure may involve anyone from the designer to the operator but because the operator is in such close proximity in time to the event, it is his errors that are most frequently noted. These errors may relate to deficiencies in the man/machine interface or the inability to cope with the situation as it exists. Evidence is mounting which suggests, however, that more subtle and dynamic factors associated with the individual's personal limitations, background, or lifestyle are involved.

The Air Force has embarked upon some efforts which should result in a suggested human factors investigator's outline. The Form 711gA for the medical officer's report is being revised, and with the current emphasis on human factors information, it is almost inevitable that there will be other suggested approaches. These serve a valuable purpose. Without them, the systematic accumulation of data so necessary to define some of the variables in mishap causation is not possible.

There should be some cautions added, however. One of these is that full compliance with the requirements of the formal checklist or procedures will not guarantee the answer to the all important question of what caused the mishap. This frequently is hidden in information requested and information which would normally not be accumulated and must therefore be addressed in addition to the formal requirements. This dictates a need to explore possibilities in an open-

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The key to effective mishap prevention is understanding and controlling human factors.

The first critical step is documentation of human factors variables by the investigators.

ended way to assure that related information is developed. There was, for example, one mishap in which an aircraft struck a mountain. Considerable discussion developed on why an experienced pilot violated a number of directives in weather in an area of known hazard. A fact never included at any point in the report was that one of the crewmember's wives was expecting a baby at any moment and that the pilot was doing his best to get the expectant father to the event.

While this circumstance was almost inevitably the background cause of the errors in the mishap cited, there is frequently no way of documenting the actual role which observed tension or personal pressures played in the mishap. This brings into focus another consideration, namely, that association is not causation. Even frequent association can be considered causation only if the association in mishap experience can be determined to be different from association in the population as a whole. Only then can any degree of credence be given to assumptions that some observed personal problem was probably causative. Nowhere other than the human factor area, is this baseline so critical and probably in no other are there fewer baseline measures available.

If true mishap prevention is to be the result of mishap investigation, these definitive differences must be determined. This is not ordinarily the role of the investigators, but represents a deficiency in the general area which needs to be remedied. Only then will the investigator's painstaking efforts produce maximum benefit.

As was indicated in the initial portion of this discussion, decision-makers and managers are constantly seeking advice as to the best decision to make. Frequently, this involves some kind of human factor information. It is unfortunate that there are few centers where this kind of summarized information together with the best available conclusions can be obtained. More frequently, it is obtained from a project officer, if one can be found, or in some cases a computer tabulation is developed without appropriate evaluation or summarization.

Decisions are made almost daily in the human factors area by those ill prepared to make them, because members of the human factor community are either not available or unwilling to commit themselves to recommendations on the basis of what is known without another long term study. The decision-makers in the meantime have long since made the decision without benefit of expert guidance and the study is then conducted in a vacuum.

The Air Force has consistently considered human factors to include the entire spectrum of human capabilities and limitations as these are pertinent to the sucessful accomplishment of an operational mission and as they are related to a threat in the form of mishaps. The more restricted approach used by some agencies which would equate human factor to human factors engineering or ergonomics is not inclusive enough for the real world of mishap prevention.

Deficiencies in human information as defined above need remedial effort. The first and critical step is the documentation and quantification of those human factor variables associated with mishap occurrences. This is the role of the investigator. Without this, the remaining steps of analysis and use are impossible. The message is straightforward and simple. Maximize the effectiveness of investigation in the human factor area for the greatest probability of improvement in long term mishap prevention and operational efficiency. ■

Stress, Life Quality, And Aviation Safety

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■ Imagine that you have never before seen or heard of the automobile. One day a stranger calls you over, leads you around a fence, and there it is, a shiny, four-wheel contraption. He gives you a key, briefs you on the way internal combustion engines can wear out and rushes off. You're left standing there wondering if that's all there is to know about a car, since that's all you've been told.

Often the subject of stress is approached in the same way; generally, out of context and, too quickly. The human mind and human body are inextricably linked through needs (real and perceived), motivations, motivational conflict, emotions, experience, and logic (both true and faulty).

All human qualities are connected in one way or another with all others. Therefore, to discuss "stress" as an isolated entity is to imply that it is well defined, and can be separated neatly from other aspects of the mind and body . . . like a section lifted neatly from an orange. It would be more like discussing the wear characteristics of an engine while glossing over the functional relationship of the engine to all other parts of the car.

Members of the flight safety community (flight surgeons, aerospace physiologists, human factors specialists and flight safety officers, to name a few) are being exposed to concepts that go beyond the simplified, isolated descriptions of stress as the Air Force approach to human factors in aviation becomes more encompassing. Their concern with stress in the aviation community is legitimate, because stress can easily develop into a major source of risk in aircrew members. Stated simply, stress is a safety problem. Let me explain how this works.

While a new aircraft is being designed, engineers work not only with the experts in the proposed mission of the product, but also with human factors experts. This is to ensure that the physical arrangement and subsequent workloads of the cockpit (controls, instruments, systems gauges, warning indicators, etc.) are within the physical and mental capabilities of the persons expected to fly it. The relationship of the cockpit/flight deck arrangements to the pilot or crewmembers is referred to as the

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"man-machine interface."

Of the many variables considered during the establishment of this interface the greatest is attention. Nothing in the man-machine interface can change so rapidly as a person's attention.

A crewmember's focus of attention must be shifted rapidly from object to object in the cockpit, but every time that shift takes place there exists the possibility that attention will shift to the wrong object, be held on the next object too long, that the information presented will be seen but not be fully understood or appreciated, or that a change in the situation will take place somewhere else outside the margin of attention and not be noticed at all.

What does this have to do with stress? Everything. Stress can interfere with your ability to attend to what you're doing in an airplane. It can distract you, cause you to give one isolated area your undivided attention when your attention needs to be distributed, and can cause you to revert to old and inappropriate habit patterns. It reduces your ability to respond properly, either in a normal situation or in a crisis. That's why stress is a safety problem.

A buildup of stress in your life, from whatever souce or combination of sources, can ravage your personal life, render you inefficient or dangerous on the job, make you sick and possibly, directly or indirectly, kill you. So let's discuss stress. I won't emphasize the self-imposed kind that we physiologists harp about so often, but rather the kind you cannot prevent or ignore and which you must deal with effectively.

Let's start with some definitions.

- Mechanical Stress. An applied force or system of forces that tends to strain or deform a body.
- Psychological Stress. A mentally or emotionally disruptive or disquieting influence. A stimulus that evokes a response.

As you can tell from these definitions, to understand stress we must understand cause and effect. This is simple, perhaps obvious. What is not obvious is that it also requires an understanding of attention and emotion — very normal aspects of our daily lives. As with mechanical stress, psychological stress must evoke a response.

We recognize events, situations or

conditions through our attention, evaluate them through some complex thought processes, and judge whether or not to respond, and if so, how. If the event, situation or condition means nothing to you, does not affect you or requires no response, it is not a stress. If it evokes any emotion or an attempt to respond in any way, it becomes a stress until it is resolved. For example, an oil pressure gauge which indicates oil pressure within normal limits requires no response and is therefore no stress. An out of limits indication requires additional attention, evaluation, and response and, therefore, would be considered a stress.

A stress can be situational. A landing gear handle in the up position at cruise altitude is not a stress. The same condition noticed in another situation, such as the landing flare, would be a considerable stress. If your attempt to respond is effective, the stress will be eliminated or reduced; if ineffective, it will remain unchanged or get worse. The ineffective response may further result in another attempt to respond, a modified response, confusion, frustration, disorganization, emotion or a combination of these. The psychology and physiology of emotion has such great bearing on the subject of stress that it warrants detailed attention.

Emotion is a normal part of life. We are emotional beings by nature, and we must look hard to find any aspect of our lives that is not touched by emotion.

Increased frequency and intensity of emotional outbursts is a common sign of stress. Negative emotion can arise from a marginally effective or ineffective response to a stress. Positive emotion and excitement (relief, joy) can result from an effective response. This emotional component of stress is more pronounced in some people (so-called "hot reactors") than others and can have myriad effects.

The most important effect is a narrowing or focusing of attention, the degree of which depends on the intensity of the emotion. This narrowed focus is a normal and necessary part of the "fight or flight" response to threat, which has its place when there is a burglar in the house, or when you're confronted by a starving tiger, but it is of little help to us in potentially frustrating situations found in the airplane, scheduling meetings, or counseling sessions.

The net result of very narrow attention in situations requiring a distribution of attention and mental agility is that it prevents us from considering likely alternatives, noticing changes in the situation that require an adjustment in our thinking, or recognizing additional problems or threats arriving from other areas. This is a safety problem from both a planning and operations standpoint. There are yet other dangers to the individual who is exposed to the emotional effects of stress. These are the short-term and long-term effects of stress on health.

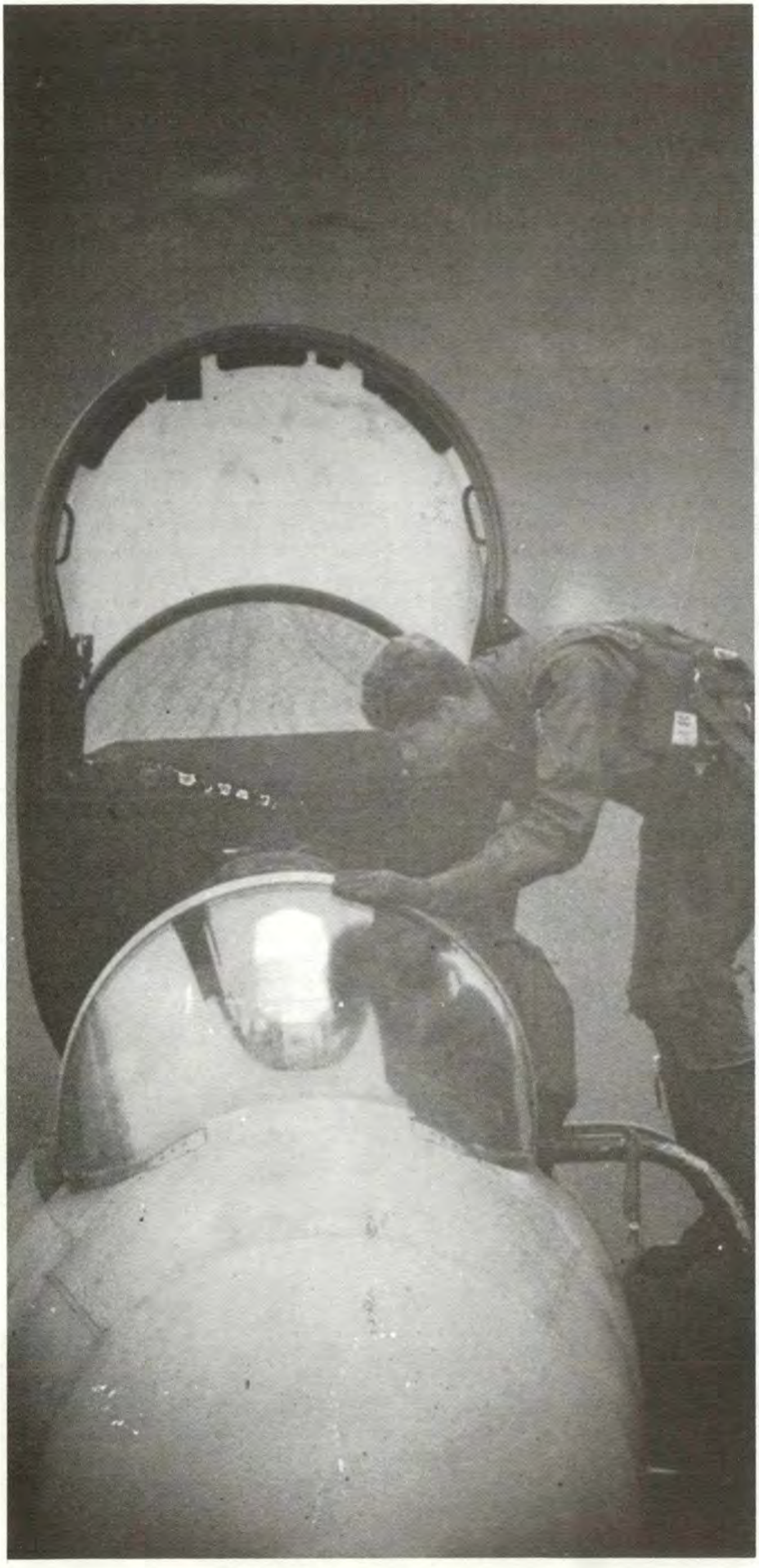
When we are exposed to a fight-or-flight situation, our insides are flooded with chemical messengers which prepare our bodies to meet a rigorous physical test. Some of these chemicals, it turns out, are destructive to body tissues and repeated exposure to them can have long lasting physical effects. Among the physical symptoms of stress we find fatigue, which will usually last as long as the stress lasts.

As time goes on and our exposure to difficult and taxing situations increases without a break, our resting blood pressure increases as well as our rate of arteriosclerosis (hardening of the arteries). The result can be heart damage and heart attack. Depression of the immune system, leading to increase in disease and infection ranging from colds to tuberculosis and cancer, is also a demonstrated and direct result of stress, especially in very emotional stress over which we have little or no control. And, of course, let us not forget the trademark illness of stress — the peptic ulcer.

Emotional anxiety is a common psychological reaction to stress

continued

Stress can be situational. Your wingman sighting a "bogie" at 7 o'clock high may not be particularly stressful over the plains of Texas, but it certainly could be during a "flag" mission. Stress causes a narrowing or "sharpening" of attention. We tend to focus only on the stressor. In an aircraft such channelized attention has been and will continue to be a killer.



Stress,

when that stress is associated with a fear — fear of pain, humiliation, etc. Anxiety is simply a state of uneasiness and distress about future uncertainties. It's apprehension, worry, dread. You don't know what's going to happen but you expect it to be bad. We all experience this occasionally as a result of the usual stresses associated with living. (Anxiety has also been referred to as "nerves.")

There are mature and immature psychological reactions to stress.

As you would expect, the immature stress-induced psychological reactions tend to be on the highly emotional side — hostile, aggressive, or antagonistic behavior. Escape devices are common reactions of people inexperienced in dealing with stress situations, but are also manifested in some people under a great deal of pressure, regardless of experience level.

Escape devices are used when other methods of reducing or overcoming stress are not known or for some reason are not working. The most serious reactions to stress include neurotic fatigue, depression and psychosomatic illness; however, these latter reactions are very rare in aircrew members and safety is usually compromised well before they occur.

Now that you know what stress is, and what it can do to you, you might want to know some effective ways of dealing with it.

By this time you may have the mistaken impression that all stress is bad. It's not really. Stress is a necessary part of our lives. It provokes the behaviors that make life possible, rewarding and happy as well as occasionally causing us ulcers, headaches, illness, fear, and fatigue. The problems with stress occur when it is piled on too heavily or when it is of a highly emotional and uncontrollable nature, such as illness, injury, or death of a family member, etc.

The first thing you must do is to recognize the sources of stress in your life. At the beginning of this article I promised not to harp on self-imposed stresses, so I won't. I will, however, mention them; excessive or poorly timed consumption of alcohol, smoking, over-the-counter drugs (self-medication prior to flight), failure to eat properly, and failure to obtain rest and sleep. But these stresses are controllable. Most of the persistent stress problems for aviators arise from environmentally-imposed stress from three major sources; from life in general (family worries or conflicts, social and peer pressures, financial situation, etc.); flight stress (noise, vibration, extremes of temperature, G-forces, physical restriction, poor circulation due to confinement, discomfort, hunger, thirst, elimination, circadian desynchronization and resulting fatigue); and job or task stress (checklist tasks, mission, mission changes, bad or deteriorating weather, "glitches," emergencies, additional duties, unit morale, and interpersonal relationships).

You surely have ways of dealing with many of these stresses, but how well will your techniques work when the stress is really loaded on? I'm sure those of you who have faced troubles in volume from various sources will agree that the constant pressure, dread and feeling of marginal (or total lack of) control arising from these situations can pervade your thoughts.

I mentioned earlier how emotion narrows your focus of attention. This, in effect, amplifies the stress as well as reduces your ability to cope with it. Therefore, a key to dealing with stress is *emotional control*. We may not be able to eliminate emotion, and on the positive side emotion can give us a sense of urgency in our performance when we're confronted by threat or challenge. However, we must avoid a strong emotional reaction when we are required to perform demanding tasks requiring skill and coordination. Strong emotion reduces skillful and coordinated effort. Emotional control comes from conscious effort and experience (practice). Be aware of the emotional issues that get you going and be careful about how you react.

The subject of emotional support deserves mention at this point. The benefit of emotional support (from spouse, family, friends, etc.) cannot be overestimated. Good management of your personal life is of paramount importance. Dr. Frank Dully, a Navy flight surgeon and expert in the field of human factors in aviation, points out that emotional support is a two-way street. Life is full of examples, as Dr. Dully puts it, of "the man who has always placed his family second to his career, and, upon the occasion of his first failure, turns to his family for support and is told to pack it." In everyday affairs we try to keep personal problems and our jobs separate. If you want to avoid serious stress problems as relates to emotional control and emotional support, a good place to begin is at home.

A build-up of stress can ravage your personal life, make you inefficient or dangerous on the job, make you sick, or possibly even kill you.

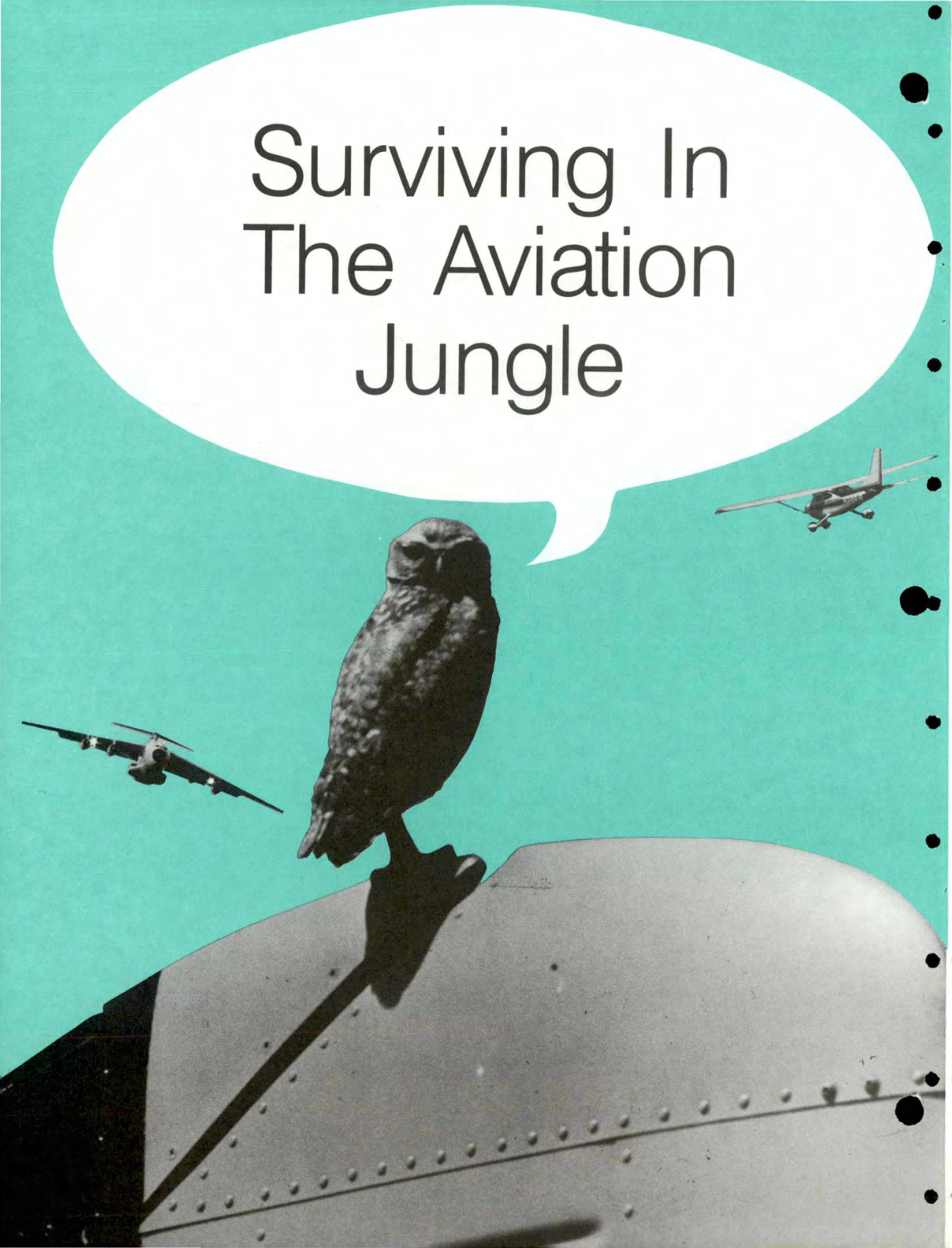
The best and easiest way to tone down the physical and psychological effects of stress is, of course, to control the stress. The greater ability you have to do your job, the less stressful are those challenges, changes, and unforeseen circumstances. According to Lt Col Don Baines, a widely acknowledged authority on stress management, lack of confidence in one's ability to do one's job is a leading cause of work-related stress. His advice aimed at countering this is to work especially hard when you get a new job. Jump in there, get your feet wet, become an expert, an authority. Then that will be that.

Another area of attention is your stress tolerance level, which can be simply defined as your ability to deal effectively with and withstand the physical effects of stress. Often referred to as an individual's "capability," you could say it is a combined measure of your ability and toughness. It is a function of your education, experience, intelligence, personality, foresight, insight, faith, interests, attitude, confidence, physical condition, diet, fatigue level, and emotional state. In other words, it is who and what you are. It is everything we've discussed to this point. Improve on any of these areas and you'll reduce your susceptibility to stress.

Remember that stress is cumulative. A high stress load makes it tough to deal with other stresses. In the face of great stress your only option may be to limit your exposure to further stress. In the aviation world this may include temporary grounding. Take special measures to maintain strong resistance to disease. Eat right, rest well, stay in good physical condition, and seek support and counsel following emotional trauma.

Finally, you must know yourself, be aware of your capabilities, and build them methodically. Look for new and rewarding challenges, yes, but don't get in over your head. Take on additional responsibilities only when you're reasonably sure you can do them justice. The road to success is traveled in increments between rests. In addition to regular vacations, you may find it helpful to take some time to relax and meditate every day for 15 to 20 minutes. And don't forget your ultimate goals. I like the way Lt Col Baines puts it; "Remember why you got into the rat race in the first place. If it was to enjoy life, then enjoy it!"

It is reasonable to assume that most people ultimately seek happiness. Enjoying life on the way will make the trip seem much shorter. One key to this, stress management, not only makes it easier to enjoy the trip, but places the ultimate goals of success and happiness more within your grasp. ■


Surviving In The Aviation Jungle

The vast majority of aviation activity in the United States involves general aviation aircraft and pilots operating primarily under VFR. Military pilots must also know and understand these rules for we share the air with our general aviation counterparts.

CAPTAIN GREG TREBON
HQ MAC/DOXS
Scott AFB, IL

■ There are approximately 200,000 aircraft in the United States. Of that number only 5 percent are military/airline aircraft. The remaining 195,000 are classified as general aviation aircraft or "bugsmashers" as some military pilots refer to them.

General aviation aircraft are typically small, single-engine aircraft. However, they fly 84 percent of the total hours flown annually in this country and, surprisingly, carry 60 percent of the passengers transported intercity by air.

The vast majority of general aviation pilots operate according to visual flight rules (VFR). VFR is something unfamiliar to most military pilots because, by directive, we use instrument flight rules (IFR) to the maximum extent possible. Let's talk about visual flight rules and how civilian pilots operate in accordance with them.

The basis of VFR flying is keeping the aircraft in weather conditions which allow the pilot to maintain aircraft control by visual outside references and to visually avoid other aircraft. To that end, the FAA has established certain weather minimums for VFR operations and published them in FAR Part 91. Our 60-16 largely duplicates FAR Part 91 but there are many exceptions.

To understand the FAA VFR minimums you have to understand that there are really two sets of VFR minimums — one which applies to VFR operations in uncontrolled airspace and one which applies to controlled airspace.

So what is controlled and what is uncontrolled airspace, anyway? Open up a DOD enroute low altitude chart. All of the area depicted in white is considered controlled from 1,200′ AGL up. The areas depicted in brown are uncontrolled from the surface to 14,500′. If you are in an airport traffic area or control zone, controlled airspace does not begin at 1,200′ AGL but goes all the way to the surface. Confused? Just remember that controlled versus uncontrolled airspace has nothing to do with ATC. It simply tells you what FAA VFR weather minimums apply. First a refresher on controlled airspace.

A control zone is an area around an airport depicted by a dashed line. Generally, it is of a 5-mile radius with extensions for final approach segments and occurs at an airport that has either a tower or an instrument approach. As always, there are many exceptions. All a control zone does is extend controlled airspace to the surface where it would otherwise stop at 1,200′ AGL. This is so that weather minimums for VFR flight in controlled airspace apply for all flight operations from the surface on up. Why? Because VFR weather minimums for controlled airspace are much more restrictive.

An airport traffic area (ATA) is an area within a 5-mile radius and from the surface to 3,000′ AGL of an airport which has a tower in operation. If the tower is closed for the evening then there is no ATA.

A terminal control area (TCA) is designated airspace around the busier terminal areas where restrictions are placed on VFR operations.

What all this means is that ATA's, TCA's, and control zones all make up what we refer to as controlled airspace, and the following weather minimums apply for VFR operations.

▪ *Take off and landing* Visibility minimum, 3 statute miles, ceiling 1,000′ AGL minimum. (60-16 standards = 1,500 and 3)

▪ *Enroute* (Below 10,000′) 500′ below, 1,000′ above, 2,000 laterally from any clouds and a vis of 3 miles.

(Above 10,000′) 1,000′ below, 1,000′ above, 1 mile laterally from the clouds and an in-flight visibility of 5 miles.

That's all pretty straightforward and familiar to most of us. But what we may not be familiar with is the VFR weather minimums for uncontrolled airspace.

You are in uncontrolled airspace when you are not in a control zone, ATA, TCA, or when you are below 1,200′ AGL in the areas depicted in white on low altitude charts. If you are in a brown area on your low altitude chart the following weather minimums apply: clear of clouds and an in-flight visibility of one statute mile. If you are above 1,200′ AGL and less than 10,000′ MSL then you must maintain one mile in-flight visibility and separate yourself from the clouds by 500′ below, 1,000′ above, and 2,000′ laterally. This means that you can legally take off from Rancho California airport and fly VFR if the weather is 500 and one if you stay below 1,200′ AGL.

Special VFR is a clearance granted to VFR pilots on request which allows them to apply VFR weather minimums for uncontrolled airspace to controlled airspace. If you were flying VFR into Norton AFB, for example, and the weather were less than 1,000 and three you could request a special VFR clearance into the control zone and, when granted, it would allow you to legal-

continued

ly operate VFR and land as long as you maintained clear of clouds and with an in-flight visibility of one mile.

When flying, VFR, some prefer to navigate by pilotage or dead reckoning. The majority of pilots seem to favor using the Victor Airway System. Air Force regs discourage the use of VFR for military aircraft on Victor Airways. However, it is quite the norm for civilian pilots to do so.

When you are below 3,000′ AGL anywhere there are no required enroute altitudes that must be maintained during VFR cruise. A VFR pilot can fly any altitude below 3,000′ AGL. (How much of the time on locals and low levels are we operating below 3,000′ AGL?)

Above 3,000′ AGL the VFR hemispherical cruise altitudes are required to be flown, i.e., 5,500′, 6,500′, etc., depending on your direction of flight. A couple of points should be emphasized with regard to the amount of time a general aviation pilot may spend at his correct hemispherical cruise altitude.

Most light, single-engine aircraft are only capable of between 500 and 1,000 fpm rate of climb at gross weight, while climb rates of 3 to 4,000 fpm are not uncommon for military jets. Also, most big jets make what amounts to an idle power descent. You will seldom, if ever, find a piston pilot doing the same. Why? Because the rapid cylinder head cooling that would result from such a descent would be hazardous to the engine's health, and when you are paying the maintenance bills yourself you pay close attention to such details. As a result most general aviation pilots will make a gradual "cruise power" descent to maximize ground speed and avoid overcooling their engine(s). These two things: slow climb performance and gradual descents, mean that a general aviation pilot spends a disproportionate amount of time off the VFR hemispherical altitude and a lot of time climbing or descending through IFR altitudes.

Terminal radar service areas (TRSA's) are areas established around relatively busy flying areas to provide a radar service for VFR aircraft. Most military pilots remember something about Stage III service being mandatory for military aircraft to the maximum extent possible. It does not affect IFR operations. What it does is enable those civilians who choose to request the service to receive radar sequencing and it will guarantee them traffic separation from other participating VFR aircraft and all IFR aircraft. But, while it is mandatory for Air Force aircraft to participate in Stage III TRSA's, it is *not* mandatory for civilians. Probably only 30 to 40 percent of them participate for various reasons.

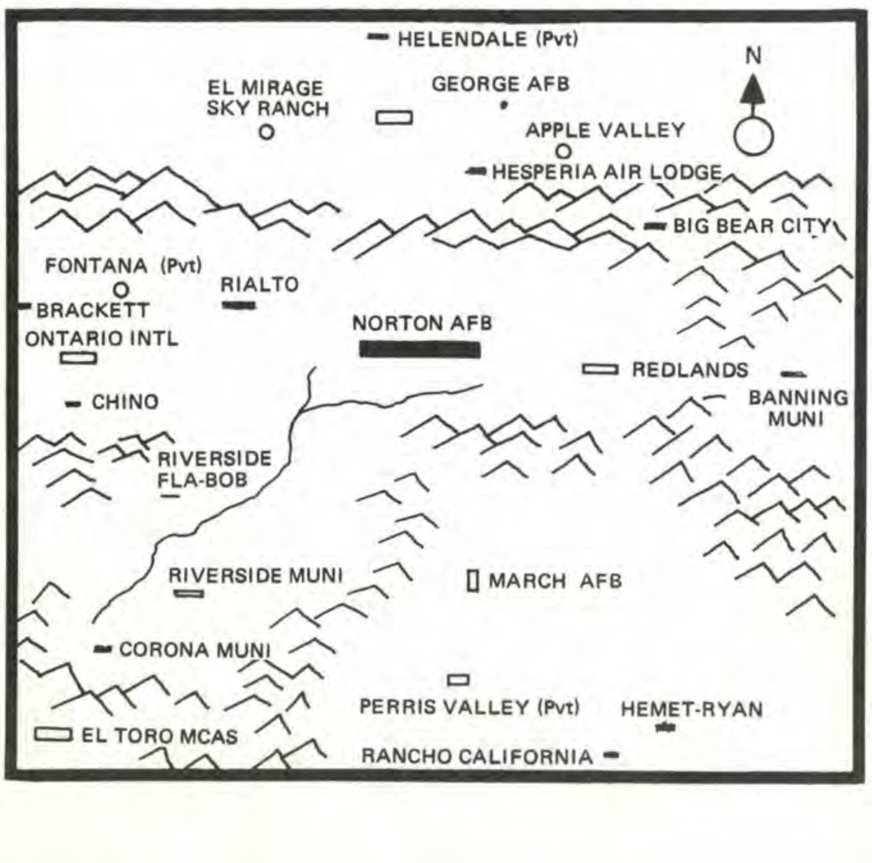
Terminal control areas (TCA's) are the biggies — for VFR aircraft, that is. Basically, they have no effect on IFR aircraft but they tend to severely restrict VFR operations. TCA's have two levels called groups. Group one TCA's are the most restrictive on VFR operations (LAX, Chicago, etc.). Let's look at group one TCA's and how they affect VFR operations.

Basically, a TCA is a large "upside down" wedding cake chunk of airspace around major terminals. Operationally, the rules are very similar to the PCA (above 18,000′) for the VFR pilot. A VFR pilot must have two-way radio communication, a VHF Nav receiver, a transponder with encoding altimeter, and at least a private pilot's license and a clearance to enter a group one TCA. All of these things tend to scare away many general aviation pilots from operating in TCA's.

How To Avoid A Midair

Now that we have all of this new knowledge, let's put it to work to help avoid a midair confrontation. I will use a C-141 operation at Norton AFB to illustrate. By the way, there are 26 general aviation airports with 3,000 aircraft flown by over 9,000 pilots within 40 NM of Norton AFB.

Is there a problem? Look at this map of the Norton AFB area. Within 40 NM of Norton there are 26 general aviation airports with 3,000 aircraft and over 9,000 pilots.



When you are flying the C-141 in the local area on the IFR clearance, very little of your time airborne is spent in "protected airspace." By protected I mean those times when you can be reasonably sure you'll be made aware of all aircraft that may be a potential conflict with you and/or that you will be separated from these aircraft by ATC. If you are operating on an IFR clearance and flying in IMC conditions, you can be reasonably confident that ATC will keep you separated from other aircraft.

However, if you are operating on an IFR clearance in VMC conditions in the Norton local area, the *only* time you can consider yourself to be in protected airspace is when you are operating in an airport traffic area (5-mile radius and below 3,000' AGL). While the tower may not be able to provide radar advisories (depending on their equipment), they should keep you aware of any other traffic they are working and sequence you accordingly.

But we don't spend too much time in the clouds around here and even less time within 5 miles of a tower controlled field. So, as a result, we spend the majority of our time in airspace where we have no guarantee, beyond our own ability to see and avoid VFR traffic, that separation will be provided with any of the 3,000 general aviation aircraft that share our local airspace.

Even though you're talking and squawking and complying with an ATC clearance, if you are in VMC conditions it is see and avoid and every aircraft has an equal/legal right to the chunk of airspace you are in. See and avoid the VMC puts the responsibility for collision avoidance squarely on the pilot's shoulders.

And you can't avoid if you don't see. You won't see if you don't look! General aviation pilots are looking, believe me. They are looking much more than we are because they are maintaining aircraft control and navigating visually. Also, their minimal cockpit workload allows them more time to look.

On the other hand, we in the C-141 don't look as much because we are busy. One pilot is typically on the gauges while the IP is tasked with running checklists, talking on the radios, monitoring/critiquing the approach, etc. If we were looking outside a little more we would see that our vectors are aiming us right at general aviation in many cases. For example, if you get vectored from BANDS (one of our fixes) for a right turn on to an ILS final at Norton, the vector will take you right over Riverside Muni and Flabob Airport at 3,000' AGL or so.

Flying the CAM departure out of Norton, you keep your airplane on the deck while you rapidly accelerate to your rejoin airspeed and turn to 130. That one will have you flying through Redlands downwind (which is north of their airfield for noise abatement) at or slightly above their pattern altitude. Make a big right hand turn into holding at the March VOR. That goes right over the world's busiest parachuting operation at Perris Airport (30,000 jumps a year from 14,500' MSL and below!) If you are vectored off of the Berdu Arrival for a left hand downwind for an ILS at Norton you will be doing 250 KCAS, several thousand feet per minute down, looking into the smog and setting sun as you overfly Rialto Airport. I would like to rename that procedure the kamakazie one arrival!

And, don't be lulled into a sense of complacency because Approach occasionally calls out VFR traffic to you. Reporting VFR traffic to IFR aircraft is very low on their duty priority list. Also, remember that transponders are not required on VFR aircraft. No official figures here but I would estimate that less than 50 percent of the 3,000 local aircraft have transponders installed. And what exactly is Approach telling you when he calls out VFR traffic, anyway?

"MAC 001 VFR traffic 12 o'clock 2 miles no altitude."

This means that the controller is either skin painting (no transponder) an aircraft or has a 1200 squawk that has no encoded altitude (no Mode C).

"MAC 001 VFR traffic 12 o'clock 2 miles, 8,500', not verified."

This means the controller is receiving a 1200 squawk with an altitude readout but is not talking to the aircraft, hence "the altitude is not verified."

"MAC 001 VFR traffic 12 o'clock 2 miles 9,500 feet."

This means the controller is in contact with your traffic — an aircraft at 9,500', so the altitude has been verified.

Lastly, let us review a few possible VFR/IFR traffic conflict situations and see who has the right of way, who is legal, and why the situation could happen in the first place?

You are approaching Pettis (the FAF) on the localizer at 3,200 feet MSL when you see a light Cessna at your altitude crossing from right to left one-half mile or so in front of you!

Scary — yes! Violate him? No. If a collision were to occur you would both be at fault. Why? If it is VMC outside it is both pilots' responsibili-

continued

Surviving In The Aviation Jungle continued

ty to see and avoid the other. How can it be legal for the Cessna to be there. I mean 3,200′ over Pettis! No way! Well, he is outside Norton's airport traffic area (5 nm from the field) so he doesn't have to talk to the Tower. He is flying below 3,000′ AGL so there are no required or recommended VFR altitudes to be maintained.

Why isn't he talking to Ontario Approach? Ontario has only a TRSA with Stage III service which is not mandatory for civilians and since the controllers' strike it has been a lot harder to get even if a VFR aircraft requested it. OK, OK, it is legal, but why is he there? Doesn't he know that Pettis is the FAF for Norton's ILS? Nowhere on the guy's VFR map does it show Pettis as an ILS FAF or in any way warn a guy that it is on a final approach course. Why is he there? If you are flying anywhere north of the valley from the Riverside, Corona, or Flabob Airports, you will most likely have to go through the Cajon Pass because your aircraft does not have the capability to climb above the mountains in the short distance required.

- You're on Victor 16 proceeding from Palm Springs to Paradise IFR at 12,000′. All of a sudden a light twin passes you head on a mere 500′ below you. Five hundred feet is what the safety guys consider a near miss. But was it? If you are VFR eastbound you fly odd thousands plus 500′, i.e., 11,500′. Remember, even though it is not recommended for Air Force aircraft to fly VFR on Victor Airways it is legal and quite the norm for civilians to do so. And what if you were 100′ low and the other aircraft was 100′ high?

- You are leading your six-ship on the CAM TWO departure. You are blocking 9 to 10 outbound from Paradise on the 130 radial just approaching the 26-mile fix when all of a sudden a group of 30 skydivers falls past your left wingtip. Talk about a FOD problem! Shortly thereafter you feel a little turbulence and look out to notice that you have just flown through a thermal which contained three sailplanes and four hang gliders. Never happen? Wrong. You just flew directly over one of the world's busiest sport aviation centers at Elsinore. You call LA and try to raise hell about the controller not calling the traffic to you and he politely informs you that he is not talking to any of them (not required to either). Furthermore, he adds that he can't even skin paint hang gliders, fiberglass sailplanes, or humans in freefall.

What can we do as pilots to avoid the disaster of a midair?

- Educate yourself about those you share the skies with and where they legitimately operate.
- Adjust your flying habits. Avoid flying locals in the valley when the smog sets in. Go up to the desert and sacrifice some training time for safety if you have to.
- Critique — tell Approach you didn't like that vector over a busy general aviation airport. If you see an approach procedure, SID, or GCA pattern that sets you up for a midair — report it!
- Clear — you've gotta look, all of you including pilots, jumpseat, engineer, nav seat. When it's VMC use the ol' composite cross check — 80 percent outside and 20 percent inside. Pilots, move your heads and not just your eyes. Those center windshield posts will hide a 747 at 2 miles! Look all of the time, too; not just when the radar controller reports traffic to you. He doesn't even see half of them out there.
- Check your attitude — it is not us against them. Just because we are the airborne semi-truck drivers we have no more right to the airspace than the general aviation pilots (this goes for WGFPs*, too). Understand their capabilities, equipment limitations, varied experience levels, and most of all, their inalienable right to be there, too! ■

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U.S. GOVERNMENT PRINTING OFFICE: 1984 — 783-026/15

FIRST LIEUTENANT
Patrick M. Mooney

FIRST LIEUTENANT
Mark C. Perkins

MASTER SERGEANT
Clifford M. Peckens

SENIOR AIRMAN
William A. Norz

601st Tactical Air Support Squadron

■ On the night of 5 May 1983, Lieutenant Mooney, Lieutenant Perkins, Sergeant Peckens, and Airman Norz were flying a routine night training mission in a CH-53 helicopter in support of a joint/combined readiness exercise. During a refueling stop, their assistance was requested from a representative of the US Army. Several jumpers from a C-130 night paradrop mission had missed the drop zone and landed in a heavily wooded area. Seven paratroopers were believed to be still suspended in 40 to 70 foot trees, and at least two of these were said to have serious injuries. A previously dispatched Army medivac helicopter had been unable to locate the area due to darkness compounded by low overcast sky conditions, and was forced to discontinue its mission when fuel ran low. Unable to contact squadron operations to inform them of developments, Lieutenant Mooney proceeded on his own, gathered all available data on the drop zone (DZ) and the crew began planning the mission. An Army medical team boarded and the helicopter launched just minutes after initial notification. Navigation was extremely difficult without an inertial or doppler system since few landmarks could be readily distinguished. The entire crew scanned for visual references and relayed the information to Lieutenant Mooney. Twenty-five minutes later they found the DZ which was supposed to have been lighted and manned with a radio-equipped ground crew. It was not lighted, however, and the ground party did not answer calls on the designated frequency. A high reconnaissance was flown to ensure a safe landing could be made. As Lieutenant Mooney flew the approach, Lieutenant Perkins monitored the engine instruments, checked for obstacles, and called out airspeed and radar altimeter readings. Sergeant Peckens and Airman Norz continued giving critically needed clearance information while Lieutenant Mooney accomplished a near vertical descent and safely landed in a field amidst the tall trees. The pilots went to a nearby village where they contacted operations by phone, coordinating medical reception, crew duty extension, updating weather and briefing squadron operations on the essential elements of the mission. They returned to the helicopter and the injured paratroops were loaded and transported to the hospital. The perseverance, professionalism and crew coordination required to successfully complete this night rescue reflect great credit on the individual crew members. WELL DONE! ■

Season's Greetings

From The Gang!