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Aerospace SAFETY

THE MAGAZINE DEVOTED TO YOUR INTERESTS IN FLIGHT

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PREFLIGHT

A midair collision is perhaps the most frightening experience one could have. Crews of ejection seat equipped aircraft might escape if the airplane goes out of control, but an uncontrollable transport is different. Violent gyrations may even prevent bailout when parachutes are available. Some aspects of the midair collision potential are discussed in "Defensive Flying," beginning on page 2.

Two articles, "Automatic Flight Control," page 8, and "The Flight Director," page 12, present information of interest to pilots on some rather exotic equipment with which our aircraft are fitted. The flight director system article will be continued in the March issue.

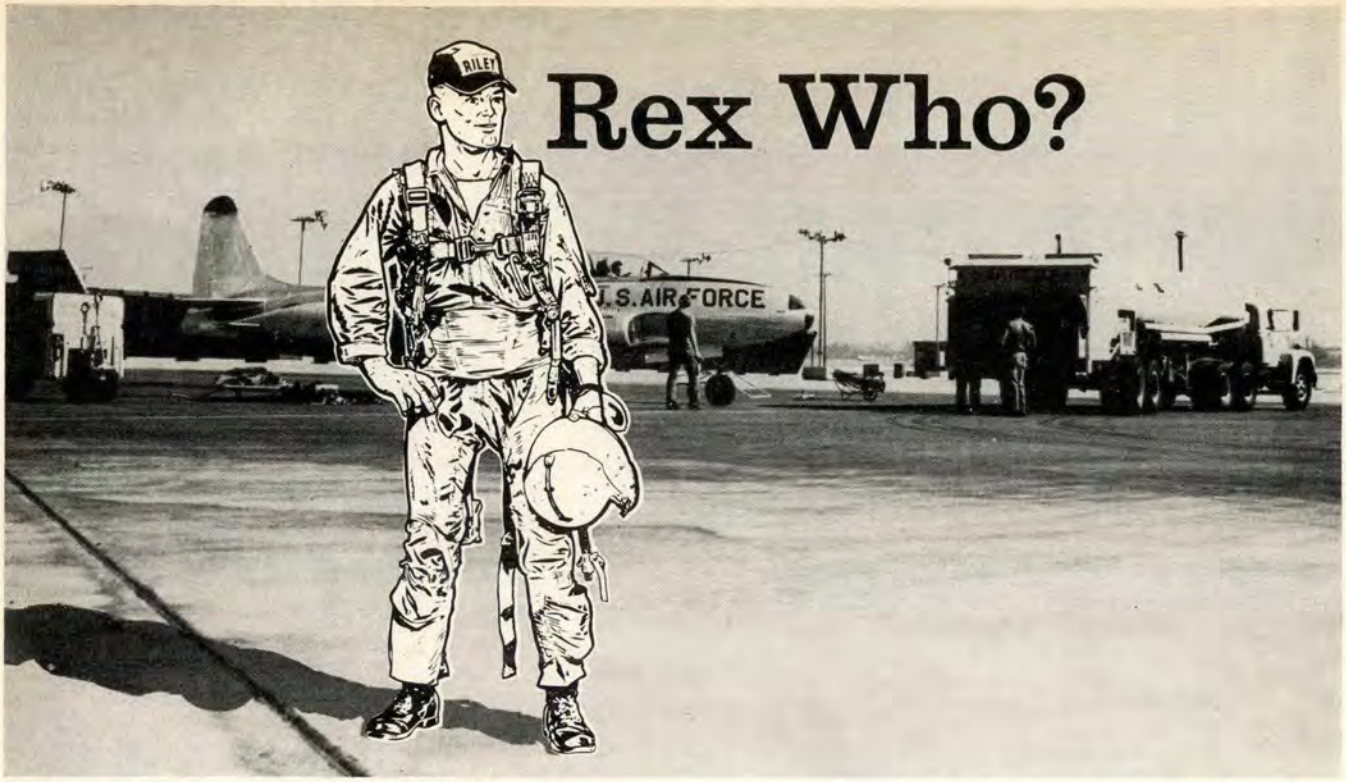
"Saved By Yankee" is a gripping account of a pilot's experience when he ejected from his damaged A-1E in South Vietnam. The article is presented in the author's words, as he taped it shortly after the experience.

Other articles this month include one on statistics. You may wonder what this subject has to do with preventing accidents. The answer is, of course, a statistic will never prevent an accident but the information the statistician can provide has and will continue to help men prevent accidents. One of the most important tools the statistician has is the computer, and the author, a statistician, tells how the skills of his profession, combined with the new computer capability in the Directorate of Aerospace Safety, can assist management in efforts to prevent accidents.

* * *

COVER

Aerospace Safety's fine cover painting of F-105's (August) really roused the nickel drivers. If you fly another type, don't feel slighted — this month we have an F-4. Look forward to some more.



Rex Who?

EARLY one morning not long ago a passenger on an Air Force transport stood in line at a flight line snack bar waiting for his eggs and sausage to cook. The pilots were filing their flight plan and would be along shortly.

The calm of the nearly deserted room was suddenly disturbed by the phone ringing. One of the help answered and quickly replaced the receiver, yelling, "Rex Riley's on his way from Ops. Let's get the place cleaned up!"

This was like a no-notice ORI. Mops and brooms appeared, ashtrays were emptied, crumbs on the tables whisked away. There was a lot of hair-patting and fingernail inspection on the part of the female employees while a busboy hurriedly straightened chairs. The man waiting for his eggs was forgotten, temporarily, and the "over easies" became "hard fried."

Who is this character whose name can cause such a ruckus? A congressman, perhaps? A general with three or four stars?

The truth is—and this may come as a surprise to some—Rex Riley is an imaginary Lieutenant Colonel—a man who doesn't really exist but who, nevertheless, wears a thousand faces. He appears in the uniform of a full colonel, a 2nd lieutenant, or perhaps, a staff sergeant. For he is the epitome of all aircrewmen.

Actually, this imaginary creature wears two hats. He represents Safety and his comments appear regularly in this magazine. But he has another role, also safety connected, that of evaluator of transient maintenance and facilities. In this role he has become a well known feature of *Aerospace Maintenance Safety* magazine. It is this aspect of his activities that we will talk about briefly.

Prominently displayed on the wall of base ops, at certain select Air Force bases may be found a certificate suitably framed and bearing the title REX RILEY TRANSIENT SERVICE AWARD.

This means that the base provides outstanding services to transient aircrews. It does not mean, simply, that the airplane is quickly fueled, windshield cleaned, transportation to base ops, although these are part of the total picture. Other items must also measure up: clean and comfortable VOQ and transient airmen's quarters; food services, clean, efficient and available; necessary transportation; prompt service with power units when the crew is ready to depart.

Efficiency, cleanliness, cheerful service and adequate facilities are required if a base is to display this award. It's a coveted thing because it means someone cares and, caring, is determined to treat aircrews as first class citizens.

Unfortunately, some bases are unable to meet the rather stringent criteria; for example, funds may not be available for providing transient quarters that meet the standards. Regrettably, these bases will not receive the award. This does not mean, however, that other services should not measure up.

Rex Riley is not one individual who travels around, base-to-base, inspecting transient services. He is all Air Force crews who, when they find outstanding service notify Rex, c/o *Aerospace Maintenance Safety* magazine. Conversely, they should tell Rex about poor service.

This information goes into a folder in the Rex file. These folders are reviewed frequently and a board in the Directorate of Aerospace Safety determines when a base should receive the Rex award, when it should be withdrawn.

Some bases have held the award for years. But long tenure is not sacred. Some bad reports may mean an anonymous visit to a base to ascertain the reason. This could mean removal from the list.

How does your base measure up? The criteria are published from time to time by *Aerospace Maintenance*, most recently in the January issue. ★

DEFENSIVE FLYING

THE PILOT'S ROLE IN PREVENTING MIDAIR COLLISIONS

THE night is pitch dark. No moon rides the sky and even the stars are obliterated by high cirrus. Two high speed jets, on a headon collision course, hurtle toward each other at a closing rate of more than 1200 knots. Suddenly the pilots see the other aircraft and attempt to turn to avoid the collision. They are unsuccessful and a horrendous crash precedes a brilliant explosion that flashes in the sky, and the noise sounds like thunder to those on the ground who have not yet retired for the night.

In stories fiction and fact, we have too often been treated to something like the above. Aircraft inadvertently zeroed in on each other, usually headon, coming together at a rate that precludes recognition and evasion. We are told that the eyeball is obsolete in preventing midair collisions and that there is a pressing need for some sort of electronic collision prevention device. They forecast a chaotic condition developing sometime in the future when the magnitude of traffic grows to the point that the airways and control facilities are saturated. The future they allude to has come and gone many times and the dire predictions continue—the "future" being moved forward from time to time.

There are a number of truisms presented: The amount of air traffic *is* increasing. The potential for midair collisions *is* growing, if we consider traffic magnitude only. A reliable collision avoidance system *is* needed. Human eyesight *is not* good enough to allow perception in time for pilots to take action, under certain circumstances. Midair collisions *do* occur.

Let's examine some of these and see where we are and where we are going.

The civil fleet has experienced tremendous growth during the past few years and shows every sign of continuing this growth, an increase that is compounded by the broad spectrum across which these aircraft operate. There are still airplanes that fly at less than 100 mph; others, many models, in fact, have top speeds in excess of 200 mph; and there are the jets ranging from rather small business types to the big transports, all of which operate at speeds approaching Mach 1 and have fairly high approach and landing speeds. The picture will shortly be complicated even more by the huge new 400-passenger airliners and the supersonic transport, both of which will be operational in a relatively short time.

What this growth in both numbers and types means is that there will be more aircraft operating in the available airspace, both at high and low altitudes and in the areas immediately adjacent to airports. Consequently, the Air Force pilot will be seeing more aircraft wherever he flies and, more significant, there will be more aircraft that he doesn't see. It is the latter with which we are most concerned.

There are plans, projects, proposals and papers, many of which we are surely not aware of, aimed at maintaining order in what could very easily become chaos in the skies. But the problems are extremely complicated and as of now there is no way of knowing for sure just what the future — five to ten years down the road — holds for aviation. However, there are some developments that seem fairly obvious:

- The number of aircraft is increasing and will continue to do so in the foreseeable future.
- Collision avoidance and pilot warning equipment will become operational, at least for certain types of aircraft.
- There will be tighter controls on airspace, very possibly from the ground up.
- Aircraft lighting and instrumentation will continue to improve, and pilots will be required to have the skills necessary to use the instruments they will have to have.
- Air traffic control methods will improve with greater use of radar and other precision aids, including television-type presentations.

Unfortunately, predictions for the future don't do much to help the guy operating in the present. And he's the one we are concerned with right now. Here are just some of the things he has to contend with: increasing air traffic, a wide range of speeds at which aircraft fly, complicated procedures, charts that have to be read in cramped, complex cockpits, an even greater mix of IFR-VFR traffic at the lower altitudes, decreased visibility in the

terminal areas because of increasing air pollution.

There are others but these seem to be of immediate import, so let's deal with these. First, more aircraft means that pilots will have to be more vigilant, especially in terminal areas or at any time while operating at low altitude. There's more than just an increase in numbers here. The traffic picture is rapidly changing because of the wide range of speeds and the capability of general aviation aircraft to operate in all kinds of weather. Air transport traffic is increasing and becoming common at airports which previously have had none or very little of this activity. Every one of these factors is going to increase and, as a matter of fact, is doing so almost daily.

It is not a bit uncommon today for a pilot to be warned by a local controller to watch for intense light aircraft traffic. After landing at Norton the other night one of the pilots of a T-29 said he'd never realized the extent of light aircraft traffic—"It scared me stiff." He was returning to the cockpit after being off flying for a couple of years and the night was extremely clear, something highly unusual for this area.

Many of the light planes routinely take off via controlled VFR, a procedure that may go by the boards soon. Even if this does become a thing of the past, more and more light aircraft have instrument capability and will be flying in low visibility weather. This could be a blessing in that these aircraft will be operating under instrument flight rules, but we still can't overlook the fact that the sheer weight of numbers will increase the load on controllers and facilities. An attendant problem is the speeds of these aircraft. Many of them at full bore cannot approach the minimum maneuvering speed of some of our jet fighters.

Feeder line and air taxi operations have been multiplying like rabbits as more types of aircraft suitable for these services have come into being. And every little town with an airport seems to want to get in the act. This means more climbs and descents to and from these airports, primarily a problem in the low altitude structure. Although most of these flights are controlled, they add to the congestion.

For years this magazine, as well as other safety publications, has warned pilots against complacency, based on an IFR flight plan, when they are flying in an environment that includes aircraft operating VFR. The increasing use of IFR by general aviation pilots may alleviate this problem eventually, but for the present we see some additional problems. For one thing, this means charts and procedures — the pilot devoting time to studying letdowns and other navigational procedures in the confines of the cockpit. This, of course, reduces time available for watching out for other aircraft. He also must spend more time looking at the gages. Even though most IFR flying is conducted in VFR weather, and see and be seen is highly important, the pilot's time is divided between scanning his instruments, making radio changes, looking at charts and letdown plates AND scanning the sky around him for other traffic.

To Air Force pilots this is an old story, as it is to most professional pilots. To the beginning or marginal general aviation instrument pilot this may be a highly complex and taxing process requiring him to devote almost all his attention to tasks within the cockpit. This leaves little time for him to be looking around outside. This mean you, as a professional, must keep your eyes working outside the cockpit, for if you don't there will be times when nobody will be looking.

In this respect, there has been some interesting research. One study by Douglas Aircraft Company (now McDonnell-Douglas) indicates that training in a simulator with collision situations being simulated outside the cockpit could improve pilot scanning ability. This is based on a time sharing concept wherein the subject must divide his time between watching the instruments and scanning for other aircraft. The investigation also indicated that training in time sharing enchanced instrument reading.

No matter how hard we try, we just can't get away from the old and much belabored see and avoid concept. We would like to; we'd like to know that every airplane has a built-in scanner-computer-indicator or reactor that would (1) "see" other aircraft, (2) compute as to whether there is a collision course, (3) indicate to the pilot what action to take, or (4) take the appropriate action. But such an animal is not yet in our zoo.

We recall attending a meeting about five years ago on the subject of collision avoidance. Just about everybody in the industry was represented, a lot of papers were presented, movies and slides were shown and there was talk, talk, talk. Most of the talk, unfortunately, had to do with how complex the problem was, why no useful hardware had been perfected, and there certainly was a need for a good pilot warning and/or collision avoidance system.

This was not a gathering of apologists crying in their beer. On the contrary, some of the sharpest minds in industry and government were at that meeting and they were honestly trying to cope with a problem that, as of that time, was too big, too complex and extremely expensive. Since then advances have been made —some of the early research having led to possible solutions. There are, in fact, some systems in being but we haven't heard of any with wide acceptance. However, as an indication of progress, Stuart G. Tipton,

—As a pro, you must help the other guy, or sometime nobody will be looking

president of the Air Transport Association, announced last summer that "The airlines are two-thirds of the way toward their goal of finding airborne collision avoidance system (CAS) equipment suitable for use in everyday flight operations." He was referring to a paper outlining airline policy and CAS requirements and design details of a system meeting the requirements.

Tipton added, "This document completes two of the three steps we have to take to reach that goal. Now we are beginning the final and most difficult step of all—that step that turns a paper design into prototype hardware, tests and tries that hardware, and refines it to the point where it is ready for production and sale. It is a difficult step because there are necessarily still some uncertainties to be resolved before manufacturers can build, and airlines can buy, an airborne CAS that meets airline requirements."

This announcement was reported in the United Airlines newsletter, *The Cockpit*, for July and August. The article described the system as follows:

"Basically, the system operates as an automatic count-off. Each aircraft transmits in turn while all others listen. The system accommodates 2000 aircraft within line of sight range. Transmission time slots of each aircraft are fixed. The time it takes from start of transmission to beginning of reception is used to compute range between the aircraft. Doppler shift in frequency is used to compute range rate. Altitude and other information is also transmitted. The system uses a single time standard. The master time will be kept by ground stations. Aircraft will resynchronize frequently to the ground stations or to other aircraft."

Other recent developments include a symposium on pilot warning system development on December 12, sponsored by the FAA and the government-industry Collision Prevention Advisory Group (COPAG). Aim of the symposium was to encourage development of a low cost instrument that would alert pilots to potential air traffic conflicts and provide information such as range, altitude and relative bearing. This is seen as a much simpler system than the computer-driven CAS.

The FAA has taken a major step toward gathering information on near collisions. Effective Jan. 1 and continuing through Dec. 31 this year, "the administrator will take no enforcement or other adverse action, remedial or disciplinary, against any person involved in a near midair collision that is reported to the FAA . . ."

The following is quoted from the FAA announcement: "By obtaining full, frank, and complete cooperation from persons involved in near midair collisions, the FAA should be in a position to obtain the necessary information for use in evaluation and development of air traffic control procedures, separation criteria, and pertinent Federal Aviation Regulations. Therefore, it is the policy of the Federal Aviation Administration that if any pilot of an aircraft, air traffic controller, or other person involved, in a near midair collision reports the facts, conditions, and circumstances thereof to the FAA,

(a) The Administrator will not subject any person involved in the near midair collision to enforcement or other adverse action, remedial or disciplinary, even though a violation of the Federal Aviation Regulations is disclosed by the report or subsequent investigation; and

(b) Upon written request of the person submitting the report, the Administrator will, to the extent authorized by Section 1104 of the Federal Aviation Act of 1958, withhold the identity of the persons involved in the near midair collision and the information contained in that report from public disclosure."

THE EYE AND MIDAIRS

For years we've been treated to gloomy statements that the human eye is not good enough to prevent midair collisions. This is usually based on tables and charts that show (accurately enough) that, when two high speed jets are aimed at each other at a closing rate of something on the order of 1200 mph or more, the pilots cannot see the other aircraft in time to prevent a collision. We can't argue with these figures, but neither can we accept them as proof that the human eye is obsolete, although it undoubtedly has some limitations.

The evidence seems to be overwhelming that very few midairs occur in a headon situation between two high speed jets. The data indicates that the most dangerous situations develops when aircraft are maneuvering — turning, descending and climbing. Most pilots know this but the reasons deserve repeating. In areas where most aircraft are maneuvering there are more aircraft than in those long straight and level areas across country. When aircraft are turning, descending, climbing they have blind spots. It is in this portion of flight that pilots are busy watching the gages, turning radio knobs, lowering flaps and gear, checking plates—in other words busy in the cockpit. It is also during turning, descending and climbing that faster aircraft are more apt to overtake slower airplanes that the pilot can't see because of aircraft attitude.

Radar, when available, does much to help prevent collisions in the maneuvering areas near airports, but not all aircraft are equipped with transponders and many of those which aren't don't paint on the scope. This means unseen bogies in the air that better equipped pilots must keep an eye out for. The "he's

wrong and I'm right" attitude won't save you in a collision.

We can look with some confidence to a future that will provide some sort of collision avoidance system. But it's going to be a while and there are some rough bumps in the road ahead. The computer-operated CAS will be very expensive and will probably be used only by the airlines and possibly military services. For light aircraft there will be pilot warning systems, but these have to be perfected and produced at a price the average aircraft owner can afford. Neither of these will provide 100 per cent protection: nevertheless, any improvement will be welcome.

In the meantime, until more exotic systems come along, what can we expect? There undoubtedly will be tighter regulations on pilot licensing that will require greater proficiency. Altimetry should improve, but don't expect any miracles. The air route traffic structure will be altered to meet traffic conditions as they develop. Better radar, wider use of transponders by general aviation, and improved navaids will appear. Aircraft instrumentation will continue to improve as will cockpit layout. And there is a lot of awareness of the need for better visibility through improved aircraft window and fuselage design.

The Air Force pioneered system safety and this concept will gradually be applied by manufacturers to new designs.

Predictions aren't worth much unless they come true. We believe the above are realistic and have a very good chance of becoming reality soon. Here are some good reasons for this belief. General aviation (not including airlines) flew more than 21 million hours in 1966, a 26 per cent increase over 1965. Seven million plus hours were flown by business aircraft, the biggest contributors to this time and the area in which the greatest gain was recorded. In miles flown there was a 30 per cent increase, business aircraft again leading the pack.

At the end of 1966 there were 104,706 general aviation aircraft of which nearly 53,000 were single engine, four place types. There were almost 13,000 multi-engine general aviation aircraft, 915 turbine and 1622 rotorcraft. These aircraft used 374,610,000 gallons of aviation gasoline and 81,300,000 gallons of jet fuel.

What has this got to do with military pilots? Quite a lot. During a three-year period ending December 31, 1966, Air Force aircraft were involved in 25 midair collisions that resulted in six minor and 19 major accidents. This does not include formation and other associated aircraft midairs, but deals strictly with non-associated aircraft.

So where do we stand? Will we be reading headlines announcing catastrophic collisions between military aircraft and commercial aircraft? We certainly hope not, but we must recognize the potential is there. We must take every step possible to avoid collisions, even to the point of making some of the effort for the other guy, particularly for the one who is not so experienced, whose aircraft is not so well equipped, who doesn't know an Oil Burner from a smudge pot.

In our multi-place aircraft at least one pilot and, when possible, another member of the crew should be scanning outside all the time and being particularly watchful in high density zones. Pilots of single seat aircraft must be even more alert than in the past and judiciously share time between the instrument panel and outside. Those who believe that scanning means sweeping their eyes around the horizon in one swoop should learn to really look, in small segments at a time, and by using reference points such as airplane structure and clouds in order to get the necessary visual depth of field.

With more aircraft in the skies and the number increasing, sloppy adherence to assigned altitude is inviting disaster, as is improper altimeter setting. Operations and Safety share responsibility for keeping aircrews up to speed on changes in Air Force and FAA regulations. OHRs should be filed for all near misses. NOTAMS should always be carefully checked; controllers' instructions followed explicitly.

During recent years there have been many changes in automobiles designed to protect the occupants in an accident. Most of these, however, have nothing to do with preventing the accident. In aviation the accident must be prevented. On the highway, you as a driver, have only two dimensions to contend with. When you leave the highway for the skyway, add another dimension plus other complications. But the rule for safe driving carries over into the air. Practice Defensive Flying—it will prevent midairs and save lives. Maybe yours. ★

The IP

Maj Thurman Lawrence, Jr
Directorate of Aerospace Safety

THE term "IP" has many meanings, but the following few words are devoted to helicopter instructor pilots. Numerous aircraft accidents in which instructor pilots were involved have been publicized. But it is again necessary to point out that many accidents still occur with an instructor pilot in command of the aircraft.

Here are a few examples:

• Instructor pilot failed to take control of the helicopter in sufficient time to prevent the tail rotor from striking the ground when the student was given a simulated forced landing.

• The IP allowed the student to place the aircraft in a position during a practice autorotation from which he could not recover. The helicopter struck the ground hard and was damaged. It was the student's first flight in the aircraft and he had only 35 hours total helicopter time.

• Instructor pilot allowed the student pilot to go too slow and fall out of a simulated single-engine landing, causing a hard landing and damage to the aircraft.

Now what is the cause? and why does a supposedly highly qualified pilot let a student place the aircraft in a position from which recovery cannot be made? Certainly the student does not get into a dangerous situation intentionally, and it is the responsibility of the instructor pilot to not only teach the student, but also, to protect him and the aircraft.

Supervisors, here are a few questions to which you should have the right answers. What are your requirements when selecting and upgrading a pilot to instructor pilot? Is he the type of person that you would want as an instructor? Is he the most qualified man for the job? Is he mature and does he completely understand his responsibility as an instructor pilot?

Is he completely familiar with his aircraft and all systems, particularly emergency procedures? Is your instructor pilot upgrade program adequate? Is flying safety education included in all aspects of training? Does each instructor know that he must maintain a margin of error for himself in addition to that of the student? Is each instructor directed to take *complete* control of the helicopter when he takes over from the student in a critical situation, particularly when near the ground? Does each instructor understand that he is there to teach the student instead of the student learning for himself? Does he pass on to the student all he has learned about the aircraft? Is adequate time allocated for an instructor to spend with his student on the ground, discussing each maneuver in helicopter flying? Is this time utilized?

Are supervision and standardization adequate to check on your instructors so that you know they are doing a good job?

Many are the questions that can be asked, but your accident and incident rate is proof of whether your flying training program is being adequately accomplished.

Complacency is not limited to rank or level of supervision. In order to prevent aircraft accidents, every pilot—and especially the instructor pilot—must be safety conscious and understand his own and his aircraft's capabilities and limitations. Your accident/incident rate can be kept low if accidents involving instructor pilots are eliminated.

Watch it, for if you are an IP in helicopters you stand a better-than-average chance of being involved in an accident! That's why you have to be a better-than-average instructor. ★

AUTOMATIC

THE morning was beautiful, the air clear and cool with just a trace of a soft breeze that carried the sounds and smells of the airfield. It would get hot around 11 o'clock but now, with the sun casting a mellow glow over the rocky hills to the east, the temperature was just right.

It was a great day to be alive, he thought, as he climbed into the Healy he used to drive to work. His wife had cheerfully got up first and he had awakened to the smell of coffee and a breakfast of bacon and eggs sizzling on the stove. Now he was on the way to what was both his life work and his favorite sport.

The mission this morning was to be weapons delivery on the range north of the base. As an IP he would be leading a flight of four youngsters not long out of flying school. Briefing completed, the group relaxed a few minutes while finishing their coffee, then headed for their aircraft.

The first indication that anything was wrong occurred just as the weight of his bird began to ease off the gear. The beast suddenly yawed hard to the right. His first thought was that he had got a bit of turbulence from the aircraft ahead, but when he corrected with stick and rudder the aircraft pitched up. Pushing forward on the stick caused a violent yaw to the left.

At this point he realized that he had no control over this wildly bucking and yawing monster. He grabbed the ring and was blasted into the air. Seconds later he saw the multi-million dollar machine he had been a part of plow into the dirt and tumble end over end, shedding parts until it collapsed in a pillar of fire and black smoke half mile ahead.

A lot of people were glad he'd made it, but for different reasons. In addition to his wife and well-wishing friends, there were several hard-headed individuals who were glad, not only for humanitarian reasons but also because they had a witness who might be able to furnish the clues needed to find the cause of the accident.

They suspected flight control malfunction of some kind and the pilot's testimony indicated they were on the right track. But finding the exact cause required sifting through the debris and sorting out a thousand pieces of metal, some twisted, others sheared or bent. Finally, though, the pieces began to fall together, until the puzzle was complete and presented the investigators with irrefutable evidence of what had gone wrong. A technician had either ignored or misread a TO and had misrouted some wiring in the automatic flight control system.

The above is purely hypothetical and is not based on any actual case. But it could have happened and may in the future. Flight control systems vary from rather simple equipment such as yaw dampers or stability augmentation to the highly sophisticated systems employing central air data computers such as found on the F-4, F-105 and the F-111. The automatic flight control system (AFCS) is indispensable for aircraft with the missions these perform.

But when an accident occurs in which flight control malfunction is suspected, pinning the cause is extremely difficult, as can be seen by the following examples:

- On pullup from a strafing pass and turning to downwind leg, the aircraft banked sharply. The pilot was unable to right it and had to eject. The flight controls failed, cause undetermined.
- A tactical evaluation pilot was leading his formation. He was seen to pull up in a 30-to-40 degree climb and enter a cloud deck; when next seen he was in a 35-to-45 degree dive from which he never recovered. Cause undetermined. Probable failure of a flight control system component.
- After acknowledging GCI instructions the pilot engaged the automatic flight control system and the aircraft pitched down. Recovery from the resulting unusual position was impossible. The RIO transmitted ejection intent to the pilot and received no response. The RIO ejected successfully, but the pilot made no attempt to get out. Automatic flight control malfunction was listed as a contributing cause.
- The pilot of a low altitude target aircraft acknowledged instructions from the lead aircraft. His aircraft crashed into the water shortly after this communication. Possible materiel failure due to hard over signal generated in the automatic flight control system.
- An aircraft on a ferry flight, cruising at 35,000

FLIGHT CONTROL

V. R. Jackson, Systems Engineer
General Electric, Johnson City, New York

feet, began to spin and roll. The pilot ejected but the aircraft commander was never found. There was a probable malfunction in the flight control system.

- The front seat pilot was practicing air combat tactics to upgrade to instructor. He was observed to roll into a 100-degree right bank with his nose dropping about 45 degrees below the horizon. When the aircraft yawed violently the back seat pilot ejected, but the front seat pilot made no attempt to get out. Possible flight control malfunction.
- As a pilot practicing ground attack tactics began his roll-in on target the dive angle appeared steeper than normal. The aircraft continued in a right bank and dive until impact with the ground. The canopy was jettisoned but the pilots did not eject because the aircraft was maneuvered to such an attitude and position that recovery from either cockpit was impossible. Probable failure of the flight control system.
- On a simulated nuclear weapons delivery the release was normal and the chute deployed as programmed. The aircraft began a roll to the left for the escape maneuver and was seen to execute a tight left turn which continued until it contacted the ground in a nose low attitude. Cause: flight control failure during a critical point in the maneuver.

From the above it is obvious that only first class maintenance will do for these systems. There can be no such thing as a "little" error, a "minor" mistake, because these can kill a crew. As for pilots, surely some have died with the airplane trying to overcome a faulty system that was beyond saving. As for those who have landed successfully with a faulty system caused by any malfunction, no matter how small, the quality of resulting maintenance is at least partially dependent on the accuracy and completeness of the pilot's write-up.

Pilots of aircraft equipped with AFCS are undoubtedly familiar with these systems. But there are many who have yet to be introduced but who have a good chance of going to AFCS-equipped aircraft. The following article by Mr. V. R. Jackson, Systems Engineer, of General Electric Company, describes automatic flight control systems and gives some history of their development as well as their application.

Today's high performance combat aircraft have large operating flight envelopes (speed, altitude, maneuver), limited natural stability, and great accuracy requirements for both offensive and defensive missions. Consequently, flight control design teams and equipment face some mighty tough challenges. Every combat mission consists of several major phases of flight, takeoff, cruise, refueling, strike (or other mission objective), and landing. All phases frequently demand assistance from the Automatic Flight Control System (AFCS); therefore, these systems must provide a much broader range of functions than simply an autopilot role.

For example, the automatic flight control system of the F-111 works full time and is considered part of the primary flight controls. The F-111 AFCS features three branches of control information each for the pitch, roll and yaw axes. Therefore, when any component malfunctions it is canceled in 0.2 of a second and the AFCS continues to operate normally. An AFCS of this type is a distant relative of the early autopilots and dampers used over the past years.

The trade-offs which must be made in the design of any weapon system are brought into sharp focus in combat aircraft and their subsystems. The numerous conflicting goals can best be resolved by continually referring to their role in satisfying the mission requirements of the total weapon system. Cost versus performance and reliability, and complexity versus maintainability tests must be applied to all system levels in determining the best system and hardware to perform the desired mission.

AUTOMATIC FLIGHT CONTROL MODES

There is a relationship of various flight control modes to aircraft/mission requirements. All guidance modes are mission oriented while the stability and control augmentation systems primarily serve the basic aircraft/pilot manned vehicle requirements.

The requirement for *stability* augmentation is more severe for supersonic and vertical takeoff and landing (VTOL) aircraft. There are two primary reasons for this: (1) maximum performance requirements compromise the design of the stabilizing surfaces; (2) natural aerodynamic stability is lost during hover flight conditions. Yaw stability augmentation, used on all types of aircraft to improve dutch roll damping, is especially important to provide a stable platform for gun-armed fighters. Pitch stability augmentation is also needed in most high performance aircraft to provide acceptable longitudinal short period damping for good flying qualities. Roll stability augmentation tends to be the most critical stability augmentation system (SAS) requirement for VTOL aircraft, because of divergent lateral oscillations which exist in all VTOL designs during some portion of hover and transition flight. Automatic roll damping in conventional aerodynamic flight is normally not required but is desirable for some operations such as air-to-air refueling.

Control augmentation is an automatic control technique to provide desired aircraft response to pilot commands. This is a mission requirement for air superiority and interdiction missions, because accurate weapon delivery (gunfire or iron bombs) against point targets requires that the aircraft respond to pilot commands in the desired manner throughout the speed, altitude, and maneuver envelope of the aircraft. For VTOL aircraft, control augmentation appears as a requirement in the pitch and roll axes because attitude control is recommended in these axes for IFR operations in the hover and transition flight region.

The automatic hold modes are sometimes referred to as pilot relief modes which describes their functions of permitting the pilot to take a break during cruise or loiter phases of the mission. This is the original autopilot role which in addition to reducing pilot fatigue provides accurate flight path control independent of weather.

Among the newer features provided by modern flight control systems are the automatic maneuver modes. The increasing defensive capability against high flying aircraft has reduced the avenue of successful penetration against well defended targets to a terrain following flight path. This mode appears, therefore, for both interdiction and strategic attack missions. Automatic intercept and landing appears as a requirement for the air defense role because this mission must be accomplished regardless of weather conditions. These features are also desired for the air superiority mission but are of less importance because VFR operations tend to dominate air superiority combat.

MISSION REQUIREMENTS

The mission frequently requires combat aircraft to operate regardless of the weather and under conditions where normal references the pilot uses to control the aircraft become inadequate to accomplish the mission. Target penetration in a low visibility environment can require several automatic flight control aids, such as automatic terrain following, ground track hold, and bomb delivery, in order to provide mission success with minimum sorties. Improved flying qualities together with all-weather flight path control and accurate weapon delivery reduce losses.

Contrary to popular forecasts of a few years ago, the role of the manned aircraft in combat operations has expanded within and beyond the scope of the traditional air-to-air and air-to-ground missions. While applications of advanced technology have contributed much to the additional capabilities of modern aircraft, the development of new skills by the crew is sometimes overlooked. Recognition that the pilot is the *most important* control element on board any manned aircraft is an important conclusion of many control system manufacturers.

FLIGHT CONTROL TECHNOLOGY

The unique human qualities of judgment, adaptability, and courage are important factors which can be complemented but never replaced with advanced control technology. The outstanding effectiveness of today's combat aircraft is achieved by making maximum use of the aircrew's tremendous talents and complementing those areas where human capacities are overtaxed. The key role of the pilot is shown in relationship to various automatic control functions in Figure 1. The mechanical/electrical/hydraulic/aerodynamic elements of a representative modern flight control system are presented in Figure 2.

Autopilot functions often utilize parallel actuators which move the controls. Control motion provides for pilot monitoring which may lead to pilot override in case of an automatic control malfunction. The ability of the pilot to override the autopilot permits full control authority to be given these actuators.

When the basic aircraft flying qualities are satisfactory without stability or control augmentation, the simplest form of automatic flight

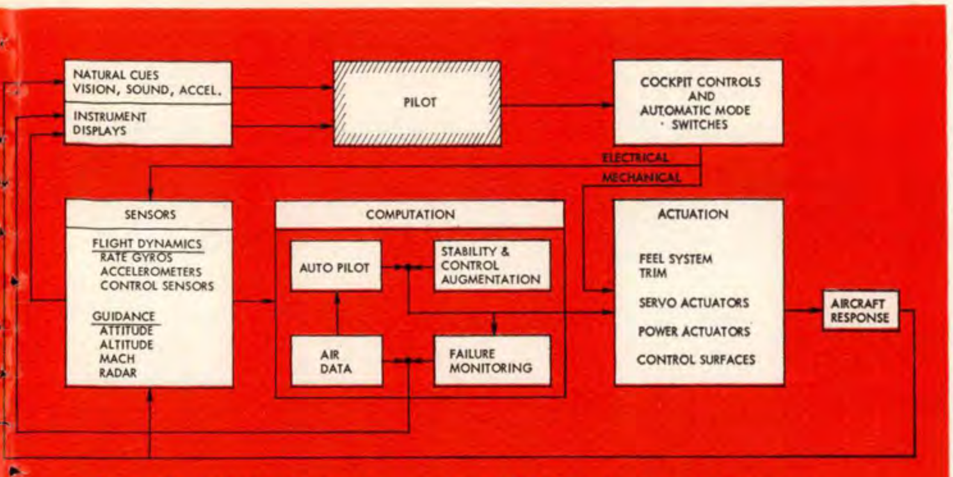


Figure 1. Relationship of Automatic and Pilot Flight Control Operations

control systems may be limited to autopilot functions. Systems of this type were employed on all-weather and long range World War II aircraft and are utilized today on many subsonic aircraft.

A stability augmentation system (SAS) is any subsystem which serves to augment the stability of an aircraft to improve its flight dynamics. The closed loop or feedback SAS which has proven satisfactory on most combat aircraft consists of an angular rate damper based upon a limited authority series servo actuator driven by a canceled rate gyro signal. The purpose of the canceller is to wash out the low frequency feedback signals so that the SAS function does not oppose long term pilot commands. Since these stabilizing commands are introduced in series with the pilot inputs, limited authority servo actuators are used to prevent undesirable transients should a hardover malfunction occur. The series servo moves the valve of the power actuator which drives the aerodynamic control surface. This arrangement permits the SAS function to be performed without moving the cockpit controls. The most noticeable affect of SAS operation is a smoother flying aircraft which provides the pilot with a more stable weapon platform. The most basic SAS application is a yaw damper, but combat aircraft frequently utilize stability augmentation in pitch, roll, and yaw.

The newest automatic control feature to find application in combat aircraft is the control augmentation system (CAS). This feature is designed expressly for the pilot to command aircraft response in a manner which he desires. A system of this type is employed on the F-111 and provides angular rate plus normal acceleration response to pilot commands in pitch, and angular rate maneuvers in roll. There is no direct relationship between the pilot's controls and the aerodynamic control surfaces. Movement of the cockpit controls by the pilot commands an aircraft maneuver which will be essentially invariant regardless of the flight condition of the aircraft. If the aircraft were at Mach 2.5 the aerodynamic control surface would deflect less to provide the desired maneuver than with the aircraft at Mach 0.5. This invariant response is achieved by proper blending of the forward (CAS) and feedback (SAS) gains within the flight control computer. The most significant effect of this automatic control feature is that the desired aircraft response results in maximum weapon system effectiveness, regardless of the mission phase whether it is air combat, refueling, bombing, or landing.

The primary objective of modern automatic flight control systems is to complement those human skills which make the manned combat aircraft an even more effective weapon system. In those areas where human capabilities are not well employed, automatic control should be used to free the pilot to devote his priceless resources of judgment and adaptability to those aspects of combat which cannot be replaced by machines. The outstanding combat aircraft is one in which the pilot's talents are complemented to the maximum possible extent considering cost, reliability, and maintainability. The ideal tradeoff of all factors involved in the stability and control of combat aircraft is a difficult assignment. However, the end result of a man/machine weapon system obtained through proper application of human factors and advanced control technology is an effective combination which has no replacement. ★

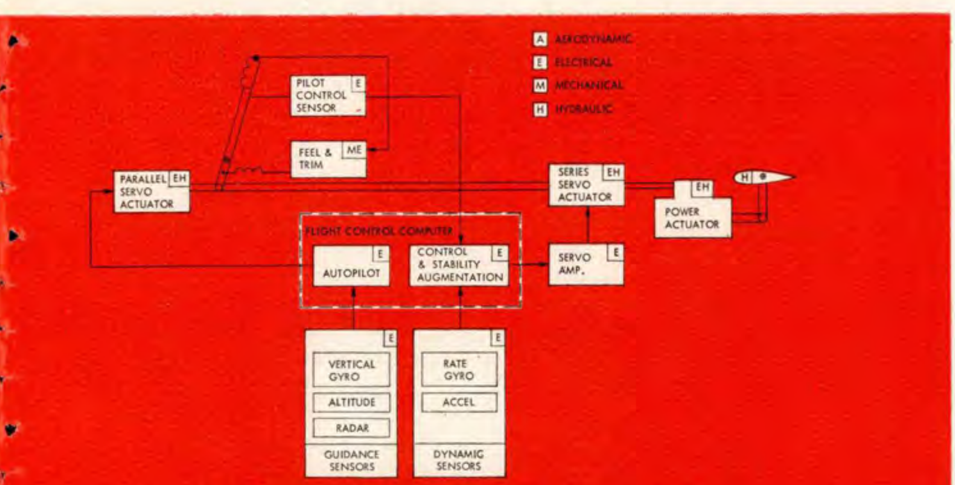


Figure 2. Modern Flight Control System Elements

the I.P.I.S. approach

By the USAF Instrument Pilot Instructor School, (ATC)) Randolph AFB, Texas

The Flight Director

ALTHOUGH more than half of the USAF aircraft are equipped with the Flight Director System, this highly useful device is not always used to the maximum extent of its capability. This can be partly explained by the fact that flight director descriptions in flight manuals are normally confined to step-by-step procedures for operating the equipment.

This limited knowledge of its operation restricts use of the flight director to those ideal situations that fit the procedures. The "why" for the procedure is often a mystery to the pilot. Therefore, an understanding of how the flight director computer works will enhance the pilot's ability to use the equipment intelligently and with greater versatility. It also will help pilots understand the limitation of the equipment and increase their overall instrument performance capability.

This simplified discussion of flight director computer operation will help clarify some of its functions. The sole function of the flight director computer is that of driving the pitch and bank steering bars on the attitude director indicator (ADI). The system was originally designed to aid the pilot in performing an ILS approach. The pitch and bank steering bars show the pilot what pitch and bank corrections are needed to place the aircraft on the localizer course and glide path and keep it there. In more advanced flight director systems, the bank steering bar can be used for other maneuvers such as intercepting VOR, TACAN, and Doppler course, or performing data link interceptors. Pitch steering bar information can vary from terrain avoidance commands to commanding a selected altitude. In all cases, the pitch and bank steering bars display *command* information and do not reflect actual aircraft position or attitude.

PILOT SELECTS INPUTS

The computer receives information from five sources or inputs. (Figure 1) These are: Horizontal situation indicator (HSI), ILS localizer and glide slope receivers, attitude gyro, navigation aids. The navigation aids input is an operational feature of later computers. Any of these inputs are available to the computer, depending upon the function or mode of command steering selected by the pilot. When a particular mode is selected, the computer compares appropriate combinations of these available inputs and positions the bank and/or pitch steering bar(s) accordingly.

MANUAL HEADING MODE

The heading mode selector usually has two positions: MANUAL and NORMAL. The MANUAL position is used to command the aircraft to a selected heading. The inputs used by the computer in this mode are (1) heading error, from the HSI; and (2) bank angle input from the attitude gyro platform. Heading error is the angular difference between the upper lubber line (aircraft heading) and the position of the heading marker (desired heading selected by pilot). This heading error signal has a maximum effective value which occurs at approximately 10 degrees of angular difference between the upper lubber line and heading marker. Heading errors greater than 10 degrees will not increase the effect of this signal value.

Bank angle input is an opposite voltage signal from the attitude gyro platform and is used to center the bank steering bar when the correct bank angle is obtained. The value of the bank input signal increases as the angle of bank of the aircraft increases. This value will be equal to the maximum effective heading of bank for one degree of heading error signal (35 degrees of bank in the CPU/4 computer). This value of bank angle differs with aircraft and computer types. If the heading error is less than 10 degrees, the bank steering bar will command an angle of bank which is electrically proportional to the heading error and it will be less than maximum bank angle. This results in bank angle commands which may be excessive for the amount of heading selector. The bank steering bar will center in the ADI. Providing the line-up was accurate and that no severe crosswind exists, keeping the bank steering bar centered during takeoff roll will keep the aircraft aligned with the runway. More important, keeping the bank steering bar centered after becoming airborne will result in maintaining a wings level attitude.

Bank input to the computer is separate from the bank synchro circheck of the turn and slip indicator and standby compass will confirm whether the aircraft is actually turning. If you blindly follow the bank steering bar, you might be trying to turn the aircraft to keep up with a failed heading system. But if the aircraft is actually turning, you can bank to center the bank steering bar and this will direct the aircraft to the selected heading.

Recent reports of accidents immediately after takeoff have been at-

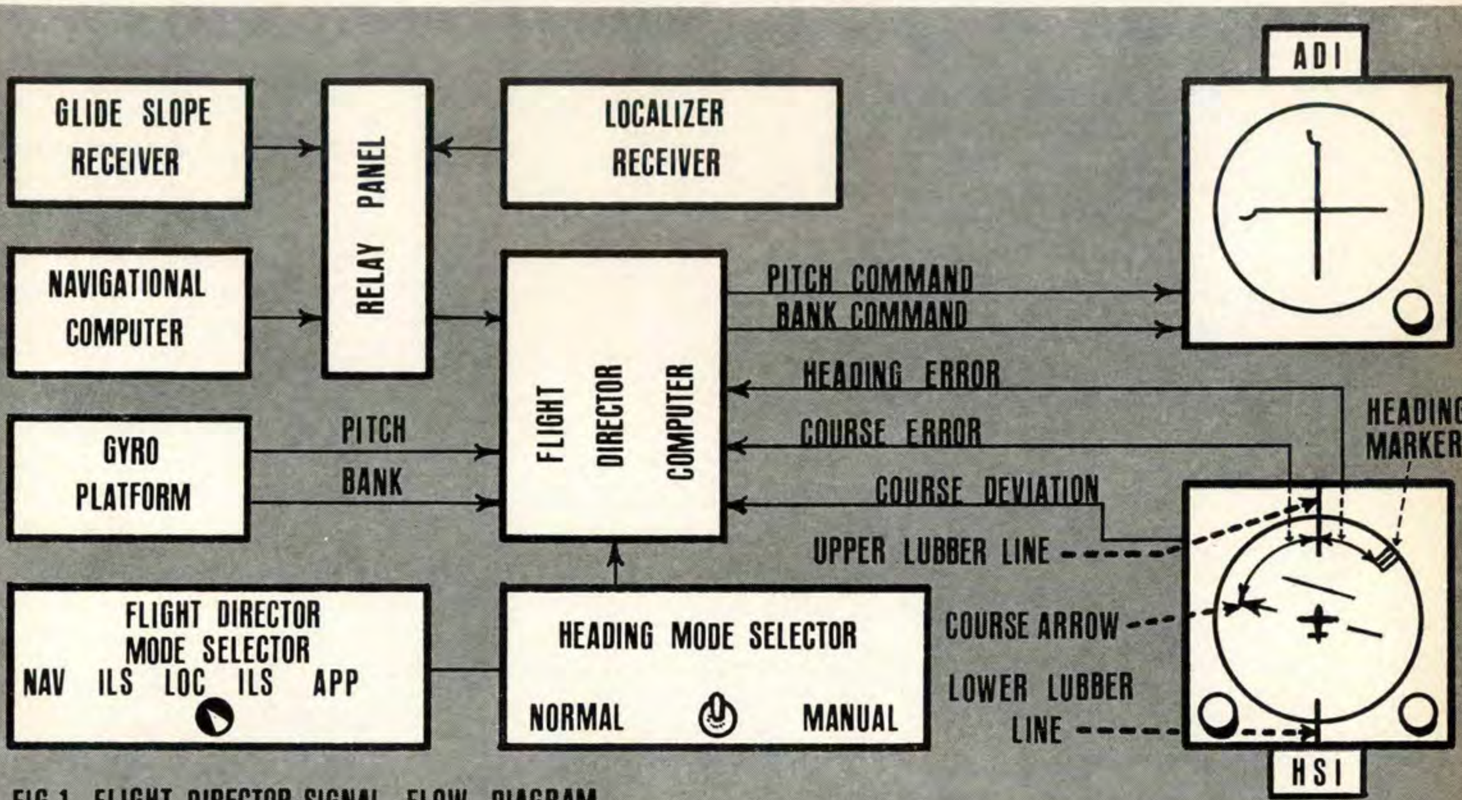


FIG 1. FLIGHT DIRECTOR SIGNAL FLOW DIAGRAM

change at low true airspeeds. In other words, the computer does not know about the rule of one degree change up to 30 degrees of bank. Since 10 degrees is always the "lead point" for starting the roll out, it also causes different roll out rates for different true airspeeds.

The MANUAL heading mode has one feature that may be used to advantage during and immediately after takeoff in instrument flight conditions. After line-up on the runway, set the heading marker under the upper lubber line and select manual on the heading mode cuit to the attitude sphere. With the gyro platform operating normally, an electrical failure between the gyro and the attitude sphere would result in atttiude sphere failure but would not affect the bank steering bar. The bank steering bar would remain usable for backup bank information. It must be remembered, however, that a complete analysis of the aircraft performance instruments must be made prior to blindly following command steering indications. For example, with the HSI showing a turn, but with a wings level indication on the ADI, a quick tributed to attitude indicator failure. The accidents may have been prevented if the pilots had a more thorough understanding of the flight director system and had used the bank steering bar to assist in bank control. If used, the bank steering bar may provide the first indication of attitude indicator malfunction and prevent that terminating aileron roll shortly after takeoff. ★

Next month the second of this three-part series will discuss the operation and use of the Flight Director for ILS localizer interception and flying the final approach.

YANKEE IN VIETNAM (...EJECTION SYSTEM THAT IS....)

EJECTION systems are usually thought of in terms of high speed jet aircraft. But Vietnam changed that with the result being a slow, recip attack aircraft with such a system. It's called Yankee *and it is installed in the A-1. There have been eight ejections with the Yankee system, the first seven, all in SEA, successful. The eighth failed to save the pilot—the ejection system got him out of the aircraft but the chute failed to open and there was not enough altitude for manual canopy deployment.*

The one failure so far, regrettable as it may be, does not negate the fact that seven pilots who might have lost their lives were saved by the system. Here is an account of one of these, as told by the man who had the experience, Major James O. Gassman, currently assigned to the 15th TAC Fighter Wing at MacDill AFB. The story is essentially as Major Gassman taped it with only minor editing for clarity.

I lay much of the whole thing (getting shot down) to complacency. I hadn't been shot at for a few missions and this looked like nothing but a toothpick mission. As a result you don't take that extra bit of effort in turning and jinking, etc., rolling on the target to get rid of the ordnance so you can go back home. It wasn't until a week and a half after I was shot down that I found out what really happened. Up until that time there was a strong possibility that the gun blew up in my left wing, and caused the fire, etc., but it turns out there was a ground party just south of where we were striking and two guys were standing there talking to each other. One guy said to the other, "If he makes one more pass he has had it," and sure as hell I rolled in for that last pass.

Anyway, getting into the mission. It was a two part mission—aircap for a team that was being infiltrated, and the second portion an armed recce. Colonel Pearce * was leading the mission. I was giving him a lead checkout. The weather was good, about 4000 scattered, something like that, visibility very good. The aircap was uneventful and we were released by the FAC. On the armed recce portion we were headed north from the well known Brassiere. About eight miles north Colonel Pearce pointed out a spot, a likely set of trees it looked like to me, but they were bad trees so I didn't mind throwing my ordnance in there. So he called and got permission to strike there and we put in some ordnance just to feel it out. We pulled away from the target and let the dust settle. About this time Covey 33 (the FAC) gave us a call. He was starting up the road from where he had been; he was southeast of the Brassiere. The team was in and settled down for awhile and there were no problems, so he elected to come on up the road. He had reports of some movers during the night and he was looking at an area for a truck parked there.

He was low and we orbited above him and stuck with him while he was VRing the road. Shortly after that, we were orbiting above him about five miles south of where we had put our strike. There was a large secondary (explosion) from where we were throwing this ordnance. We decided to run on up there. All three of us drove up to the first area. We had about three large secondaries in conjunction with this secondary explosion. We all decided that was a good area for the rest of the ordnance so we got clearance again. I put in about two passes getting rid of the rest of the stuff. Then I started to strafe for cover on Colonel Pearce who was finishing up with CBU. He had them on single so it took just a little longer to get rid of his stuff. Then we both started to strafe.

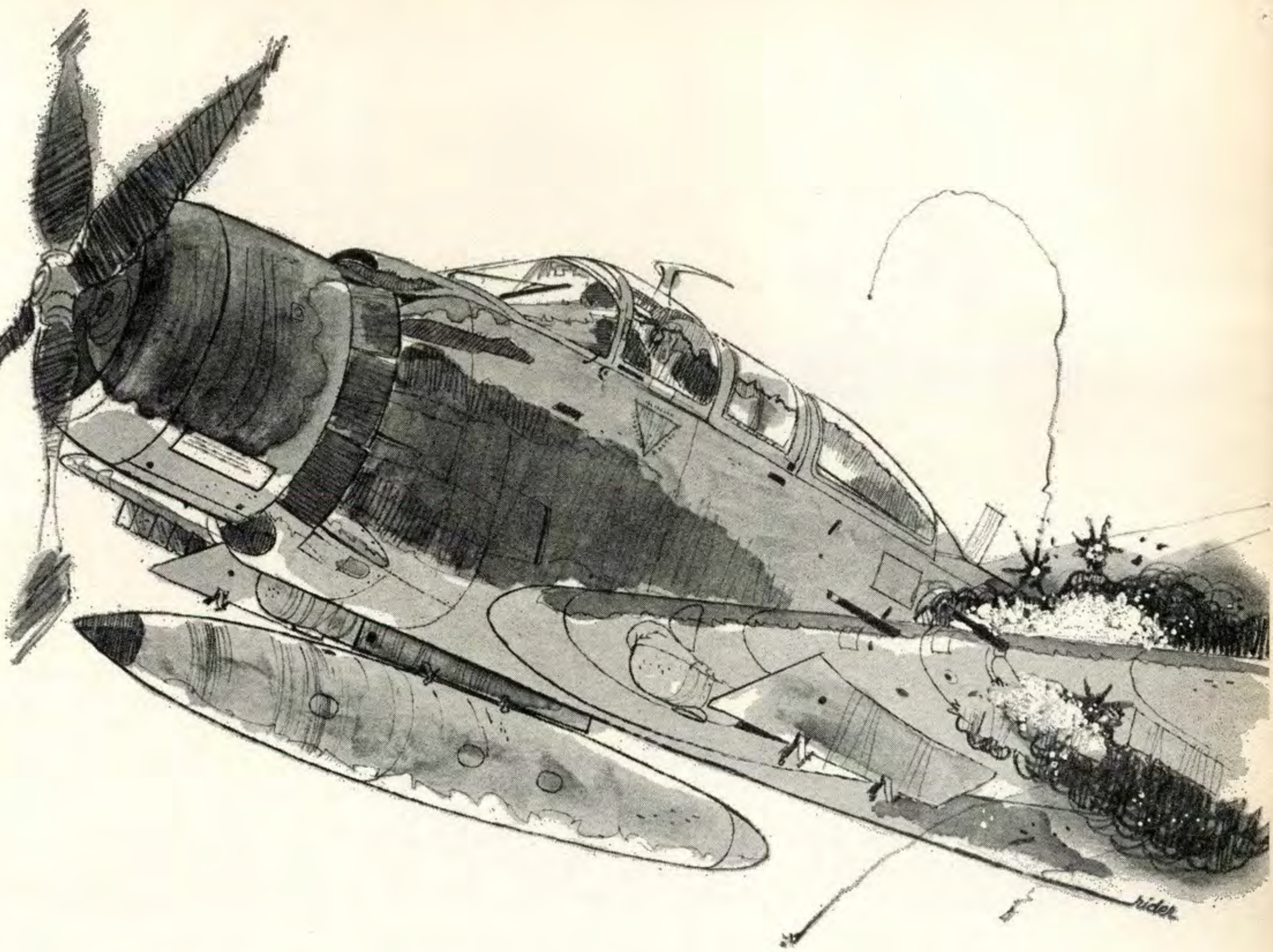
I had made about three passes when we both started strafing. I made about two more good passes so he made two and I thought maybe I shouldn't roll in for this last one, should save a little bit to go home with. About the time I was up on what you might call the old high key, rolling in from the right, I felt a slight bump or thud in the tail section. I thought nothing of it for none of us saw or heard any ground fire. So I rolled back in.

I thought I might have gone through some prop wash, something like that, from one of the previous passes. Just as I got the pipper fairly close to the target area I was hit in the left wing. A hole about eight inches in diameter developed there with fire immediately.

I pulled off the target and headed back south. I gave a call, of course, and said I was heading south in the general direction of Dak To. I gave it the needle and was climbing for as much altitude as I could get. During this time the fire built considerably and I had white hot flames coming out of there and, of course, I immediately lost one of the gun panels and there was a hole now about two feet long and 10 to 12 inches wide. It was really burning and the ammo in the gun cans was exploding.

I had about three explosions, large ones, in the wing, and on the third one some of the stuff hit the canopy. Of course I was ducking down as low as I could in the seat and still climbing for altitude. I had no idea what my altitude was. I

* Colonel W. F. Pearce



was just watching that left wing and heading in a southerly direction. I didn't know what my airspeed was or anything. I knew I wasn't going to be able to stay with the machine much longer, because at that time I had full right rudder and full right aileron. I had to hold it with both hands in order to keep the wings level on the thing. I kept reaching to grab a little bit of trim but I couldn't let go of the stick to get a whole lot, at one time, that is.

Shortly after the third explosion I lost control of the airplane. She went into a severe left roll. When I was on my back I said, "I've got to get out," so I grabbed the handle quick and decided to wait till the wings got level. At that time I pulled the lanyard. I was in a 40-degree dive screaming toward the ground. Altitude, I estimated, was about 2000 or 2500 feet above the terrain. I think I lost quite a bit of altitude in this roll I so cleverly performed—uncoordinated, of course. I never could do it, a decent slow roll in this airplane, to begin with. I pulled the handles at that time and the canopy blew immediately.

I thought it was an eternity between the time the canopy blew and I got the big charge out of the back. They say it is two-tenths of a second, something like this, but I don't believe that. I think it is longer than that; at least, it seemed longer. Finally the thing did take hold and jerked me out of the seat. The G forces involved there are not too severe. Of course, I'm one of the world's worst, I don't like those leg straps too tight. As it later turned out, I did pick up a few bruises, simply because the leg straps were not tight enough, I would say. Anyway I did not, like some of the other lads were saying, see the airplane go away from me when I was pulled out. I was looking straight ahead with my head I thought in the crotch of the headrest. When I went out the bar in the center hit me right on top of the shoulder, a good inch or inch and a half of the shoulder bone itself.* I was a little concerned getting out of the machine and getting hit like that.

* The bar referred to extends fore and aft and supports the canopies over the center of the side-by-side cockpit seating.

The next thing I remember was looking above me. I didn't have any opening shock at all, but there was the canopy above me. I lost my helmet. My chin strap was secure. My visor was not down, but I lost my helmet and my glasses, of course. I'm blind without them but the sight improves considerably there, I think. As a result of losing the glasses I got a cut on my left eye, in the eyebrow portion. They put five stitches in it later. That was the only thing other than my shoulder.

I looked up and the canopy was there and it looked pretty good, but it got awful quiet. Then I heard an explosion and there was a big fireball directly below me. I thought at that time that I was glad I was out of that little machine. There wasn't any way I could have climbed over the side because as soon as I let go of everything, to unstrap, like the lap belt with the old system, I would have lost control of the airplane and gone in immediately. I wouldn't have been able to open the canopy and dive out of that thing. So the seat saved me.

Anyway, I caught myself in a backward drift so, like the big boys, I reached up and grabbed the front risers as high as I could and held them and that stopped the backward drift. I was directly over a clearing and I wanted to land in a clearing rather than in the trees. I ended up right at the tree line and in a slight backward drift, because I let go of the thing when I found I was going to land in the clearing. I had not deployed my survival kit; it still hung to the straps. I landed on my back rolling over. I lay there just two or three seconds, got up and checked myself over real quick. I felt in pretty good shape. I tried to get out of the parachute harness, but I had severe difficulty getting out of the chest buckles. I gave up on it and went to my leg straps. I got them loose and came back to the chest strap and finally got it off.

I decided to get away from the clearing so I ran and got into this four- or five-foot elephant grass, knelt down in it. I ran maybe 50 meters. Then I pulled out my survival radio and talked to the lads above. They said they had me in sight but that I was going to have to move from there, because I was exposed from higher ground. So I looked around and saw this small stream bed. It was maybe a foot and a half deep, something like that, so I walked into it and ran up the stream bed about 10 meters. From that point on it was completely covered with vines and reeds. So I jumped in there and sat in the water.

After some five to 10 minutes I gave them another call, said I was doing fine and was told the choppers were on their way. Every five to 10 minutes I would give them a call and ask how far the choppers were out. I was on the ground about 50 to 55 minutes.

When the chopper came in the area, I ran out of my hiding place and to the clear area. They lowered the hoist and I got in the swing. About halfway up all hell broke loose. I thought I'd had it. More damn shooting than I'd ever heard in all my life. It was two gun ships that came into the area. They hosed down the tree line and they were getting ground fire. Then I was in the chopper and away we went. We landed at Dak To, I was transferred to an Air Force Huey and they pulled me back here to Pleiku.

That is about the size of the operation, but looking back on it—oh, you can always second guess yourself when you make mistakes. The biggest mistake was complacency. I don't have that anymore. I am quite aware that these people are shooting, even if we don't see them. You just can't allow yourself to get complacent over here. It is pretty easy, though, on some missions. But the missions haven't been quite like that lately. We've been working pretty hard.

I have nothing to say about the radio. It worked fine. I had two with me but I just used the one and it worked beautifully. The parachute disappeared about five to 10 minutes after I was pulled up so there must have been some bad guys in the area. All in all things worked out pretty good for me, just about the way they are supposed to, the ideal situation. I couldn't ask for anything better. ★

System Safety Course

Lt Col Edwin B. Perry
Directorate of Aerospace Safety

Those students taking a break under Tommy Trojan Statue will never play football for USC. They're Air Force officers, shown above in classroom studying System Safety.

ACCIDENT prevention can be most economically and effectively induced in the design and development phases of a system's life cycle.

Air Force recognition of this concept and its application to missile and aircraft systems led to the University of Southern California developing a course in System Safety. The university had the assistance of the Directorate of Aerospace Safety and encouragement from other organizations in the aerospace industry. On November 1 the first class of 18 students graduated.

Since 1953 the University's Institute of Aerospace Safety and Management Division has conducted various accident prevention programs, graduating more than 5000 men from 47 countries. Until now, the overwhelming majority of such education has been directed to the operational aspects of accident prevention: safety officers' courses funded by the military services.

While the safety officers' courses have focused on operational safety problems, the general objective of the System Safety Course is to lend emphasis to safety engineering problems. Specifically, this course is designed to provide education for the system safety practitioner working in the development and modification segments of the system spectrum. Aim of the course is to enhance the graduate's ability to evaluate, monitor, and otherwise directly contribute to aerospace system procurement and development from an accident prevention point of view.

Students are recruited about equally from Department of Defense agencies and civilian industry. Engineering degrees are desirable; however, three years of safety, system engineering, or maintenance officer experience is acceptable. Students selected to attend should be programmed for system safety engineering duties following their graduation.

The majority of students in this first class will now be concerned with implementing the system safety concept into systems under development. But since responsibility for updating and maintaining system hazard analysis during earlier phases will be transferred to AFLC, students from the Air Force Logistics Command will be applying this concept during the systems operational phase. These analyses will be extremely valuable in tracing malfunctions through the system, developing or modifying procedures, and conducting modifications of the equipment itself. The continual updating and maintenance of these hazard analyses is necessary through the operational phase to include new hazards as they identified and to exclude other hazards as they are eliminated from the system. It is just as important for safety engineers to keep the operator informed of probable hazards as it is to keep designers informed during system development.

The course includes three major areas of instruction:

- Fundamentals of System Safety: a basic understanding of accident prevention principles in today's environment.
- Implementation of System Safety Engineering: the methodologies to be followed within the systems management framework to perform the system safety engineering function.
- Survey of Safety Engineering Problem Areas: a review of specific safety engineering lessons learned through past experience and of probable concern in the future. ★

USAF AERO CLUB DIRECTORY

As a service to Aero Club members, AEROSPACE SAFETY provides this directory. We will try to update it from time to time by listing any changes, and we'll also try to give you a complete new listing once a year.

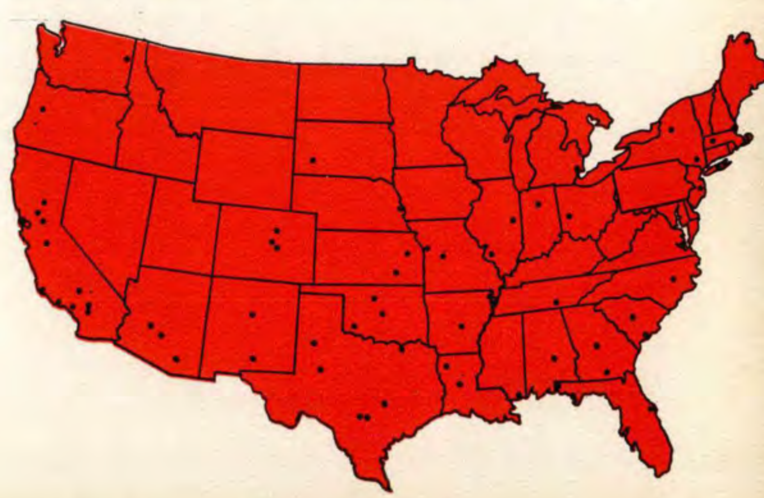
Here's the way to read it: Base name, hours of operation, gas (octane), all have oil available, and phone number. Clubs located on base are printed in black, and those located off base are in color with the name of the airport. Happy landings!

STATE & CLUB	SERVICE AVAILABLE	PHONE NO.
ALABAMA		
Maxwell-Gunter AFB Aero Club (AU) Gunter AFB	0800 to Sunset Gas-80/Oil Yes	3149
ARKANSAS		
Blytheville AFB Aero Club (SAC)	0800-1700 Gas-80/Oil Yes	691
Little Rock AFB Aero Club (SAC)	0730-1630 Gas-80/Oil Yes	7710
ARIZONA		
Davis-Monthan AFB Aero Club (SAC)	0800-1700 Gas-80/Oil Yes	327-7632
Luke AFB Aero Club (TAC) Litchfield Park Airport	0600-2000 Gas-80/Oil Yes	935-4891
CALIFORNIA		
Beale AFB Aero Club (SAC)	0730-1700 Gas-80/Oil Yes	788-1972
Castle AFB Aero Club (SAC) Merced Municipal Airport Merced, California	0800 to Sunset Gas-80/Oil Yes	722-3638
Edwards AFB Aero Club (AFSC)	0800-1600 Gas-80/Oil Yes	277-2474
Hamilton AFB Aero Club (ADC) Hamilton AFB (Ignacio)	0800-2000 Gas-80/Oil Yes	883-7711 Ext 4447
Los Angeles AFS Aero Club (AFSC) Los Angeles International Airport	24 Hours Gas-80-100/Oil Yes	643-1668
March AFB Aero Club (SAC)	0800 to 1800 Gas-80/Oil Yes	2455
McClellan AFB Aero Club (AFLC)	Sunrise to Sunset Gas-80/Oil Yes	927-4292 2434/4142
Det 1, AFSCF Aero Club (AFSC) (AFSC) Naval Air Station, Moffett Fld (San Francisco)	0900-1500 Gas-80/Oil Yes	739-4510 Ext 2584
Norton AFB Aero Club (MAC)	0800-1700 Gas-80/Oil Yes	382-2545
Oxnard AFB Aero Club (ADC) Oxnard AFB (Camarillo), Calif.	0730-1800 Gas-80/Oil Yes	Ext 3279 486-1631
Travis AFB Aero Club (MAC) Travis Sky Park Travis AFB (Fairfield), Calif.	Daylight Night on Request Gas-80-100/Oil Yes	707-437-3470
Vandenberg AFB Aero Club (SAC) Vandenberg AFB (Lompoc), Calif.	0900-1730 Gas-80/Oil Yes	866-5310
COLORADO		
Ent AFB Aero Club (ADC) Peterson Field Colorado Springs, Colorado	24 Hours Gas-80-100/Oil Yes	635-8911 Ext 4310/ 4759
Lowry AFB Aero Club (ATC) Buckley ANG Base (Denver), Colo.	0800-1630 Gas-80-100/Oil Yes	366-5363 Ext 508
USAF Academy Aero Club (USAFA) USAFA Air Field Colorado Springs, Colorado	0800 to Sundown Gas-80-115/Oil Yes	472-4423
FLORIDA		
Eglin AFB Aero Club	0700-1700 (5 days/week) Gas-80/Oil Yes	882-1252
Patrick AFB Aero Club (AFSC)	0700-1700 Gas-80/Oil Yes	494-4356
Tyndall AFB Aero Club (ADC)	0700 to Sunset Gas-80/Oil Yes	21237
GEORGIA		
Moody AFB Aero Club (ATC)	Daylight/Prior Request Gas-80/Oil Yes	244-1527
Robins AFB Aero Club (AFLC) Macon Municipal Airport Macon, Georgia	0800-1700 Gas-80/Oil Yes	912-788-1443
ILLINOIS		
Chanute AFB Aero Club (ATC)	0730-1630 Gas-80/Oil Yes	893-3111 Ext 2284
Scott AFB Aero Club (MAC)	0930-1700 Weekends 0800-1700 Gas-80-100/Oil Yes	AL 6-4394
INDIANA		
Bunker Hill AFB Aero Club (SAC)	0800-1700 Gas-80/Oil Yes	689-7268
KANSAS		
Forbes AFB Aero Club (TAC)	0800-1700 Gas-80/Oil Yes	5165/4517
McConnell AFB Aero Club (TAC)	0800-1700 Gas-80-100/Oil Yes	MU 5-1151 Ext 5180
LOUISIANA		
Barksdale AFB Aero Club (SAC)	0800-1800 Gas-80/Oil Yes	423-8871
England AFB Aero Club (TAC)	24 Hours Gas-80/Oil Yes	346
MAINE		
Loring AFB Aero Club (SAC)	0700-2000 Gas-80/Oil Yes	7284

STATE & CLUB	SERVICE AVAILABLE	PHONE NO.
MARYLAND		
Andrews-Bolling AFB Aero Club (Hq Comd USAF), Hyde Airport Clinton, Maryland	0800-1700 Gas-80-100/Oil Yes	297-9229
NOTE: Services are not available at Andrews AFB and areo club aircraft should not land there.		
MASSACHUSETTS		
L. G. Hanscom Field Aero Club (AFSC)	0800-1700 Gas-80/Oil Yes	274-6100 Ext 3329
Otis AFB Aero Club (ADC)	Daylight Gas-80/Oil Yes	563-2215
Westover AFB Aero Club (SAC)	24 Hours Gas-80/Oil Yes	2536
MICHIGAN		
Selfridge AFB Aero Club (ADC)	1700-2100 Sat-Sun 0800-2100 week days Gas-80/Oil Yes	Ext 3151
MISSISSIPPI		
Keesler AFB Aero Club (ATC)	0700 to Sunset Gas-80/Oil Yes	3948
MISSOURI		
Richards-Gebaur AFB Aero Club	0800-1630 Gas-80-100/Oil Yes	DI 5-4400 Ext 3440
Whiteman AFB Aero Club (SAC)	0800 to Sundown Gas-80-100/Oil Yes	LO 3-3311
NEBRASKA		
Offutt AFB Aero Club (SAC)	24 Hours Gas-80-100/Oil Yes	3939
NEW JERSEY		
McGuire AFB Aero Club (MAC)	0800-1700 Gas-80/Oil Yes	3113/4057
NEW MEXICO		
Holloman AFB Aero Club (AFSC) Alamogordo Midway Airport, N. M.	Daylight Gas-80-100/Oil Yes	437-0490 Ext 505
Kirtland AFB Aero Club (AFSC) Albuquerque Sunport Albuquerque, New Mexico	Prior Request Gas-80/Oil Yes	247-1711 Ext 3486
NEW YORK		
Griffiss AFB Aero Club (AFLC)	24 Hours Gas-80-100/Oil Yes	330-3435
Stewart AFB Aero Club (ADC)	0800 to Sunset Gas-80/Oil Yes	8535
Suffolk County AFB Aero Club (ADC)	24 Hours Gas-80/Oil Yes	288-1900 Ext 613
NORTH CAROLINA		
Seymour-Johnson AFB Aero Club (TAC)	0730-1730 Gas-80/Oil Yes	6245
OHIO		
Wright-Patterson AFB Aero Club (AFLC) Wright Field (Dayton), Ohio	0730-1630 Gas-80-100/Oil Yes	255-3847
OKLAHOMA		
Altus AFB Aero Club (SAC)	0800-1700 Gas-80/Oil Yes	482-7544 Ext 7011
Tinker AFB Aero Club (AFLC)	0830-1700 Tues thru Sat Gas-115-145/Oil Yes	PE 2-7321 Ext 2467
Vance AFB Aero Club (ATC)	0700-1900 Gas-80/Oil Yes	AD 7-2121 Ext 2506
OREGON		
4625th Aero Club (ADC) Adair AFS, Corvallis Municipal Airport (Corvallis), Oregon	24 Hours Gas-80/Oil Yes	924-5511 Ext 704
SOUTH CAROLINA		
Charleston AFB Aero Club (MAC)	0800-1700 Gas-80/Oil Yes	747-4111 Ext 3614
Shaw AFB Aero Club (TAC)	0800 to Sunset Gas-80/Oil Yes	2636
SOUTH DAKOTA		
Ellsworth AFB Aero Club (SAC)	0800 to Sunset Gas-100/Oil Yes	399-7967
TENNESSEE		
Arnold AFS Aero Club (AFSC) William Northern Field (Tullahoma), Tennessee	Sunrise to Sunset Gas-80-100/Oil Yes	455-2611 Ext 591

STATE & CLUB	SERVICE AVAILABLE	PHONE NO.
TEXAS		
Bergstrom AFB Aero Club (TAC)	Sunrise to Sunset Gas-80/Oil Yes	EV 5-3586
Kelly AFB Aero Club (AFLC) San Antonio International Airport San Antonio, Texas	24 Hours Gas-80-100/Oil Yes	TA 4-2313 Ext 64
Perrin AFB Aero Club (ADC)	0800-1800 Gas-80/Oil Yes	504
Randolph AFB Aero Club (ATC)	0900-1830 (Closed Tues) Gas-80/Oil Yes	Ext 4364
Reese AFB Aero Club (ATC)	0900-1700 Gas-80/Oil Yes	885-4511 Ext 709
Sheppard AFB Aero Club (ATC)	0830-1730 Gas-80/Oil Yes	2160
Webb AFB Aero Club (ATC) Howard Co. Airport (Big Springs), Texas	Daylight to Sunset Gas-80/Oil Yes	AM 3-2411
VIRGINIA		
Hq USAF Aero Club (Hq Comd USAF) MCAS (Quantico), Virginia	0800-1800 Gas-80/Oil Yes	Quantico 1000 Ext 26770
Langley AFB Aero Club (TAC)	0800 to Sunset Gas-100/Oil Yes	764/2743/5304
WASHINGTON		
Fairchild AFB Aero Club (SAC)	0800 to Sunset Gas-80/Oil Yes	CH 7-5443
ALASKA		
Eielson AFB Aero Club (AAC)	Sunrise to Sunset Gas-80-100/Oil Yes	377-1223
Elmendorf AFB Aero Club (AAC)	24 Hours Gas-80-87-100/Oil Yes	752-4167
CANAL ZONE		
Albrook AFB Aero Club (USAFSO)	24 Hours Gas-80/Oil Yes	83-7210
PUERTO RICO		
Ramey AFB Aero Club (SAC)	1000Z to 2200Z Gas-100/Oil Yes	22251/7287
EUROPEAN AREA		
Bentwood Aero Club (USAFE) RAF Woodbridge (Suffolk), England	Sunrise to Sunset Gas-80/Oil Yes	WB 3-711 Ext 457
Bitburg AB Aero Club (USAFE) Bitburg, Germany	Sunrise to Sunset Gas-80/Oil Yes	7410
Sembach AB Aero Club (USAFE) Sembach, Germany	Sunrise to Sunset Oil Yes	7630
Wheelus AB Aero Club (USAFE) Wheelus AB, Lybia	Sunrise to Sunset Gas-100/Oil Yes	3110
Torrejon Aero Club (USAFE) Torrejon AB, Spain		3529/2456
PACIFIC AREA		
Clark AB Aero Club (PACAF) Clark AB, Philippines	0600-1800 Gas-80-100/Oil Yes	44201 42293
Hickam-Wheeler AFB Aero Club (PACAF) Wheeler AFB, Oahu, Hawaii	0700-1900 Gas-80-87/Oil Yes	667790
Kadena AB Aero Club (PACAF) Yontan Airfield, Okinawa, Ryukyu Islands	Daylight Gas-115-145/Oil Yes	24296/24460
Misawa AB Aero Club (PACAF) Misawa AB, Honshu, Japan	24 Hours Gas-115-145/Oil Yes	3881

(Information prepared from "Status of Aero Club Aircraft and Operations" RCS: AF-A44, as of 31 October 1967. Clubs in the process of dissolution have been omitted.) ★



Journey Through A Statistician

Norman Weil,
Directorate of Aerospace Safety

In November 1967, an IBM 360 Model 40 Computer was installed in the Directorate of Aerospace Safety. Much of the historical Flight Record information (Form 5) and historical data relative to the number and kinds of accidents has been transferred to the computer. Many comments have been made about this new era in machine storage and retrieval of records, but little has been said about the potential research capabilities this computer system offers management.

The Rand Corporation, in a study of the proposed computer facility, highlighted, and concurred, in the importance of the research potential of the computer. In line with this thinking, a Statistical Research Section, with an allocation of three statisticians has been established for the express purpose of exploring this potential. The intent of this article is to portray the role these statisticians will play in Aerospace Safety within the changing environment of the computer system.

Of particular interest to people in the safety field is the question, "How can the statistician help support my job and improve safety?" It is hoped that this article will shed some light on the research capabilities of the statistician and his special tools of the trade in analyzing data. This is only a tour of the statistician's workshop; it is not intended to portray the mechanical derivation of formulas and application of formulas in the solution of problems.

The skills of a statistician are best utilized when one is faced with the problem of making order out of disorder of a mass of numerical records, and projecting what may or may not occur. The Directorate of Aerospace Safety receives approximately 20,000 accident and incident reports each year. "What are the significant trends?" "What relationships exist?" These are the types of questions one must answer to most effectively utilize the data system. In the past twenty years, manual handling of these records and the restrictions of machine capability have limited efforts in gleaning the full potential of the data bank. The computer has now put an entirely different complexion on the job.

In essence, the Statistical Research Section of the Directorate's Research and Analysis Group has a responsibility to provide the type of research that will assist in molding Air Force policy, and to assist management at this headquarters and in the field in learning more about the cause and effect relationships of accidents.

FREQUENCY DISTRIBUTION

When a statistician refers to raw data he is usually referring to collected data which has not been organized numerically. The thousands of accident reports filed in this Directorate contain raw data. If we were asked to make some meaningful comments about the details of these reports, such as "What is the experience level of pilots?", it becomes an impossible task unless we arrange the data in some sort of organized fashion. The basic technique used by the statistician is to distribute the data into classes and determine the number of individuals belonging to each class, called the class frequency. The tabular arrangement is called a frequency distribution. For example, Figure 1 is a frequency distribution of the experience level of 4374 pilots at ABC Command. Although this grouping process, in a way, covers up much of the original detail of the data, the key point is that we gain a clear overall picture to identify vital relationship.

Preparation of a graphic representation of the frequency distribution, as shown in Figure 2 further assists in communicating the meaning of the data. The set of rectangles is commonly known as a frequency histogram; the line curve is known as a frequency polygon. Here we see how the statistician first commences to organize the raw data into a form which permits some gross evaluations of what are the characteristics of the details reported in the massive stack of reports.

Note how the line of the frequency polygon in Figure 2 shapes what is known as a frequency curve. In practice, frequency curves take certain characteristic shapes. From an analysis of the curve, the statistician is able to accomplish a significant amount of research into the basic characteristics of the data, as well as a projection of probability of what will occur in the future. Now that we have grouped some of the raw data into a summary table and portrayed it graphically, the question arises as to how we communicate and analyze what these tables and curves represent.

MEASURES OF CENTRAL TENDENCY

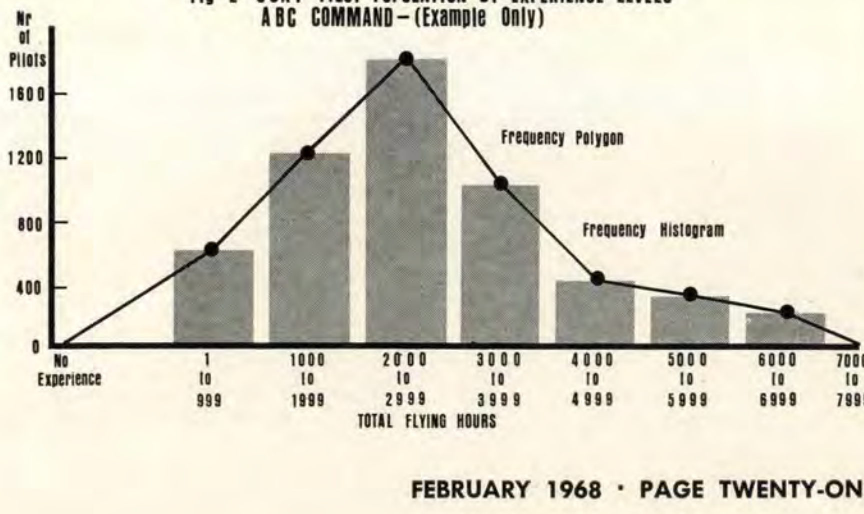
Have you ever been asked to state in a few words what is a typical or representative situation? This question comes up frequently. How many miles a year does an individual drive his private motor vehicle? Some may drive 30,000 miles a year, others only a thousand or two. But generally the typical or representative individual drives around 10,000 miles a year. What is the typical experience level of an Air Force pilot? What is the typical experience level of a Navy pilot? On the average, how many hours does a pilot fly before he experiences an accident?

When we must make decisions or policies, knowledge of this typical value is extremely important. In the trade jargon these values are often called measures of central tendency. The most common measure is the arithmetic mean, or simply

Fig 1
EXPERIENCE LEVEL OF 4374 PILOTS
AT ABC COMMAND (Example Only)

TOTAL FLYING HOURS	NUMBER OF PILOTS
1 — 999	465
1000 — 1999	1089
2000 — 2999	1583
3000 — 3999	760
4000 — 4999	204
5000 — 5999	162
6000 — 6999	111
	TOTAL 4374

Fig 2 USAF PILOT POPULATION BY EXPERIENCE LEVELS
ABC COMMAND—(Example Only)



the sum of the cases divided by the number of cases (referred to as the average). Other measures of central tendency are the median (the value in the middle), and the mode (the value occurring most). Each has its advantages and disadvantages depending upon the data and its particular application. However, they all have one characteristic in common, the ability to communicate a meaning for a mass of statistical data.

MEASURES OF DISPERSION

Once a statistician has developed a figure to depict the typical case, he has at his disposal a tool to measure how all cases scatter about this average. This second measure evaluates the dispersion of data. Why are we interested in dispersion? Because the measure of central tendency by itself can be misleading. For example, if we know that the average number of a certain type of ground accidents in a week is 60, it is still possible that in a particular week we would have only one accident whereas in other weeks we may have as many as 100 accidents. (Note the experience level of pilots as illustrated in Figure 1 shows a wide dispersion.)

The tools that the statistician has at his disposal to measure dispersion provides more insight into what are the lows and highs and the frequency of such. Further, from these measures, it is possible through refined techniques to advise management what the probability is of incurring a specific number of accidents in a day, week, month, etc. The range, the mean deviation, the standard deviation, and the quartile deviation, are some of the measures of dispersion commonly used.

SAMPLING TECHNIQUES

When an individual is faced with a decision, the more facts he has available, the more confidence he can have in the final decision. However, sometimes it would be too expensive or it would take too long to collect the information. The statistician has techniques which permit him to sample or to obtain facts from a part of the total number of cases and, in turn, to scientifically interpret what all of the facts would reveal, if we had the time and money to collect them. In application of these techniques, the statistician is faced with one key technical question. How can I ensure that the sample is representative? Random, cluster, stratified sampling, are but a few of the sampling approaches used by research personnel. The main point is that they provide the scientific approach in developing the most reliable facts per dollar invested.

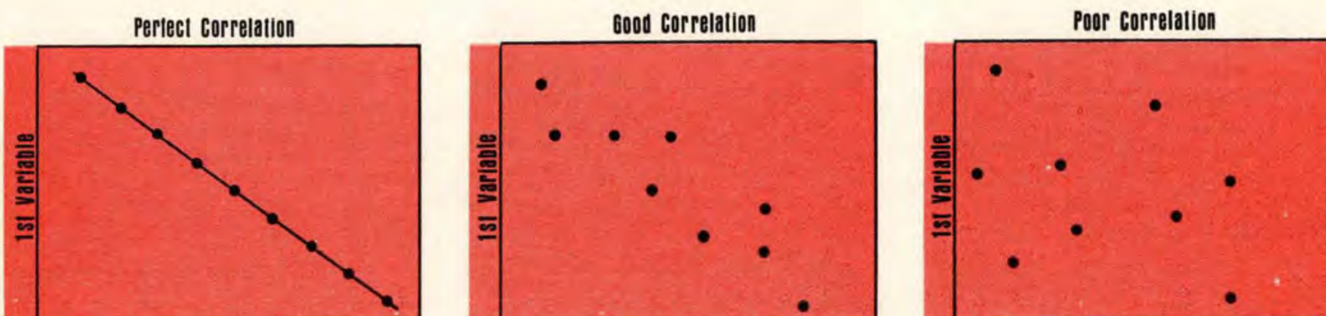
CORRELATION, CAUSE AND EFFECT

Relationships are frequently important. For example, the higher the alcohol content of an individual's blood, the greater the chance of his having an accident when he is driving. As the alcohol content increases the point comes where the individual has practically no control of the automobile. The statistician can measure with precision the degree of relationship between two (or more) variables; for example, between alcoholic content of the blood and the probability of an accident occurring.

The coefficient of correlation is a measure commonly used in this approach. Perfect correlation is denoted by a value of one, whereas no correlation is denoted by a value of zero. Within these two extremes the statistician can interpret the numerical value of the coefficient of correlation.

A graphic tool commonly used in quickly obtaining a measure of correlation is known as a Scatter Diagram. Figure 3 represents this graphic approach and how the diagram would look under varying circumstances of correlation. The first variable could be, for example, the accident rate and the second variable could be pilot experience.

Fig 3 SCATTER DIAGRAM



The main point is that we are communicating graphically the underlying degree of relationship.

Linear correlation, multiple correlation (measurement of relationship between more than two variables), partial, rank correlation are all technical approaches which can be applied under specific circumstances.

TESTS OF SIGNIFICANCE

Do you look at statistical facts and ask how meaningful these numbers are, particularly where only a small number of observations are available? How many times has management implemented a new policy and wondered whether any significant changes have really resulted from the new policy? The statistician has tools and techniques to answer these questions.

In the process of reaching a decision, the statistician can make important tentative evaluations about the population involved. For example, he might make a null hypothesis, meaning there is no difference, between effectiveness of one ejection system versus another ejection system. Procedures are available to evaluate the data and determine if significant differences really exist or if they occurred purely by chance and, therefore, validate the null hypothesis.

Of particular value are the techniques of setting up a controlled experiment whereby a new policy is implemented for one group of individuals, and the old policy instructions are still applicable to another group. After a specified time period (sufficient for the policy to take effect) the statistician can take measurements and through tests of significance, determine whether the difference between the two groups is really significant or whether it might be purely chance. This provides an intelligent approach to critiquing the value of a proposed policy or a new training program.

FREQUENCY DISTRIBUTION CURVES

Frequency distributions can be assigned to different mathematical families depending on the shape of the curve. Of particular interest to the statistician is the Normal Distribution, the Binomial Distribution and the Poisson Distribution. The Binomial and Poisson distributions permit us to deal with the occurrence of distinct events, for example, the number of defects in a sample at a factory or the number of accidents at an airport. You have one, two, three, etc., accidents (distinct events). There is no such thing as 1.2 accidents. The Normal distribution deals with quantities whose magnitude is continuously variable, for example, height of an individual.

The Poisson distribution plays an important role in accident research since it is descriptive of situations where the occurrence of an event is rare compared with the total number of times it could occur. In other words, the exposure rate is high but the event occurs infrequently. Mathematicians and statisticians have developed tables which define the probability of an event occurring. For example, if an average of five aircraft accidents per month is experienced, the probability of eight accidents in a month is seven in one hundred, the probability of 16 accidents is one in 20,000. Through further study, management can set control limits which describe (with a fair degree of certainty) how many accidents can occur with no underlying change in the safety situation. If the number of accidents goes over this level, then serious remedial action is required.

COMPUTER APPLICATION

The statistical tools which have been briefly described have been available for many years. The installation of the computer now provides the mechanism to accomplish a mass of mathematical computations which are required in the application of statistical techniques. What the computer can accomplish in a few hours represents thousand of manhours, were the same computations to be attempted by statistical clerks utilizing the equipment previously available. The main limitation of statistical research with the computer lies in areas where data have not been stored in the data bank. As research needs develop, it is anticipated that additional historical data will be extracted from manual records and placed in machine readable form.

RESEARCH PLANS FOR THE FUTURE

The Statistical Research Section is in its first preliminary phase with emphasis now on staffing the statistician positions and developing a research program. In the design of the research projects the important thing is to answer the needs of the safety officer as well as management. The statistician has techniques for application in two basic areas of research. First, the measurement of the characteristics of what has actually happened. Secondly, inferring what the probability of something happening will be, so that we can build from our experience to project toward the future.

Your comments and suggestions on particular aspects of research which you feel are needed, are solicited. These should be forwarded to the Records and Statistics Group, Directorate of Aerospace Safety, Norton AFB, California 92409. ★

KEEP IT DRY—Desiccants have limitations which are not readily apparent. A desiccant will not remove moisture unless the two come in contact. A common occurrence is the presence of water in metal containers supposedly protected by tubes of desiccants with color indicators. Large amounts of water may be present although the indicator shows the capacity of the desiccant has not been exhausted. Moisture and air may enter the container as it "breathes" with changing ambient temperatures and pressures. When the metal cools, the moisture condenses and flows to the bottom of the container. It is not removed by the desiccant.

For another reason, the amount of moisture removed by a desiccant is less than generally expected. The small amount of moisture which does contact the desiccant causes a reaction (chemical in the case of an absorbent; physical with an adsorbent) which liberates heat. This heat, even though small, raises the temperature of the desiccant and its surroundings slightly above that of the cold metal. Condensation is therefore less likely to take place in the vicinity of the desiccant.

For a desiccant to be effective, a mechanism must be provided which establishes contact between it and moisture. This may be accomplished by either passing the moisture laden air through or over the desiccant.

If this cannot be done, containers should be sealed as tightly as possible against entrance of moisture-laden air and opened as infrequently as possible. Critical components or assemblies should be put in sealed vapor proof containers, such as plastic bags, from which air has been exhausted.

Moisture can do no damage where it can't enter.

Willie Hammer
Directorate of Aerospace Safety

MISSILANEA

MISSILE HAZARD REPORTING, WHY?—During visits to tactical fighter wings, project officers reviewed the Missile Hazard Reporting (MHR) system. At the majority of wings there was little or no activity. Educational programs were established and the MHR was a special subject during safety meetings, but to no avail. Many hazards just do not get reported. The odd part to this story is that incidents caused by a recognizable hazard are still being reported. If an MHR had been submitted, there is a good possibility these incidents would not have occurred. Some problems which have been seen in the field, or were reported as incidents, and which could have been submitted on an MHR, are:

- A Bullpup missile was damaged when an MHU-32/E storage dolly collapsed. The dolly had struck a one-inch lip at the entrance to the storage bay. The problem has been corrected, but it took an incident for someone to notice that the lip presented a hazard.
- Frayed hydraulic hoses on the MJ-1 Bomb Lifts. It was also noted at the same wing that on three units checked, the hoses were all installed differently.
- At one base, a pipe carrying ammonia was broken three feet from where it entered a water pit for neutralization. The ammonia was seeping into the ground and to the atmosphere. This hazard was noted during a project visit and had been present for some time.
- In a missile maintenance hangar there was no travel limit on an overhead crane. The crane could hit the wall at a point where a power line was installed. Again, no hazard report.

Why weren't reports submitted on the above problems? Is it because the airmen just don't care, don't know, or because of a poor education program? The problem could be due to one of these reasons or a combination of all.

There are two primary reasons why a hazard report should be submitted: One, to provide a warning to unit commanders that a dangerous situation exists; and two, to advise other commanders with similar equipment. To be corrected, a hazard must be known!

A next question frequently asked is, "Why bother with an MHR when there are URs, AFTO 22s, construction deficiency reports, and others?" All of these reports don't cover every situation, nor are all personnel familiar with the reports.

Isn't it about time that you, the working airman, look around and start telling people about the hazards in your area of work? It's easy. Just fill out the first section on the AF Form 471 in pencil, or any way you desire, and give it to your local safety officer. DO IT NOW before there's a missile damaged or a person injured.

Maj Edward J. Fiske
Directorate of Aerospace Safety

STABLE, INERT, NON-TOXIC KILLER!

Lt Col Moses R. Box, Directorate of Aerospace Safety

ONE of the gases used extensively in work related to missile/space systems is nitrogen. In systems in which liquid oxygen (LOX) is used as the primary oxidizer, liquid nitrogen is often used to check out the propellant loading system. It is also applied as a blanket over highly reactive propellants such as *hydrazine*. These are safety measures; yet, how safe are they?

Nitrogen is a stable, fairly inert gas which is not toxic. It does not readily react with other elements and is not explosive or corrosive. All of these qualities are desirable in gases used to pressurize, blanket, or purge missile/space systems.

With these good qualities you may wonder why we bother to discuss this gas any further. There is a reason. Periodically this same inert, stable, non-toxic gas causes injury and death to Air Force personnel. With all its good points, nitrogen creates hazards. Nitrogen, though not toxic, is an asphyxiant. At normal temperatures it is lighter than air but its weight is so near the weight of air that a small leak will not diffuse rapidly, allowing a concentration to build up. This concentration dilutes the oxygen in the air and results in a hazard to personnel.

Nitrogen is often used as a cryogenic liquid. As it vaporizes, the cold gas is heavier than air and will settle into sumps, pits and depressions in the ground. It is especially dangerous since it is odorless and colorless and cannot be detected by our normal senses. Cases are on record where persons were overcome in a matter of seconds in low areas where cold nitrogen gas had concentrated.

Where nitrogen, as a cryogenic liquid, comes in contact with the skin the tissues will freeze. The metal piping used in cryogenic systems is also at sub-zero temperatures and should not be touched without protective equipment. In a dry atmosphere the low temperatures of the nitrogen pipes may cause oxygen to condense out of the air creating liquid oxygen on the pipes, which, in turn, creates an explosive safety hazard. For this reason the frost coating which forms on the nitrogen lines should not be removed.

Another major hazard related to liquid nitrogen results from pressurization. In missile/space systems nitrogen is used at pressures up to 6000 psi. These "normal" systems have all the hazards associated with other high pressure systems. In addition, where the liquid nitrogen is trapped in a closed system it may build up excessive pressure and the results will be a violent rupture of the tank or lines.

The accident prevention measures associated with nitrogen become common sense once the hazards are recognized. To protect from extreme temperatures, goggles or face shields along with protective clothing, gloves, and shoes must be worn. Avoid contact between bare skin and low temperature nitrogen lines. Operations involving liquid nitrogen should be performed by two or more persons working in groups so they can assist each other in the event of an emergency. Lines should be kept free from the accumulation of moisture which could freeze at cryogenic temperatures in valves or traps, which in turn would block the line and result in rupture from pressure buildup. Storage, use, and disposal of liquid nitrogen should be conducted in well-ventilated areas. Don't enter areas containing liquid nitrogen or greater than normal concentrations of nitrogen until normal oxygen concentrations are re-established or unless self-contained breathing apparatus is used. Normal gas masks are not effective against nitrogen concentrations since they do not provide the wearer with additional oxygen other than that found in the surrounding air.

In summary, nitrogen is used as a safety measure in many activities of the Air Force. It is safe as long as the person using it has a knowledge of its limitations and conforms to simple accident prevention rules and established technical data. Where people become careless or disregard established procedures this stable, inert gas becomes a killer. So handle with care. ★

ARRESTING GEAR information. Current FLIP ENROUTE SUPPLEMENTS now carry all information necessary for a pilot to determine the Arresting Gear/Jet Barrier status at any airfield. This information is an important part of your flight planning. Not only should a pilot know his aircraft hook capability and limitations, he should know the type of arresting gear/barrier system available at the point of intended landing. An extremley important factor is that it may require up to 15 minutes to rig an arresting gear for an approach end engagement.

Operational considerations at some airfields have dictated the removal of the BAK-6, BAK-9 or BAK-12 cable on the approach end of the runway. This information is not available in the FLIP ENROUTE SUPPLEMENTS, NOTAMs or anywhere else. The fact that 15 minutes rig time may be necessary, covers this contingency. At other bases, the 15-minute time period is needed to disconnect the MA-1 on the approach end and get it out of the way. An approach end engagement over an in-place MA-1 Jet Barrier can cause a missed engagement of the hook arresting gear even if the MA-1 is in the down position. On interconnected MA-1/BAK-9 or BAK-12 systems, damage to the aircraft can occur as well as a missed engagement.

Who knows when a situation will dictate an approach end engagement? No One! The best you can do is to insure the arresting system is ready for you if you need it.

Lt Col Richard R. DeLong
Directorate of Aerospace Safety

PAX BRIEFING—The symptoms of moderate turbulence are "Occupants require belts and are occasionally thrown against belt. Unsecured objects move about . . ." Severe turbulence: "Occupants are thrown violently . . ."

Now suppose that you are the aircraft commander

of a transport carrying a load of passengers and you encounter conditions such as described above. Not all aircraft have FASTEN SEAT BELTS signs. But even the presence of such a sign will not guarantee that all passengers will be strapped in.

What are we getting at? Just this: Several injuries occurred when passengers in a troop carrier aircraft were thrown violently about in turbulence. According

AEROBiTS

to the report we received, the passengers had not been briefed prior to the flight.

Most crews seem to do a good job of briefing their passengers. But it is an item that can easily be forgotten if some distraction occurs. The briefing is a checklist item so there's really not much excuse for skipping it. The aircraft commander should either conduct it himself or designate the briefer and insist that he report "passenger briefing completed." This may prevent an injury. At least it will save a lot of embarrassment later if some unfortunate incident causes a passenger to be injured.

ILLUSION—On final the aircraft seemed a bit low so it was eased up slightly on the glidepath. Suddenly the left wing dropped sharply and the crew made an AB go-around followed by an uneventful landing. Later the left wing tip was found to be bent upward, indicating that it had struck the ground.

Weather was not a factor. Since the aircraft was the only one in the pattern and there had been no recent departures, wake turbulence was ruled out. So, how to account for this incident? Possibly the pilot was a victim of an illusion. The field was strange to the crew, the approach lights and VASI were inoperative because of airfield construction. The first 1000 feet of the runway was unusable and temporary lights marked the relocated threshold. The runway width was different from that at home base and there was a downslope to the newly constructed overrun.

These factors could have fooled the pilot during the first landing attempt and apparently did. The aircraft stalled, causing the rapid roll to the left during which the wing tip struck the ground.

The pilot bought this incident, but we know from bitter experience that it can happen to anyone. Some points to remember: When the lights are not standard, the runway is of a different width than you're accustomed to; there's an unusual slope to runway or overrun, the approach terrain rises or falls rapidly; play it a little closer to your vest.

F-100F NOTE. From Luke AFB comes this item: "The safety pin for the F-100F rear seat windblast shield has been found tied to the hand hold on the rear seat instrument shroud. What will happen to the pin if the canopy is jettisoned during flight?

"Items that serve no useful purpose for mission accomplishment but must be carried in the cockpit should be securely stowed."

Getting the MOST FROM WHAT'S AVAILABLE: From an article by Mr. Crocker Snow in the Air Traffic Control Journal: "Take the case of Runway 22L at Boston, the longest runway. The only authorized instrument approaches are an ADF on the 4R middle marker and a VOR on a VORTAC displaced a mile to one side of the runway. 4R has an ILS, but the localizer back course doesn't meet FIDO (Flight Inspection District Office) standards, although I can't see anything wrong with it. It brings me straight to the end of the runway, which is a lot better than either the VOR or the ADF will do.

"Anyway, those of us who know the ropes, which includes some FAA and airline pilots, 'monitor' our 22L, ADF approaches with the localizer and make it with no sweat, while the pilots who go strictly by the book have more than their share of missed approaches. Here's a situation, and I'll bet there are others like it, where at no cost at all, either reliability or minimums or both can be improved, and right now, by making better use of what we have."

An excellent example of using every practical navigational aid at your disposal, especially during letdowns and approaches. MAC has long hammered this into its pilots but we can all stand a good reminder once in a while. *Always have a good backup system tuned in if there is one available.*

AERO CLUB—Gear-up landings have been one of the aero clubs' biggest headaches. So much so, in fact, that many clubs have converted to fixed gear aircraft exclusively. Nevertheless, there are still quite a few L-17 Navions around and they occasionally give trouble in the gear-up department. Here's an example:

The pilot had neglected to positively ascertain that the gear was down and locked. In the Navion, the pilot must push the gear handle *down* and *in* at the bottom of its travel; he pushed it down but not in. He wasn't afraid that he'd make a mistake, so he made one.

Any pilot in *any* aircraft can make costly mistakes if he is so "cocky" that he has subdued all personal doubts about his own ability. DON'T TRUST YOURSELF. . . . USE THAT CHECKLIST. . . . DOUBLE CHECK THE CRITICAL ITEMS LIKE GEAR DOWN, MIXTURE RICH, CARBURETOR HEAT.

A PORTABLE OXYGEN regulator tester small enough to carry into fighter cockpits is currently under evaluation. This means that regulators could be field checked to almost eliminate the current practice of having to send serviceable regulators to the depot to have them checked for suspected malfunctions.

Existing regulators would have to be modified to be compatible with the tester, but the manufacturer believes this modification could be readily accomplished as the regulators are returned to depot on an attrition basis.

With this tester an experienced mechanic can, in about five minutes:

- Check delivery capacity to make sure that the regulator has no restricted inlet fittings, improperly functioning valves, levers or diaphragms,
- Measure effort required to draw oxygen to make certain it is within limits,
- Check to see that air inlet check valves are operating,
- Measure the altitude at which the air dilution control aneroid closes the air port, switching the supply to 100 per cent, and
- Check operation in the pressure breathing range.

AEROBITS continued

HOSE GOES—At 45,000 feet indicated, 18,000 cabin, the IP's personal leads—oxygen, emergency oxygen and communication—disconnected. The pilot in the front seat discovered something was wrong and, declaring an emergency, rapidly descended to below 10,000 msl.

The problem was in the rotating disconnect lock, which allowed the leads to disconnect even though the lock remained in the locked position. Also, the leads were short which, in the safety officer's opinion, contributed to this incident.

During the investigation it was found that leads would remain locked during a direct pull but that they would disconnect when moved back and forth to simulate body movements.

MORAL: Check those leads before you leap off, particularly if you're a six-footer, weigh a couple hundred pounds and are wearing heavy winter clothing. ★

THERE'S ALWAYS . . .

Thumbing a fresh December copy of *Aerospace Safety*, I paused to read the article "There's Always an Angle." Sure enough Major Hughes' analysis of the situation proved to be both informative and interesting. My compliments to Major Hughes!

However, as a T-37 driver, I must submit a degree of puzzlement in relation to Fig IV on page 21. The T-37 is not, in fact, equipped with an angle of attack indicator as specified. As reported to me by the folks at England AFB, neither is the A-37. The T-37 is merely equipped with a device (transducer vane) that senses airspeed and extends a spoiler mechanism which in turn simulates approaching a stall.

Many T-37 students who may read this article may well be confused, not to mention their new challenge of "smarts" to their respective IPs.

Perhaps this is a misprint of sorts. I understand that a few selected T-38 birds are equipped with some type of angle of attack sensor and indicator.

Just thought I'd bring this matter to your attention. I will take this opportunity to express my years of thanks for your fine publication so interested in the welfare of us pilots.

Capt Norman A. Little
3561st Student Sqdn
Webb AFB, Texas 79720

You're right, and your description of the system explains it very well. Thanks. Incidentally, the author was not responsible for this error.

SNOW REMOVAL . . .

I've read with interest the article "Snow Removal in Reverse" in your October issue. It is really amazing what a thinking man with the courage of his convictions can do to improve the probability of a Low Damage/Injury Recovery of the aircraft in distress.

Now that Major Elsea has shown the way, would not the next logical step be to compact the snow on one side of each main runway as it is removed, thus providing an immediately available strip for gear up landings?

This procedure would provide all the advantages described in Major Elsea's article and in addition would leave the main runway unobstructed, reduce the time required to prepare the strip (crossing runways might have to be filled in), reduce the fire hazard (the snow depth should normally be adequate to prevent the aircraft's penetrating to ground level), and reduce aircraft damage. Aircraft recovery after landing would not have to proceed at a panic pace because the runway would not be blocked.

The bearing strength of frozen ground should be adequate to suport the load imposed by any aircraft on its belly so this should not be a problem.

Your fine magazine is widely read by members of the 409 All Weather Fighter Squadron and throughout the Royal Canadian Air Force. Keep up the good work.

T. H. Buchan, WO, Class 2
Canadian Forces Base Comox
Lazo, B. C.

Thank you. Glad you like our book. There were extensive studies made on snow compaction a few years back. Perhaps some of our cold weather engineers will note your suggestion and consider giving it a try.

THE ARRS

I read with considerable interest your article on MAC operations in the December issue. I was particularly interested in the coverage given the Rescue and Recovery Service for, as a search and rescue aviator, I am especially mindful of some of the achievements of that fine organization.

A statement was made concerning the ARRS mission which I consider sufficiently misleading to justify comment, if not correction. I cannot resist pointing out the following: to say ". . . part of the ARRS mission is 'responsibility for the coordination of all search and rescue activities throughout the nation,'" incorrectly implies control over the fourteen U.S. Coast Guard Rescue Coordination Centers which coordinate all SAR in the maritime region. I am sure that the author meant to convey that the Air Force is responsible for SAR activities throughout the *land area* of the nation as prescribed in the National Search and Rescue Plan (known as AFM 64-2 as well as CG-308). In the plan, the Coast Guard is specifically charged with the responsibility for SAR in the maritime region which includes all waters subject to U. S. jurisdiction and the high seas. The Great Lakes, for example, are part of the maritime region.

I trust that you will not be provoked by this dissent from a member of a small but very proud service.

LCDR, R. J. Copin, USCG
Chief, Flight Safety Section
USCG Hq., Washington, D.C. 20591

As you say, the U. S. Coast Guard is small but it has every right to be proud. Your observation is correct. Keep up the good work.

☆ U.S. GOVERNMENT PRINTING OFFICE 1968 301-214/8

WELL DONE

Captain
Wilfred G. Volkstadt

6593 TEST SQUADRON (SPECIAL) (AFSC), APO SAN FRANCISCO 96553

On 23 May 1966 Captain Volkstadt was acting as aircraft commander of a JC-130B on a local proficiency flight at Kahului Airport, Maui, Hawaii. The first three approaches and landings were normal as was the fourth until touchdown. Immediately after touchdown a loud noise was heard, but the aircraft continued to perform normally. Then Captain Voldstadt was advised that his aircraft had "blown a tire." He then heard a loud noise and the aircraft listed and swerved to the right. Captain Volkstadt expertly controlled the path of the aircraft using reverse thrust from the left engines and nose wheel steering. At the same time he performed a precautionary emergency engine shutdown on the listing right outboard engine. He was able to stop the aircraft within 45 feet of the runway centerline and within 20 degrees of the runway heading.

Investigation subsequently revealed that within 75 feet after touchdown the torque strut cylinder connecting and controlling the two right main wheels had failed, the right rear tire had blown out and the right forward tire was merely tracking true from inertia. At the time of the warning call, the right front tire started to wobble, then rotated 90 degrees and blew out. At this time both right main wheels and their connecting torque strut were turned 90 degrees to the aircraft—dragging and smoking—causing the aircraft to swerve and list to the right.

Captain Volkstadt exhibited exceptional alertness and a high degree of proficiency and skill in maintaining directional control of the aircraft throughout the after-landing roll. His handling of this emergency minimized aircraft damage and prevented possible injuries. WELL DONE! ★

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