Fatigue Factor On Two-Man Crew

With the proliferation of two-member crews on air carrier aircraft and the broadening of operations from essentially regional to intercontinental, aircraft manufacturers and airline management must be prepared to increase their efforts to minimize fatigue-producing factors.

by

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and
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This presentation has been prepared with an honest attempt to stay within the title subject; however, at this early stage I must admit defeat. When contemplating the title subject, I found difficulties in isolating the topic to two-man crews; what became very clear was the importance of fatigue with reduces crew numbers in general. Degraded performance by one pilot in a two-pilot crew not only reduced the effectiveness by 50 percent, it also increases the work load on the remaining pilot by 100 percent. Fatigue may be experienced in any crew concept but the effect on a two crew cockpit may be catastrophic.

Throughout this presentation I have adopted a practical approach to fatigue and it's effects on the assumptions you do not need to be told you have it, you know it and you feel it.

How many times have you sat in the cockpit while flying through the night waiting patiently for the sunrise with eyelids heavy, and every movement of your eyeballs feels like contact with coarse sandpaper. As the sun rises, displaying it's beauty, a comment from a visitor to the flight deck is totally opposite to your own thoughts, "Isn't it beautiful, aren't you lucky. You must see lots of sunrises." While this interpretation is correct in one assumption, it is questionable on the two others. It is at moments like this you would be justified to question the wisdom of long-haul flying, particularly when a large portion of the flight is at night.

When you analyze the reasons for your tiredness and try to quantify the causes, you may wonder, isn't there a better way, can't we improve the situation. Yes, I believe we can, but it takes understanding of the problems and a coordinated approach by all concerned to minimize the effects.

Aviation by its nature is conducive to **fatigue,** yet as insidious as it is, we must accept that **it is as much a part of aviation as is lift.** Unlike lift, which can be defined as a component of the resultant force which acts at right angles to the direction of motion of the airfoil, fatigue does not have a specific scientific meaning since it cannot be unequivocally defined or measured. Yet it certainly can be felt.

Everyone has experienced fatigue. It is characterized by feelings of drowsiness, apathy and weakness and these feelings commonly occur as a result of illness, boredom, sustained work or lack of sleep. The classical Cambridge cockpit studies of the 1940s concluded:

- The timing of motor responses suffered more and more as fatigue developed;

- Subjects became increasingly willing to accept lower standards of accuracy and performance;

- They shifted from following the six primary flying instruments to making more automatic reactions; and,

- They increasingly forgot to check instruments out of their immediate range of vision.

Since that time, a great deal of research has been undertaken by eminent medical practitioners and psychologists to validate the assumptions that performance will degrade as a result of fatigue. However, in reviewing some of the literature that has been published it is tempting to conclude that the wheel is continually being re-invented.

To illustrate this point, consider the first of 16 conclusions in a 1980 report on fatigue stressors in simulated long duration flights. "Flying performance was significantly degraded during two 4.5-hour flights when the subject has been awake 12 hours prior to the flight."

One can question whether the motivation of some of the work being conducted is to meet an academic requirement of the time rather than being an attempt to address a safety issue.

I do not wish to be interpreted as being critical of fatigue research per se—quite the contrary. What I am saying is that with such a small portion of overall research and development effort being devoted to specific human factors research and even less to fatigue in particular, we need to be presented with operationally relevant data, not academic studies that state the obvious.

We know that the operation of jet aircraft requires complex psycho-motor coordination, high rates of information processing and high-speed decision-making; that the small error margin inherent in aviation can create psychological stress, that long periods of vigilance are necessary in a relatively monotonous environment, and that error rates are increased by lack of practice or experience. I recall one captain informing his pupils, "It's long hours of boredom with occasional seconds of terror," a quotation aptly summing up our industry.

We also know pilots are required to adhere to schedules over which they have little or no control; these are dictated, for the most part, by economic or marketing considerations. (It should be emphasized, nevertheless, that no responsible management would, or should, expect the pilot to place schedule before safety.) It would then seem incongruous to introduce a monetary payment for on-time departures or arrivals, a practice now contemplated by some carriers. These various factors create situations in which human behavior is highly susceptible to fatigue stressors.

Fatigue is a potential aviation safety hazard and, as such, needs to be dealt with in the same practical manner as other known hazards such as wind shear or asymmetric flight. There are accidents where the cause has been solely or partially due to pilot fatigue. It is interesting from an airline point of view to see that the majority of fatigue-related accidents have been in corporate and commuter operations; nevertheless from an industry point of view no accident is acceptable. Maybe tighter controls by flight departments and more rigorous monitoring by the regulatory agencies are the reasons fewer accidents occurred in airline operations.

In 1965, 10 airlines operated 39 two-crew commercial jet aircraft. At the end of 1983, a total of 227 airlines operated 2,457 two-crew jet transports. With the industry finely tuned to cost-effective operations, it is an economic fact of life that, with constantly advancing electronic technology, future aircraft will be exclusively operated by a minimum crew of two pilots. Indeed, one would almost be naive not to suggest that a future minimum crew may well be one human pilot and one electronic copilot, or even no pilots, except in an emergency or for passenger confidence. I am happy I will not see the day when the pilot is housed in a glass case with an affixed sign "Break in case of emergency."

We should not confine this discussion to two crew/EROPS situations as we know them today. [*The previous acronym ETOPS, Extended-range Twin-engine Operations, which set safety standards for long-range transoceanic routes, has been replaced by EROPS, Extended Range Operations, which applies regardless of the number of engines the airplane has. — Ed.*] EROPS aircraft of the immediate future, and I refer now to the Boeing 747-400, McDonnell Douglas MD-11 and Airbus A340, are multi-engine, extra long-haul, two-crew aircraft. What, then, are the factors that contribute to fatigue? If we accept that all aircraft crews, irrespective of size, suffer from fatigue, it becomes obvious that fatigue among two-pilot crew aircraft is more critical.

Fatigue is a multi-faceted phenomenon on which a multitude of papers have been written, and for this reason I have deliberately avoided many of the factors commonly addressed in other papers. The factors I will discuss have been chosen as they are practical aspects and have day-to-day implications for management and pilots alike. I believe each of the factors to be discussed has a distinct bearing on fatigue and hence aircraft safety.

The Automation Factor

In the 1950s we really had little automation. The pilot, assisted by a co-pilot, navigator, flight engineer and radio operator, was engaged in the moment-to-moment control of the aircraft and was responsible for making virtually all inflight decisions. With the passage of time and the advances in electronic information technology and computer science, the fundamental role of the pilot underwent significant change. The modern pilot, assisted by only a co-pilot, has become more a manager in the accepted sense rather than a controller. An increasing proportion of his time is spent monitoring the automatic systems that have taken over a growing share of the flight tasks.

But we know humans are, at best, relatively poor monitors who are affected by boredom, lapses of attention, complacency and under-arousal. Each of these elements is conducive to fatigue and is a by-product of automation. These by-products can be dealt with in two ways:

- Training and standards; and,
- Development.

First, training and standards. In the report “Human Factors of Cockpit Automation” by Dr. Earl Wiener, University of Miami, the author noted that check pilots and line pilots appear to differ on the subject of monitoring as a workload item, with the check pilots placing much greater emphasis on monitoring activities. This could be reasonably expected as the check pilot, by virtue of his role in operations, is monitoring orientated. But regardless, this observation should be a warning.

Company operation manuals should reflect the need for monitoring and cross-checking. Further, basic and continuation training, line checks, standards checks and procedures should emphasize the necessity of constant vigilance and cross-checking.

Today’s pilots, by and large, have a reasonable understanding of their role in the man-machine relationship. However, a review of accident statistics supports the requirement for greater emphasis being placed on this aspect in flight crew training. Perhaps the trend to the quick conversion may well be contributing to a breed of pilots who have to place too much reliance on automation, simply because they have not been given enough time to fully understand and gain confidence with auto-flight systems. The old saying “What is going on” has been replaced with “Where are we going.”

Second, development. During the design phase of aircraft development, more careful and explicit considerations will have to be given to keep the pilot in the loop. There is little sense in automating a system that utilizes the pilot for monitoring and back-up if the pilot does not understand the system to be monitored. Not only engineers and human factors specialists, but the ultimate user — the line pilot — should be involved in such studies. This vast and valuable data bank is largely untapped, not just in cockpit layout and automation applications, but in flight safety in general.

Being in the loop will become even more important in the future as automation becomes more complex, more autonomous and more capable. New techniques for enabling the crew to monitor the performance of the automated systems, flight progress and departures from desired procedures must be developed. Automation, unfortunately, will also have an affect on the pilot’s ability to retain his manual flying skills. A good manipulator of automatics usually displays a lower standard of manual handling techniques, causing frustration to all professional pilots. Perhaps the desire to retain good aircraft handling techniques is one reason why some pilots reject the use of cockpit automation. The older pilots usually fall into this category and may have greater difficulty in converting to new concept cockpits in the future. The importance of aircraft handling and avionics usage become more important in a two-crew aircraft.

The Ergonomic Factor

I do not intend discussing the overall ergonomic design of cockpits, but rather one element, the pilot’s seat. You would think it reasonable if asked to remain in your seat for up to 12 hours, with possibly one comfort break, that the design of the seat should offer maximum comfort. You would think the priority of design between the cockpit seat and the first class seat would be obvious, but sadly this is not always the case.

One of the most common complaints of civilized man is backache, and among aircrew members there is a tendency to accept backache as an occupational nuisance. Medical advice is rarely sought because treatment generally offers temporary relief with re-occurrence of symptoms being synonymous with resumed flight status. Back pain may be tolerated for many years, provided it is not too severe and is confined only to the inflight period. Aging aircrew members, particularly, are loathe to seek treatment because of the real or imagined danger of loss of licence. No one accepts readily the fact that one is getting older, not even aging pilots.

The aircrew seat is a work seat at which the occupant must remain for many hours at a time. Given that it is located in a relatively cramped environment, it is hardly likely to be considered comfortable by even the very young aircrew member with a full complement of elastic fibres in his or her intervertebral discs.

It is not possible to design a pilot’s seat that is ideal for all occupants under all conditions at all times. Yet it is possible to remain seated for many hours at a time, alertly, without pain or fatigue providing that:

- The pilot possesses a structurally normal spine;
- The design of the seat is adequate and allows the occupant to adopt a number of good posture positions while discouraging the adoption of a single poor one; and,
- The seat design and the immediate environment allow the occupant to affect frequent minor postural changes without hindrance.

While an expensive, adjustable lounge-type seat may be anatomically and physiologically desirable, it is hardly suitable as an alert working station.

In Australia during 1985, the Occupational Health Division of the National Occupational Health & Safety Commission, at the request of Qantas and the Australian International Pilots Association, conducted an ergonomic evaluation of pilot seats. Following a comprehensive analysis of all seats available at the time, they concluded that there were few seats manufactured today that displayed even minimal ergonomic considerations; the remainder were conducive to back pain and body fatigue.

The Scheduling Factor

The brilliance of Thomas Edison and basic geography result more in aviation being a fly-by-night industry than do some of the financial arrangements. Recognition and acceptance of the effects of time zone crossing and shift work on performance has led regulatory authorities to apply limitations on duty hours, both short and long term. This in no way absolves management or the crew from using their own judgment in avoiding fatigue when periods do not exceed the stated limits.

Full and frank participation by both management and the union bodies in scheduling consultative meetings prior to each bid or roster period is an acceptable means of ensuring that the proposed flight patterns take into account factors relative to the interest of both the company and of the operating pilot.

Most authorities have included in the flight time limitations a notwithstanding clause similar to the following extract from the Australian Air Navigation Order 48.1:

> "Notwithstanding anything contained in these orders, a pilot shall not fly and an operator shall not require him to fly if either the pilot or the operator has any reason to believe that the pilot is suffering from undue fatigue or having regard to the circumstances of a particular flight to be undertaken, is likely to suffer from undue fatigue during the flight."

This order is implicit and the pilot cannot be in breach of his employment contract if refusing to fly a service that the pilot feels is too fatiguing to carry out, even if the duty is within the published limits contained in the air navigation orders.

Of course, if the reason for his excessive fatigue is his own misbehavior or failure to take adequate rest when the opportunity was offered him, the pilot might be guilty of a breach of some other term of his contract that will justify disciplinary measures. The present flight time limitations applicable to Australian-registered aircraft operated with two-man crews are: a maximum of eight hours flight time and 11 hours duty time, and in the event of a delay after commencement of duty, these limitations may be increased by one hour.

The Individual Factor

Pilots and other flight crew members may be subject to both a greater variety and increased amounts of stress and fatigue than is common in their terra firma-entrenched work force. Currently, the best instrument to assess fatigue is the individual himself.

As a professional, the pilot has a responsibility to ensure that he appears for work in a reasonable rested state. Ideally, he should live near his base so as to minimize travel fatigue. He should adopt a prudent life style, which includes a sensible exercise program, and should avoid excesses of alcohol and cigarette smoking.

Studies of pilots' personalities have been well documented and having a need to publicly demonstrate their mastery of complex skills, pilots tend to deny their internal mental lives. As a group, they tend to conform to a stereotype pilot image. During 1982, a researcher asked a group of pilots two questions:

- Are you familiar with the possibility that individuals under stress may regress to their earlier learned behaviors; and,

- Are you familiar with the possibility that domestic and job conflicts may take the pilot's attention away from the job?

In every case the pilots were unable to identify what was meant by the first question without further clarification, which was given. The group was almost evenly split in its responses. Half stated it was a matter of concentration and that a good pilot will never forget to pay attention to what he is doing. The other group responded that the extensive training of commercial pilots makes it impossible to respond to old habits in an aircraft. All responded that the phenomena could never happen to them.

In answer to the second question the group responded: that it was only a matter of concentration; that anyone can concentrate and eliminate external disruptions; and, that it is a matter of personalities or of being a problem person. All responded with assurances that the phenomena could not happen to them.

Additionally, four airline training organizations were interviewed with the same questions. All stated that no written material was presented on this phenomena, as information of this type may be offensive to pilots.

A pilot should be cautioned in becoming involved in outside activities that are stress and fatigue producing. This also applies to management pilots. I recall that during an International Air Transport Association (IATA) Conference in Miami on flight training, an eminent colleague informed the group of his procedures for chosing a management pilot. First, he said, select your candidate and telephone him with the following questions:

- I'm offering you a position and you won't fly as much as you do presently;
- You will need to work much harder than at present;
- You will have less time at home with the family;
- You will be on 24-hour-a-day call; and,
- You won't be paid any more money.

Should the candidate accept the position being offered, you must immediately suspect his judgment.

Management pilots are often not as familiar with route operations as line pilots and the built-in desire to do well may not be realized. It is important that the management pilot flies well, as his performance is usually under the microscope. Lack of practice and pre-occupation with management duties, unfortunately, does show on occasions.

Most pilots are involved in outside businesses or tax minimization schemes. These activities can attract personal stress and when these stresses are more intense than the concentration that is required at the moment on the job, the attention will be unerringly diverted from work to the source of stress. Although this is universally experienced, it is not appreciated as a technical occurrence having definable effects on the human component of the cockpit monitoring system. As a result, the personal life of the pilot, including family matters and job situations, may directly affect the pilot's performance. The personal life of the pilot then becomes a direct concern of the management, crew and passengers.

The Frustration Factor

Today's manufacturers of aircraft and aircraft accessories seem to overlook the pilot's needs on some occasions. The industry is expert in orchestrating the cockpit with bells, whistles, horns, flashing lights and whoop-whoop-pull-up, but what about doing something to relieve the pilot's frustration factor?

Sometimes small annoyances cause frustrations when a person is tired. The following fall into this classification. All pilots during flight must consume fluids due to the reduced humidity of the cockpit environment. This being a fact of life, where does the manufacturer cater for the storage of a cup or glass. Why do some manufacturers not supply a proper holder in their multi-million dollar machines? What about waste paper? We all know airlines do not operate without copious pieces of paper. We also know pilots usually generate waste paper during flight, but where do they store it? Usually in a large plastic bag attached to the rear of the central pedestal.

Earlier, I mentioned those beautiful sunrises; well, why doesn't the sun visor cover all of the windscreens? Why is there always that one position where you cannot block out the sun? On another small point, where do you store your pen and pencil, because the manufacturers forgot to cater for this basic need of the pilot. While we do, and will continue to accept aircraft without these basic facilities, frustration during periods of fatigue can only magnify the problem. Manufacturers in the future could well be advised to discuss basic needs of the cockpit with normal operating line crews, after all, they are the ones who have to do the task. I acknowledge that some improvements have been seen in our latest generation of aircraft purchases.

The Operational Factor

The operational workload required to satisfy the requirements of ETOPS, whether working to the 60-minute, 90-minute or 138-minute rule, is apparent. In the Qantas Boeing 767 ETOPS operation, the pilots find that more complex flight planning and inflight management are required. The need to continually monitor the distance from, suitability of, and weather conditions at, nominated contingency/adequate airports adds to the pilot's workload. While flying within our region, some of the airports are daylight operations only, some have poor navigation aids and communications, some are unacceptable due to physical deficiencies and all need to be monitored daily by management and inflight when nominated, monitored by the pilot.

Because of limited facilities available to the flight crew, numerous flight plans covering various routings are required preflight to ensure compliance to ETOPS requirements and fuel minimization. Once airborne, the pilot is responsible for operational control. Some companies utilize a dispatch facility; in Qantas the captain is the dispatcher. It is the captain's responsibility to ensure the requirements of ETOPS are satisfied. Additional workload when operating over remote areas noticeably increases the pilot's workload.

Perhaps the difficulties of operating an ETOPS aircraft are not appreciated within this region. The comfort of ILS-equipped airports, continuous meteorological forecasting for nominated adequate airports is not always available and, indeed, requires a pilot to seek confirmation and information by alternate sources. This often requires the pilot to utilize domestic radio frequencies to obtain the latest meteorological updates for the nominated contingency/adequate airports, even though this airport will only be used if a severe in-flight emergency should occur.

Not necessarily did the industry reduce workloads when it reduced crew numbers.

Where To From Here?

Throughout this presentation I have not directed my discussion solely towards the two-man crew. Fatigue is a factor in all crew complements. A degraded performance by an individual in a three- or four-man crew is of obvious concern, but a degraded performance by an individual in a two-man crew is critical, as the balance in distribution of workload and important monitoring and cross checking function so vital in these operations can be grossly eroded. This erosion is a potential aviation safety hazard.

It would be nonsense to suggest that fatigue can be totally eliminated in an aviation environment. The individual will continue to be the best judge of his fatigue level. However, with the proliferation of two-crew member aircraft and the concurrent broadening of their scope of operation from essentially regional to intercontinental, aircraft manufacturers and airline management will have to be prepared to increase their efforts to ensure the fatigue producing factors on two-man crews are minimized.

It is important that pilot understanding and co-operation is satisfied in a two-man crew. There is a great danger if the co-pilot is unwilling or does not warn the captain of any deviation from standard operating procedures. The two pilots must work together, monitoring and cross checking. The difficulty for a junior copilot advising a senior captain of errors is not easy.

The regulatory authorities should be reminded that rule-making can contribute to fatigue. The practicality of complying to ill-conceived rules and regulations may grossly increase the workload of the air crew unnecessarily.

The industry will be increasing it’s use of two-man crew aircraft in the future and it is incumbent on manufacturers, regulatory authorities, airline management, pilot unions and safety associations to work in cooperation with the line pilot to see and understand his needs. After all, he is the one who will be ultimately required to perform either satisfactorily or unsatisfactorily.

The choice is ours.♦

Beyond MTBF

Applying probability logic to the relationship between component reliability and the concept of Mean Time Between Failure.

by

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We are all aware that quality errors can lead to disaster, and that high-performance components and conscientious workmanship are critical to good quality. However, just meeting quality standards is not good enough. It is just as important that the system, and its components, perform adequately over the proposed life of the product. This ability of a system or component to continue operating without a failure is often measured by the value MTBF (mean time between failures; also called “mean life” and “time per failure”).

The problem with MTBF (or any average value) as a control measure is that it concentrates on the center of the distribution of failure times and provides no information about maximum or minimum possibilities. The possibility, probability or chance, that the system can operate for a specified time is known as reliability (we will call this “basic” reliability). The minimum, or maximum, probability that the system can operate for the specified time is called a “confidence limit”; the lower confidence limit for minimum probability and the upper confidence limit for maximum probability. In reliability, only the lower confidence limit is usually meaningful, although there are some rare exceptions.

The specified operating time is called the mission time and can be thought of as the minimum acceptable operating time without a failure. The mission time should not be the same as the MTBF. Suppose, for instance, that the MTBF is used as the time specification, the mission time, and that the distribution is normal. Since the distribution of failure times centers around the MTBF (see Figure 1), one half of the failures will occur too soon, making half of our product unacceptable (the unacceptable portion will vary from 38 percent to over one-half, depending on the distribution). Therefore, the actual minimum acceptable operating time, the mission time, must be less than the MTBF. The question is; how much less? Reliability, and reliability confidence limits, provides this answer.

Many different formulas can be used to calculate reliability, depending on the applicable probability distribution. The main ones are: normal (Guassian), exponential and Weibull. Since the Weibull approximates most other distributions under most conditions, it can usually be used effectively in place of the others, even when the distribution is unknown (although it is very complex to use without a computer).

The following explanation will first cover "basic reliability" and then "reliability confidence limits." These are general concepts and procedures that apply equally well to all products. Since probability logic, in general, is often most clearly illustrated by the normal, the normal will be used to illustrate the concepts.

Basic Reliability

In Figure 1, the horizontal axis represents time while the vertical axis represents the number of failures occurring at a particular time. The center vertical line represents the MTBF, while the far left vertical line represents the mission time, which we will call T. The area under the curve above the mission time represents the reliability (which we will call R). Although Figure 1 uses a normal curve to demonstrate the concepts, the same logic applies to all distributions; only the shapes of the curves differ. The three values shown in this figure are interrelated through the applicable distribution formulas. Any one of these values can be calculated when the other two are known. The two known values derive from contract specifications, sample information or management assumptions.

An example problem will be used to illustrate the method. A certain component has had 20 failures which occurred in: 450, 510, 555, 585, 610, 625, 655, 675, 690, 710, 730, 750, 765, 785, 800, 825, 850, 885, 915 and 1,000 hours respectively. The sample mean, therefore, is 718.5 hours between failures and the standard deviation is 140.7 hours. Three questions can be asked, depending on which of the three values are desired.

1. What is the reliability of our product at a specified mission time (we will use T = 500 hours)?

2. What must the mission time be (what is the minimum acceptable hours to failure) for a stated reliability (we will use R = 90 percent)?

3. What must the new MTBF be for the stated mission time (of 500 hours) and reliability (of 90 percent)? This third question does not require a sample test and can, therefore, be used to determine design and production requirements even before the design is started. However, certain distribution parameters may have to be assumed; standard deviation for the nor mal, and shape parameter for the Weibull. Since our example uses the normal, the standard deviation of 140.7 from the above test has been assumed for this question.

The answers to these three questions, using the normal, are listed in Table 1, under "basic reliability." They can be interpreted as follows:

1. We can expect 94 percent or more of our product to operate for 500 hours or more without a failure.

2. We can expect 90 percent or more of our product to operate for 538 hours or more without a failure.

3. In order to have 90 percent or more of our product operate for 500 hours or more without a failure, we must produce the product to an MTBF of 680 hours or more.

Since we are already producing to an MTBF of 718.5 hours, our product is obviously more than satisfactory. However, if tighter specifications were desired (say R = 99 percent or T = 600 hours), the product may not be as acceptable. For instance, the new MTBF for a desired reliability of 99 percent and a mission time of 600 hours is 915 hours; which would require quite an improvement in our design or quality or process procedures.

Table 1 Reliability Values

	Basic Reliability
1. Reliability	94.0 percent
2. Mission time	538 hrs
3. New MTBF	680 hrs
4. Confidence Level	________

Graphic Unavailable

Figure 1 Basic Reliability Logic

Reliability Confidence Limits

In the basic reliability example just used, no confidence level was specified. When confidence levels are added, the effect on our answers is dramatic. Confidence limits can be thought of as a form of "safety factor," with the confidence level being the probability that a "safety margin" is not exceeded. The "safety margin" can be either specified or calculated from statistical considerations. As the desired confidence level is increased, the safety margin increases and vice versa.

With confidence limits, four questions can be asked.

1. What is the reliability of our product at a specified mission time and a specified confidence level?

2. What must the mission time be (what is the minimum acceptable operating time without a failure) for a stated reliability and a specified confidence level?

3. What must the new MTBF be for the stated mission time, a specified reliability, a specified confidence level and an assumed mean? This third question does not require a sample test and can, therefore, be used to determine design and production requirements even be fore the design is started.

4. What confidence can we have that our product can operate to a stated mission time at the specified reliability?

These calculations can be made manually using a scientific hand calculator, but they are somewhat complex, especially for confidence limits and most especially for Weibull distributions. A computer can be of immense assistance in these calculations, and almost a necessity with the Weibull. ♦

[*For information on computer programs available for all the above distributions contact the author at P.O. Box 78618, Tucson, AZ 85703, or phone 602-293-7436. FSF does not attest to the completeness or accuracy of available computer programs. — Ed.*]

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Reports Received at FSF Jerry Lederer Aviation Safety Library

Reports:

Airline Service: Changes at Major Montana Airports Since Deregulation — Fact Sheet for the Chairman, Subcommittee on Rural Economy and Family Farming, Committee on Small Business, U.S. Senate. U.S. General Accounting Office. Report No. GAO/RCED-89-141FS. May 1989. 10p.

The fact sheet responds to a request to provide data on changes in airline service at major airports in Montana since the airline industry was deregulated in 1978. The data indicate that, between 1978 and 1988, the number of airline passengers carried increased at two airports, decreased at two others, and remained about the same at three. For the seven airports as a group, the number of passengers carried increased by 15 percent. The number of aircraft departures increased at all seven airports, but the percentage of those departures on jet aircraft decreased at all seven. The number of routes with direct service also decreased at all seven airports. Fares will be examined in another report.

World and United States Aviation and Space Records (as of December 31, 1988). National Aeronautic Association of the USA. Washington, D.C. 1989. 305p.

…"a complete, accurate and up-to-date listing of aircraft performances which have been recognized as official World or World Class records."

Aviation Research: Information on FAA's Research, Engineering, and Development Program. Fact Sheet for the Chairman, Committee on Science, Space, and Technology, House of Representatives. U.S. General Accounting Office. Report No. GAO/RCED-89-122FS. April 1989. 42p.

Provides information on FAA's R&D program regarding funding, staffing, and scheduling for fiscal year 1987-89 at the subprogram level.

Aircraft noise: Status and management of FAA's West Coast plan — Report to Congressional Requesters. U.S. General Accounting Office. Report No. GAO/RCED-89-84. May 1989. 31p.

GAO "believes that in this instance one of the essential ingredients for an informed assessment (of environmental impact of noise) was missing because FAA regional officials did not have the benefit of the public's view. …the assessment did not provide information regarding the geography the revised procedure would cause aircraft to traverse, the altitudes to be flown, or the estimated changes in noise levels that would occur along the proposed route. Although the assessment discussed an alternative to the proposed procedure in terms of safety differences, it did not compare, on an environmental basis, alternatives as called for in Council of Environmental Quality regulations." The report also includes a summary chart of the ten FAA West Coast Projects.

Aviation Security: FAA's Assessment of Foreign Airports — Report to the Chairwoman, Subcommittee on Government Activities and Transportation, Committee on Government Operations, House of Representatives. U.S. General Accounting Office. Report No. GAO/RCED-89-45. December 1988. 16p.

GAO "evaluated the methodology that the FAA uses to assess security at foreign airports, especially those airports deemed to be at high risk of terrorist and other criminal activities. In addition, (GAO) obtained information on the Department of State's use of anti-terrorism assistance funds to enhance foreign airport security. It is important to understand that the scope of (GAO) work did not include evaluating the adequacy of security at these airports."

Air Traffic Control: Voice communications System Continues to Encounter Difficulties — Report to Congressional Requesters. U.S. General Accounting Office. Report No. GAO/IMTEC-89-39. June 1989. 15p.

GAO "evaluated the FAA's efforts to implement the Voice Switching and Control System (VSCS), …intended to improve communications at air traffic control facilities. VSCS is intended to provide a computer-controlled voice system for both ground-to-ground and air-to-ground communications that is flexible, expandable, and highly reliable. …The objectives of (the GAO) review were to determine (1) if previously reported VSCS cost, schedule, and technical difficulties were continuing; and (2) if these difficulties would adversely affect deployment of new air traffic controller workstations."

Human Factors in Aviation: Terminal Control Area Boundary Conflicts. William P. Monan. Battelle Columbus Division, ASRS Office. NASA CR-177522. February 1989. 49p.

Air-to-air conflicts in the vicinity of TCA boundaries were studied to obtain a better understanding of the causal dynamics of these events with particular focus on human factors issues.

Human Factors in Aviation Operations: The Hearback Problem. William P. Monan. Battelle Columbus Division, ASRS Office. NASA CR-177398. March 1986. 32p.

This report covers a study of ASRS reports wherein ATC controllers failed to monitor adequately ("hearback") incorrect readbacks of ATC clearances. Factors examined in the study were: the reasons for the flight crew's getting clearances incorrectly, the operating factors that caused controllers to mishear or not hear the incorrect readbacks, and consequences of the various types of hearback misses. The principle conclusion of the study takes the form of a precaution to flight crews that a controller's not challenging a readback does not necessarily mean the readback is correct and that flight crews must explicitly question any doubtful or unusual aspects of clearances rather than depending upon controllers to detect readback errors.

Regulations/Advisories:

AC 61-101. *Presolo Written Test.* [U.S] Federal Aviation Administration. 4/21/89. 1p.

A revision of FAR Section 61.87(b) became effective August 31, 1989. This revision requires the satisfactory completion of a written test by student pilots prior to solo flights. The flight instructor who endorses the student pilot certificate for solo flight is required to administer and grade the written test prior to certificate endorsement. This AC provides guidance to flight instructors in developing a written test to administer to student pilots prior to solo flight.

AC 150/5100-14B. C*hange 1. Change 1 to Architectural Engineering, and Planning Consultant Services for Airport Grant Projects — Editorial Changes.* [U.S.] Federal Aviation Administration. 4/11/89.

Replaces pages 3 and 4 and 17 and 18 of subject Advisory Circular dated 11/21/88.

AC 61-103. *Announcement of Availability: Industry-Developed Transition Training Guidelines for High Performance Aircraft.* [U.S.] Federal Aviation Administration. 5/23/89. 2p.

Federal Aviation Regulations Section 61.31(e) prescribes minimum requirements for private and commercial pilots to act as pilot in command of high-performance airplanes (those with more than 200 horsepower, or that have retractable landing gear, flaps, and a controllable propeller). To address the need for a standard training syllabus for pilots transitioning into high-performance aircraft, the General Aviation Manufacturers Association has developed a Transition Training Master Syllabus (GAMA Specification No. 5). The document is a general outline of the items which GAMA recommends be included in the ground and flight training of pilots transitioning into specific airplanes. The master syllabus lists groups of airplane makes and models produced by its member companies which are sufficiently similar so that a pilot trained or experienced in one airplane model would not normally require full transition training to operate another model in that group. The Transition Training Master Syllabus may be obtained by writing or calling GAMA, Suite 801, 1400 K Street, Washington, D.C. 20005-2485 USA. Telephone: 202-393-1500.

AC 121-24A. *Passenger Safety Information Briefing and Briefing Cards.* [U.S.] Federal Aviation Administration. 5/9/89. 10p. Cancels AC 121-24 dated June 23, 1977.

This advisory circular (AC) provides information regarding the items that are required to be, or should be, covered in oral passenger briefings and on passenger briefing cards. The advisory circular provides specific information about air carrier operations conducted under Federal Aviation Regulations (FAR) Part 121. It also provides suggestions about making this information interesting and meaningful. This AC encourages individual operators to be innovative in their approach in imparting such information.

AC 21-26. *Quality Control for the Manufacture of Composite Structures.* [U.S.] Federal Aviation Administration. 6/26/89. 14p.

This advisory circular provides information and guidance concerning an acceptable means, but not the only means, of demonstrating compliance with the requirements of Federal Aviation Regulations (FAR) Part 21, Certification Procedures for Products and Parts, regarding quality control (QC) systems for the manufacturer of composite structures involving fiber reinforced materials, e.g., carbon (graphite), boron, aramid (Kevlar), and glass-reinforced polymeric materials. This AC also provides guidance regarding the essential features of QC systems for composites as mentioned in AC 20-107, Composite Aircraft Structure. Consideration will be given to any other method of compliance the applicant elects to present to the Federal Aviation Administration.

AC 25.812-1A. *Floor Proximity Emergency Escape Path Marking.* [U.S.] Federal Aviation Administration. 5/22/89. 11p. Cancels AC 25.812-1, dated September 30, 1985.

This advisory circular provides guidance material for use in demonstrating compliance with the provisions of Part 25 of the Federal Aviation Regulations (FAR) requiring floor proximity emergency escape path markings. This AC is not regulatory but is to provide guidance for applicants in demonstrating compliance with the objective safety standards set forth in the rule.

AC 150/5345-42C. *Specifications for Airport Light Bases, Transformer Housings, Junction Boxes, and Accessories.* [U.S.] Federal Aviation Administration. 6/8/89. 34p. Cancels AC 150/5345-42B dated 9/21/81.

This advisory circular contains the specifications for containers designed to serve as airport light bases, transformer housings, junction boxes and related accessories. The principal changes include establishment of specifications, requirements and testing for Type L-868, Class II, field fabricated containers; redefinition of prototype and production testing procedures for all types, classes and categories of containers; revision of all drawings for clarity and addition of metric units.

AC 23-8A. *Announcement of Availability of Advisory Circular 23-8A; Flight Test Guide for Certification of Part 23 Airplanes.* [U.S.] Federal Aviation Administration. 5/3/89. 1p.

Advisory Circular 23-8A provides guidelines for the flight test evaluation of Part 23 airplanes including commuter category airplanes added by amendment 23-34. The guidelines provide an acceptable means of demonstrating compliance with the applicable airworthiness requirements. The methods and procedures described in the AC have evolved through many years of flight testing of Part 23 airplanes, and as such, represent current certification practice. They are derived from previous FAA experience in finding compliance with the airworthiness requirements. AC 23-8A, dated February 9, 1989, is available as a sale document from the Superintendent of Documents for $12.

AC 61-102. *Computer-Assisted Airmen Knowledge Testing.* [U.S.] Federal Aviation Administration. 5/3/89. 1p.

This advisory circular announces the implementation of a prototype computerized airmen knowledge testing method applicable to all Federal Aviation Administration (FAA) pilot and flight engineer certification areas and disseminates information to all interested commercial vendors desiring to qualify as FAA-approved computer testing designees. Potential vendors may contact the FAA for additional information.♦

Aviation Statistics

U.S. Civil Aviation Safety Records
First Six Months, 1989

General Aviation

In the first six months of this year, U.S. general aviation recorded 1,010 accidents, 193 of which were fatal, accounting for 340 fatalities. The following Tables 1, 2 and 3 show the monthly distribution of accidents, fatal accidents and fatalities by kind of flying.

Table 1
General Aviation Accidents
January - June, 1989

Kind of Flying	Jan.	Feb.	Mar.	Apr.	May	June	Total
Personal	94	87	100	119	120	137	657
Business	12	8	12	13	15	13	73
Corporate/Executive	1	1	2	1	1	1	7
Aerial Application	0	4	10	8	22	25	69
Instructional	18	16	19	25	24	25	127
Other	10	13	18	26	20	6	83
Total	133	127	161	182	200	207	1010 1/

1/ Detail may not add to the total because of aircraft involved in midair or ground collisions.

Table 2
General Aviation Fatal Accidents
January - June, 1989

Kind of Flying	Jan.	Feb.	Mar.	Apr.	May	June	Total
Personal	23	18	24	17	18	31	131
Business	4	1	3	3	4	2	17
Executive	0	0	1	1	1	1	4
Aerial Application	0	0	0	0	3	3	6
Instructional	0	1	1	3	4	3	12
Other	5	1	4	1	9	4	24
Total	32	21	33	25	39	44	193 1/

1/ Detail may not add to the total because of aircraft involved in midair or ground collisions.

Table 3
General Aviation Fatalities
January - June, 1989

Kind of Flying	Jan.	Feb.	Mar.	Apr.	May	June	Total
Personal	39	31	53	29	31	53	236
Business	7	1	3	6	10	7	34
Executive	0	0	1	3	2	1	7
Aerial Application	0	0	0	0	4	3	7
Instructional	0	1	2	5	9	4	21
Other	7	1	4	2	14	7	35
Total	53	34	63	45	70	75	340

A comparison of total accidents, fatal accidents and fatalities for the first six months of this year with those recorded in the same period of past two years as shown in the following Table 4 reveals that the safety performance of general aviation this year continues improving. — The total accidents in the first six months of 1989 dropped 8 percent from 1988 and 15 percent from 1987. Fatalities in 1989 also show more than 5 percent drop as compared with previous two years. The continuing decrease of general aviation total accidents in recent years could be considered a clear indication of improvement in safety because general aviation activities in terms of annual hours flown in recent years has been very stable: It was 29,317,000 flying hours in 1986, 29,208,000 hours in 1987 and 29,600,000 in 1988.

Table 4
General Aviation Accidents, Fatal Accidents and Fatalities
January - June

	Year			Changes		
	1987	1988	1989	1987-1988	1988-1989	1987-1989
Total Accidents	1,199	1,099	1,010	-100(8.3%)	-89(8.1%)	-189(15.7%)
Fatal Accidents	192	203	193	+11(5.7%)	-10(10.5%)	+1(0.5%)
Fatalities	367	360	340	-7(1.9%)	-20(5.5%)	-27(7.3%)

U.S. Air Carrier

In the first half of this year, U.S. Air Carrier, including airlines, commuter air carriers and air taxi operators, were involved in 79 accidents, 18 of which were fatal accidents, resulting in 201 fatalities. The high in fatalities this year is the result of a fatal accident involving a non-scheduled international passenger service, in which all 144 persons aboard a jetliner were fatally injured. Following Table 5 is a breakdown of accidents, fatal accidents and fatalities by air carrier operating categories. Table 6 is the briefs of the 7 fatal accidents involving air carriers operating under CFR Parts 121, 125 and 127 (airlines):

Table 5
Air Carrier Total Accidents, Fatal Accidents and Fatalities
January - June

	Total Accidents		Fatal Accidents		Fatalities	
	1988	1989	1988	1989	1988	1989
Airline	19	15	1	7	1	163
Commuter	7	9	2	1	21	2
Air Taxi	51	55	15	11	32	36
Total	77	79	18	19	54	201

Table 6
Briefs of U.S. Airline
(14 CFR 121, 125 & 127 Operators)
Fatal Accidents
January - April 1989

Date	Location	Operator	Type of Opn	Type of Aircraft	Damage	Fatalities
2-8	Santa Maria, Azores	Independent Air, Inc.	NSCH IN PASS	Boeing 707	Dest	144
2-9	Lubbock, TX	Evergreen International	SCH DOM CARGO Douglas DC-9-32	McDonell	None	1
2-19	Puchong, Malaysia	Flying Tigers	SCH INT CARGO 747-200	Boeing	Dest	4
2-24	Honolulu, HI Inc.	United Airlines,	SCH INT PASS/ CARGO	Boeing 747-122	Subst	9
3-9	Dayton, OH	Piedmont Airlines	SCH DOM PASS 737-200	Boeing	None	1
3-15	West Lafayette, IN	Mid Pacific Airlines	NSCH DOM CARGO YS-11A-600	Nihon	Dest	2
3-18	Saginaw, TX	Evergreen Intl Airlines, Inc.	SCH DOM CARGO	McDonnell Douglas DC-9-33	Dest	2
					Total	163

Midair Collision Accidents

In the first six months of 1989, there were 7 midair collisions involving U.S. civil aircraft, a decrease of 42 percent from the same period of last year. This is the lowest number of midair to occur during the first half of a year since 1983. A comparison of mid collision accidents happened in the first six months with those happening in a whole year over the past six years as shown in Table 7 reveals that an average of 52 percent of midair collision accidents occur in the first half of a year. At this ratio, the year 1989 would see a total of only 14 midair collision accidents.

Table 7
Midair Collision Accidents
1983 - 1989

	1983	1984	1985	1986	1987	1988	1983-88 (Average)	1989
January-June	6	14	10	15	13	12	12	7
January-December	14	25	25	29	25	19	23	(14)
1st-6-Months/full yr	43%	56%	40%	52%	52%	63%	52%	(52%)

Accident/Incident Briefs

The following information on accidents and incidents is intended to provide an awareness of problem areas through which such occurrences may be prevented in the future.

Air Carrier

Third Attempt in Fog

McDonnell Douglas DC-8: Aircraft destroyed. Fatal injuries to 169; 14 survivors.

The airline jet was trying to land at Zanderij Airport, Surinam, in early pre-morning fog. It had departed Amsterdam's Schiphol Airport, in The Netherlands, shortly after midnight, about six hours behind schedule. The destination airport serving Paramaribo was reported to have no electronic landing aids and pilots rely on visual contact during approaches. Two previous approaches had been aborted because of the thick fog.

The aircraft crashed during the third landing attempt about two miles short of the runway in a flat area of fields and woodlands. The airplane reportedly hit the ground nose-first, somersaulted, disintegrated and caught fire, with the landing gear left pointing up and only the tail section, which broke off on impact, left intact. Of the 174 passengers and nine crew members aboard, 169 were killed.

Rescue work was seriously hampered when scores of people flocked to the airport after news of the crash was announced just after 0415 local time. Rescue crews and ambulances carrying victims from the scene of the accident were held up in heavy traffic jams.

Copilot Shot by Security Guard

Antonov An-26: Aircraft damaged extensively. Fatal injuries to six; 35 survivors.

The Afghan twin-turboprop airliner was on a domestic flight from Kabul to Zaranj when it diverted into Iranian airspace and made an emergency landing. The aircraft landed on a strip of sand, and the fuselage buckled and turned over. Four persons, a woman and three men, were killed in the crash-landing and two persons died later in a hospital. Thirty-four others were reported to have received hospital treatment.

Initial reports said the incident occurred after a struggle between unidentified hijackers and the pilot.

Later accounts of the in-flight trouble reported that there had been no hijacking, but that the armed altercation had been between the aircraft's copilot and the chief of flight security. According to radio reports, an argument broke out between the security guard and the copilot, both of whom had shared a long-standing hostility. The two were said to be upset with each other over an earlier row about the late arrival of a cargo shipment. During the argument which flared up in flight as a result of the earlier dispute, the guard shot the copilot in the shoulder. He then tried to open a rear door to prevent the aircraft "from straying," presumably into adjacent Iranian airspace. However, during the altercation, the An-26 did cross the border into southeast Iran where it crash-landed.

Turbulent Encounter

Lockheed L-1011 Tristar: No damage. Minor injuries to 25.

The widebody airliner was en route from Seattle, Wash., to Orlando, Fla., U.S. The early afternoon flight had 282 passengers aboard.

Approximately 30 minutes prior to a scheduled stop at Atlanta, Ga., the aircraft was at 25,000 feet over Tennessee, 220 miles northwest of the airport. It ran into unexpected heavy turbulence during which a number of unbelted passengers were thrown from their seats.

The aircraft was met by paramedics when it landed, and 25 passengers were taken to local hospitals with back, head and neck injuries and lacerations. Fifteen persons were treated for minor injuries and released.

Pre-takeoff Collision

Boeing 757: Damage to tail. No injuries.
Boeing 747: Damage to wingtip. No injuries.

The two aircraft were preparing to take off at London's Heathrow Airport, United Kingdom. The Boeing 757 was bound for Brussels with 119 persons on board and the 747, with 374 occupants, was on its way to Bangkok.

The 747 was taxiing onto the runway past the 757 which was holding short. A wingtip of the larger aircraft came in contact with the horizontal stabilizer of the smaller one. As a result of the collision, approximately two feet of the 747's wingtip was sheared off and there was substantial damage to the tail surface of the 757. There were no injuries. The aircraft both taxied back to the terminal where the passengers were transferred to other flights.

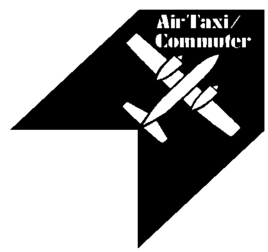
Birds vs. 737s

Boeing 737: Damage to engine. No injuries.
Boeing 737: Damage to cockpit area. Injuries to one.

Two cases illustrate the continuing hazard of encounters with birds.

One Boeing 737 ingested a bird shortly after takeoff from London's Gatwick Airport, United Kingdom. The aircraft was climbing out on the way to Madeira when the bird was sucked into the engine. The pilot shut down the engine and returned to the airport without further incident.

The other Boeing twin-jet had taken off from New Delhi, India, on an internal flight when a flock of birds smashed into the cockpit. The copilot was injured and the aircraft received extensive damage. After the aircraft returned to the airport, examination revealed that the incident had caused an estimated $100,000 worth of damage. The airline reported that it was the sixth company aircraft that had collided with birds that month, and the 52nd such occurrence for the year.



Looters Beat Rescuers

Cessna 310D: Aircraft destroyed. Fatal injuries to four.

The chartered aircraft was departing the new Manila domestic airport in the Philippines headed for Palawan. On board were the pilot, three passengers — and 75,000 pesos in company money.

Shortly after takeoff, the aircraft crashed into a rice field, killing the four occupants. Looters arrived at the accident scene before rescuers could get there and they made off with most of the money; only 3,000 pesos were later recovered.

Heavy Load and Heavy Weather

de Havilland DHC-5 Buffalo: Aircraft destroyed. Fatal injuries to 60.

The aircraft was being used as part of a Peruvian Air Force civil action program, through which low-cost transport is provided to residents of outlying areas that have little or no access by road. It was on a flight from Pucallpa, on the Amazon lowlands, to Lima.

The aircraft was reported to have been heavily loaded with tropical timber and civilian passengers when it took off from a stopover at San Ramon, in the foothills of the Andes. Shortly after takeoff, it struck the side of a mountain in a sparsely populated area of high, rugged mountain ranges, 1,100 miles east of Lima, near the town of Tarma. The fuselage broke in half on impact and all 60 occupants were killed.

The aircraft was reported missing after it failed to arrive at Lima's Jorge Chavez Airport. Rescue parties did not reach the site of the accident until the next day. On the night of the crash, weather in the area was reported to be rain and fog.

Crossed Up by Wind

Cessna 404 Titan: Damage to nosewheel. No injuries.

The pilot, the only occupant of the twin-engine aircraft, was en route from Southend Airport to Leeds-Bradford Airport in the United Kingdom. As he approached Runway 14 at Leeds-Bradford in the late afternoon, he encountered crosswinds.

During the landing the left wing dropped and the aircraft ran off the runway into the grass at the side and the nose wheel sheared off. The aircraft came to rest on its nose. The pilot exited without difficulty.

Engine Failure on Takeoff

Cessna 404 Titan: Aircraft destroyed. Fatal injuries to one.

The aircraft had just taken off at midday from Santa Cruz, Bolivia, when the pilot reported that he was experiencing engine trouble. He attempted an emergency landing at the Las Palmas Country Club golf course which was the only clear place in the area. However, one of the aircraft's wings apparently struck a tree and the aircraft crashed and exploded. It burned completely and the pilot was killed.

Pedestrian Crossing

Gulfstream AA-5B Tiger: Damage to propeller, nose gear and fuselage. No injuries.

The aircraft was completing a flight from Leeds to Brands Hatch, United Kingdom, in the late afternoon. On board were a pilot and three passengers.

During the landing, a person walked across the runway in front of the aircraft. The pilot took avoidance action and the aircraft left the runway. It ended up on a grassy bank. There were no injuries reported to the aircraft occupants or the person on the ground, but the aircraft sustained damage to the propeller, the nosewheel, the underside of the fuselage and the tail section.

From One Thing to Another

Cessna F172H: Extensive damage to rear fuselage. No injuries.

Inbound to Coventry Airport, United Kingdom, the pilot received weather information that reported winds from 210 degrees at 15 knots gusting to 30 knots; the runway in use was Runway 23. On board were the pilot and one passenger.

During final approach, the pilot received word that a Piper PA-31 was inbound behind him with a landing gear problem. After landing, the Cessna pilot intended to vacate the runway as soon as possible to clear it for the inbound Piper. As he began a left turn to exit the runway at the first available taxiway, the pilot found his way blocked by another aircraft holding short of the runway and emergency vehicles standing by to assist the inbound Piper.

To clear the way for the vehicles, the Cessna pilot turned his aircraft to the right, which placed it downwind. The wind caught the tail of the Cessna and lifted it, causing the aircraft to settle onto its nose and right wingtip. The pilot and his passenger were not injured and evacuated the aircraft without difficulty.

A few moments after the Cessna occupants had left, however, their aircraft was again caught by the wind. This time it was blown completely over onto its back, sustaining extensive damage to the rear fuselage. A special weather observation taken at the time indicated a surface wind from 220 degrees at 20 knots gusting to 30.

Didn't Verify the Wind

Piper PA-28: Damage to landing gear and right wing. No injuries.

When he checked the April weather prior to the flight from Blackpool Airport to Caernarfon Airport, United Kingdom, the pilot noted that the wind at the destination airport was six knots. The student pilot was the only occupant of the airplane.

The flight took 45 minutes. The pilot later reported that he had trouble hearing the landing instructions because of poor radio reception and he had requested a repeat of the active runway, traffic pattern direction and altimeter setting. He did not copy the report of surface wind, but he did not ask that it be repeated because he assumed that it still would be less than 10 knots.

Shortly after the aircraft landed on Runway 08, it veered sharply to the left. The Piper came to rest in a nose-down attitude off the runway. The pilot exited the aircraft without injury.

A surface wind observation at the time of the accident revealed that the wind varied from 330 degrees to 010 degrees at 17 knots, gusting to 24 knots. The maximum demonstrated crosswind for the airplane is 17 knots.

Rotorcraft

Triple Trouble

Sikorsky S-58J: Substantial damage. Minor injuries to one.

The pilot had just lifted off with an air conditioning unit at the end of a long cable when he heard two popping sounds after which the engine failed. Since there was not enough altitude for an autorotation, the helicopter landed hard, resulting in collapse of the landing gear.

Untrimmed Takeoff

Sikorsky S-58BT: Substantial damage. Serious injuries to one.

During sling load operations at a construction project, the helicopter experienced a dual engine failure. It was a July day and the aircraft was hovering with a load of gravel 50 feet above the roof of a 15-story building.

The pilot tried to drop the external load but the release did not work. He entered autorotation and maneuvered the helicopter and its load to a boat channel where he landed between rows of boat slips. The helicopter submerged and the pilot, with serious injuries, was able to swim to the surface where he was assisted to the shore by onlookers.

Crash in Jungle

Bell 214B: Aircraft destroyed. Fatal injuries to seven.

The military helicopter was carrying four civilian oil company workers and three crew members. While it was flying over a jungle area near Cascales, Equador, 125 miles northeast of Quito, the aircraft crashed.

Rescuers found the helicopter destroyed and all of the occupants, three military crew members and the civilians, were dead. No cause for the crash was available.

Low-Level Filming

Bell 206B JetRanger II: Aircraft extensively damaged. Fatal injuries to one; five others in aircraft injured; one on ground injured.

The helicopter was being used to carry a film crew during the making of a motion picture on the island of Corfu, Greece. On board during the June flight were a stuntman, four members of a film crew and the pilot.

During a scene that required low-level filming, the aircraft collided with the top of a tree and crashed into a hill near a 15th century Venetian castle. The aircraft was extensively damaged and the stuntman was killed. The four members of the film crew were injured. A fifth member of the film crew who had been on the ramparts of the castle was injured when he jumped to safety as the helicopter spun out of control towards him.♦