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Collision Avoidance Must Go Beyond “See and Avoid” To “Search and Detect”

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In This Issue

Flight Safety Foundation (FSF) is an international membership organization dedicated to the continuous improvement of flight safety. Nonprofit and independent, FSF was launched in 1945 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce positive influence on aviation safety. Today, the Foundation provides leadership to more than 660 member organizations in 77 countries.

Collision Avoidance Must Go Beyond "See and Avoid" to "Search and Detect"

Eye function and eye-brain coordination are not naturally optimized for visual searches in airspace. But experimental evidence shows that pilots can train themselves in techniques for more effective visual detection of traffic.

Shari Stamford Krause, Ph.D.

In the United States, pilots are expected to avoid midair collisions by complying with U.S. Federal Aviation Regulations (FARs) Part 91.113(b), which states, "vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft ... ." Under these guidelines, pilots depend on "see and avoid" as their primary way to avoid collisions.

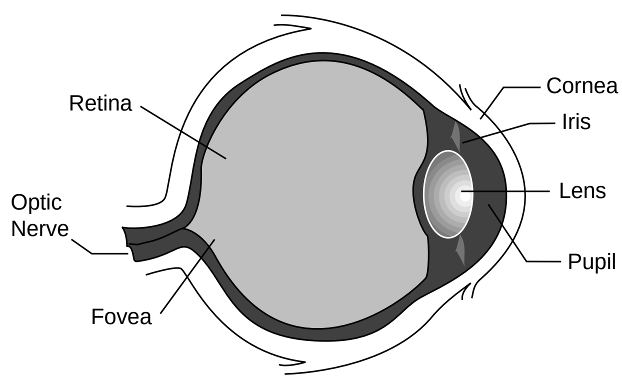
But according to scientific and operational evidence, "see and avoid" is not necessarily the best technique. Instead, safety in visual meteorological conditions (VMC) depends on a pilot's use of specific, active visual-detection techniques. The evidence suggests that the standard-issue eyeball may be more effectively used to avoid midair incidents through a conscious search-and-detect — rather than see-and-avoid — plan.

Most pilots know from experience that visually detecting another aircraft in airspace is difficult, and in some circumstances it is virtually impossible. Studies cited in this article suggest that the ability to spot another airborne aircraft may be a skill that pilots can develop. The research points to four key elements of successful target acquisition:

- Ignoring conflicting or distracting close-up and peripheral stimuli;
- Optimizing the eye-brain connection to visually imagine distant targets;
- "Looking through" (or past) structured surfaces; and,
- Using a distant object to adjust focus for search.

To understand the problems associated with see-and-avoid, it is necessary first to examine the physical structure of the eye (Figure 1).[1]

Physical Structure of the Human Eye



Source: Shari Stamford Krause, Ph.D.

Figure 1

At the front of the eye is the cornea, a thick, transparent tissue that forms the outer coat of the eyeball and covers the iris, the colored part of the eye. The pupil, the circular opening in the center of the iris, allows light to enter the eye. The iris and pupil rest against the front of the lens, which is held in place by thousands of elastic fibers. These fibers, and the muscles to which they are attached, enable the lens, by changing shape, to focus on objects at varying distances.

The retina, the inner layer of the back of the eye, contains more than 125 million light-sensitive receptor cells that receive information about an object being viewed.

Rods and cones are the two main types of light-sensitive cells found in the retina. Rods, which are approximately 20 times more numerous than cones, respond to darkness, faint light, shape and movement. Thus rods, with their light-sensitive pigment (rhodopson), are responsible for adaptation to darkness (night vision) and perception of shades of gray.

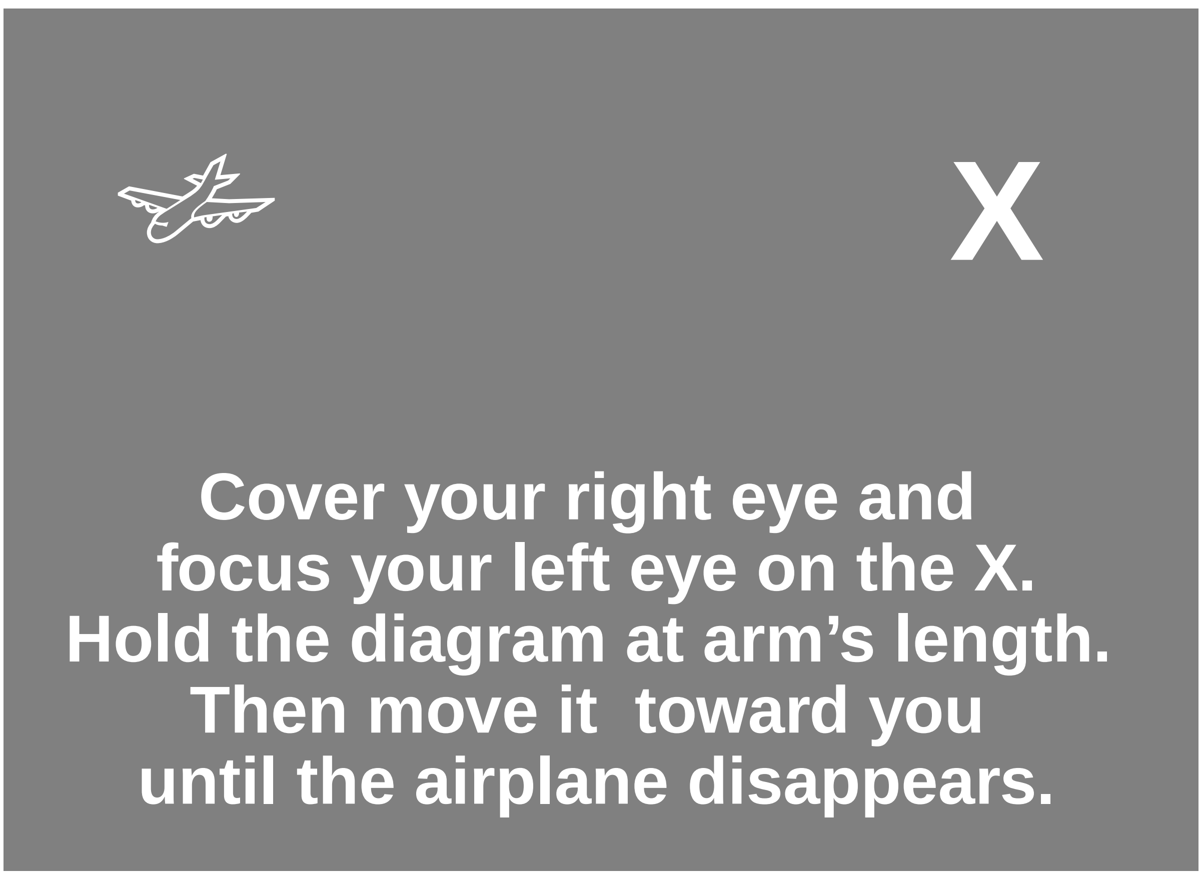
Cones, on the other hand, are stimulated by bright light and are responsible for our ability to perceive colors. Cones are concentrated in the highly sensitive central section of the retina, the fovea. Light entering the eye is focused directly on the fovea, making it the site of greatest visual acuity (sharpness of vision) and providing the ability to distinguish fine details.

Visual acuity depends not only on the proper focusing of the image on the retina, but also on the ability of the retina to distinguish between objects that are extremely close together. In this area of maximum resolving power, there are approximately 170,000 receptor cells per square millimeter (10.6 million receptor cells per square inch). This vast number of receptors makes it possible to discern tightly spaced, minute objects as separate visual targets.[2]

The optic nerve, which consists of some one million nerve fibers, connects each eye to the brain and supplies blood to the retina. The retina transforms the information about the patterns of light and dark received by the rods and cones into electrical impulses that travel through the optic nerve to the brain, where they are interpreted as an image.[3]

The optic nerve is joined to the eye in the retina at a point called the optic disk. Because the optic nerve contains no light-sensitive receptor cells, it is considered “blind” and renders the optic disk blind, as well — creating the area commonly referred to as the “blind spot.” Normally, the blind spot is between five degrees and 10 degrees wide. The small size of the blind spot may make it sound insignificant, but it is enough to allow an aircraft to disappear from view, often before the eyes have detected it. The exercise in Figure 2 demonstrates the blind spot.[4]

Exercise for Demonstrating the Eye’s Blind Spot



Source: Shari Stamford Krause, Ph.D.

Figure 2

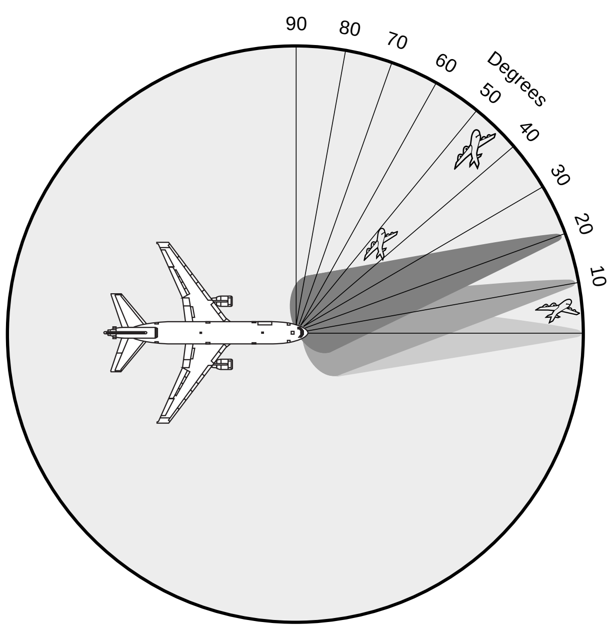
Scientists have found neurophysiological evidence that establishes the importance of the eye-brain connection in collision avoidance. The evidence indicates that there are two separate and parallel visual channels in the brain, each of which is directly linked to the ability to search and detect. One channel responds to the visual functions of target detection and acquisition (except in the most technical discussions, these terms are often used interchangeably). It contains both rods and cones and allows the brain to interpret peripheral (side) vision.

The second channel originates from the fovea, the area of sharpest acuity, making it possible to identify a target. These two channels converge in a third pathway, which researchers believe may integrate these peripheral and central inputs in a way that enables the eyes simultaneously to focus on and track a moving target.[5] This ability is a key to visual search and detection.

In the absence of a visual stimulus (for example, empty airspace), the muscles in the eye relax, preventing the lens from focusing. This creates a problem for a pilot who is attempting to scan for traffic in a clear, featureless sky. Because the eye cannot properly focus on empty space, it remains in a state of unfocused, or blurred, vision. This phenomenon, known as "empty-field myopia," hinders effective search and detection.

Another aspect of eye functioning that is relevant to visual searching is saccadic eye movement. When they are not tracking a moving target, the eyes do not shift smoothly; they shift in a series of jerky movements or "jumps" called saccades (Figure 3). As a result of saccadic eye movements, it is not possible to make voluntary, smooth eye movements while scanning featureless space.

Saccadic Eye Movement



Source: Shari Stamford Krause, Ph.D.

Figure 3

Saccadic Eye Movement Decreases Distant Visual Acuity

A study conducted at the U.S. Naval Aerospace Medical Research Laboratory (NAMRL) showed that when the eyes are in saccadic movement, visual acuity decreases sharply, leaving large gaps in the distant field of vision.[6]

Visual acuity is greatest for objects that are directly in front of the eye. But the fovea is a mere two degrees wide, which results in a very narrow high-acuity detection area and leaves as much as 178 degrees of the detection area in the realm of peripheral vision. This is one reason that we often tend to spot traffic or obstacles out of the "corner" of our eye.

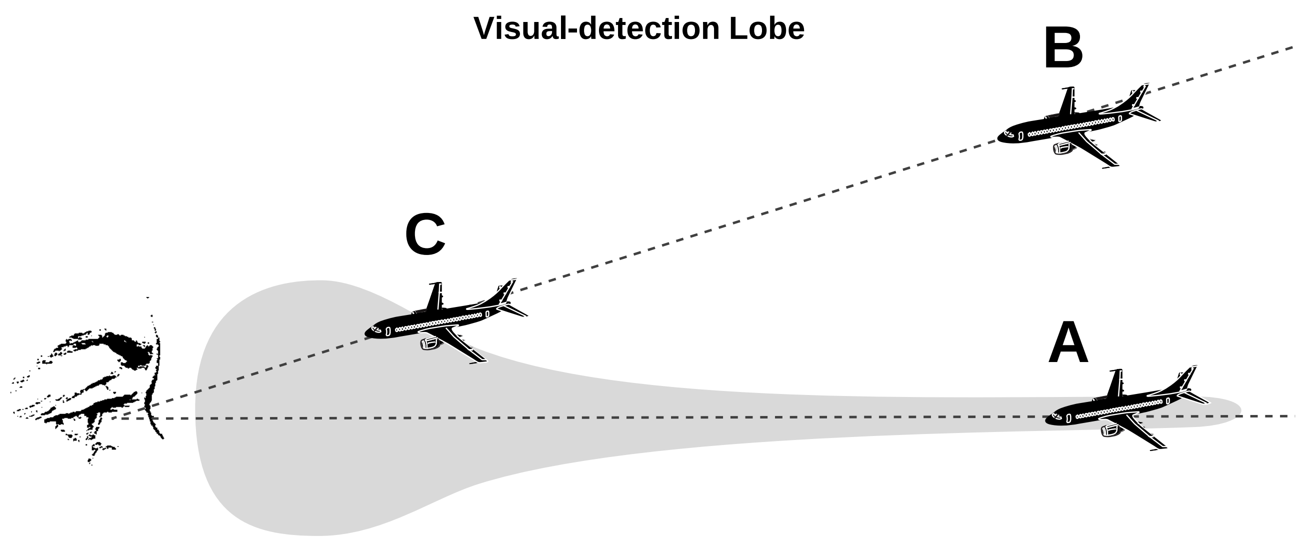
Researchers at NAMRL found that optimizing peripheral-scanning skills is an important element in improving target-detection skills. They described the visual-detection lobe (Figure 4, page 4). As the figure illustrates, the detection range for central vision is narrow but extends relatively far, whereas the detection range for peripheral vision includes a wider area but extends a much shorter distance. The visual-detection lobe represents the range in which detection is probable, not certain.

The shaded areas in Figure 4 depict how the visual-detection lobe relates to saccadic eye-movement scans. Compared to near searches, distant searches using central vision must be scanned over a much larger field in a relatively short period of time.

The spaces between the tips of the cone-shaped shaded areas shown in the figure are the visual gaps created by saccadic motion. These gaps cause a significant problem for a pilot who is scanning for traffic because aircraft can easily slip into those transition areas undetected. When searching for aircraft at a closer range, within 3.7 kilometers (2.3 miles), for example, fewer "fixations" (focused scans) are required because of the increased probability of detecting a target through peripheral vision.

In Figure 4, the same type of aircraft is shown in the three positions — A, B and C. Aircraft A, in the central field of vision, is likely to be detected. Aircraft B, although it is at the same range as Aircraft A, is outside the visual-detection lobe and unlikely to be detected. Aircraft C is the same number of degrees off the direct line of vision as Aircraft B; but because it is within the visual-detection lobe, it is likely to be detected through peripheral vision.

Depending on closure rate, crossing angle and routine cockpit distractions, aircraft can seem to appear suddenly, leaving little time to react and avoid a collision. Researchers at the



Source: Shari Stamford Krause, Ph.D.

Figure 4

Massachusetts Institute of Technology (MIT) devised several mathematical models to analyze visual acquisition and to determine detection probabilities. [7] The parameters were restricted to bright daylight conditions, constant flight paths and a constant rate of range decrease. No unusual visual environments were considered. Although the variables were carefully controlled, the calculations indicated that the probability of target detection was quite low in most cases.

Two examples illustrate that even under perfect conditions, probability of detection is frequently remote:

Example 1

Target aircraft/airspeed: Single-engine Piper Dakota (PA-28-236)/241 kilometers per hour (kph) (130 knots)

Search aircraft/airspeed: Boeing 727/333 kph (180 knots), on approach

Encounter: Head-on

Detection Probability: On a clear day with unlimited visibility, the crew of the B-727 would have a 12 percent probability of visual acquisition of the PA-28 12 seconds before collision. At a distance of 5.5 kilometers (2.6 miles), the probability would decrease to 2.47 percent.

In Example 2, below, the heading crossing angle (HCA) is derived by subtracting the heading of Aircraft B from the heading of Aircraft A.

Example 2

Target aircraft/airspeed: Boeing 727/444 kph (240 knots)

Search aircraft/airspeed: King Air/333 kph

Encounter: 120-degree heading crossing angle (Figure 5, page 5)

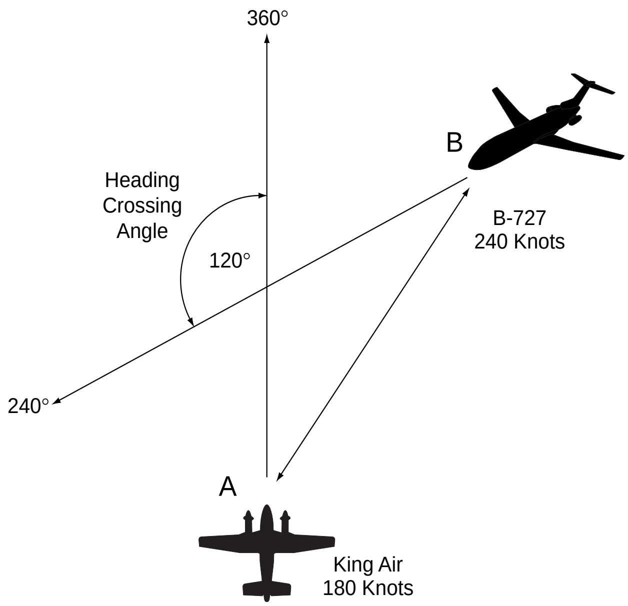
Detection Probability: At a distance of nine kilometers (5.75 miles), the King Air pilot would have a 76 percent probability of visual acquisition 12 seconds before collision. At a distance of 3.7 kilometers, the probability would decrease to 28 percent.

A 120-degree heading crossing angle provides a larger cross-section of the target aircraft and thus a higher probability of detection than in a head-on meeting between the same two aircraft.

The effectiveness of central and peripheral detection also depends on restrictions in the visual field. In an aircraft, the most common restriction is the visual boundary created by the overall structure of the cockpit. The visual field of each eye encompasses about 130 degrees. The visual field of each eye overlaps with that of the other eye, which creates our "binocular" (two-eyed) vision.

Because each eye has a different viewing angle, the images formed on the two retinas are not identical. The brain combines the two images into a single, three-dimensional perception of the object. Thus the perception of depth is a particular feature

Illustration of a Heading Crossing Angle of 120 Degrees



Source: Shari Stamford Krause, Ph.D.

Figure 5

of binocular vision. Conversely, if only one eye is viewing an object (monocular vision), the image is perceived in a single dimension, with no depth perception.[1]

Cockpit Creates Monocular Visual Areas

The restricted visual field of the cockpit can interfere with a pilot's ability to detect targets. In a study that included nine subjects, each with at least 20/20 corrected or uncorrected vision, a viewing booth was designed to simulate a cockpit windshield; and through this "windshield," a binocular field 25 degrees high and 38 degrees wide could be seen by the participants.[8] Because of the distance between the observers' eyes, slightly different fields were seen by the right eye and left eye. This created monocular visual borders — areas at the extreme right and extreme left edges of the visual field where an object in that area could be seen only with one eye (the right and left eye, respectively).

The target was a dark disk with a diameter of 1.2 meters (four feet) against a white background screen that had a uniform brightness contrast of nearly 80 percent. There were 45 possible target positions varying from zero degrees, five degrees and 10 degrees above and below the visual center; and zero degrees, five degrees, 10 degrees, 15 degrees and 18 degrees left and right of center. The targets at 18 degrees appeared within the monocular visual field.

Each observer was given a total of 50 timed acquisition trials. During each 12-second trial, the target disk appeared in one of the 45 possible target positions in random order, and there were five blank screens (trials in which no disk appeared). A target that was not reported within the 12-second search time was recorded as a missed target.

Test results were plotted on a grid to determine the search areas that had the most missed targets. All the missed targets in the binocular field of vision (a total of 18 misses) had appeared along the bottom of the visual field. There were fewer missed targets (10 misses) in the monocular field (along the extreme left and right sides of the screen) than in the binocular field.

In other words, the presence of a visual boundary can cause a pilot to concentrate the search near the center of the binocular field, or directly out the front window. The results further suggested that if no target is detected, a pilot scans the outer edges of the window structure first because crossing traffic generally presents the greatest potential threat; this scan is followed by a search below the nose. The pilot tends to scan in a relatively small area, which is one reason that other aircraft remain undetected. Because of the limitations of central vision, it is important to search all sectors, especially those around the edges of the cockpit. Aircraft maneuver in three dimensions, so visual scanning above and below the horizon is also important.

Effective Scanning Based on Sectors

To achieve the most effective coverage, the NAMRL study recommended that scanning be done by horizontal and vertical sectors. Horizontal sectors should be 90-degree segments of the horizon. Depending on the aircraft, these segments may be more easily defined along the lines of the aircraft structure, such as a wing line.

Vertical scanning should extend from 45 degrees above the horizon to the lower limit of wing-level cockpit visibility. The pilot should begin by scanning forward above the horizon and move aft. Then, scanning should continue below the horizon, moving forward.

Although most civilian aircraft are not equipped with bubble canopies, it should still be possible to scan at least 45 degrees high off the nose and to the side of the aircraft. Depending on the type of aircraft, scanning the extreme upper and lower sectors may require a slight bank to look around the wing.

These techniques and suggestions were designed to compensate for visual limitations, but there are also ways to enhance overall visual skills. An analysis was conducted at the U.S. Air Force Aerospace Medical Research Laboratory (USAF AMRL) to determine the effects of the pilot's visual environment on the accuracy of accommodation to a distant target. The AMRL defines accommodation as adaptation in the lens of an eye to permit retinal focus on images of objects at different distances. The results of these studies provide clues as to how visual acquisition skills can be developed.

As researchers discovered, pilots of high-performance aircraft are frequently unaware of how the cockpit environment can be "visually hostile." Dirty, scratched or fogged windscreens are annoyances with which pilots must routinely contend. Windows should be cleaned before every flight because seemingly benign marks on the window can affect dramatically the pilot's ability to suppress saccadic eye movement, which prevents the eyes from focusing on a distant object.

Pilots have failed to notice aircraft on collision courses because they assumed "that little black smudge on the window" was nothing more than a bug splatter. Perhaps the most insidious visual obstructions in the cockpit are those created by the curved, laminated transparencies in the windscreen itself. The symbology associated with a head-up display (HUD) can further impair the search area. As a result, a pilot may experience glare, reflections, haze and optical distortion. These factors can hinder a pilot's ability to perceive a target by reducing the level of contrast or by producing overlapping and "phantom" (illusory) targets.

Despite these obstacles, researchers discovered that test subjects were able to "look through" such structured surfaces and detect distant targets.

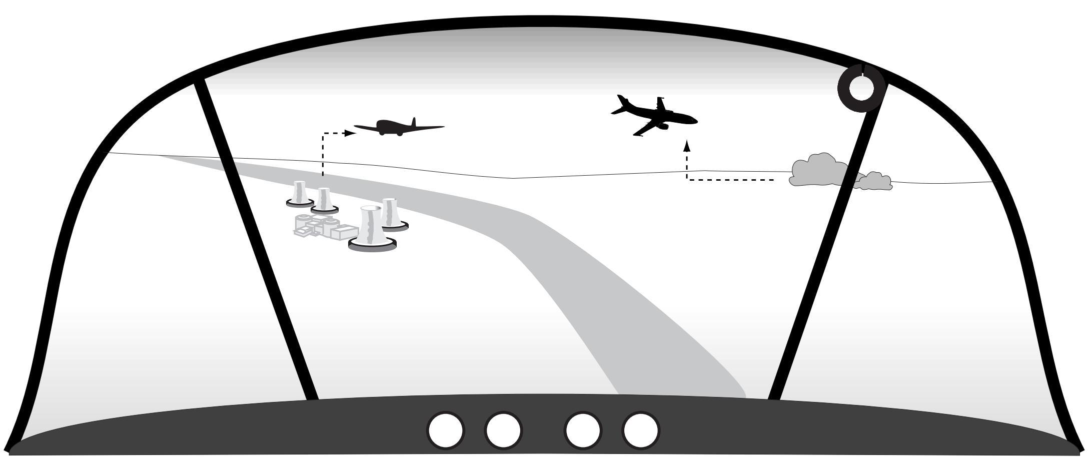
After several trials, half of the observers seemed to be able to ignore conflicting peripheral stimuli and concentrate on the target. Researchers believed that the subjects achieved this by simply disregarding nearby obstructions, while concentrating on target acquisition in the far distance. The evidence suggested that ignoring conflicting images (insect marks, scratches, windshield frames) to concentrate on target acquisition is a skill that can be developed.

In a related study, researchers found two observers with the apparent ability to focus and defocus on a target at will. The subjects were slightly younger than the participants in the earlier experiments, and each had a far acuity of 20/15 uncorrected. The target was a dark aircraft silhouette viewed against a white background. With minimal practice and no feedback during the sessions, the observers were able to change their accommodation nearly instantaneously. Each subject claimed to have focused on specific objects at various ranges to scan at that range.

Figure 6 depicts a scan pattern in a clear and featureless (except for possible targets) sky. Note that the top of the instrument panel and the window posts can easily reduce the ability to accommodate distant targets. Learning to "look through" those structures makes it possible to concentrate on collision avoidance in the entire environment. Suggested practical methods for using these techniques include the following:

- Anticipate the target in the location and ranges you are searching;
- Locate a sizable, distant object (e.g., a cloud formation, mountain peak, prominent landmark, building or pier) that is within the range of the anticipated target, and focus your eyes on it as you begin each scan pattern;

Search Technique in Clear Sky



The eye muscles relax and the eyes become unfocused when staring into empty space. Looking at a distant object (e.g., a cloud) immediately before searching for traffic refocuses the eyes to the range where meaningful targets will be found.

Source: Shari Stamford Krause, Ph.D.

Figure 6

- Refocus frequently on a distant point as you begin each new scan;
- Allow three to five seconds for your saccadic eye movement to suppress before shifting your search to the block of airspace around the object; and,
- Vary distances to ensure a thorough scan and to reduce visual fatigue.

These focusing techniques offer a significantly more effective visual-detection plan than simply "seeing" and then "avoiding" an aircraft whose course represents a threat. Using search-and-detect techniques, the pilot takes a more active role in collision avoidance, and the reward will be a greater margin of safety.♦

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About the Author

Shari Stamford Krause, Ph.D., is an aviation textbook author for McGraw-Hill Professional Book Group. Her books include Aircraft Safety: Accident Investigation, Analyses, and Applications *(abstracted in* Flight Safety Digest, *January 1997, p. 36) and* Avoiding Mid-Air Collisions. *Krause is on the faculty of Embry-Riddle Aeronautical University and Pacific Western University. She is a licensed pilot.*

U.S. "Large-carrier" Fatalities, Accident Rates Increased in 1996

The number of fatalities was the highest since 1985, and the fatal-accident rate was the highest since 1990. There were six "major" U.S. accidents, as defined by an accident classification newly introduced by the U.S. National Transportation Safety Board.

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U.S. "large-carrier" accidents resulted in more fatalities in 1996 than in any year since 1985, according to preliminary statistics released by the U.S. National Transportation Board (NTSB). The statistics were included in a comparison of accident rates for the 1982–1996 period.

A total of 350 passengers and crew members were killed in U.S. large-carrier accidents, compared with 162 in 1995. Only 1985, with 525 on-board fatalities, had a higher total within the period (Table 1, page 9).

The large-carrier classification encompasses U.S. carriers operating scheduled and nonscheduled (charter) passenger service using aircraft with 30 or more seats, as well as cargo carriers using large aircraft.

The fatality totals must be viewed in the context of a large increase in flight activity during the 15-year period: 8.55 million departures in 1996 compared with 5.35 million departures in 1982. The fatal-accident rate per 100,000 flight hours (0.037) was the highest since 1990 (0.049) but lower than the rates for 1982, 1983, 1985, 1987 and 1989.

Looked at in a different way, as fatal accidents per 100,000 departures, the 1996 rate (0.058) was again the highest since 1990 (0.074), but lower than the rates for 1982, 1983, 1985 and 1989.

There were six "major" airline accidents in 1996 (Table 2, page 10). According to a new accident-classification system introduced in the latest statistical report, the NTSB defines a major accident as one in which any of three conditions exist:

- A large aircraft operated under U.S. Federal Aviation Regulations (FARs) Part 121 was destroyed;
- There were multiple fatalities; or,
- There was one fatality and a large aircraft operated under Part 121 was substantially damaged.

The number of major accidents in 1996 was higher than in any years during the 1982–1996 period except 1985 and 1989, in each of which there were eight major accidents. The 1996 major-accident rate was 0.439 per million hours flown, higher than the rates for any years in the period except 1983, 1985, 1987 and 1989.

The NTSB has also established categories for "serious," "injury" and "damage" accidents. Serious accidents are those that meet either of two conditions:

- There was one fatality without substantial damage to an aircraft operated under Part 121; or,
- There was at least one serious injury and an aircraft operating under Part 121 was substantially damaged.

As defined by the serious category, U.S. Part 121 carriers had a perfect year in 1996 — there were no serious accidents. Injury accidents, defined as nonfatal accidents with at least one serious injury and without substantial damage to an aircraft operated under Part 121, occurred at a higher rate than any year since 1986. Damage accidents, in which no one was killed or seriously injured but any aircraft was substantially damaged, occurred at a lower rate in 1996 than in 1995, but otherwise at a higher rate than any year since 1987.

Table 1
Accidents, Fatalities and Rates, 1982–1996, for U.S. Air Carriers Operating Under FARs Part 121, Scheduled and Nonscheduled Service

	Accidents		Fatalities					Accidents per 100,000 Flight Hours		Accidents per Million Aircraft Miles Flown		Accidents per 100,000 Departures	
Year	All	Fatal	Total	Aboard	Flight Hours	Miles Flown	Departures	All	Fatal	All	Fatal	All	Fatal
1982	18	5	235	223	7,040,325	2,938,513,000	5,351,133	0.241	0.057	0.0058	0.0014	0.318	0.075
1983	23	4	15	14	7,298,799	3,069,318,000	5,444,374	0.315	0.055	0.0075	0.0013	0.422	0.073
1984	16	1	4	4	8,165,124	3,428,063,000	5,898,852	0.196	0.012	0.0047	0.0003	0.271	0.017
1985	21	7	526	525	8,709,894	3,631,017,000	6,306,759	0.241	0.080	0.0058	0.0019	0.333	0.111
1986	24	3	8	7	9,976,104	4,017,626,000	7,202,027	0.231	0.020	0.0057	0.0005	0.319	0.028
1987	34	5	232	230	10,645,192	4,360,521,000	7,601,373	0.310	0.038	0.0076	0.0009	0.434	0.053
1988	29	3	285	274	11,140,548	4,503,426,000	7,716,061	0.251	0.018	0.0062	0.0004	0.363	0.026
1989	28	11	278	276	11,274,543	4,605,083,000	7,645,494	0.248	0.098	0.0061	0.0024	0.366	0.144
1990	24	6	39	12	12,150,116	4,947,832,000	8,092,306	0.198	0.049	0.0049	0.0012	0.297	0.074
1991	26	4	62	49	11,780,610	4,824,824,000	7,814,875	0.221	0.034	0.0054	0.0008	0.333	0.051
1992	18	4	33	31	12,359,715	5,054,916,000	7,880,707	0.146	0.032	0.0036	0.0008	0.228	0.051
1993	23	1	1	0	12,706,206	5,249,469,000	8,074,393	0.181	0.008	0.0044	0.0002	0.285	0.012
1994	23	4	239	237	13,122,221	5,478,118,000	8,242,903	0.168	0.030	0.0040	0.0007	0.267	0.049
1995	36	3	168	162	13,513,219	5,648,512,000	8,451,606	0.266	0.022	0.0064	0.0005	0.426	0.035
1996	38	5	380	350	13,683,000	5,761,935,000	8,554,000	0.278	0.037	0.0066	0.0009	0.444	0.058

FARs = U.S. Federal Aviation Regulations
Notes:
1996 data are preliminary.
Hours, miles and departures are compiled by the U.S. Federal Aviation Administration.
The 62 total fatalities in 1991 include the 12 persons killed aboard a Skywest commuter aircraft and the 22 persons killed aboard a USAir airliner when the two aircraft collided.
Suicide and sabotage accidents are included in “Accidents” and “Fatalities” but are excluded from accident rates in this table.

Source: U.S. National Transportation Safety Board

Table 2
Accidents and Accident Rates, by NTSB Classification, for U.S. Carriers Operating under FARs Part 121

	Accidents					Accidents per Million Aircraft Hours Flown			
Year	Major	Serious	Injury	Damage	Aircraft Hours Flown (Millions)	Major	Serious	Injury	Damage
1982	3	4	6	7	7.040	0.426	0.568	0.852	0.994
1983	4	2	9	8	7.299	0.548	0.274	1.233	1.096
1984	2	2	7	5	8.165	0.245	0.245	0.857	0.612
1985	8	2	5	6	8.710	0.918	0.230	0.574	0.689
1986	4	0	14	6	9.976	0.401	0.000	1.403	0.601
1987	5	1	12	16	10.645	0.470	0.094	1.127	1.503
1988	4	2	13	10	11.141	0.359	0.180	1.167	0.898
1989	8	4	6	10	11.275	0.710	0.355	0.532	0.887
1990	4	3	10	7	12.150	0.329	0.247	0.823	0.576
1991	5	2	10	9	11.781	0.424	0.170	0.849	0.764
1992	3	3	10	2	12.360	0.243	0.243	0.809	0.162
1993	1	2	12	8	12.706	0.079	0.157	0.944	0.630
1994	4	0	12	7	13.122	0.305	0.000	0.914	0.533
1995	3	2	14	17	13.513	0.222	0.148	1.036	1.258
1996	6	0	18	14	13.683	0.439	0.000	1.316	1.023

FARs = U.S. Federal Aviation Regulations
NTSB = U.S. National Transportation Safety Board

NTSB Accident Classifications:

Major: an accident in which any of three conditions is met:
- A Part 121 aircraft was destroyed;
- There were multiple fatalities; or,
- There was one fatality and a Part 121 aircraft was substantially damaged.

Serious: an accident in which either of two conditions is met:
- There was one fatality without substantial damage to a Part 121 aircraft; or,
- There was at least one serious injury and a Part 121 aircraft was substantially damaged.

Injury: A nonfatal accident with at least one serious injury and without substantial damage to a Part 121 aircraft.
Damage: An accident in which no person was killed or seriously injured, but in which any aircraft was substantially damaged.

Source: U.S. National Transportation Safety Board

FAA Advisory Circular Offers Guidance For Aviation Safety Action Programs

U.S. General Accounting Office report finds "long-standing problems" in U.S. Federal Aviation Administration inspection program.

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FSF Editorial Staff

Advisory Circulars (ACs)

Crew Resource Management Training. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 120-51B. Feb. 25, 1997. 3 pp. Available through GPO.*

This AC contains changes to Appendix 3, Appropriate CRM Training Topics, for U.S. Federal Aviation Regulations (FARs) Parts 121 and 135 operators. This revision to Appendix 3 is necessary because accident investigations conducted by the U.S. National Transportation Safety Board (NTSB) indicate that many accidents are caused by crew members who may not have been sufficiently knowledgeable of and/or properly trained in crew resource management. [Adapted from AC.]

Turbine Engine Continued Rotation and Rotor Locking. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 33.74/92. Feb. 14, 1997. 4 pp. Available through GPO.*

Differences were identified between the Joint Aviation Requirements–Engines (JAR–E) and Part 33 of the U.S. Federal Aviation Regulations (FARs) concerning windmilling and rotor locking. A study group of representatives of the FAA, the Joint Aviation Authorities (JAA), Transport Canada and the aviation industry worked to produce improved requirements that were subsequently incorporated into Part 33 of the FARs. This AC is a guide to implementing these new requirements during certification, providing acceptable (but not the only) methods to demonstrate compliance. This AC combines Part 33 sections 33.74 and 33.92 and will eventually be incorporated into AC 33.2, *Aircraft Engine Type Certification Handbook*. [Adapted from AC.]

Turbine Engine Vibration Survey. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 33.83. Feb. 14, 1997. 7 pp. Available through GPO.*

Differences were identified between the Joint Aviation Requirements–Engines (JAR–E) and Part 33 of the U.S. Federal Aviation Regulations (FARs) concerning vibration tests/surveys. A study group was formed of representatives of the FAA, the Joint Aviation Authorities (JAA), Transport Canada and the aviation industry to produce improved vibration requirements that were subsequently incorporated into Part 33 of the FARs. This AC is a guide to implementing these new requirements during certification, providing acceptable (but not the only) methods to demonstrate compliance. This AC will eventually be incorporated into AC 33.2, *Aircraft Engine Type Certification Handbook*. [Adapted from AC.]

Aviation Safety Action Programs (ASAP). U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 120-66. Jan. 8, 1997. 5 pp. Available through GPO.*

Recently, the FAA and the air transport industry have cooperated in seeking alternative ways to address safety problems and identify safety hazards. Several demonstration

Aviation Safety Action Programs (ASAPs) have been established with the objective of increasing the volume of safety information to the air carriers and FAA alike. This AC is designed as a guide for establishing ASAPs.

Participating programs included the USAir Altitude Awareness Program, the American Airlines Safety Action Program and the Alaska Airlines Altitude Awareness Program. An important aspect of these programs was the inclusion of incentives to encourage air carriers' employees to disclose information and to identify possible violations of the U.S. Federal Aviation Regulations (FARs) without the fear of enforcement penalties. Apparent violations of the FARs by an air carrier participating in a program were handled under the voluntary disclosure policy, so long as the requirements of the policy were met.

Appendix 1 contains a "Sample Memorandum of Understanding," which outlines the ASAP provisions among the FAA, certificate holders, management and employee groups or their representatives. [Adapted from AC.]

Small Airplane Certification Compliance Program. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 23-15. Jan. 2, 1997. 31 pp. Available through GPO.*

Several aviation and industry organizations have expressed concern that the typical means of compliance for certain sections of Part 23 of the U.S. Federal Aviation Regulations (FARs) are needlessly demanding for small low-performance airplanes. In response, a team was formed to study the situation.

With the goal of improving certification efficiency, FAA designated engineering representatives (DERs), aircraft certification offices (ACOs) and industry representatives studied specific regulations along with means of compliance. The results are compiled in this AC, which lists each regulation followed by a means of compliance that improves certification efficiency. The means of compliance listed are acceptable and known to succeed, but are not the only possible methods to show compliance; certain highly sophisticated aircraft may need additional or more accurate solutions. [Adapted from AC.]

Driver's Enhanced Vision System (DEVS). U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5210-19. Dec. 23, 1996. 7 pp. Available through GPO.*

Poor visibility was a contributing factor in three major fatal accidents between January 1990 and February 1991 on active runways at night. The response of aircraft rescue and fire-fighting (ARFF) vehicles in two of these accidents was slowed by poor visibility. When fog or other poor-visibility conditions are present, ARFF operators may have difficulty locating accident sites and may need to drive more slowly to keep from colliding with obstacles or becoming lost.

An emergency response time of three minutes to a simulated airport runway accident site is required to achieve certification. The Driver's Enhanced Vision System (DEVS) program is an effort to reduce ARFF response times and help in: (1) locating the accident site, (2) navigating to the accident site and (3) avoiding obstacles on the way to the accident site. DEVS technology can improve a driver's performance in these areas, according to evaluations conducted at the FAA Technical Center and at airports around the country.

DEVS includes three subsystems: (1) night vision, consisting of a forward-looking infrared device or comparable state-of-the-art night-vision technology; (2) navigation, making the ARFF operator aware of the vehicle's location and helping to locate the accident site; and (3) tracking, a subsystem that can be closely integrated with the navigation subsystem through data link.

Although DEVS is designed to be an integrated system, particular airports, depending on financial circumstances, can derive safety benefits by using only part of the complete DEVS. This AC, a guide for the design and installation of DEVS equipment on ARFF vehicles, contains DEVS standards, specifications and recommendations. The greatest potential benefits are for airports with operations at a runway visual range of less than or equal to 366 meters (1,200 feet). [Adapted from AC.]

Announcement of Availability: Changes to Practical Test Standards. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 60-27. Nov. 18, 1996. 1 p. Available through GPO.*

Modern information and communications technology make it possible to issue changes to practical test standards immediately, whenever appropriate and necessary. Issuing changes electronically means that the practical test standards are always current and accurate. This AC announces the electronic accessibility to changes to the practical test standards from FedWorld through the National Technical Information Service (NTIS), an agency of the U.S. Department of Commerce. [Adapted from AC.]

Repair Stations for Composite and Bonded Aircraft Structure. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 145-6. Nov. 15, 1996. 16 pp. Available through GPO.*

This advisory circular (AC) outlines one acceptable way of demonstrating compliance with the requirements of the U.S. Federal Aviation Regulations (FARs) Parts 21, 43, 121, 125, 127, 135 and 145 concerning procedures and facilities for repairs and alterations of structures consisting of metal-bonded and fiber-reinforced materials (e.g., carbon, boron, aramid and glass-reinforced polymeric materials mentioned in AC 20-107, *Composite Aircraft Structures*). The FAA will consider other possible methods of compliance presented by an applicant. [Adapted from AC.]

Waivers of Provisions of Title 14 of the Code of Federal Regulations Part 91. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 91-72. Nov. 8, 1996. 2 pp. Available through GPO.*

This AC contains information about applying for waivers of certain sections of Title 14 of the U.S. Code of Federal Regulations (U.S. Federal Aviation Regulations [FARs]) Part 91. The FAA may issue a waiver to provide temporary regulatory relief from designated sections of Part 91 for a specific operation or series of related operations. [Adapted from AC.]

Conversion of the Inspection Authorization Knowledge Tests to the Computer Based Airmen Knowledge Testing Program. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 65-29. Oct. 29, 1996. 1 p. Available through GPO.*

This AC announces the FAA conversion from pencil-and-paper inspection authorization (IA) knowledge tests to computer-based testing. The FAA IA knowledge test is an internal FAA test used to measure an applicant's ability to inspect aircraft and components in accordance with the safety standards of the U.S. Federal Aviation Regulations (FARs). For the past 35 years, the IA knowledge test has been taken using paper and pencil. On Aug. 1, 1996, the IA knowledge test was converted to computer format. The computer format offers enhanced security, improved statistical data, substantially lower administrative costs and the ability to provide immediate test results to the applicant. [Adapted from AC.]

Reports

Analysis of Structural Factors Influencing the Survivability of Occupants in Aeroplane Accidents. R.G.W. Cherry & Associates. U.K. Civil Aviation Authority (CAA) Paper No. 96011. December 1996. 69 pp. Tables, figures, appendix. Available through U.K. CAA.****

This report describes a study conducted for the Commission of the European Communities that was based on an analysis of accidents to study the factors that influence the survival of passengers in aircraft accidents. The accidents studied were chosen as a representative sample of all survivable accidents. The research included the development of an accident database of survivable accidents containing information about more than 500 accidents to in-service aircraft.

Additional study was done on behalf of the U.K. CAA to analyze structural factors important to cabin safety. Objectives of the report include making use of the work done for the European Commission, along with research to: (1) assess the expected improvement in terms of the number of fatalities and injuries related to developments in aircraft structures and cabin safety; (2) note any other failures that might warrant study into structural improvements that would increase the chances of occupant survival.

This report outlines the methods in the analysis and the conclusions reached supporting the potential benefit of improvements to structural survivability factors. [Adapted from Introduction.]

[A paper representing an earlier version of this report is described in detail in *Cabin Crew Safety*, January–February 1997.]

Airport Privatization: Issues Related to the Sale or Lease of U.S. Commercial Airports. U.S. General Accounting Office, Report to the Subcommittee on Aviation, Committee on Transportation and Infrastructure, U.S. House of Representatives. Report No. GAO/RCED-97-3. November 1996. 55 pp. Tables, figures, appendices. Available through GAO.***

Much debate has been generated by the possibility that U.S. commercial airports may be sold or leased to private companies. Those in favor of privatization envision such sales or leases providing more capital for the aviation infrastructure, making airports more commercial and financially independent. Those opposed see privatization as a way for local governments to spend money intended for aviation infrastructure elsewhere, resulting in higher costs for airlines and passengers.

This report examines: (1) private sector involvement at commercial airports in the U.S. and in other countries; (2) present incentives and barriers to the sale or lease of commercial airports; and (3) the possible consequences for those who hold a major stake in the results — passengers, airlines, and local, state or federal government — if commercial airports are sold or leased.

In contrast to the U.S. air traffic control system, owned entirely by the federal government, the ownership of commercial airports is divided among local governments, and to a limited degree, states and the federal government. Because these commercial airports receive federal grants and tax-exempt financing and are subject to federal regulations, the decision to sell or lease by a public owner or the decision for a private company to buy or lease has many repercussions. And despite commercial airports being publicly owned in the United States, the private sector plays a significant role, both in operations and financing, with 90 percent of employees at the largest U.S. airports working for private companies.

Realizing the potential benefits of privatization, the U.S. Congress established an airport privatization pilot program as part of the Federal Aviation Reauthorization Act of 1996. This program allows the U.S. Secretary of Transportation to exempt up to five airports from certain legal requirements that block privatization, but the agreement requires the private owner or lessee to maintain the highest degree of safety and security.

The report concludes that legal and economic concerns are blocking progress in the sale or lease of U.S. commercial airports. The FAA has allowed privatization on a limited scale, but has discouraged the sale or lease of entire airports. The FAA's greatest legal objection has to do with the use of airport revenue. A recently proposed policy on the use of airport revenue states that the "agency will consider privatization proposals on a case-by-case basis and will be flexible in specifying conditions on the use of airport revenue that will protect the public interest and fulfill restrictions on diverting revenue without interfering with privatization." [Adapted from Executive Summary.]

Air Traffic Control: Remote Radar for Grand Junction. U.S. General Accounting Office, Report to Congressional Requesters. Report No. GAO/RCED-97-22. November 1996. 12 pp. Appendices. Available through GAO.***

Studies were conducted by the U.S. Federal Aviation Administration (FAA) between 1992 and 1995 to determine the most cost-effective and efficient way to maintain radar-based air traffic control activities for the Grand Junction, Colorado, airport. The focus of the studies centered on two possible options: (1) a local option establishing a terminal radar approach control (TRACON) facility in Grand Junction; and (2) a long-distance option called "remoting," in which a radar signal from the radar installation at Grand Junction would be transmitted and monitored at a TRACON 250 miles away in Denver, Colorado.

The final decision announced by the FAA in June 1995 was the second option. Based on its analysis, the FAA determined that it was more cost-effective to remote the radar signal than to establish an approach control in the Grand Junction airport tower. As a result of this decision, the FAA proposes that the tower at Grand Junction and its remaining air traffic control functions be contracted out to a private firm.

This report examines some of the concerns raised by representatives of the city of Grand Junction, about the FAA decision. Three questions are addressed: (1) Did the FAA select the most cost-effective option for air traffic control activities at Grand Junction? (2) Would the FAA's decision compromise the safety and efficiency of the air traffic control system? and (3) How can the FAA process for deciding when and where to remote radar data be improved? The report agrees with the FAA decision that the more cost-effective option is to remote the Grand Junction radar data to a TRACON facility in Denver. The report says, however, that FAA estimates of the 20-year financial benefits of the remote option are overestimated by roughly US$500,000 ($5.9 million vs. $5.4 million), because of costs associated with telecommunications and staffing that the FAA overlooked. [Adapted from Background and Results in Brief.]

Aviation Topic Speech Acts Taxonomy (ATSAT) PC User's Guide Version 2.0. Prinzo, Veronica; Maclin, Otto. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report No. DOT/FAA/AM-96/20. August 1996. 20 pp. Tables, figures, appendices, references. Available through NTIS.**

Keywords:
1. ATC-Pilot Communications
2. Communication Taxonomy
3. Operational Communications
4. Coding ATC Phraseology

The aviation topics speech acts taxonomy (ATSAT) is used for categorizing pilot or controller communications according to their purpose and for classifying communication errors. This report serves as a manual for ATSATpc, a Windows®-based software product designed to encode voice communications data into a predefined electronic format. The steps for processing air traffic control communications using ATSATpc software are identical to the steps for encoding communications manually. [Adapted from Introduction.]

[For an account of a pilot-controller communications study based on the ATSAT, see *Airport Operations*, January–February 1997.]

Electromagnetic Compatibility Assessment of Large Air Traffic Services Equipment. Nensi, S. U.K. Civil Aviation Authority (CAA) Paper No. 96007. October 1996. 86 pp. Tables, figures, appendix. Available through U.K. CAA.****

As of Jan. 1, 1996, the European Directive 89/336/EEC for electromagnetic compatibility (EMC), implemented by U.K. EMC regulations, is now mandatory. Suppliers of air traffic services (ATS) transmitting equipment are responsible for certifying that their equipment complies with the European Directive. In the United Kingdom, aeronautical equipment is certified by the Civil Aviation Authority (CAA). The testing must be done by an appointed EMC test laboratory. The testing assesses the emissions produced by the equipment and its susceptibility to electromagnetic activity. Because there are no current product standards for ground-based ATS transmitting equipment, the CAA determined that there was a need to establish the EMC requirements for ATS transmitting equipment.

This report is based on a study whose goals were to: (1) identify relevant ATS systems; (2) review how appropriate the current EMC standards are and select test methods and limits; (3) investigate conditions suitable for testing the operation of the ATS transmitting equipment and its use while being tested; (4) identify facilities and equipment for proper testing of ATS transmitting equipment; (5) conduct EMC trials using the data to support the selected tests; and (6) produce a guide for the documentation of standardized EMC procedures and limits.

Appendix 1 contains a guide for the U.K. CAA, the testing labs, and the suppliers of ATS transmitting equipment to achieve certification for EMC. [Adapted from Introduction.]

Review of Safeguarding of Radar Units at Airfields. Fry, C.R.; Prendergast, J.R. U.K. Civil Aviation Authority (CAA) Paper No. 96008. October 1996. 58 pp. Tables, figures, appendices. Available through U.K. CAA.****

This report discusses the history and usage of radar safeguarding criteria (RSC) for modern radar installations in the United Kingdom. The Civil Aviation Authority (CAA) Safety Regulation Group (SRG) is responsible for the establishment and control of RSC so that air traffic control (ATC) radar sites are protected from changes in the surrounding environment.

Understanding how the environment affects the performance and operation of the radar is necessary to remove, reduce or compensate for any detrimental effects. This report assesses the effects of new technology, materials and structures, such as wind-farm generators, and problems in radar-data processing. The purposes of the study on which the report is based were to: (1) review, assess and revalidate or improve the safeguarding criteria presently in use for airfield or other radar sites; (2) establish, wherever necessary, new criteria for recent obstructions that could interfere with the visible horizon of the radar; and (3) justify and recommend any additional guidelines to support the choice of criteria should it be needed for use by the SRG.

This report concludes that the basic format of the existing criteria will remain but will be written in a more precise and user-friendly way. [Adapted from Executive Summary and Introduction.]

Aviation Safety: New Airlines Illustrate Long-Standing Problems in FAA's Inspection Program. U.S. General Accounting Office (GAO), Report to Congressional Requesters. Report No. GAO/RCED-97-2. October 1996. 48 pp. Table, figures, appendices. Available through GAO.***

Deregulation of the U.S. commercial airline industry in 1978 led to the formation of many new airlines. Between January 1990 and December 1994, 79 airlines with less than five years operating experience were providing scheduled service to the public.

This report looks at: (1) the new-airline certification process; (2) the safety performance of airlines with five years or less of operating experience compared with the established airlines (five years or more of operating experience); (3) how often the U.S. Federal Aviation Administration (FAA) inspects new airlines compared with the inspection frequency for established airlines; and (4) the potential for publishing airline-specific safety data.

The analysis shows that on average, airlines during their first five years of operation had higher accident, incident and enforcement action rates than established airlines, especially in their earliest years. For example, the accident rate for new airlines from 1990 to 1994 was 0.60 per 100,000 departures vs. 0.36 per 100,000 departures for established airlines. The report adds that these data must be interpreted carefully; the definition of "accident" used by the U.S. National Transportation Safety Board (NTSB) is broad, covering a range from major fatal accidents to far less serious ones. The report also notes that these data do not necessarily mean that new airlines do not provide safe air travel.

Several theories are suggested to account for this situation with new airlines. One is that the size of their fleets increased faster than their ability to organize the new growth, train their staff and maintain their aircraft. Uncertain finances may also play a part; or the major functions like maintenance might be contracted out, with the attendant loss of control or oversight.

This report concludes that the performance of new airlines should be closely monitored during the first several years of operation, with increased or comprehensive inspections of airlines with high levels of safety-related concerns. The report notes that the FAA's resource targeting could better establish priorities for FAA inspections using initiatives such as the Safety Performance Analysis System (SPAS), which is based on information from several safety-related databases, in addition to better training for inspectors. [Adapted from Background and Results in Brief.]

Airline Deregulation: Barriers to Entry Continue to Limit Competition in Several Key Domestic Markets. U.S. General Accounting Office, Report to the Chairman, Committee on Commerce, Science and Transportation, U.S. Senate. Report No. GAO/RCED-97-4. October 1996. 36 pp. Tables, figures, appendices. Available through GAO.***

Prior to deregulation in 1978 of the U.S. airline industry, the U.S. Civil Aeronautics Board (CAB) controlled the markets that established airlines could enter and prevented the formation of new airlines. To address these and other concerns, the U.S. Congress passed the Airline Deregulation Act of 1978, designed to encourage fares and levels of service to be determined by the marketplace instead of the federal government. As a result, many startup airlines have appeared and the established airlines have expanded service into new markets. The recent period of economic growth, the abundant supply of reasonably priced used aircraft and a buyer's market for pilots have also encouraged startup airlines.

Despite the progress the startups have made, significant barriers still exist in the airline industry. Among these are impeded access to airports resulting from (1) restricted takeoff and landing slots, with federal limits at major airports in Chicago, Illinois; New York, New York; and Washington, D.C.; (2) long-term, exclusive gate leases; and (3) flights prohibited at New York LaGuardia Airport and Washington National Airport by "perimeter rules," which affect flights that exceed a certain distance.

Marketing strategies can also make it difficult for a startup airline. An established airline may dominate by using marketing strategies such as bonus commissions paid to travel agents, frequent flyer plans and ownership of computer reservation systems used by travel agents, among other strategies. This has the effect of limiting competition in key eastern and upper midwestern markets, thereby increasing airfares.

This report concludes with two recommendations to increase competition and reduce airfares: (1) Create available slots by "periodically withdrawing" slots once controlled by established carriers, taking into consideration their investments at the airports that are slot-controlled, and distributing the newly available slots by lottery; and (2) Direct the U.S. Federal Aviation Administration (FAA) to award federal grants based on an airport's efforts to make gates available to competitors. [Adapted from Background, Results in Brief and Conclusions.]

International Aviation: DOT's Efforts to Promote U.S. Air Cargo Carriers' Interests. U.S. General Accounting Office (GAO), Report to Congressional Requesters. Report No. GAO/RCED-97-13. October 1996. 80 pp. Tables, figures, appendices. Available through GAO.***

U.S. exports and imports transported by aircraft in 1995 totaled $355 million, or 27 percent of all U.S. trade. Sixty percent of the freight carried by U.S. airlines was carried by all-cargo airlines. Nevertheless, their efficiency and competitiveness abroad are often hampered by operating barriers. This report addresses the following questions: (1) What problems do all-cargo airlines encounter doing business abroad, and what actions have been taken by these affected airlines and the U.S. government? (2) How have U.S. government policy and bilateral aviation negotiations addressed air-cargo issues and what possibility is there to separate air-cargo negotiations from the broader negotiations concerning passenger services?

The U.S. Department of Transportation (DOT) and the U.S. State Department develop U.S. international aviation policy and attempt to resolve, wherever possible, problems encountered by U.S. airlines doing business abroad. This report contains the results of a GAO survey of 26 U.S. airlines authorized by the DOT and currently doing business abroad in all-cargo services as of September 1995. Twenty-two responses were received, including three major airlines (with annual revenues greater than US$1 billion), nine national airlines (with annual revenues between US$100 million and $1 billion) and nine regional airlines.

Barriers to doing business abroad or affecting competitiveness were reported. Problems related to foreign government regulations and foreign aviation authorities, such as difficulty getting cargo through customs, topped the list; most of these reports came from Latin America and the Asia/Pacific region. The survey showed that 18 of the 22 all-cargo carriers dealt with such problems independently, or as just a cost of doing business, seven out of 10 requested assistance from either the DOT or the State Department and two all-cargo carriers did not know that any assistance was available.

To try to improve the situation, 13 of the 22 all-cargo carriers are in favor of separating air-cargo negotiations from any broader negotiations (such as passenger rights). The DOT and the State Department disagree with this approach as a general policy. The report makes two recommendations: (1) Provide U.S. airlines with information about available assistance and guidance in the procedures necessary for requesting U.S. government aid in resolving problems encountered doing business abroad; and (2) Extend the effort by the DOT to collect information on the problems U.S. airlines encounter doing business abroad to include all U.S. all-cargo airlines operating internationally. [Adapted from Executive Summary.]

Shift Work, Age, and Performance: Investigation of the 2-2-1 Shift Schedule Used in Air Traffic Control Facilities II. Laboratory Performance Measures. Della Rocco, Pam; Cruz, Crystal. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report No. DOT/FAA/AM-96/23. September 1996. 60 pp. Appendices, tables, figures, references. Available through NTIS.**

Keywords:
1. Shift Work, Performance
2. Multiple Task Performance Battery
3. Age

The job of the air traffic control specialist (ATCS) involves demanding and complex tasks: for example, monitoring complex traffic patterns to ensure aircraft separation through application of established rules and procedures; resolution of aircraft conflicts; traffic sequencing; assessing developing weather patterns; and providing appropriate routing adjustments.

This report, the second in a series, presents the findings of a study concerning the 2-2-1 shift schedule used at U.S. Federal Aviation Administration (FAA) air traffic control facilities. The 2-2-1 is a counterclockwise rotating shift schedule consisting of two afternoon shifts, then two morning shifts and then a night shift, all within a typical work week. This study was designed to gather empirical data in a laboratory setting using two groups of ten male subjects. A "younger" group (aged 30–35), and an "older" group (aged 50–55). In addition to the age factor, this report considers how the 2-2-1 schedule contributes to sleep and circadian rhythm (biological, sleep/wake and performance) disruption, performance decrements and changes in subjective measures of sleepiness and mood.

To test the ability to accommodate the variety of workloads encountered frequently in both the cockpit and air traffic control, the multiple task performance battery (MTPB), originally developed to study the performance of flight crews, was used to simulate a comparably varied environment in which performance could be measured.

Examining the performance results of each individual task revealed a pattern of performance decrement in the night shift, not apparent in the first few hours, but observable as the night shift progressed. The study suggests that the problems associated with the 2-2-1 counterclockwise rotating shift schedule are centered on the night shift, and that fatigue and sleepiness countermeasures might provide a remedy. [Adapted from Introduction and Discussion.]

[This report was described in detail in *Airport Operations*, March–April 1997.]

Aviation Security: Technology's Role in Addressing Vulnerabilities. Statement of Keith O. Fultz, Assistant Comptroller General, Resources, Community, and Economic Development Division, U.S. General Accounting Office (GAO), before the Committee on Science, U.S. House of Representatives, Sept. 19, 1996. Report No. GAO/T-RCED/NSIAD-96-262. 13 pp. Table. Available through GAO.***

This report says that measures to protect civil aviation from the threat of terrorism in the United States are urgently needed. This report consists of testimony discussing (1) the aviation security system and its vulnerabilities, (2) the present state of explosives detection technology and its availability and limitations, as well as other ways to counteract the threat and (3) current efforts to improve aviation security.

The Sept. 9, 1996, recommendations from the Presidential Commission on Aviation Security and Terrorism, led by U.S. Vice President Albert Gore (the Gore Commission), are discussed. This heightened threat of terrorism has prompted the U.S. Federal Aviation Administration (FAA) to mandate additional security procedures, especially for international flights.

The present aviation security system consists of procedures that the airlines and airports must implement and pay for, and screening devices such as metal detectors and X-ray machines. Despite these measures, serious vulnerabilities still exist in both domestic and international aviation security systems. For example, in the United States, the use of walk-through metal detectors and X-ray screening of carry-on baggage were efforts to address the threat of hijackings in the 1970s and 1980s. Today, the X-ray screening devices offer inadequate protection against terrorists with sophisticated explosive devices.

The Gore Commission has recommended that the federal government purchase explosives detection equipment for use in airports, but all of the equipment has limitations. Screening cargo and mail presents even more problems. The Gore Commission has also recommended the expansion of security measures such as matching passengers with their bags and the profiling of passengers. According to this report, all the parties involved in the needed improvement in aviation security (especially the FAA, the intelligence community and the aviation industry) must agree on which action to take and how it will be paid for. Furthermore, it will be important for the U.S. Congress to monitor the implementation, progress and effectiveness of these efforts to improve aviation security. [Adapted from Summary.]

Flight Inspection Crew Resource Management Training Needs Analysis. Bailey, Lawrence L.; Shaw, Rogers V. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report No. DOT/FAA/AM-96/24. September 1996. 17 pp. Tables, references. Available through NTIS.**

Research conducted since the 1970s has determined that it takes more than technical skills for effective flight crew performance. Also required is the coordination of individual efforts, known as crew resource management (CRM). More recent findings suggest that there are three factors that determine flight crew performance: (1) technical proficiency, (2) CRM skills and (3) the crew's organizational context. On Oct. 26, 1993, there was a fatal crash of an FAA flight inspection aircraft, the second in five years. The U.S. National Transportation Safety Board (NTSB) identified flight crew performance factors as a contributing cause in the accident. As a result of the NTSB investigation, a recommendation was issued to institute CRM training. This report contains the results of the training needs analysis and discusses the implications of CRM awareness training, along with the need to develop a flight inspection CRM training program. [Adapted from Introduction.]

<u>Keywords:</u>
1. Crew Resource Management
2. CRM
3. Training

Fatal General Aviation Accidents Involving Spatial Disorientation. Collins, William E.; Dollar, Carolyn S. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report No. DOT/FAA/AM-96/21. August 1996. 12 pp. Tables, references. Available through NTIS.**

<u>Keywords:</u>
1. Spatial disorientation
2. General Aviation
3. Fatal accidents

Spatial disorientation is a false perception of distance, attitude or motion of a pilot and an aircraft, relative to the surface of the earth. This study examines the circumstances surrounding fatal general aviation accidents involving spatial disorientation and explores the demographic and behavioral characteristics of spatially disoriented pilots.

Brief reports of all spatial disorientation accidents between 1976 and 1992 were retrieved from the U.S. National Transportation Safety Board (NTSB) database and were analyzed based on factors such as pilot experience, pilot actions, time of day, weather and other conditions. The total number of fatal and nonfatal general aviation accidents increased between 1976 and 1978 and then steadily decreased through 1992. This decline in fatal spatial disorientation accidents was clearly related to overall reductions in the number of active pilots, the number of hours flown, the total number of accidents and the number of fatal accidents.

Nevertheless, the study concludes that the proportionately larger reduction in fatal spatial disorientation accidents during this period was more directly related to the increased proportion of pilots with instrument ratings, to FAA training programs and to improved decision-making skills of general aviation pilots. [Adapted from Introduction, Discussion and Conclusion.]

Aviation Acquisition: A Comprehensive Strategy Is Needed for Cultural Change at FAA. Report to the Chairman, Subcommittee on Transportation and Related Agencies, Committee on Appropriations, U.S. House of Representatives, August 1996. Report No. GAO/RCED-96-159. 68 pp. Tables, appendices. Available through GAO.***

Steady increases in air traffic and aging equipment are realities facing the air traffic control system. Modernization is critical to preserving aviation safety and efficiency. Nevertheless, acquisition problems persist at the U.S. Federal Aviation Administration (FAA) that call into question the agency's ability to manage the timely acquisition of new ATC equipment.

Because of concerns about FAA acquisitions, the chairman, Subcommittee on Transportation and Related Agencies, Committee on Appropriations, U.S. House of Representatives asked the U.S. General Accounting Office (GAO) to (1) determine if the organizational culture at the FAA contributed to the acquisition problems and (2) if so, identify ways the FAA can change its culture and improve its management of acquisitions.

Large cost overruns, schedule delays and performance problems have recurred over the past 15 years of the FAA modernization program. In more than five major projects, increases in per-unit costs ranged between 50 percent and 511 percent, with average schedule delays of almost four years. On previous occasions, GAO has identified technical difficulties and problems with FAA acquisitions management as major contributing factors to this situation.

This GAO report focuses on four areas of the FAA culture and the agency's acquisitions: (1) mission focus: pursuing goals based on the best course of action for the organization; (2) accountability: empowering employees while holding them responsible for their decisions and actions; (3) coordination: involving all employees in decisions affecting them, encouraging collaborative problem solving and cooperation; and (4) adaptability: being open to new approaches and accepting demands and opportunities from inside and outside the organization.

In its analysis, GAO reviewed many studies including those by the FAA, other organizations, surveys of FAA employees working on acquisitions, top agency officials, and studies on organizational culture in the public and private sectors. An FAA reform effort called the Integrated Product Development System was reviewed. A principal finding of this GAO report is that the organizational culture at the FAA is a fundamental cause of the agency's acquisition problems.

The GAO report recommends that the U.S. Secretary of Transportation direct the FAA administrator to develop a strategy for change in organizational culture. The report contains five appendices: Summary of Studies Used to Characterize FAA's Organizational Culture; Organizational Theories Used to Analyze FAA's Organizational Culture; Individuals Who Reviewed GAO's Strategy for Cultural Change; Components of a Strategy for Cultural Change; and Major Contributors to This Report. The report also includes a bibliography. [Adapted from Executive Summary.]

A Further Validation of the Practical Color Vision Test for En Route Air Traffic Control Applicants. Mertens, H.W.; Milburn, N.J.; Collins, W.E. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report No. DOT/FAA/AM-96/22. August 1996. 9 pp. Tables, references. Available through NTIS.**

The U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine developed job-specific color vision tests to validate the integrity and fairness of color vision testing for the selection of air traffic control specialists (ATCS) for either en route or terminal ATC work. These secondary color vision tests are designed to evaluate the ability to perform the most important safety-related tasks involving color coding for applicants who fail the eye exam during the pre-employment physical examination.

This report presents the results of research to obtain further evidence in support of the practical color vision test for en route ATC work. The flight progress strips test (FPST) is used to test for the most difficult color vision task at en route centers —distinguishing the details and colors on flight progress strips (FPSs). The nonredundant use of the colors black and red on the FPS is critical, differentiating between assigned and nonassigned information having to do with altitude, route, departure, approach and other parameters. Even slight inaccuracies can jeopardize safety.

Results achieved using the FPST are compared with a previous test, the criterion flight progress strips test-1 (CFPST-1). The criterion to pass either test was the same, no more than one error, and every subject participating in the experiment with normal vision passed. The greater the subject's degree of color vision deficiency (CVD), the greater the chance of failing the FPST. In all, three tests were administered to participants for this study. The integrity of the FPST results were evaluated by comparison to the pass/fail performances on the other two tests.

The research conducted in this study supported the validity of the FPST, thereby increasing the effectiveness and fairness of practical vision testing for en route ATCS applicants. [Adapted from Introduction.]

Keywords:
1. Air Traffic Controllers
2. Color Vision Standards
3. Performance Tests
4. Color Vision Tests

A Comparison of the Effects of Navigational Display Formats and Memory Aids on Pilot Performance. Beringer, Dennis B.; Harris, Howard C. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report No. DOT/FAA/AM-96/16. May 1996. 11 pp. Table, figures, references. Available through NTIS.**

Keywords:
1. Personal Computer-based Flight
2. Simulation
3. Simulator Research
4. Instrument Flight
5. Display Integration
6. Psychology
7. Applied Psychology

This report describes part of a series of studies that examined efforts to integrate navigational data within a common reference frame. The horizontal situation indicator (HSI) is a commonly available integrated instrument that combines the functions of the very high frequency omnidirectional radio range (VOR) and directional gyro (DG) indicators. This instrument has proven beneficial to both private and instructor pilots in tracking and orientation tasks.

The first question addressed was whether it is cost-effective to install these units in general aviation aircraft. (Costs range from US$3,200 to $4,500 plus installation and VOR/DG configuration costs.)

A second question dealt with whether inexpensive memory aids or "bugs" (adjustable indices on the display faces) were effective in countering the occasional altitude or heading overshoot or reference loss. Their cost can range from as little as US$10 to as much as $200, but bugs are more economical than autopilot altitude- and heading-preselect systems, which are not usually found on inexpensive training aircraft.

A third question concerned the use of moderate-fidelity personal computer (PC)-based flight simulation systems for use in this type of experimentation. Tested using the basic general aviation research simulator (BGARS), both private pilots and instructor pilots committed significantly fewer navigational reversals and orientation errors using HSI than they did using the traditional VOR and directional gyro combination. Similar results were found when bugs or adjustable index markers were used as short-term memory aids. [Adapted from report.]

Books

Aircraft Mishap Photography: Documenting the Evidence. Panas, John Jr. Ames, Iowa, United States: Iowa State University Press, 1996. 156 pp. Figures, photographs, appendices, glossary, bibliography.

It is vitally important to the subsequent investigation of an aviation accident to record the site with high-quality photographs. Author John Panas Jr. presents a concise guide that covers every step in the photographic documentation needed for the investigation.

Aircraft Mishap Photography supplies the inexperienced photographer with information about how accidents are investigated, what to expect, what to look for, how to be prepared, and how to protect and care for the photographs. Chapters include: (1) The Accident Investigation Team; (2) Wreckage Patterns; (3) The Photographer's Response Kit; (4) Care of Film and Photographic Equipment; (5) Coping with Problem Environments; (6) Photographic Priorities and Mishap Evidence; (7) Aircraft Systems; (8) Aircraft Metals; (9) Power Plants; (10) Aircraft Fires and Explosions; (11) Photographic Specialties; (12) Photographic Techniques; (13) Administration and Preservation of Photographs; and (14) Mishap Photographs.

The author also describes how photographs are used to document other aircraft-related situations such as improper maintenance or installation of components. Photographs can help prevent mishaps and be used as visual aids for maintenance or training. The book contains 120 illustrations and five appendices: Symptoms of and Treatments for Exposure to Aircraft Fluids; Military Aircraft Accident Investigation; Fire Mishap Information; Solving Impact Problems with Photography and Trigonometry; and Answers to Chapter Review Questions. [Adapted from Introduction.]

Unheeded Warning: The Inside Story of American Eagle Flight 4184. Fredrick, Stephen A. New York, New York, U.S.: McGraw-Hill, 1996. 326 pp. Index.

A loss-of-control accident to American Eagle Flight 4184, an Avions de Transport Regional (ATR)-72 turboprop, near Roselawn, Indiana, U.S., on Oct. 31, 1994, killed all 68 people aboard. This account of the accident is by Stephen A. Fredrick, an American Eagle pilot, who knew three of the four crew members flying on Flight 4184. He maintains (based partly on a near-accident in an ATR-72 in which he was a pilot) that the ATR-72 had a history of problems with icing.

Deregulation in 1978 of airlines in the United States caused the industry to change. Through a combination of restructuring, elimination of unprofitable routes and expansion into new markets previously restricted by government regulation, the major carriers looked for ways to adapt. This environment gave rise to a system of regional partnerships between major carriers and small regional carriers. The ATR-72 was introduced into the market to operate in many smaller cities where expensive jet service was not economically justified.

The author questions whether this aircraft, designed and built by a consortium of the French company Aérospatiale and the Italian company Alenia, was scrutinized and tested by the FAA to the same extent as domestically manufactured aircraft.

Fredrick claims that there was a fatal flaw in its design. He supports his argument with findings from the U.S. Federal Aviation Administration (FAA) and U.S. National Transportation Safety Board (NTSB), along with personal interviews with family and colleagues of the victims of American Eagle Flight 4184. The book includes a bibliography. [Adapted from inside cover.]

GPS Aviation Applications. Clarke, Bill. New York, New York, United States: McGraw-Hill, 1996. 303 pp.

Air navigation during the past 40 years has used forms of radio direction finding such as the nondirectional beacon (NDB) and very high frequency omnidirectional radio range (VOR). Of more recent vintage is the LORAN-C system, originally designed for marine navigation and later used in aviation as well. None of these systems is perfect in its accuracy.

The 1970s begun the development of a satellite system of global radio navigation known as the global positioning system (GPS), initiated by the U.S. military.

The U.S. Federal Aviation Administration (FAA) has outlined a number of benefits of GPS. Among these are: (1) Aircraft are able to fly more direct routes, thus conserving time, fuel and money; (2) Precision approaches are possible at almost any properly configured airport; (3) Aging ground-based navigation systems that are expensive to operate and maintain can eventually be phased out; (4) System capacity can be safely increased, making room for more aircraft in the same airspace without additional risk; and (5) Better airspace management will mean more efficient scheduling and reduced congestion and delays for passengers. An additional benefit of GPS is its simplicity and ease of use.

This book is designed for the aviation student as a comprehensive reference work about GPS. Topics discussed range from the hardware that makes up the system, to accuracy, applications and national defense measures to protect the system. FAA regulations covering GPS usage and operation are included for reference. [Adapted from Introduction.]

Airport Planning and Management, third edition. Wells, Alexander T., Ed.D. New York, New York, United States: McGraw-Hill, 1996. 413 pp.

This book is intended as a definitive resource for both students and aviation management professionals. The first objective is to thoroughly cover the significant aspects of the planning and managing of airports; the second is to review the application of these processes in the current postderegulation environment.

Individual chapters include (1) chapter outlines, (2) chapter objectives, (3) practices and functions of airport planning and management that remain largely unchanged over time, (4) logical organization and frequent headings, providing a systematic arrangement of topics and direction for the subject material, (5) key terms used in each chapter for reference, study and review, (6) review questions and (7) suggested readings, for anyone interested in pursuing the subject further. The text is arranged in four parts. Part I: Introduction presents chapters on the airport system, including structure, planning and history; Part II: Planning and Funding the Airport includes chapters about airport master planning; Part III: Managing Growth includes chapters that discuss issues of better utilization; and Part IV: The Management Process discusses finances, administration, airport operations and public relations. [Adapted from Preface.]♦

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U.S. Government Printing Office (GPO)
Washington, DC 20402 U.S.

** National Technical Information Service (NTIS)
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**** U.K. Civil Aviation Authority (CAA)
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Updated U.S. Federal Aviation Administration (FAA) Regulations and Reference Materials

Advisory Circulars (ACs)

AC No.	Date	Title
150/5000-3S	11/07/96	*Address List for Regional Airports Divisions and Airports District/Field Offices*. (Cancels AC 150/5000-3R, dated 03/13/95.)
150/5000-5C	12/04/96	*Designated U.S. International Airports*. (Cancels AC 150/5000-5B, *Designated U.S. International Airports*, dated 07/28/88.)
183.29-1EE	12/18/96	*Designated Engineering Representatives*. (Cancels AC 183.29-1DD, *Designated Engineering Representatives*, dated 09/12/95.)
91-63B	02/28/97	*Temporary Flight Restrictions (TFRs)*. (Cancels AC 91-63A, *Temporary Flight Restrictions*, dated 10/31/90.)
120-57A	12/19/96	*Surface Movement Guidance and Control System*. (Cancels AC 120-57, *Surface Movement Guidance and Control System*, dated 09/04/92.)
61-116A	01/27/97	*Announcement of Cancellation: FAA-S-8081-11, Flight Instructor-Lighter-than-Air (Balloon/Airship) Practical Test Standards*. (Cancels AC 61-116, *Announcement of Availability: FAA-S-8081-11, Flight Instructor-Lighter-than-Air (Balloon/Airship) Practical Test Standards*, dated 03/10/95.)
60-26A	02/26/97	*Announcement of Availability: Flight Standards Service Airman Testing and Training Information*. (Cancels AC 60-26, *Announcement of Availability: Flight Standards Service Airman Testing and Training Information*, dated 04/18/96.)

Federal Aviation Regulations (FARs)

Part	Date	Subject
Part 25	12/09/96	*Airworthiness Standards: Transport Category Airplanes*. (Incorporates Amendment 25-88, "Type and Number of Passenger Emergency Exits Required in Transport Category Airplanes," adopted Nov. 1, 1996, and Amendment 25-89, "Allowable Carbon Dioxide Concentration in Transport Category Airplane Cabins," adopted Nov. 21, 1996.)
Part 91	10/09/96, 01/15/97, 05/01/97	*General Operating and Flight Rules*. (Incorporates Amendment 91-252, "Airplane Operations, adopted Nov. 21, 1996, and Amendment 91-253, "Special Flight Rules in the Vicinity of Grand Canyon National Park," adopted Dec. 24, 1996, and "Special Federal Aviation Regulation 77, Prohibition Against Certain Flights Within the Territory and Airspace of Iraq," adopted Oct. 9, 1996.)
Part 13	12/21/97	*Investigative and Enforcement Procedures*. Change 4. (Incorporates Amendment 13-28, "Inflation Adjustment of Civil Monetary Penalties," adopted Dec. 13, 1996, which adds a new Subpart H to Part 13.)

Federal Aviation Administration Orders

Order No.	Date	Subject
7110.10L	11/04/96	*Flight Services*. (Cancels Order 7110.10K, *Flight Services*, and eight changes.)
7210.3M	11/04/96	*Facility Operation and Administration*. (Transmits revised pages to Order 7210.3M, *Facility Operation and Administration* and the *Briefing Guide*.)
7110.65J	11/06/96	*Air Traffic Control*. (Cancels Order 7110.65H, *Air Traffic Control*, dated 09/16/93, and all changes to it.)
7110.65J	01/30/97	*Air Traffic Control*. (Transmits revised pages to Change 5 to Order 7110.65J, *Air Traffic Control*.)

Accident/Incident Briefs

Boeing 767 Touches Down Normally, Then Strikes Tail Skid

Cessna 310 strikes snowbank after landing in severe weather.

FSF Editorial Staff

The following information provides an awareness of problems through which such occurrences may be prevented in the future. Accident/incident briefs are based on preliminary information from government agencies, aviation organizations, press information and other sources. This information may not be entirely accurate.

Air Carrier

Jet Blast Sends Ramp Worker Flying

Boeing 747-200. No damage. One minor injury.

The Boeing 747 had completed an uneventful landing and was taxiing to the gate when a question arose about which gate that aircraft had been assigned.

The captain stopped the aircraft between the two gates in question. After determining the assigned gate, he assessed the clearances and determined that he could maneuver the aircraft to the left and then execute a right turn into the proper gate. The gate's ground marshaler moved forward and began signaling for the turn. The captain's attention was directed to the marshaler, and the first officer was monitoring clearance of ground equipment.

Believing that the jet blast was still directed toward the taxiway, the captain increased thrust on the no. 1 and no. 2 engines. The thrust caused a belt loader to strike a fuel truck, a baggage cart to overturn and a ramp worker to lose her balance. The ramp worker received minor injuries.

An investigation determined that the captain was confused about what gate to use and incorrectly judged the amount of power needed, the spool-down time of the engines after application of thrust and the direction of the thrust during the turn.

Tail Strike Surprises Flight Crew

Boeing 767-300. Minor damage. No injuries.

The Boeing 767 was flown on a stabilized approach and touched down normally. The engines were reversed and the speed brakes were deployed.

As the speed brakes were deployed, the nose floated for a moment and the tail-skid lights illuminated. Examination at the gate determined that the tail skid had touched the runway on landing. Hydraulic fluid was observed leaking and the tail skid pad was worn, but there was no damage to the fuselage.

The captain reported that the touchdown felt smooth and that he applied some back pressure because he "felt the nose wanting to come down." He said that the aircraft "appeared to float and then settled back down."

An investigation determined that the tail skid will contact the runway at eight degrees of pitch. The operator noted to flight crews that there was a "long history of tail strikes in the Boeing 757/767 fleets" and cautioned pilots about the possibility of the nose rising following deployment of the speed brakes. The operator concluded that flight crews "may not fully appreciate how close they are to a tail-skid strike during normal Boeing 767-300 landings."

Icing Is Encountered at FL 330

Fokker F-100. No damage. No injuries.

The F-100 was flying at Flight Level (FL) 330 (10,000 meters [33,000 feet]) through a weather system. The outside air temperature was -43 degrees C (-45 degrees F). With no warning, the data generated by the air data computer became erratic and airframe vibrations began. The symptoms abated when the aircraft exited the weather.

An investigation determined that the erratic computer data were caused by ice accretion in the pitot tube, and that the airframe vibration was caused by the formation of ice on the unheated engine spinner. According to icing authorities, supercooled water can exist at temperatures as low as -45 degrees C (-49 degrees F).

Missing Hidden Bolt Triggers Hydraulic Failure

Learjet 25D. No damage. No injuries.

After activation of thrust reversers on landing, the Learjet 25D abruptly lost hydraulic pressure. Investigation showed that the end of the reverse-thrust actuator had blown out.

The end of the actuator is secured by three bolts, one of which is hidden from view. The hidden bolt was missing, causing uneven pressure on the other two bolts. In this incident, the two bolts finally gave way; the end separated from the actuator, allowing the hydraulic fluid to evacuate and causing the hydraulic pressure to fall to zero.

Blowing Snow, Crosswind Send Twin Out of Control on Landing

Cessna 310. Substantial damage. No injuries.

The twin-engine Cessna 310 landed on Runway 09 at a Canadian airport with a crosswind from the north at 31.5 kilometers per hour (17 knots). The runway was covered with snow and the wind was blowing snow onto the runway during the night approach and landing.

The aircraft was landed using standard crosswind procedures but was veered right during the landing roll. The right wheel struck a snowbank, and the aircraft spun around 180 degrees and came to a stop facing Runway 27. The pilot and three passengers were not injured.

Language Difficulties Lead to Approach Incident

Canadair CL-600. No damage. No injuries.

During the final approach, the Canadair 600 entered severe precipitation at 213 meters (700 feet) above ground level, and visibility dropped to zero. During the go-around the airspeed decreased abruptly and the wind-shear warning, ground-proximity warning system (GPWS) and stick shaker simultaneously activated. The preceding aircraft had executed a missed approach because of the severe precipitation, but the Canadair crew had not understood the communication between the preceding aircraft and the tower because it was conducted in Spanish, a language they did not comprehend. The aircraft landed with no injuries to the occupants or damage.

Flight Test Ends Prematurely on Runway

Beech 55. Substantial damage. No injuries.

The private pilot was undergoing a flight test for a multi-engine rating with a Transport Canada examiner. During a touch-and-go landing, the pilot inadvertently selected the "gear-up" handle instead of the flap handle while the aircraft was still on the runway.

The flight-test examiner was unable to reselect "gear down" before the aircraft settled on its nose on the runway. The right wing and both propellers came to a stop on the runway. The accident resulted in no injuries and no multi-engine rating.

Hard Landing Ends in Snowbank

Cessna 172. Substantial damage. No injuries.

The student pilot was practicing soft-field landings when the aircraft landed hard and porpoised.

The pilot lost control of the aircraft, which exited the left side of the runway and hit a snowbank. The engine, propeller, engine cowling, right-wing tip and nosewheel and strut were damaged. The pilot was not injured.

Sun Reduces Visibility Below Minimums

Cessna 150. Aircraft destroyed. No injuries.

The 69-year-old pilot held a private pilot's license and had 164 hours of flight time. He took off in a Cessna 150 in the late afternoon from Bodmin Field, Cornwall, England, with the intention of making touch-and-go landings on Runway 14. The runway had a right-hand pattern, so the crosswind leg was into the sun. Weather conditions at the time were: wind, 140 degrees at 18.5 kilometers per hour (10 knots), visibility eight kilometers to 10 kilometers (four miles to six miles) with patchy, light mist.

After takeoff, at an altitude of 153 meters (500 feet), when the pilot turned onto the crosswind leg, he realized that his visibility was minimized because of the sun shining in his eyes. He decided to complete a low-level (right-hand) circuit and land as soon as possible. Nevertheless, he had difficulty seeing the airfield, and he was further distracted when another aircraft called in to advise the tower that it was approaching the field.

Because he could not see the other aircraft, the accident-aircraft pilot reversed course and began a left-hand circuit, and on the downwind leg he spotted the runway briefly and tried to reposition the aircraft for landing. Shortly afterwards, the aircraft struck the ground. The point of impact was about one kilometer (0.6-mile) short of Runway 14.

The pilot later stated that he recalled hearing the stall warning just before impact.

Rotorcraft

Helicopter Enters Uncontrollable Descent During Test Flight

McDonnell Douglas 600N. Aircraft destroyed. No injuries.

A McDonnell Douglas 600N undergoing a flight test was destroyed after touching down with a vertical speed of 5.2 meters per second (17 feet per second). During a test maneuver, the pilot initiated an autorotation at 46 meters (150 feet) above ground level and at a speed of 157 kilometers per hour (85 knots), with a one-second delay in collective reduction.

The aircraft began descending at an excessive rate, which the pilot was unable to reduce. As the helicopter touched down, the skids collapsed and the tail boom was severed when it was struck by the main rotor blades. The helicopter rolled onto its right side, deforming the main rotor blades.

The pilot, the helicopter's only occupant, was not injured. The accident occurred in visual meteorological conditions, with 16 kilometers (10 miles) visibility.

Snapped Cable Fouls Rotors

Hiller UH-12E. Substantial damage. One minor injury.

The helicopter was conducting logging operations and was approaching a staging area with a load attached to a 46-meter (150-foot) cable. Before reaching the staging area, the helicopter began to settle under power, and the pilot released the load.

The helicopter continued to descend without the load and the pilot lowered the collective and pushed forward on the cyclic. The helicopter began to climb, but the cable snagged on logs piled in the staging area. Before the pilot could react, the cable snapped five meters (15 feet) above the extended hook and recoiled back to the helicopter, becoming entangled in the main and tail rotors. The helicopter struck terrain and was substantially damaged. The pilot received minor injuries.♦

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