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SPATIAL DISORIENTATION IN GENERAL AVIATION ACCIDENTS

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16. Abstract Spatial disorientation (SD) refers to an incorrect self-appraisal of the attitude or motion of the pilot and his aircraft with respect to the earth. This paper defines elements of SD problems as encountered in general civil aviation.

Accident reports made by the National Transportation Safety Board for a recent 6-year period were reviewed. Statistical computations were made relating SD to fatal accidents. SD was involved in 2.5 percent of all general aviation accidents, nonfatal and fatal. However, SD ranked as the third highest "cause" in fatal small fixed-wing aircraft accidents and is closely related to the second highest "cause," "continued VFR flight into adverse weather." SD was a cause or factor in 16 percent of all fatal accidents. When SD was ascribed as a cause or factor in an accident, 90 percent of the time that accident involved fatalities. Small fixed-wing aircraft (under 12,500 lb) accounted for 97.3 percent of all SD accidents.

Inclement weather was associated with 42 percent of all fatal accidents, and SD was a cause or factor in 35.6 percent of these cases. Flight was initiated into and continued into adverse weather in 19.7 and 68.7 percent, respectively, of SD weather-related fatal accidents. Fog (56.8 percent) and rain (41.8 percent) were the most prevalent adverse weather conditions. Non-instrument-rated pilots were involved in 84.7 percent of SD weather-involved accidents. These and other data attest to the importance of this psychophysiological phenomenon (SD) in flight safety. Suggestions are made of ways to improve pilots' awareness and understanding of this problem.

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SPATIAL DISORIENTATION IN GENERAL AVIATION ACCIDENTS

I. Introduction.

In aviation, spatial disorientation refers to an incorrect self-appraisal of the attitude or motion of the pilot and his plane with respect to the earth (7). On some occasions, disorientation in the air consists of true vertigo (sensations that the world or the pilot is spinning) and/or dizziness (sensations of unsteadiness with a feeling of movement within the head). Indeed, the three terms "disorientation," "vertigo," and "dizziness" are usually (if inaccurately) used interchangeably to describe a variety of symptoms, such as false sensations (i) of turning, (ii) of linear velocity, or (iii) of tilt. When mentioned by pilots, "vertigo" almost always means their awareness of any of the various forms of disorientation. Thus, "pilot vertigo" and the more technical term "spatial disorientation" are virtually identical in the language of pilots (9). In fact, the Flight Instructor's Handbook issued by the Federal Aviation Administration (FAA) from 1969-1977 defined vertigo as "a disorientation in space" (10).

Most of the "disorientation" difficulties encountered by pilots in aircraft are due to inadequate and unreliable sensory information (3,4,6,7, 12,14,15,18,20). In this regard, the visual (seeing) and the vestibular (position and motion detecting) systems are of critical importance. As terrestrial beings, we use our vision in almost all situations to maintain stability and orientation with our surroundings. However, when we leave our firm base on the ground for the platform of an aircraft that can roll, pitch, and yaw simultaneously and at various rates, we may exceed the capability of our senses to keep us properly oriented in space. In "good weather" flight a pilot relies heavily on external visual cues provided by the horizon or terrain to maintain orientation. If these external cues are lost, as at night or in adverse weather, the pilot is left with secondary orientation modalities (vestibular organs, proprioceptor systems) which can fail to perceive changes in attitude and motion or can give false cues of attitude and motion. If proper orientation is not quickly regained, the pilot may inadvertently maneuver the aircraft violently, thereby overstressing it, or lose control of the aircraft and impact with the ground. The rationale for visual flight rules, therefore, is to keep inexperienced (non-instrument-rated) pilots out of weather conditions that are highly conducive to the production of spatial disorientation. In fact, the early impetus for developing aircraft flight instrumentation (as compared with engine instrumentation) was to provide instruments that would indicate the true attitude of the aircraft and thus allow the pilot to perceive accurately his orientation in conditions under which vision was obscured and in spite of his own erroneous vestibular sensations of orientation.

How serious is the problem of spatial disorientation in aviation? The greatest attention has been given to this problem in connection with military aviation where high-performance aircraft are involved. The role of spatial disorientation in United States Air Force (USAF) accidents has been analyzed in a number of studies covering the years 1954-56 (19), 1964-67 (16), 1958-68 (2), 1969-71 (1), and 1968-72 (13). Spatial disorientation was a significant factor in 4-6 percent of all accidents (1,13), in 4-9 percent of major accidents (2,16,19), and in 10-26 percent of fatal accidents (1,2,16,19). Barnum and Bonner (2) describe the average USAF pilot involved in a spatial disorientation accident as a 30-year-old fighter pilot with 10 years of flight experience, 1,500 hours of first pilot/instructor pilot time, and with 25 flights in the 3-month period prior to the accident.

If approximately 15 percent of fatal accidents in military aircraft flown by highly trained and instrument-rated pilots have spatial disorientation as a cause, what role has spatial disorientation in general aviation accidents? There are obvious differences between military and general aviation flying. Military aircraft are, for the most part, high-performance aircraft that subject pilots to greater levels of angular and linear accelerations in the air. Military pilots have considerable experience with instruments and can fly their aircraft well in conditions in which vision is obscured. They also receive a considerable amount of physiological training and attend regular refresher courses. On the other hand, general aviation aircraft are slower and their pilots are not subjected to the high-acceleration maneuvers of military planes. In addition, many general aviation pilots are not qualified for instrument flying. Furthermore, general aviation pilots, in contrast to military pilots, are not, by and large, familiar with the unreliability of the human vestibular organs in flight and lack indoctrination or awareness of the potential for spatial disorientation. For the most part, civilian pilots do not appreciate that one of the greatest dangers of weather conditions to the safety of flight is not in the chance of getting lost or of encountering severe turbulence but in the obscuration of vision leading to spatial disorientation and subsequent loss of control of the aircraft.

This report was undertaken to document the incidence of spatial disorientation in civil aviation accidents and to define the conditions in which spatial disorientation has occurred as revealed by accident statistics. It is hoped that such data may be a useful part of the total information employed to educate general aviation pilots concerning this hazard to flight safety.

II. Materials and Methods.

The National Transportation Safety Board (NTSB) investigates all fatal aviation accidents primarily to determine their cause. Usually, nonfatal general aviation accidents in aircraft of less than 12,500 lb are investigated by the FAA (under an agreement with the NTSB) and its reports are then made to the NTSB. The NTSB determines, codes, and enters into computer files a variety of data relating to pertinent causes, factors, and conditions that prevailed in each accident. Brief reports and tabular summaries of these causes, factors, and conditions in accidents are compiled in various formats. Data taken from NTSB reports were compiled into the tables used in this report.

In addition, several computer retrievals were made on special request to the NTSB for data that had not yet become available in printed form or that otherwise had not been isolated from the bulk of the accident data. Some of the data in this report were compiled and tabulated by individually reviewing all briefs of accidents for the periods reported. In some instances only current and the most readily available data were used. The tables in this report reflect only accidents from three categories of aircraft: large fixed-wing, small fixed-wing, and rotorcraft. Such accidents represent 97.6 percent of general aviation accidents in the period from 1968 through 1975, and the data used were considered representative of general aviation accidents. In most instances in which spatial disorientation was determined to have occurred in the accident, it was listed by the NTSB as a cause. In some accidents it was listed only as a factor. In this report "cause" and "factor" are combined and shown as "cause/factor," except in a few instances.

III. Results.

A. Overall Incidence of Spatial Disorientation in General Aviation Accidents. The number of general aviation accidents, the number of accidents in which spatial disorientation was recorded as a cause/factor, and the incidence as a percentage of total accidents for the period 1968-75 are presented in Table 1. These figures do not include the relatively few air carrier accidents. The yearly incidence ranged from 1.8 to 3.0 percent with a mean of 2.5 percent. Unfortunately, these data obscure the significance of spatial disorientation in flight safety. It is in fatal accidents that spatial disorientation assumes a clearly important cause/factor role.

TABLE 1. Spatial Disorientation as a Cause/Factor in General Aviation Accidents*

		Spatial Disorientation			
Year	Total Accidents	Cause	Factor	Total Cause/Factor	Percentage Cause/Factor of All Accidents
1968	4,812	89	0	89	1.8
1969	4,647	102	0	102	2.2
1970	4,592	109	1	110	2.4
1971	4,520	127	1	128	2.8
1972	4,127	114	1	115	2.7
1973	4,119	123	0	123	3.0
1974	4,294	110	2	112	2.6
1975	4,071	109	0	109	2.7
Totals	35,182	883	5	888	2.5

*Accidents in large fixed-wing aircraft, small fixed-wing aircraft, and rotorcraft in which cause/factors were assigned.

5. Spatial Disorientation in Fatal Accidents. Table 2 shows the yearly incidence of all fatal and nonfatal accidents for which spatial disorientation was assigned as a cause or factor during 1970 through 1975. On the average, 90 percent of the time, when spatial disorientation is ascribed to an accident, that accident involved fatalities. In addition, there appears to be a trend toward fewer nonfatal disorientation accidents.

TABLE 2. Severity of Accidents in Which Spatial Disorientation Was a Cause/Factor--U.S. General Aviation

Year	With Spatial Disorientation			Percentage of Total	
	Total Accidents	Nonfatal Accidents	Fatal Accidents	Nonfatal Accidents	Fatal Accidents
1970	110	16	94	14.5	85.5
1971	128	19	109	14.8	85.2
1972	115	10	105	8.7	91.3
1973	123	11	112	8.9	91.1
1974	112	4	108	3.6	96.4
1975	109	10	99	9.2	90.8
Total	697	70	627	Mean 10.0	90.0

Table 3 provides a different perspective. In this table, the annual frequency with which spatial disorientation was identified as a cause/factor in fatal accidents is presented for the years 1970 through 1975. The data indicate that spatial disorientation was involved in 16 percent of all fatal accidents.

TABLE 3. Frequency of Fatal General Aviation Accidents in Which Spatial Disorientation Was a Cause/Factor

Year	All Fatal* Accidents	Spatial Disorientation as a Cause/Factor	
		Number of Fatal Accidents	Percentage of All Fatal Accidents
1970	632	94	14.9
1971	638	109	17.1
1972	674	105	15.6
1973	700	112	16.0
1974	712	108	15.2
1975	656	99	15.1
Totals	4,012	627	15.6

*In large fixed-wing aircraft, small fixed-wing aircraft, and rotorcraft only.

C. Spatial Disorientation Accidents by Aircraft Type. Table 4 gives the distribution of accidents, fatal accidents, and spatial disorientation accidents by the three major aircraft types in general aviation for 6 years, 1970 through 1975. In this period there were 697 spatial disorientation accidents, 678 in small fixed-wing aircraft, 18 in rotorcraft, and only 1 in large fixed-wing aircraft. No instances of spatial disorientation were recorded in other categories of aircraft. The following data can be derived: 90.1 percent of all accidents in all types of aircraft including gliders, balloons, etc., 91.1 percent of all fatal accidents, and 97.3 percent of all spatial disorientation accidents occurred in small fixed-wing aircraft. *

TABLE 4. Spatial Disorientation as a Cause/Factor

in U.S. General Aviation Accidents by Aircraft Types

	Large Fixed-Wing Aircraft			Small Fixed-Wing Aircraft			Rotorcraft		
Year	Accidents	Fatal Accidents	Spatial Disorient. Accidents	Accidents	Fatal Accidents	Spatial Disorient. Accidents	Accidents	Fatal Accidents	Spatial Disorient. Accidents
1970	40	14	1	4,290	587	105	262	22	4
1971	38	7	0	4,263	605	123	239	26	5
1972	28	6	0	3,858	632	114	241	36	1
1973	42	13	0	3,802	660	119	275	27	4
1974	34	18	0	3,975	647	109	285	47	3
1975	31	9	0	3,738	624	108	302	23	1
Totals	213	67	1	23,906	3,755	678	1,604	181	18

* D. Spatial Disorientation and the Pilot. During the years 1970 through 1975, 87.5 percent of fatal accidents involving small fixed-wing aircraft were categorized by the NTSB as due to (cited as "cause") an action or condition of the pilot in command (as opposed to a condition of the aircraft power plant, the airframe, instruments, weather, etc.). In this regard, the role of spatial disorientation takes on additional significance. For all fatal accidents in small fixed-wing aircraft from 1970 through 1975 the actions or conditions of the pilot that were most frequently cited as a cause can be described as follows:

① → (i) failed to obtain/maintain flying speed (26.3 percent).

② → (ii) continued VFR flight into adverse weather (22.2 percent).

③ (iii) spatial disorientation (16.4 percent).

No other action or condition from the lengthy list reported by the NTSB reached 8 percent. (The list includes conditions such as misjudgment of altitude, failure to follow procedures, etc.) * Thus, spatial disorientation ranks as the third highest cause in fatal, small, fixed-wing aircraft accidents. *

Given the significance of spatial disorientation in fatal accidents attributed to a condition of the pilot, are there any salient features of this cause/factor which might be related to pilot age or experience? Table 5 gives the age distribution of pilots involved in fatal weather-related spatial disorientation accidents; the greatest incidence is in the fifth decade (ages 40-49). In total hours of flying experience, 60.8 percent of the pilots had 500 or less and 39.2 percent had more than 500 hours. In those with less than 500 hours, the greatest incidence, 18.6 percent, involved pilots with 100-200 hours; an almost identical proportion, 19.2 percent, involved pilots with 1,000-5,000 hours of flying experience. In terms of certification, 70.3 percent had private pilot certificates, 10.1 percent had student certificates, 16.3 percent had commercial pilot certificates, and 2.2 percent of the pilots were listed as having no license.

The greatest accident rate, 29.8 percent, occurred in pilots with 50 or less hours in aircraft type. The incidence declined with experience in type of aircraft.

TABLE 5. Age and Experience of Pilots in Fatal Weather-Related Accidents With Spatial Disorientation as a Cause/Factor

	1970	1971	1972	1973	1974	1975	Total	Percent
Age of pilot								
< 20	2	1	1	6	2	3	13	2.3
20-29	8	9	17	13	20	11	78	14.1
30-39	28	33	23	34	26	23	167	30.2
40-49	25	28	30	23	38	35	179	32.4
50-59	13	15	17	20	12	17	94	17.0
60-69	2	4	5	5	0	4	20	3.6
70-79	0	1	0	0	0	0	1	0.2
80-89	0	0	0	0	1	0	1	0.2
Total flight hours								
< 100	14	20	18	11	13	11	87	15.7
100-199	20	15	16	19	14	19	103	18.6
200-299	11	13	6	9	16	10	65	11.8
300-399	4	7	5	9	8	5	38	6.9
400-499	0	2	9	7	5	2	25	4.5
500-999	14	9	8	16	12	22	81	14.6
1,000-4,999	8	17	20	23	24	14	106	19.2
5,000-9,999	4	1	2	1	1	2	11	2.0
= or > 10,000	0	0	1	3	1	2	7	1.3
Unknown	3	7	8	1	5	6	30	5.4
Type of license								
Student	8	18	8	9	7	6	56	10.1
Private	58	59	64	68	73	63	389	70.3
Commercial	10	11	12	19	16	22	90	16.3
Transport	1	0	2	2	0	0	5	0.9
Unknown	0	0	1	0	0	0	1	0.2
None	1	3	2	1	3	2	12	2.2
Hours in type aircraft								
< or = 50	27	26	33	26	25	28	165	29.8
51-200	23	24	18	23	33	21	142	25.7
201-500	6	12	9	18	5	13	62	11.2
501-999	5	0	1	4	1	6	17	3.1
= or > 1,000	4	1	4	3	2	0	14	2.5
Unknown	13	29	26	25	33	27	153	27.7

E. Weather and Spatial Disorientation Accidents. A significant percentage of fatal general aviation accidents occur in inclement weather (17). Although weather itself is rarely listed as the sole, direct cause of an accident, it is often cited as a contributing factor. Thus, during the 6-year period from 1970 through 1975, weather was the sole cause in only 3.8 percent of fatal accidents in small fixed-wing aircraft as compared to its role as a contributing factor in 38.4 percent of fatal accidents. Inclement weather, then, was associated with over 42 percent of the fatal accidents during that 6-year period.

Because inclement weather plays a major role, as noted earlier, in causing spatial disorientation, the incidence of disorientation in weather- and non-weather-related general aviation accidents was tabulated for the years 1970 through 1975. During that 6-year period, spatial disorientation was a cause/factor (i) in 10.3 percent of all weather-related accidents (fatal and nonfatal in all aircraft types) and (ii) most significantly, in 35.6 percent of all weather-involved fatal accidents in small fixed-wing aircraft.

Inclement weather and spatial disorientation thus interact in a significant fashion to produce fatal accidents. To examine this interaction more clearly, various features of fatal accidents that occurred during the most recent 6-year period for which data are available and in which spatial disorientation and weather were a cause/factor are summarized in Table 6. Flight was initiated into adverse weather in 19.7 percent of these accidents; flight was continued into adverse weather in 68.7 percent. By far the greatest number of accidents, 78.5 percent, occurred during inflight descent, but inflight breakup occurred in 12.8 percent. The most prevalent weather condition involved fog (56.8 percent) with rain the next in prevalency (41.8 percent); turbulence (12.7 percent) and thunderstorms (13.9 percent) were also prominent. At the time of accidents, VFR weather conditions existed 29.2 percent and IFR conditions 67.8 percent of the time (4 percent unknown or not given); 67.5 percent of the accidents occurred during daylight hours, 25.7 percent at night (6.9 percent unknown or not given). No flight plan was filed in 64.7 percent of the fatal flights; IFR flight plans were filed in 12.9 percent; only 15.7 percent of the pilots were instrument rated.

TABLE 6. Characteristics of Weather-Related Fatal Aircraft Accidents With Spatial Disorientation as a Cause/Factor

Characteristics Cited	1970 76	1971 91	1972 93	1973 99	1974 99	1975 95	Total 553	Percentage
	Year and number of fatal accidents							
Flight into adverse weather:								
Initiated	18	10	15	20	25	13	109	19.7
Continued	53	60	65	71	61	70	380	68.7
Unknown/not listed	7	21	13	0	13	10	64	11.6
Weather conditions:*								
Snow	13	10	10	11	19	13	84	15.2
Rain	23	40	46	37	46	43	231	41.8
Fog	43	50	52	64	49	56	314	56.8
Thunderstorm	7	7	19	12	20	12	77	13.9
Turbulence	10	13	15	11	12	9	70	12.7
Ceiling < or = 500	28	31	32	46	30	26	192	34.7
Ceiling > 500	29	43	47	42	42	19		. . .
Ceiling unknown/not given	20	17	14	11	27	30	119	21.5
Weather type:								
VFR	33	36	26	23	27	11	156	28.2
IFR	38	51	63	75	69	78	375	67.8
Unknown/not given	7	4	4	1	3	3	22	4.0
Type of flight plan:								
None	53	65	57	62	65	56	358	64.7
VFR	14	16	26	19	22	23	122	22.1
IFR	7	8	10	18	12	4	69	12.5
Unknown/not given	2	2	0	0	0	0	4	0.7
Instrument-rated pilots	9	11	14	19	14	20	87	15.7
Time of accident:								
6 a.m. to 8 p.m.	49	64	66	75	64	55	373	67.5
8 p.m. to 6 a.m.	24	20	18	16	32	32	142	25.7
Unknown/not given	3	7	9	8	3	8	38	6.9
Phase of flight:*								
Takeoff climb	1	0	2	8	10	6	27	4.9
Inflight	7	0	5	3	3	4	22	4.0
Inflight descent	66	81	81	76	67	63	434	78.5
Landing	5	10	6	7	4	4	36	6.5
Other	3	1	7	13	15	14	53	9.6
Type of accident:*								
Collision w/ground or water	67	86	83	73	77	81	467	84.4
Collision w/structures	3	4	6	4	2	3	18	3.2
Inflight breakup	10	5	10	19	16	11	71	12.8
Other	0	0	1	3	4	1	9	1.6

*More than one category sometimes listed for a single accident.

In this same 6-year period there were 71 accidents involving inflight breakup of aircraft structure in which both weather and spatial disorientation were listed as a cause/factor (Table 6); although thunderstorms and/or turbulence were listed as a cause/factor in 31 percent of these accidents, more than twice as many (69 percent) did not involve thunderstorms or turbulence as a cause/factor. These latter figures suggest that spatial disorientation may lead to loss of control of the aircraft in relatively nonturbulent air while flying through clouds, causing the pilot to overstress the airplane in attempting to correct attitude and direction.

IV. Discussion.

Because spatial disorientation is a cause/factor in only 2.5 percent of all types of general aviation accidents combined, its significance may be underestimated by the aviation community. It is in the category of fatal accidents that the significance of this psychophysiological phenomenon is clearly highlighted. As we have seen, spatial disorientation is the third leading cause in all fatal accidents (16 percent) and is also closely associated with the second leading cause (continuing VFR flight into adverse weather); it is a cause or factor in 35.6 percent of all weather-involved fatal accidents. Moreover, when spatial disorientation is associated with an accident, it is a fatal accident 90 percent of the time.

Is the incidence of spatial disorientation truly this high in aircraft accidents, or is spatial disorientation just a convenient "wastebasket" cause used to explain "unexplainable" events in weather accidents? In 10 percent of spatial disorientation accidents that prove nonfatal, the pilot is frequently able to describe the problem in orientation. Also, in some fatal accidents there have been radio communications prior to impact that indicated the pilot was disoriented. In the majority of accidents, however, spatial disorientation can be surmised after thoughtful and objective evaluation of the evidence at hand; thus potential criticism of the citation of the accident cause as a subjective or judgmental matter can usually be dispelled. However, the difficulty of determining without question if spatial disorientation was a cause in an accident is possibly the reason little mention is made of the subject in discussing civil aviation accident statistics. On the other hand, spatial disorientation may be underestimated as a cause/factor on similar grounds. Because the judgment of spatial disorientation is somewhat subjective or is sometimes based on circumstantial evidence, investigators may tend to avoid listing it as the cause of an accident. In any case, the accident data and the testimonies of numerous pilots who have had nonfatal brushes with spatial disorientation signify unequivocally that this phenomenon continues to be a serious problem in aviation.

Although the problem of spatial disorientation is as old as aviation itself, its significance in flight safety is clearly underplayed. For example, in flight training and throughout general aviation a great deal of attention is given to weather and the movement of weather fronts. But little or no mention is made about the connection between weather and spatial disorientation. In the "Pilot's Handbook of Aeronautical Knowledge" (11) the student pilot can obtain a wealth of information on weather. This text also notes: "Despite the development of many ingenious devices, improvement in aircraft design, power plants, radio aids and navigational techniques, safety in flight is still subject to conditions of limited visibility, turbulence and icing." Although a half-page discussion of "vertigo" appears elsewhere in the Handbook (11) under medical facts for pilots, in the entire section on weather (almost 50 pages) the relationship of restricted visibility to spatial disorientation is not mentioned. As another example, an NTSB study of fatal weather-involved general aviation accidents (17) does not discuss spatial disorientation as such; yet, the tabular information in the report shows spatial disorientation as a frequent cause of weather-involved accidents, second only to continued VFR flight into adverse weather. While there is no discussion in the NTSB study of the significance of spatial disorientation in accident causation, the report does quote from a 1969 NTSB weather briefing guide, as follows: "Too many of the fatal, weather-involved, general aviation accidents are caused, in part at least, by the pilot's mistaken idea of his ability to cope with certain weather situations." Similarly, the FAA's recently issued "Aviation Instructor's Handbook" (9) discusses the desirability of "integrated flight instruction" from the first time each maneuver is introduced. When this training technique is used, instruction in the control of an airplane by outside visual references is "integrated" with instruction in the use of flight instrument indications for the same maneuver. This handbook states that such instruction "provides the student with the ability to control an airplane in flight for limited periods if outside references are lost. This ability could save the pilot's life or those of the passengers in an actual emergency." While the authors strongly support this teaching approach, the real hazard of loss of visual references, i.e., spatial disorientation, is not specifically identified and such identification, in our view, is important if both pilots and flight instructors are to more successfully deal with this flight hazard.

The lack of emphasis on spatial disorientation as a significant factor in general aviation safety is not limited to textbooks and reports. In a recent survey of disorientation training in FAA-certified flight and ground schools, Collins, Hasbrook, Lennon, and Gay (8) reported that more than one-third of over 600 respondent schools evaluated their disorientation training program as inadequate and defined the inadequacy most often as a lack of appropriate instructional materials, aids, and information. The report (8) also suggested methods that could be used to provide flight training students and private pilots with a greater awareness of the dangers of spatial disorientation. In this regard, it was suggested that during early training greater emphasis should be placed on (i) the seriousness of spatial disorientation problem in fatal aviation accidents, (ii) causes of disorientation, (iii) disorientation-induced dangers associated with flying in poor visibility and/or IFR conditions, (iv) the need to acknowledge to oneself when an orientation problem exists, and (v) ways to overcome disorientation in flight. Combinations of appropriate lectures, films, and demonstrations were suggested to accomplish this objective with emphasis both on the dangers of disorientation and on how to deal with it in flight. The latter, the authors noted, involves proficient use of appropriate flight instruments.

The need for the ability to control an aircraft solely by response to its instruments cannot be understated. The data indicate that 85 percent of all fatal accidents involving spatial disorientation also involve non-instrument-rated pilots. On the other hand, the fact that 15 percent of these accidents (about the same percentage as that for military pilots) involved instrument-rated pilots attests to the importance of proficiency and recency in the use of the flight instruments and to the need for good judgment about flying conditions irrespective of ratings or skill.

All pilots must be made aware of the significance of spatial disorientation in fatal accidents. We agree with the previously expressed approach (8), based on data from flight and ground schools, to accomplish this goal. That approach includes:

(i) improved flight school lectures relative to spatial disorientation.
(ii) ground-based demonstrations of disorientation with appropriate briefings (7).
(iii) inflight demonstrations on two or more occasions during student pilot training. Appropriate briefings and lecture material must accompany these experiences.
(iv) specifically encouraging pilots always to obtain preflight weather briefings.
(v) specifically encouraging pilots not to take off or fly in poor visibility or at night unless they are highly proficient in the use of flight instruments.
(vi) requiring flight test examiners to assure themselves that pilot applicants have a basic understanding of spatial disorientation and giving applicants an opportunity to demonstrate their ability to cope with such conditions during the flight test.

We would add to these three additional recommendations. First, student pilot manuals and training handbooks should be revised to include information on the contribution of spatial disorientation to fatal accidents. Second, emphasis on spatial disorientation should be made in chapters and sections dealing with weather problems in flight. Third, written tests for all pilot applicants should include questions which require responses based on an awareness and understanding of the fatal hazards associated with spatial disorientation and the importance of avoiding weather conditions that may produce it. Pilots should have a built-in association between adverse weather, disorientation, and fatal accidents.

A former FAA administrator has stated: "The skies are more crowded today, but the real hazards to safe flight are precisely what Wilbur Wright warned against--carelessness and overconfidence on the part of some pilots, such as inadequate preflighting, risky weather decisions, and lack of visual alertness for other aircraft" (5). Relative to "risky weather decisions," it should be the understanding of all pilots that unless they are thoroughly trained and experienced in instrument flying techniques, they are basically incapable of safely coping with weather situations that obscure vision. The accident statistics attest to this. Unless understanding is brought to the consciousness of every pilot, no substantial reduction in fatal weather accidents is likely to be achieved in the foreseeable future.

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