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In This Issue

Flight Safety Foundation is an international membership organization dedicated to the continuous improvement of aviation safety. Nonprofit and independent, the Foundation was launched officially in 1947 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 910 member organizations in more than 142 countries.

Pilot Selection Systems Help Predict Performance

Research shows that structured selection systems can identify applicants who possess the knowledge, skills, abilities and personality traits most valued by a particular aircraft operator and who will succeed as pilots in that operator's line operations.

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Diane L. Damos, Ph.D.

Air carriers, on-demand operators and corporate flight departments use various methods to identify the pilots they want to employ among applicants who meet minimum requirements of certification and experience (see "Hiring Procedures Differ Among Airlines," page 2). Recent research has shown that structured pilot selection systems are most effective in helping aircraft operators to identify pilots who match their requirements, compared with casual selection systems.

In casual selection systems, the interview often is unstructured, and the interviewer may not be trained in interview techniques. Typically, there is no systematic method of combining information from the interview, the flight-skills test and the application form; a hiring decision, therefore, is based solely on a manager's judgment, which sometimes can be influenced by a variety of subjective factors. Casual pilot selection systems typically have not been developed by specialists with appropriate expertise, and often there is no historical documentation of how and why they came to exist. These systems also may lack explicit hiring standards, and the manager often has only a general idea of how to determine which applicants would best match the company's requirements.

Casual systems typically fail to accomplish three major goals common among pilot selection systems:

- To identify the pilots who best match the operator's requirements;
- To accomplish this identification in a cost-efficient manner; and,
- To be legally defensible if the process or selection decisions are challenged.

In contrast, structured pilot selection systems — which typically include a consistent set of written and/or computer-based tests of knowledge, skills and abilities (KSAs); personality assessments; interviews; and simulator assessments (check rides) — achieve these goals in the following ways:

- Developing the system requires management to analyze the KSAs and personality traits required by the aircraft operator. This development process often reveals many different assumptions and disagreements among individuals directly involved in the hiring process. Developing the system requires management to evaluate these assumptions and to confront differences in opinion about which KSAs and personality traits are required;
- Hiring decisions are made through the use of a decision aid — a statistical process that combines scores from all tests administered as part of the pilot selection process to predict how well the applicant will perform as a pilot in the company. The decision aid does not eliminate the human decision maker but rather reduces the subjectivity of the hiring process;

Continued on page 3

Hiring Procedures Differ Among Airlines

Some air carriers determine whether a pilot will be hired after a single interview; others base their hiring decisions not only on interviews but also on the pilot's performance on a number of tests.

Capt. Kit Darby, owner and president of Air Inc., an Atlanta, Georgia, U.S., career information resource company that provides services to pilots seeking airline jobs and administers tests for smaller U.S. airlines, said that the hiring process is "consistently inconsistent."[1]

"There are major airlines that don't do anything but [conduct] a 45-minute interview," said Darby, also a Boeing 767 captain with United Airlines. "Others have more rigorous testing."

Several major U.S. airlines administer complete sets of written tests or computer-based tests, more than half administer psychological tests, most administer simulator evaluations, and almost all administer aeronautical knowledge tests, he said. A few airlines have eliminated simulator evaluations in favor of cognitive tests (typically computer-based tests or paper-and-pencil tests intended to measure an individual's reasoning ability), he said.

Pilot selection systems are most effective when they include thorough and consistent testing, Darby said. As an example, he cited one airline that added cognitive tests to its pilot selection system without telling its ground instructors that the system had been changed. The instructors became aware of a change, however, because they observed that, compared with the previous students as a whole, the new students were quicker to understand concepts being taught in the classroom.

Darby's company monitors the hiring activities of about 200 U.S. airlines and projects that they will hire about 7,000 pilots in 2003, compared with 6,000 pilots in 2002, 12,000 pilots in 2000 and 19,000 pilots in 1999, which was the sixth consecutive annual record. Of the 7,000 pilots expected to be hired this year, about 500 pilots will be hired by major airlines, he said. About 7,500 U.S. pilots have been furloughed.

Capt. Charles Hogeman, vice chairman of the Air Line Pilots Association, International (ALPA) Pilot Training Council, said that he has "mixed feelings" about the elimination of simulator evaluations.[2]

"Simulator evaluations for hiring pilots are just snapshots of a pilot's ability," Hogeman said. "There are a number of enterprises that prepare applicants for these evaluations — teach the test — so I'm not sure they are a real gauge of the applicant's real flying ability. However, if applicants are evaluated evenly and fairly, a simulator evaluation may identify applicants who may not have sufficient skills to adapt to training in jet transports."

Hogeman said that he is "skeptical" about the extent to which cognitive tests can aid in the selection of new pilots but that "valuable insight to applicant thought processes and attitudes toward flying airplanes can be discovered through a well-managed personnel interview."

Sharon Jones, a flight operations recruiter in the human resources department of Comair, said that her airline is one of those that has eliminated the simulator evaluation because "it may not give an accurate reading of the applicant's ability to fly the airplane."[3]

The pilot selection process at Comair — which has 1,600 pilots and expects to add 388 pilots in 2003 — includes interviews, a short psychological test and a computer-based cognitive test.

"Cognitive screening gives us a better opportunity to test their skills in a certain way," said Nick Miller, Comair manager of media relations.

Jones said that Comair's selection process has "always been well-defined. Years of refining that process have proven that's what works best."

Capt. Christian Magnusson of Scandinavian Airlines System (SAS) said that for the past two years, the airline has been working to determine "how to recruit a new type of pilot into SAS — not because the recruiting profile we use is wrong but because it needs to be updated."[4]

Magnusson, manager of the project, said that the work has included a task analysis "to see what a pilot in SAS really does today," an assessment of the requirements of SAS aircraft and a review of the abilities of young job applicants.

"We're looking more into the non-technical skills required of pilots — communicating, understanding other people's points of view, managing a system involving an airplane and people," he said. "Pilots in the future need to have basic flying skills but that isn't enough. They need to fly an aircraft and also manage the system."

Previous pilot applicants have undergone three days of tests and interviews, including one day of psychosocial tests and written tests, one day of simulator evaluations and one day of interviews. New tests are being developed and should be in place for applicants in late 2004 or in 2005 to assess leadership and management skills, Magnusson said; those tests will involve evaluations by psychologists and pilots of applicants' performances on non-written problem-solving tests.

Representatives of several air carriers contacted for this article did not respond to questions about their pilot selection procedures. Some air carriers, however, discuss their hiring processes — in varying detail — in printed information or on their Internet sites.

Some airlines tell prospective applicants what to expect during the selection process, describe minimum requirements for pilot applicants and/or provide considerable detail on their selection systems.

For example, British Airways describes the personality traits it values in its pilots: "leadership, determination, reliability, high personal standards, motivation, flexibility, well-developed customer-service skills and teamwork."[5]

Qantas Airways describes its tests — four aptitude tests designed to assess verbal reasoning, numerical reasoning, diagrammatic abilities and spatial abilities — and questionnaires — two questionnaires dealing with motivation and personality. Qantas also provides samples of the types of questions that will be included on each test and questionnaire, provides suggestions for improving test performance and offers the following advice:[6]

> Don't be discouraged if you found the questions difficult. There are several things you can do to improve your performance. … Read newspapers, reports, business journals; do verbal problem-solving exercises [e.g., crossword puzzles]; read financial reports in newspapers; study tables of data; practice your mental arithmetic; solve puzzles in newspapers and magazines involving diagrams; play games involving sequences or strategies (e.g., chess …); look at plans and [do-it-yourself] manuals; make up patterns or designs; [and] imagine how various objects look from different angles.♦

— FSF Editorial Staff

Notes

1. Darby, Kit. Telephone interview by Werfelman, Linda. Alexandria, Virginia, U.S. Jan. 28, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
2. Hogeman, Charles. E-mail communication with Werfelman, Linda. Alexandria, Virginia, U.S. Feb. 5, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
3. Jones, Sharon; Miller, Nick. Telephone interview by Werfelman, Linda. Alexandria, Virginia, U.S. Feb. 7, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
4. Magnusson, Christian. Telephone interview by Werfelman, Linda. Alexandria, Virginia, U.S. Feb. 10, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
5. British Airways. *Direct Entry Pilot Scheme: The Qualities We Seek and How We Develop Them.* <www.britishairwaysjobs.com/cc/pilots/deps/qualities.jsp>. Jan. 31, 2003.
6. Qantas. *Qantas Pilot Psychometric Test Practice Leaflet.* <www.qantas.com.au/info/about/employment/pilots>. Feb. 3, 2003.

- System results are easy to evaluate quantitatively. All pilot selection systems are, in some sense, methods of prediction (i.e., they predict how well a job applicant will perform as a pilot in the company). The predictive validity of the pilot selection system can be tracked over time. (Predictive validity is the determination of the extent to which the scores on a test predict actual performance.) A decrease in predictive validity may indicate a need to revise parts of the pilot selection system, to look for new sources of pilot applicants or to change the initial training of newly hired pilots. This measurement of results also allows the cost-effectiveness of the pilot selection system to be determined relatively easily; and,

- The system relies on documentation. In countries with laws prohibiting discrimination in hiring — for example, the United States and South Africa — documentation can be used to defend the company before courts and regulatory bodies. The documentation also provides important "corporate memory" for the human resources department and the flight operations department.

The statistical methods used in a structured pilot selection system require that, when an aircraft operator begins to hire, approximately 30 new pilots begin training each year. (The number of pilots who complete training is not relevant; nor is the total number of pilots employed by the operator.) If an operator does not hire anyone for five years and then hires approximately 30 new pilots in the sixth year, this system can be used.

Some air carriers and other aircraft operators have employees with the specialized skills required to manage a structured pilot selection system, such as technical knowledge in employment law and the mathematics of selection, including knowledge of scientific literature involving pilot selection. Aircraft operators who do not have employees with those skills sometimes hire consultants to perform the required pilot selection tasks.

Selection Systems Differ From Screening Systems

In informal discussions, screening systems frequently are confused with selection systems. A screening system is designed to eliminate from consideration for employment any applicant who does not meet the minimum requirements for hiring. For example, an air carrier might require a pilot to have 1,000 flight hours to be considered for a job. Nevertheless, the air carrier might receive applications from pilots with fewer than 1,000 flight hours. A pilot-screening system would eliminate those pilots.

A pilot-screening system also might require background checks to identify job applicants with criminal records or histories of alcohol abuse or drug abuse and to ensure that applicants have authentic credentials to show that they have the education, certification and experience that they say they have.

A selection system is designed to identify the best job applicants.

Selection systems use "select-in" processes to identify applicants who best meet operator requirements and to bring them into the company; screening systems use "select-out" processes to eliminate unacceptable applicants from consideration.

An aircraft operator's human resources department should allow a pilot applicant to begin the selection process only if he or she has successfully completed the screening process.

A structured pilot selection system consists of the following five major elements:[1]

- The criterion is the measure of success in training or success on the job. The criterion — which establishes what type of individual will be hired — is the most important element of the selection system because it represents the aircraft operator's definition of the KSAs and personality traits required in the company's pilots.[2] An inappropriate criterion might result in the hiring of new pilots who do not meet the operator's expectations. Some aircraft operators ignore this element and say only that they attempt to select "good pilots" rather than specifying exactly what KSAs and personality traits are required by the operator, such as a person who will complete initial training within the "standard footprint" (the typical amount of time and resources allowed for training), will score at least 90 points out of 100 points on the final simulator assessment and will arrive on time 98 percent of the time for his or her flights). Those specifications are criterion measures;

- Testing may include written tests or computer-based tests of intelligence, personality traits, motor skills and information-processing ability. Testing also may include interviews to assess knowledge and experience and assessments of flying skills, such as simulator assessments. The battery (group or set) of tests to be used should be identified relatively late in the development of a structured pilot selection system, after the criterion has been established, and the tests should complement the criterion;

- Models determine when qualified applicants will be eliminated from the group of those being considered for pilot jobs. A structured pilot selection system is designed around one of three models — the single-hurdle model, the multiple-hurdle model or the progressive model. The choice of model affects the cost per applicant of the pilot selection process.

  The simplest model is the single-hurdle model (Figure 1). An aircraft operator using this model administers all tests to all candidates for the job before making any hiring decisions. Thus, every pilot applicant receives all of the written/computerized tests, all of the interviews and a simulator evaluation. This model is used rarely because of the per-applicant costs.

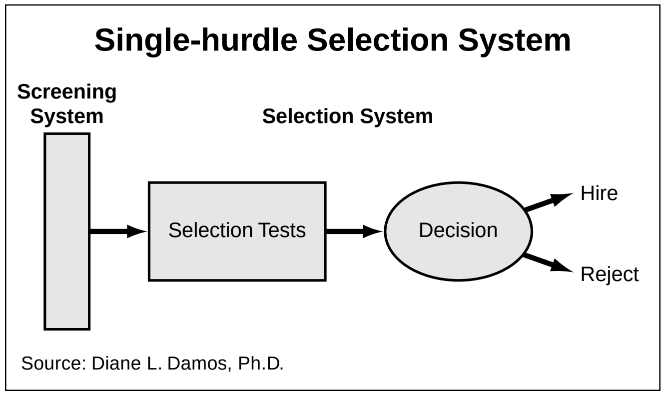

Figure 1

A pilot selection system used by Scandinavian Airlines System (SAS)[3] was the only example of the single-hurdle model found to have been analyzed in scientific literature. A 1959 report said that in this SAS pilot selection system, applicants were administered written tests and other tests of personality, motor skills, intelligence and "timesharing" (simultaneous performance of multiple tasks). The tests were administered independently by two psychologists or three psychologists. After all tests had been administered and scored, the psychologists met, reached an agreement on each job applicant and sent their hiring recommendations to SAS management for a final decision. The process was costly and time-consuming.

The costs of the single-hurdle model may be justified primarily when applicants must be transported over long distances. For example, if an Asian air carrier recruits its pilots in North America and Europe, the costs involved in transporting applicants to Asia may be substantial, and the air carrier may want all applicants to complete all selection tests at one time so that the complete results can be used in hiring decisions.

Most structured pilot selection systems use a multi-hurdle model (Figure 2, page 5) that consists of at least two stages.[4,5] For example, when an aircraft operator

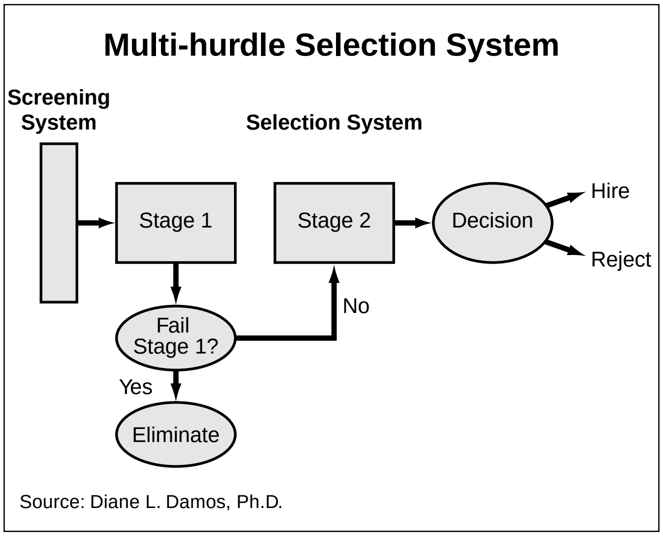

Figure 2

uses a multi-hurdle model with two stages, the selection tests are divided among the two stages, with the least expensive tests administered during the first stage and the most expensive tests administered during the second stage. All applicants complete the first-stage tests. The tests then are scored, and a substantial proportion of the lowest-ranking applicants are dropped from further consideration. The remaining applicants then complete the second-stage tests. The test results are analyzed with a decision aid, and a hire/reject decision is made for each applicant. The stages may occur successively on the same day, or they may be separated by substantial periods of time. Typically, the per-applicant costs for a structured pilot selection system with a multi-hurdle model are less than those for a single-hurdle model.

The third model is a progressive model, also known as a rolling model or a cascade model. This model is essentially a multi-stage model but differs on two major philosophical issues from the single-stage model and the multi-stage model. One major difference is that the pilot selection process continues during training, rather than ending at the time of the hiring decision.[6] The second difference is that the progressive model is designed to help ensure that the aircraft operator does not overlook an applicant who would perform well on the criterion measures; both the single-stage model and the multi-stage model are designed to minimize the possibility that an operator would hire an applicant who subsequently would perform poorly on the criterion measures. A progressive model is most useful when training is conducted over many months or years and when the applicant pool is small, compared with the number of available positions. Progressive models most often are used for ab initio systems because ab initio training typically requires several years;

- The decision aid uses a variety of statistical methods to relate scores on the tests to the criterion to produce an employment recommendation. The most commonly used statistical method is regression analysis, in which the selection scores on one or more tests are used to predict performance on a criterion; and,

- A feedback loop is used to monitor the predictive validity of a structured pilot selection system. All selection data for newly hired pilots should be recorded in a database. The feedback loop correlates the hired pilot's criterion measures with his or her scores on selection tests. Periodically, a manager calculates the predictive validity of the system. The predictive validity of any selection system decreases over time because of factors such as changes in the applicant pool, changes in the criterion or changes in the initial training. The feedback loop enables the aircraft operator to determine when the predictive validity is decreasing and to take appropriate countermeasures. In countries where employment litigation is common, the fact that a company has a feedback loop shows that the company has an intent to improve its pilot selection process and, therefore, provides an additional measure of protection against litigation.

Selection systems must be designed and must be administered to comply with all applicable regulations and employment laws, although complying with employment laws typically is not considered an element of a structured pilot selection system.

Selection-system Development Includes Five Steps

The first selection systems were developed by industrial/organizational psychologists more than 50 years ago.[7] Selection systems for pilots typically are developed according to the same principles as selection systems for other categories of employees.[8,9]

Aircraft operators should follow five steps in the development of a structured pilot selection system. The steps need not begin in the order given (i.e., step 2 may begin before step 1), and some steps may overlap, but all steps must be completed in order (i.e., step 1 should be completed first, then step 2, step 3, step 4 and step 5). The process and the outcome of each of the five steps also must be documented carefully for internal use and for defending against subsequent legal challenges.

Step 1 is conducting a job analysis to identify the KSAs and personality traits required to perform successfully as a pilot for a specific operator. The job analysis describes what the pilot does on the job, what the pilot must know to perform the job and what resources the pilot must use to perform the job successfully.

Much of the job analysis for a pilot involves task analysis, which is a detailed description of a pilot's work activities. An aircraft operator may obtain a task analysis for its pilots by one of three methods:

- If the air carrier participates in an advanced qualification program (or other voluntary alternative to traditional regulatory requirements for pilot training), then the carrier already should have a task analysis of the pilot's job that was developed for training purposes. That task analysis can be modified for use in a structured pilot selection system. This is the best method to obtain a task analysis for the selection system because the analysis has been designed specifically for the operator's fleet and procedures;

- Some specialists (either in-house employees or outside consultants) in structured pilot selection systems have task analyses for pilots that can be modified for a specific aircraft operator. (Consultants may not have task analyses for the operator's aircraft, however.); and,

- An air carrier may conduct the task analysis itself. Performing a task analysis for a pilot job description can be a time-consuming process and can require substantial expertise, so this method of obtaining a task analysis is often beyond the in-house resources of many smaller aircraft operators.

The results of a task analysis rarely identify the personality traits that are required to perform well at a specific company; other techniques must be used to identify those traits. Usually, aircraft operators have strong opinions about the personality-trait requirements for the pilots they want to hire, and the most effective method to identify those requirements is to ask subject matter experts (SMEs), who typically are chief pilots and senior captains. These SMEs can identify the problems that the aircraft operator has experienced with its pilots (i.e., insufficient job skills, lack of dependability, poor leadership skills or poor stress management). They also can identify the personality traits of successful pilots, such as conscientiousness — typically one of the most highly valued personality traits for pilot applicants — and leadership abilities. This information may be obtained through interviews, surveys or small discussion groups, and after the information has been obtained, a specialist in structured pilot selection systems typically matches each of the successful-pilot traits with a generally recognized personality trait. After this step is completed, the aircraft operator will have a list of all of known KSAs and traits of a successful pilot within the company.

Step 2 is the identification of the tests (or types of tests) to be considered for inclusion in a selection system.

Identifying appropriate tests usually is a straightforward procedure for human resources specialists. Typically, a specialist in structured pilot selection systems recommends tests that measure the required KSAs and personality traits identified in step 1. If more than one test is available to measure a specific KSA or personality trait, the specialist typically makes a recommendation based on the cost per applicant, the time required to administer the test, the reliability of the test and the probable predictive validity of the test, based on the experience of other operators.

Sometimes there are no existing standardized tests to measure a specific KSA or personality trait. In such circumstances, the aircraft operator has two choices: develop a test to measure the KSA or trait or choose not to assess the KSA or trait. Test development should be pursued if the KSA or trait is considered very important for pilot success. Aircraft operators that do not employ individuals with expertise in test-development must hire specialists. Most commonly, tests cannot be administered to assess all KSAs and personality traits identified in step 1 because of time limitations; some tests must be omitted.

Step 3 requires the identification or development of performance measures to serve as the criteria for the pilot selection system. For example, one performance measure, such as the score on the check ride at the end of training, rarely assesses all of the important facets of a pilot's job for a particular aircraft operator.

Structured pilot selection systems can be designed to predict several attributes of the criterion. For example, an air carrier may want to predict measures of a pilot's performance during training, during probation and during operational flying. Many measures are generated during training that can be used in the criterion, such as time to complete training, the score on the final check ride or the score on the final oral examination. Computer-based training (CBT) programs also may generate a number of measures of a pilot applicant's progress during training. During probation, the score on the check ride administered at the end of probation and captains' assessments of an applicant are potential measures. Performance as an operational pilot may be reflected in check ride scores and the time required to complete recurrent training; CBT measures also may provide useful indicators of performance during recurrent training or upgrade training. Scores on annual check rides may be useful, and personnel records may include valuable measures that have been overlooked, such as the number of times during a 12-month period that a pilot arrives late for a flight.

Nevertheless, the following difficulties may occur in assessing pilot performance:

- Many common measures of performance in aviation are expressed as pass/fail. Such measures, which are referred to as "dichotomized" scores, typically are not good criterion measures, and accurate performance prediction is difficult.[10] Measures that use carefully developed scales are preferable; and,

- Occasionally, there are no performance measures that are appropriate for the criterion. For example, the aircraft operator may have no measures of how well a pilot interacts with other crewmembers. In that event, the operator must develop performance measures. Nevertheless, development of performance measures requires specific technical knowledge and should be undertaken in consultation with appropriate specialists.

Step 4 requires administration of the tests to obtain predictive measures, to collect the criterion data, when available, and to identify the most cost-efficient tests.

This step begins the process of determining how well the chosen tests actually predict performance. Traditionally, in aviation, this step has been conducted by administering the new tests to a group of pilot applicants who have passed the screening procedure.[11] The scores on the new tests are not used in making an employment decision about the applicants; at this stage, the usefulness of the scores is unknown. Instead, management receives scores from the tests and/or interviews used previously and makes hiring decisions based on them. For example, if the aircraft operator has been using an interview and a simulator evaluation, these scores are used in making hiring decisions.

Newly hired pilots receive training, and those who complete training proceed to line flying. Scores on the criterion measures are collected at the appropriate time from each newly hired pilot. Statistical analyses would determine how accurately the scores on the new selection tests predict the criterion measures and how much they improve the predictive validity of hiring decisions. These analyses may show that some of the new tests are not cost-efficient and should be dropped from further consideration. Similarly, the analyses may show that some of the tests that the aircraft operator had been using are not cost-efficient and should be eliminated.

After identification of the tests that best predict the criterion, the resulting set of tests may be given to the next group of applicants. For this group, the scores from all of the tests are given to management. After the criterion data are collected, statistical analyses again are used to calculate the predictive validity and to help ensure that the predictive validity is sufficient for the operator's requirements.

Step 5 is the development of a monitoring system. Before further groups of applicants are tested, management should establish a monitoring system so that they will know whether the pilot selection system continues to predict the criterion measures established by the aircraft operator.

A typical monitoring system collects test scores and criterion scores, performs the statistical analysis and alerts management if the predictive validity of a structured pilot selection system decreases below a preset value. If a decrease occurs, the system notifies management that changes are required in the set of tests or in the analyses (decision aid). Management should identify reasons for the decrease (changes in the pool of pilot applicants, changes in training content or standards, etc.) and should take corrective action.

The monitoring system also documents the aircraft operator's intent and actions to ensure that a structured pilot selection system functions as intended and is improved periodically.

Selection Tests Assess Many Skills and Abilities

Many types of tests, including intelligence tests,[12] currently are used to assess KSAs and personality traits. Since World War II, scores on intelligence tests have been related demonstrably to performance in ab initio military pilot training.[13] Research from Qantas Airways[14] and SAS[15,16] shows that scores on these tests also provide a valid prediction of training performance and operational performance for experienced pilots. In addition to their predictive validity, the following reasons should be considered for including an intelligence test in the set of tests used in a pilot selection system:

- Intelligence tests are relatively inexpensive and cost-efficient to administer. The traditional paper-and-pencil tests require no special apparatus and can be administered to large groups of applicants. Tests usually can be administered by an operator's human resources personnel. Computer-based intelligence tests may be more expensive but offer the advantage of immediate results;

- Many other tests used in pilot selection correlate moderately with scores on intelligence tests. In terms of overall predictive validity, intelligence tests often are the best predictors of pilot performance among all tests in a particular set; and,

- Many aircraft operators today find that the education level and background of pilot applicants is changing. For example, until relatively recently, many U.S. air carriers hired predominately ex-military pilots. These pilots previously had been selected through rigorous military processes,[17] and they had college degrees. U.S. air carriers no longer hire predominately ex-military pilots, and some do not require pilot applicants to have degrees from accredited colleges or universities. Air carriers in some other parts of the world have reported difficulties recruiting pilots at the ab initio level and the experienced level, and, like their U.S. counterparts, some have lowered their educational requirements and/or have begun recruiting from nontraditional sources.

  When educational requirements are lowered, however, some pilot applicants may not have the knowledge required to complete training within the required time. A carrier could expect to correct deficiencies by providing additional training. Nevertheless, some individuals may not have the required intelligence to overcome the deficiencies in the allotted time. Intelligence testing is one of the few valid methods of identifying such individuals.

Motor Tests Best Suited to Ab Initio Pilot Selection

Tests that involve manipulation of some type of physical apparatus[18] are known as "motor tests" or "psychomotor tests." (They formerly were called "apparatus tests.") The distinction between a motor test and a psychomotor test is not standardized, but "psychomotor" generally implies that some type of cognitive processing is required to perform the test well. For example, a test that requires the applicant to tap his/her index finger as rapidly as possible would be called a motor test. A test that requires the applicant to place a pointer on a dot that moves at different speeds in a figure-eight pattern on a computer screen usually would be called a psychomotor test.

Motor tests typically are not used to select experienced pilots. Nevertheless, motor tests, which often use relatively inexpensive apparatus, may be useful for ab initio pilot selection in places where pilot applicants may have had limited exposure to technologically advanced machinery and computers. Psychomotor tests — which often measure eye-hand coordination — are included in test batteries for experienced pilots; for example, the set of tests used by Qantas contains a test of eye-hand coordination and a test of eye-hand-foot coordination.[19] Psychomotor tests also may be used in ab initio pilot selection batteries, such as one used during the 1990s by Cathay Pacific Airways, which contains an eye-hand coordination test and an eye-hand-foot coordination test.[20] Scores from the psychomotor tests used by Qantas correlated with flight-training performance reports that were obtained after the pilots were assigned to operational flying almost as well as scores from a simulator test that also was included in the set of pilot selection tests.

The major disadvantage of psychomotor tests is their expense. Additionally, although the Qantas results show a correlation between scores on the psychomotor tests and scores on the flight-training performance reports, they reflect data from only one carrier.

Aircraft operators should develop a structured pilot selection system carefully, should establish its predictive validity and then should determine whether adding a psychomotor test would be cost-efficient.

Information-processing Tests Measure Reaction Time

Information-processing tests measure the speed at which an individual performs various cognitive functions.[21] The distinguishing feature of these tests is their use of reaction time, measured in milliseconds, as the primary measure of performance. Because reaction time must be measured so accurately, these tests are conducted using computers.

For example, an information-processing test might be designed to determine how rapidly an individual can respond to a simple stimulus on a computer display. During the test, the numerals "1" through "8" would be shown one at a time, at random, on the display. The job applicant would be required to press the corresponding number on a keypad, and the computer software would measure how rapidly the test-taker responded to the appearance of each numeral. A total of 100 numerals might appear, and the 100 response times would be averaged to measure the test-taker's performance.

Many commercial software packages are available to conduct information-processing tests. Basic software packages include several different information-processing tests. More comprehensive software packages include separate tests and combinations of tests that are designed to assess timesharing skills.[22] In a timesharing test, the test-taker is asked to perform two information-processing tasks concurrently. The predictive validity of timesharing tests is slightly greater than the predictive validity of information-processing tests.

The most comprehensive software packages include psychomotor tests, combinations of information-processing tests, combinations of information-processing tests with psychomotor tests, and feedback (a response) about the individual's performance on the tests. The software can assess factors such as an individual's risk-taking traits and decision-making abilities, in addition to the speed of cognitive processing and timesharing. Some software may require specialized computers and peripheral equipment to administer the tests.

Information-processing tests have several characteristics that make them attractive for structured pilot selection systems. They have a "game-like" quality that pilot applicants typically enjoy. Because they are administered using a computer, the results are available immediately. When used under controlled conditions, scores on these tests are unaffected by gender and ethnicity.

The major disadvantage of these tests is their cost. Aircraft operators may be required to purchase proprietary hardware and software, and may be charged a fee for each applicant who takes the test.

Personality-trait Testing Involves Caveats

Tests to evaluate personality traits of pilots may be the least successful type of test in ethnically heterogeneous countries. For example, some reports on personality-trait testing in U.S.

military pilot selection systems say that such tests have not succeeded.[23,24]

"The use of self-report personality scores did not enhance the predictive validity of a selection system," said one report on personality-assessment tests used by the U.S. Air Force. "The analyses of personality variables under investigation by the Air Force show very little promise for use in selecting or classifying aviation candidates."

A study of the pilot selection system at Qantas, however, said that there were significant positive correlations between personality scales and performance scores in training and probation.[25]

European air carriers have had more success with tests to evaluate personality traits. A study of one European charter operator (the study did not identify the operator) measured an increase in the "classification accuracy" of its pilot selection system from 73.8 percent to 79.3 percent after a test to evaluate personality traits was added to the set of tests.[26] (Classification accuracy is the percentage of applicants whose performance on a pass/fail criterion was predicted correctly.) Two reports on SAS's pilot selection system — written more than 30 years apart — present data from personality tests. Both reports said that SAS used experienced psychologists to administer the tests and to interpret them.[27,28]

Tests to evaluate personality traits have been criticized for their culture-specificity. For example, data show a strong predictive validity for one test — the Defense Mechanism Test — in Scandinavia and an absence of predictive validity for the same test in the Netherlands and the United Kingdom.[29] Other data show that a test developed for Lufthansa Airlines in Germany had poor predictive validity in China to a pilot applicant's overall flight-training grade.[30] Researchers were unsure of the cause but planned to conduct further studies to compare tests developed in China with the one developed in Germany.

Some researchers also have criticized tests to evaluate personality traits for their "transparency" — that is, the ease with which job applicants determine the desired response to each question and then respond accordingly.[31,32,33,34] Their answers may reflect little about their real personalities; the predictive validity of the test is, therefore, questionable.

In the United States, legal factors in testing related to personality also must be considered. The Civil Rights Act of 1991 specifically prohibits differential scoring of items by ethnic group or gender. For example, if a question asks the job applicant about his/her favorite sports in secondary school and answers of "boxing," "diving" and "gymnastics" are known to correlate highly with success in training men, these answers could be given a higher score than other answers to this item. "Boxing" may have a negative correlation with success in pilot training for women, however. Nevertheless, under the civil rights law, this answer must receive the same score for both men and women. This restriction on differential scoring has limited the usefulness of personality tests for pilot selection in the United States.

Biographical inventories — types of questionnaires — sometimes are used instead of personality-related tests, particularly in the United States, to ask about the applicant's family, education, hobbies and sports interests.[35] Some questions also pertain to interest in aviation and career goals. Reponses to the items are correlated with criterion scores. Items that correlate positively with one or more of the criterion scores are included in the applicant's total score.

Interviews Remain Valuable Tools

Interviews may be the most common element of a pilot selection system used by aircraft operators. Interviews may be conducted by one person or by a board (group). The interviewers may be human resources specialists, psychologists or senior pilots. At large air carriers, a pilot applicant may have several individual interviews, as well as a board interview.

Studies have shown that structured interviews (in which the same questions are asked of all applicants and the responses are assessed) have greater predictive validity for job performance than unstructured interviews, perhaps because unstructured interviews typically do not present all applicants with the same questions and because they lack scoring guides.[36,37]

Cost is one problem associated with interviews conducted by one or more pilots who are on flight status. Some aircraft operators may underestimate the cost, as they pay not only the pilots' salaries and benefits but also lost-revenue costs.

Another problem is that interview questions may become known in advance to applicants, compromising spontaneous responses: Some aircraft operators' interview questions are available on the Internet for a fee, many books provide guidance on how to respond in an interview, and consultants may advise job applicants on the appropriate responses and appropriate demeanor for interviews at specific air carriers. The effect of this advance preparation on the predictive validity of interviews has not been established.

Flight-skills Tests Conducted on the Ground

Many aircraft operators require an assessment of pilot applicants' flight skills. Traditionally, these assessments were conducted in an aircraft, but today, they typically are conducted in a simulator or other flight-training device.

Some simulator assessments are based on national test standards for the appropriate level of pilot license (i.e., the airline transport license or an instrument rating), and scoring of the assessments sometimes presents problems. The predictive validity of a test is closely related to its reliability. If a test has a low reliability, its predictive validity also is low. For tests with scores based on observer ratings, reliability is measured in terms of "inter-rater reliability" (the correlation between the scores given by two check pilots rating the same pilot performance).

Two 1997 research reports said that inter-rater reliability typically is poor at air carriers. The reports said that reasons were not determined but that insufficient training of check pilots might be one cause.[38,39] Research on improving the inter-rater reliability of check pilots found that more intensive training of check pilots and periodic retraining would help improve inter-rater reliability.[40,41,42]

System Development Can Take Months

Aircraft operators typically make two mistakes in developing or revising a structured pilot selection system.

They do not allow sufficient time for the development process or revision process and, therefore, introduce the process too late in their hiring cycle. If an air carrier decides to develop a new pilot selection system, the process must begin before pilot hiring begins. Some air carriers, however, wait until a few weeks before hiring begins to consider changing the pilot selection system. Management should allow three months to six months to develop a new structured pilot selection system for a small-size air carrier to a medium-size air carrier. This allows sufficient time for system developers to schedule meetings with management, to make informed decisions about the criteria and tests, and to train testing personnel, check pilots and interviewers. A large air carrier that annually hires hundreds of new pilots may require considerably more time for the development process.

Revising an existing pilot selection system typically requires much less time than developing a new system. Three months is sufficient for making most changes.

The other common mistake is purchasing an expensive test without adequate consideration of the purpose of the test or the alternatives. Management should not purchase a test unless the test is demonstrably related to the KSAs or personality traits that an aircraft operator wants its pilots to possess. Even if a test is related to KSAs or personality traits of importance to the operator, adding the test may not increase the predictive validity of the selection system.

Management should not purchase a test solely because of the reported usefulness of the test to other aircraft operators; operators that appear similar may differ in subtle ways that affect the predictive validity of their tests. For example, although one air carrier may find that a particular test increases the predictive validity of its structured pilot selection system, another air carrier may find that the same test has no effect on the predictive validity. Aircraft operators who consider purchasing such tests should seek appropriate expertise to evaluate the vendor's claims and perform cost/benefit analyses.

For maximum effectiveness, tests, like other elements of the pilot selection system, should be developed to match an aircraft operator's specific requirements. In that way, the system will be able to identify the applicants most likely to succeed as pilots for a specific aircraft operator.♦

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    Another commonly misunderstood term is "stanine." This term refers to a method of scoring a test on a nine-point scale and is a contraction of the term "standard nine," [according to *Introduction to Classical and Modern Test Theory*, by Linda Crocker and James Algina. Fort Worth, Texas, U.S.: Harcourt Brace Jovanovich, 1986, and "U.S. Air Force Pilot Selection Tests: What Is Measured and What Is Predictive?" by Thomas Carretta and Malcolm J. Ree in *Aviation, Space and Environmental Medicine* Volume 67 (1996): 279–283]. During World War II, the pilot-assessment tests were scored using the stanine method. Pilots seem to have referred to the tests as "stanine tests," and gradually this term began to be used to refer to any paper-and-pencil ability test.

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About the Author

Diane L. Damos, Ph.D., has worked in the area of pilot selection for more than 30 years. She received a doctorate in aviation psychology from the University of Illinois in 1977 and taught from 1977 until 1997 at the State University of New York, Arizona State University and the University of Southern California. She has lectured and has taught courses on pilot selection in Taiwan, South Africa, Spain and Canada. In 1995, she founded Damos Aviation Services.

Damos has conducted research on pilot selection for the U.S. Air Force and the U.S. Navy and helped develop the computer-based testing used by the Air Force. She has consulted with national governments and air carriers on military pilot selection and civilian pilot selection. Damos has received numerous grants and contracts from the Navy, Air Force and the U.S. National Aeronautics and Space Administration to support her research. She has written more than 25 articles in scientific publications and 50 technical reports and proceedings articles on training, cognition and pilot selection systems. She is a consulting editor for the International Journal of Aviation Psychology *and a fellow of the Human Factors and Ergonomics Society. She served on the National Academy of Sciences/National Research Council Panel of Human Factors in Air Traffic Control Automation. She also has been an expert witness in many aviation-related court cases on pilot certification, training and performance.*

Damos holds a commercial pilot certificate with ratings in single-engine airplanes and multi-engine airplanes and an instrument rating, an advanced ground instructor license and an instrument ground instructor license.

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Foundation Launches Project To Prevent Ground Accidents

The FSF Ground Accident Prevention (GAP) project was initiated to prevent accidents and incidents that occur on airport aprons and adjacent taxiways, and while moving aircraft in hangars. The first phase of the project will include collecting and analyzing data, which will serve as the basis for developing recommendations and tools for preventing ground accidents.

FSF Editorial Staff

Meetings conducted by Flight Safety Foundation (FSF) in August 2002 and in January 2003 have established a steering team and a conceptual framework of tasks for international aviation safety specialists who will be assembled to develop methods for preventing ground accidents (also called ramp damage). The specialists will participate in working groups that are being formed under the FSF Ground Accident Prevention (GAP) project, which is defined as follows:

> GAP is a project to prevent accidents and incidents that occur during ground operations on airport aprons (including adjacent taxiways) and during the movement of aircraft in and out of hangars, and that directly affect airport operations and/or result in injuries or damage to serviceable aircraft, facilities or ground-support equipment.

Project co-chairs are Robert Vandel, FSF executive vice president, and Earl Weener, Ph.D., FSF fellow and former chief engineer, systems engineering, for Boeing Commercial Airplanes.

Vandel said that the project will include analyses of the risks of ground accidents to air carriers, which operate approximately 16,000 aircraft at 1,350 airports worldwide, and to business aircraft operators, which operate approximately 10,000 aircraft at 10,000 airports worldwide that are adequate for business-aircraft operations.

"We have just begun work on GAP," he said. "One of the Foundation's priorities is human error, and every indication is that human error plays a very large role in ground accidents."[1]

Vandel said that a significant financial toll is taken by ground accidents that result in injuries and fatalities, and/or damage to or loss of aircraft, service vehicles and service facilities.

"We do not know the exact magnitude of this problem; one of our goals is to find out," he said. "Nevertheless, a conservative estimate indicates that the annual costs of aircraft damage, alone, are US$4 billion for air carriers and $1 billion for business aircraft operators."

Weener said that many air carriers, in effect, "self-insure" against aircraft damage from ground accidents — that is, the deductible limits specified in their insurance policies are higher than the direct costs of repairing the damage.

For example, one U.S. air carrier told the Foundation that the direct costs of 273 of the 274 ground accidents in which its aircraft were involved were below the deductible limits of its insurance policy. The air carrier said that the average direct cost of a ground accident was $250,000 and that the deductible limits of its insurance policy are $1 million for a wide-body airplane, $750,000 for a modern narrow-body airplane and $500,000 for an older narrow-body airplane.

"Expenses such as these come off the bottom line of an industry that currently is bleeding red ink," Weener said.

Vandel said that the financial impact of ground accidents on aircraft operators is exacerbated by indirect costs that often are substantially higher than the direct costs.

"Indirect costs are difficult to measure, but a conservative estimate is that indirect costs are three times higher than the direct costs," he said. "Some estimates indicate that indirect costs are 200 times higher than direct costs."

For example, the direct costs of repairing damage to an air carrier aircraft that was struck by a catering truck were $17,000; the indirect costs of the ground accident were $230,000.

"The indirect costs are significant also for business aircraft operators," Vandel said. "In one case, a tow bar broke while a business jet was being moved by a tug; the business jet then moved forward on its own and struck the tug. The direct costs of repairing damage to the business jet were $160,000; the indirect costs were $300,000, which included expenses for replacement transportation while the jet was being repaired.

"We also have learned that a major repair substantially impacts the resale value of a business aircraft. One estimate is that a major repair knocks 15 percent off the resale value."

Vandel said that, for air carriers, indirect costs of ground accidents involving aircraft damage include the following:

- Lost revenue from ticket sales;
- Aircraft repositioned to replace the damaged aircraft;
- Flight cancellations;
- Meals and lodging for passengers whose flights were cancelled;
- Replacement labor and overtime;
- Damage to the airline's public image;
- Management and supervision time; and,
- Accident/incident investigation.

Aircraft damage is only one part of the problem. Data collected by Airports Council International (ACI) indicate that the majority of ground accidents and ground incidents in 1999 through 2001 involved equipment-to-equipment damage (Figure 1, page 15).[2]

ACI data also indicate that injuries caused by ground accidents and incidents have increased from approximately 0.04 injuries per 1,000 aircraft movements in 1996 to nearly 0.12 injuries per 1,000 aircraft movements in 2001 (Figure 2, page 15).

Participants in the Aug. 27–28, 2002, meeting in Alexandria, Virginia, U.S., confirmed that significant benefits can be achieved from prevention of ground accidents.

"During our first meeting, we conducted an exercise that consisted of reflecting upon what the world would be like if the problem of ground accidents was solved completely," Weener said. "The 20 participants in that meeting envisioned some very significant results, including lower insurance rates, increased profitability, higher pay and job satisfaction for employees, less government intervention, less regulatory intervention, and an improved public perception of aviation safety."

The participants also identified issues involved in ground accidents and evaluated the potential for improvements related to each issue.

"The participants established a baseline of more than 90 issues, ranging from symbols, signs and markings, to pilot situational awareness," Weener said. "The next step was to prioritize the issues, because it is just as important to know which issues to disregard as it is to know which issues to focus on."

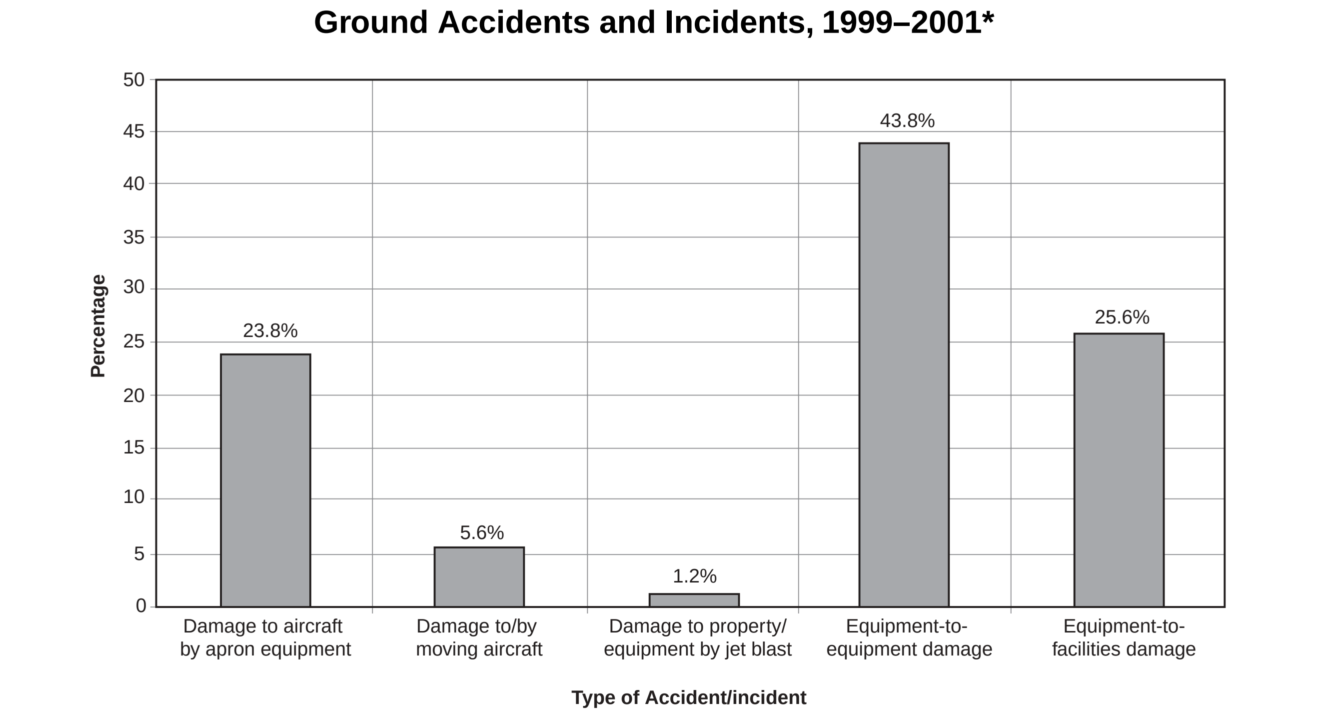
Each issue was evaluated to determine its possible influence on preventing ground accidents and to determine the possible level of difficulty in making needed changes related to each issue.

For example, the participants found that improvement of markings, signs and lighting would have a strong influence on reducing ground accidents and that improvements would be relatively easy to make. The participants also found that improving pilot situational awareness also would have a strong influence on the problem but would be moderately difficult to achieve.

"One question that we will consider when we study this issue is how to go about changing situational awareness," Weener said. "Should the changes involve more training, different training, changes to policy or procedures, new technology — or a combination of these factors? Perhaps the changes involve something that we have not yet identified.

"Situational awareness is an integral part of the way an employee does his or her job, which implies that improving situational awareness requires fundamental changes to the way the job is done or the way the job is structured. I agree that such changes would be moderately difficult to accomplish."

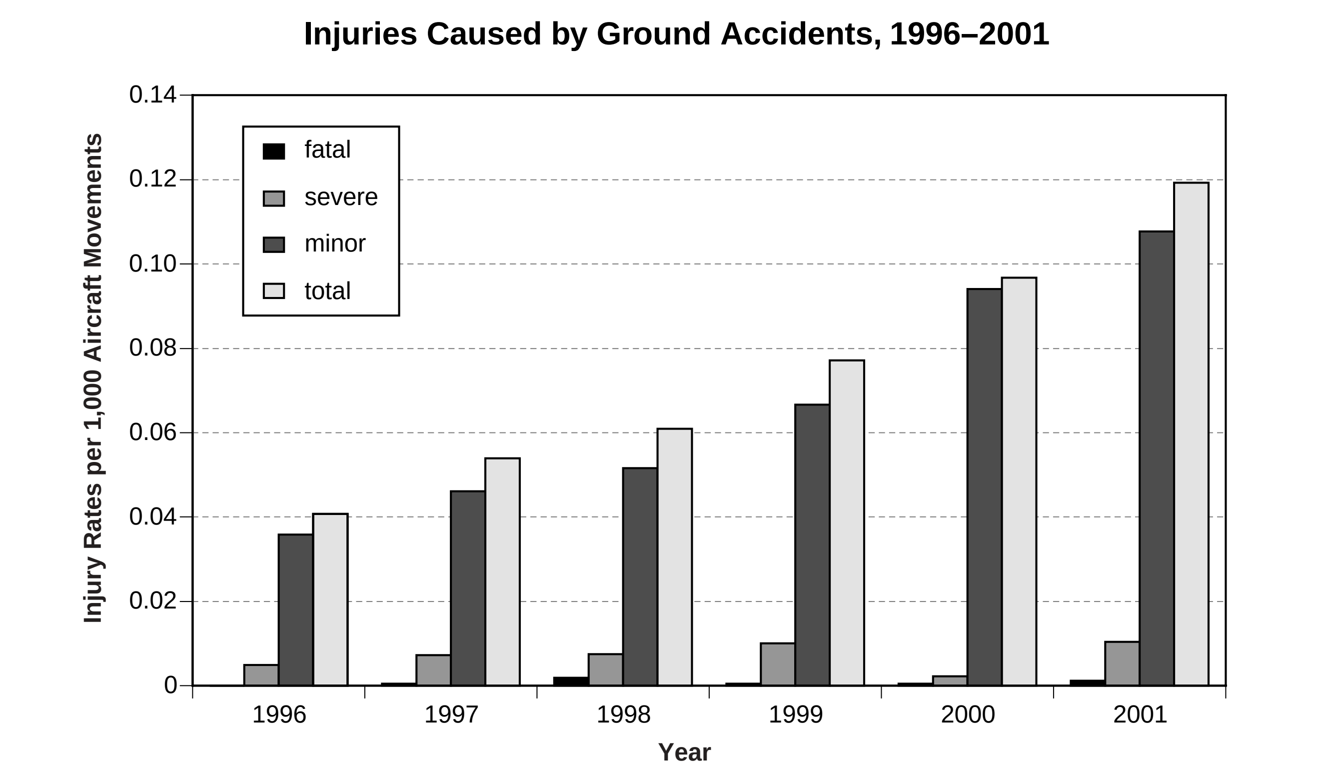
The priorities identified during the first meeting provided a framework for establishing working groups and identifying tasks for each working group.



*Data were collected from surveys at 341 airports in 1999, 376 airports in 2000 and 359 airports in 2001.

Source: Airports Council International

Figure 1



Source: Airports Council International

Figure 2

"The first meeting was a brainstorming session," Vandel said. "We achieved a better understanding of the problem and its scope, and we came away with a clearer idea of the directions in which we will proceed."

Vandel and Weener invited representatives of air carriers, business aircraft operators, airport organizations, apron-service organizations, regulatory agencies, manufacturers and other organizations to participate in the second meeting Jan. 22–23, 2003, in Alexandria as members of the GAP steering team.

"We knew that if we could get the right people into the room, we could make a significant impact on reducing ground accidents," Vandel said. "We were very pleased with the people who participated in the second meeting, which actually was the first meeting of the GAP steering team. They worked very hard and accomplished much in two days."

Sixteen aviation professionals participated in the steering team meeting. Vandel said that several other aviation professionals expressed a desire to participate on the GAP steering team but were not able to attend the steering team's first meeting. They will be invited to attend the steering team's next meeting, which is scheduled for May 2003.

During the January 2003 meeting, the GAP steering team established objectives for working groups that will focus on data collection and analysis; education and training; facilities, equipment and operations; management and regulatory processes; and awareness and industry relations.

"One of the first tasks of the working groups will be to re-examine all the issues that were identified and the priorities that were assigned to the issues during the August meeting, and develop an accepted taxonomy — a classification of the issues that we need to look into," Vandel said. "The taxonomy must enable us to get what we want from the data we collect; we do not want to collect data for data's sake."

Vandel said that the work conducted under the aegis of the Foundation's GAP project will build upon considerable work that has been conducted by ACI, Australasian Aviation Ground Safety Council, European Regions Airline Association, International Air Transport Association, International Civil Aviation Organization, National Business Aviation Association, Regional Airline Association and other organizations.

"As with the Foundation's work to prevent controlled flight into terrain (CFIT) and approach-and-landing accidents, the conclusions and recommendations from the GAP project will be data-driven and will be developed to provide the greatest possible benefit for the lowest possible cost," Vandel said.♦

Notes

1. In addition to human error, the priorities of Flight Safety Foundation are controlled flight into terrain (CFIT), approach-and-landing accidents and loss of control. CFIT occurs when an airworthy aircraft under the control of the flight crew is flown unintentionally into terrain, obstacles or water, usually with no prior awareness by the crew. This type of accident can occur during most phases of flight, but CFIT is more common during the approach-and-landing phase, which begins when an airworthy aircraft under the control of the flight crew descends below 5,000 feet above ground level (AGL) with the intention to conduct an approach and ends when the landing is complete or the flight crew flies the aircraft above 5,000 feet AGL en route to another airport.

2. Airports Council International. *ACI Survey on Apron Incidents/Accidents: 2001*. December 2002. A total of 359 airports participated in the 2001 ACI survey; 376 airports participated in the 2000 ACI survey; 341 airports participated in the 1999 ACI survey.

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U.S. Data Rank Meteorological Conditions in Weather-related Accidents, 1989–2000

Clear-air turbulence was the most cited meteorological condition in weather-related accidents involving U.S. Federal Aviation Regulations (FARs) Part 121 air carriers. Low ceiling and fog were present most often in weather-related accidents involving Part 135 commuter air carriers and on-demand operators, according to data from the U.S. Federal Aviation Administration.

FSF Editorial Staff

Clear-air turbulence (CAT) was the meteorological condition cited most often in weather-related accidents involving U.S. Federal Aviation Regulations (FARs) Part 121 air carriers in the period from 1989 through 2000 (Table 1, page 18). CAT was present in 29.2 percent of the accidents. Turbulence in clouds was present in 15.9 percent of the accidents, turbulence involving thunderstorms was present in 9.7 percent, convection-induced turbulence was present in 0.9 percent and unspecified turbulence was present in 23.0 percent.

Among weather-related accidents involving Part 135 commuter air carriers and on-demand operators during the same period, the most frequent meteorological condition reported was low ceiling (Table 2, page 18), reported in 23.0 percent of the accidents. Other conditions frequently present were fog (20.3 percent), snow (12.3 percent), icing (11.2 percent) and crosswind (10.1 percent). CAT was present in 0.5 percent of the Part 135 accidents.

The statistics were derived from a set of data provided and categorized by the U.S. Federal Aviation Administration (FAA) National Aviation Safety Data Analysis Center (NASDAC), based on final accident reports of the U.S. National Transportation Safety Board (NTSB). The data, which were further analyzed by Flight Safety Foundation, comprised 113 accidents involving Part 121 air carriers and 365 accidents involving Part 135 commuter air carriers and on-demand operators during the 1989–2000 period in which weather was cited either as a cause or as a factor. Weather was a cause in 63.7 percent of the Part 121 accidents and in 4.4 percent of the Part 135 accidents, the data showed.

Effective March 20, 1997, scheduled passenger operations in airplanes with 10 or more passenger seats and scheduled passenger operations in turbojet engines must be conducted under Part 121. The associated amendments to FARs, known as the commuter rule, affect whether specific operators' accidents occurred during Part 135 operation or Part 121 operation in the 1989–2000 period. This analysis considered only meteorological conditions and accidents as grouped by Part 121 operation or Part 135 operation at the date of the accident.

Daylight conditions were present in more than 60 percent of weather-related accidents (Figure 1, page 19 and Figure 2, page 19). The next-most-frequent light condition reported was dark night, in 29.2 percent of Part 121 accidents and 24.9 percent of Part 135 accidents.

Of the accidents involving Part 121 air carriers, 33.6 percent occurred in instrument meteorological conditions (IMC) and 64.7 percent occurred in visual meteorological conditions (VMC). In 1.8 percent of the accidents, the IMC/VMC category was unknown. (Percentages do not total 100 because of rounding.) Of the accidents involving Part 135 commuter air carriers and on-demand operators, 46.8 percent were in IMC, 48.8 percent were in VMC and 4.4 percent were unknown.

Phase of flight was included in the data for 100 of the 113 accidents involving Part 121 operations and 339 of the 365 accidents involving Part 135 operations. The most frequent phase of flight assigned to Part 121 accidents (Figure 3, page 19) was cruise (38.0 percent), followed by descent (29.0 percent). The most frequent phase of flight assigned to Part

Table 1
Meteorological Conditions in 113 Weather-related Accidents, U.S. Federal Aviation Regulations (FARs) Part 121 Operations, 1989–2000

Meteorological Condition	Number of Accidents In Which Condition Was Present[1]	Percentage of Accidents In Which Condition Was Present[1]
Turbulence, Clear-air	33	29.2
Turbulence	26	23.0
Turbulence, in Clouds	18	15.9
Turbulence (Thunderstorms)	11	9.7
Crosswind	4	3.5
Snow	4	3.5
Rain	3	2.6
Icing	3	2.6
Fog	2	1.8
Gusts	2	1.8
Unfavorable Wind	2	1.8
Wind Shear	2	1.8
Downdraft	1	0.9
Drizzle/Mist	1	0.9
Hail	1	0.9
Lightning Strike	1	0.9
Microburst/Dry	1	0.9
Mountain Wave	1	0.9
Thunderstorm	1	0.9
Turbulence, Convection-induced	1	0.9
Whiteout	1	0.9
Low Temperature	1	0.9
Other	2	1.8

[1]Numbers of accidents total more than 113, and percentages total more than 100, because some accidents included more than one meteorological condition and percentages have been rounded.

Source: U.S. Federal Aviation Administration National Aviation Safety Data Analysis Center (NASDAC) and Flight Safety Foundation

135 accidents (Figure 4, page 20) was landing (23.3 percent), followed by approach (17.4 percent) and takeoff (15.6 percent).

The set of data included an NTSB category for whether the flight crew of the accident aircraft was given a weather briefing from any source. Among Part 121 air carriers involved in 82 accidents in which the information was known, 92.7 percent of crews received a full weather briefing. Among Part 135 air carriers involved in 147 accidents in which the information was known, 75.5 percent had been preceded by a full weather briefing. In 16.3 percent of the 147 Part 135 accidents, the briefing was "partial — limited by briefer" and in 1.4 percent, the briefing was "partial — limited by pilot."

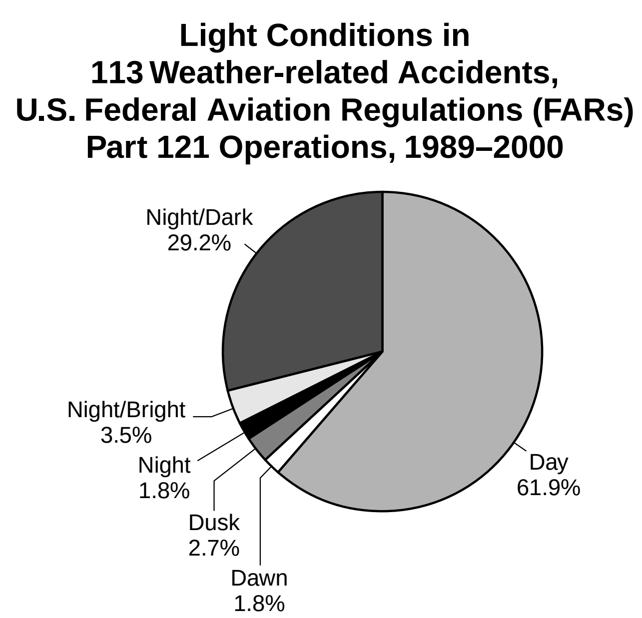
Table 2
Meteorological Conditions in 365 Weather-related Accidents, U.S. Federal Aviation Regulations (FARs) Part 135 Air Carriers, 1989–2000

Meteorological Condition	Number of Accidents In Which Condition Was Present[1]	Percentage of Accidents In Which Condition Was Present[1]
Low Ceiling	84	23.0
Fog	74	20.3
Snow	45	12.3
Icing	41	11.2
Crosswind	37	10.1
Gusts	35	9.6
Tailwind	35	9.6
Downdraft	26	7.1
Rain	26	7.1
Obscuration	24	6.6
Whiteout	24	6.6
Clouds	23	6.3
High Density Altitude	23	6.3
Unfavorable Wind	21	5.8
High Wind	14	3.8
Drizzle/Mist	10	2.7
Turbulence	8	2.2
Thunderstorm	6	1.6
Carburetor Icing	4	1.1
Turbulence, in Clouds	4	1.1
Turbulence, Terrain-induced	4	1.1
Freezing Rain	3	0.8
Turbulence, Thunderstorms	2	0.5
Variable Wind	2	0.5
Wind Shear	2	0.5
Haze/Smoke	2	0.5
Below Approach/Landing Minimums	2	0.5
Hail	2	0.5
Turbulence, Clear-air	2	0.5
Lightning	1	0.3
Microburst/Wet	1	0.3
Temperature Extremes	1	0.3
Mountain Wave	1	0.3
Static Discharge	1	0.3
Low Temperature	1	0.3

[1]Numbers of accidents total more than 365, and percentages total more than 100, because some accidents included more than one meteorological condition and percentages have been rounded.

Source: U.S. Federal Aviation Administration National Aviation Safety Data Analysis Center (NASDAC) and Flight Safety Foundation

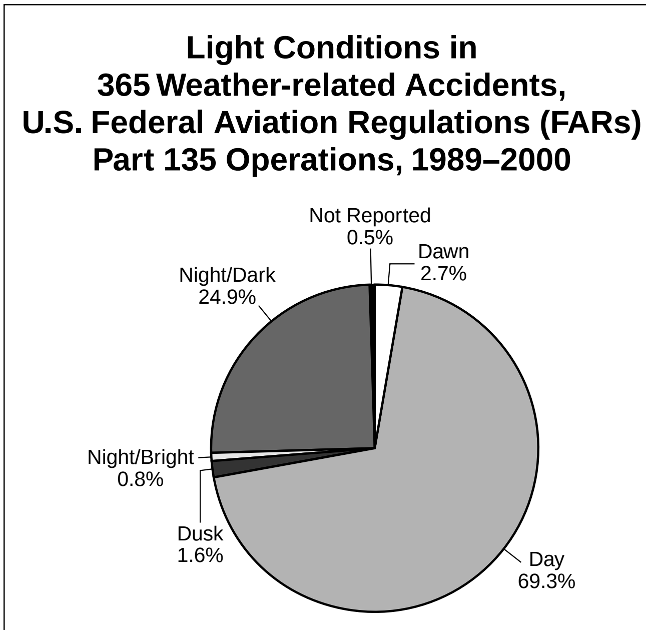
Among weather-related accidents involving Part 121 air carriers, 79.6 percent resulted in serious injuries and 7.1 percent resulted in fatalities (Figure 5, page 20). Among Part 135 weather-related accidents, 34.8 percent resulted in fatalities, and 12.6 percent resulted in serious injuries (Figure 6, page 20).



Note: Percentages do not total 100 because of rounding.

Source: U.S. Federal Aviation Administration National Aviation Safety Data Analysis Center (NASDAC) and Flight Safety Foundation

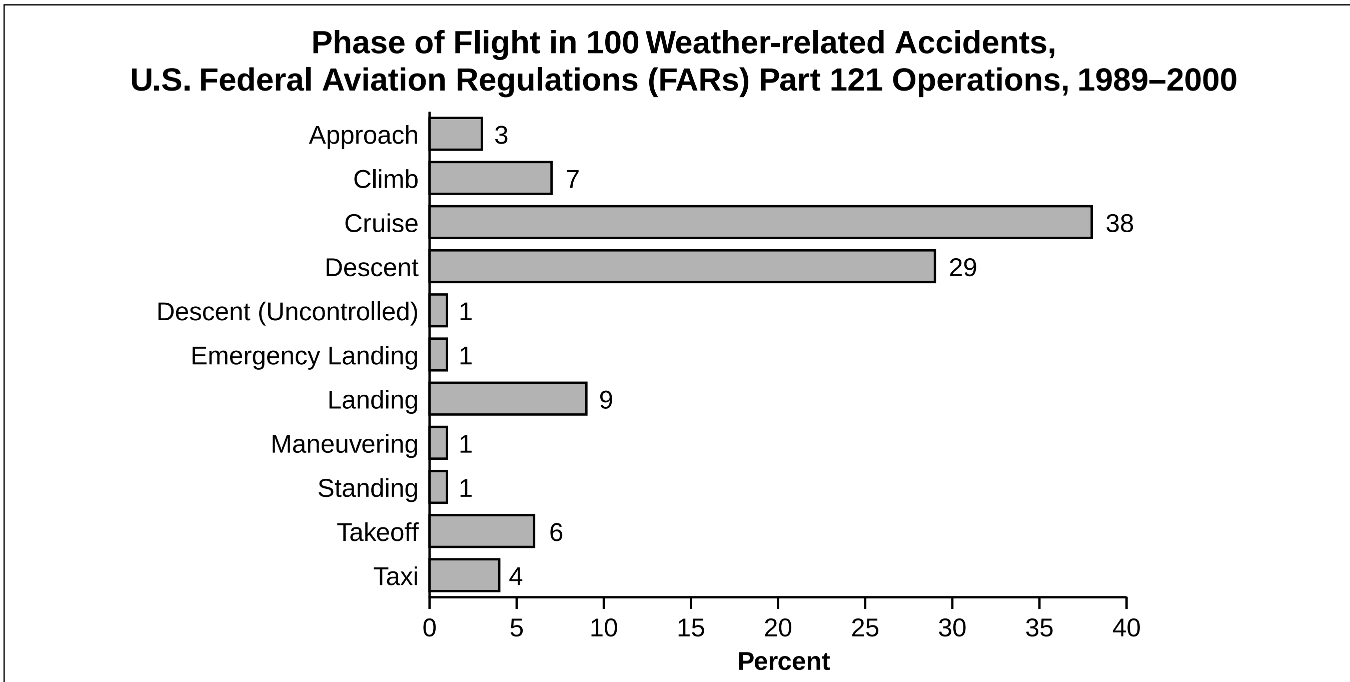
Figure 1



Note: Percentages do not total 100 because of rounding.

Source: U.S. Federal Aviation Administration National Aviation Safety Data Analysis Center (NASDAC) and Flight Safety Foundation

Figure 2

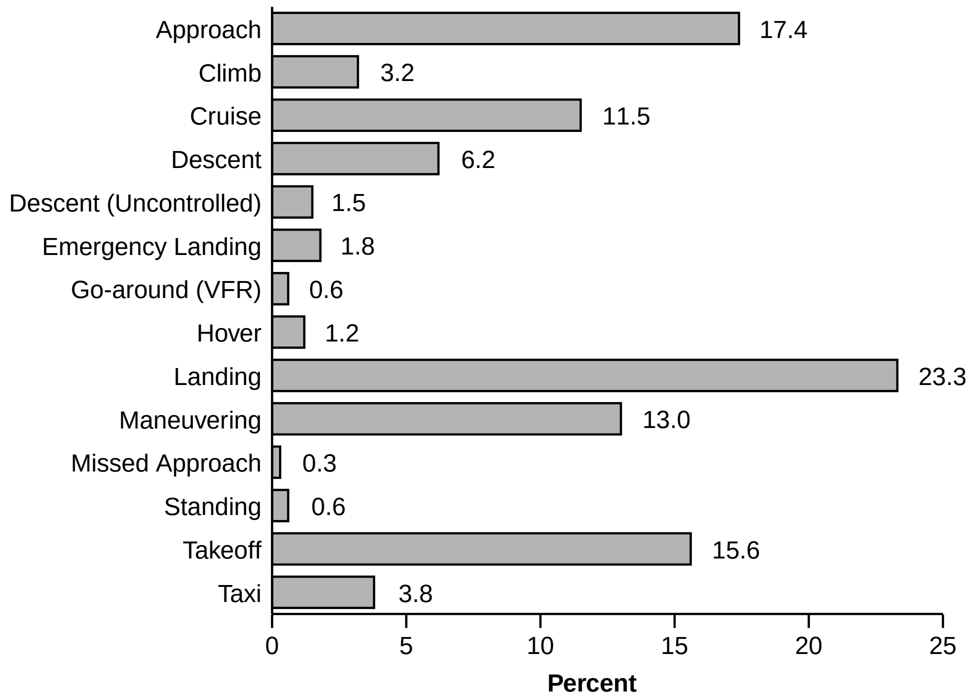


Source: U.S. Federal Aviation Administration National Aviation Safety Data Analysis Center (NASDAC) and Flight Safety Foundation

Figure 3

Four aircraft (3.5 percent) were destroyed in weather-related accidents involving Part 121 air carriers, 15.9 percent of accident aircraft sustained substantial damage, 9.7 percent sustained minor damage and 70.8 percent were undamaged. In weather-related accidents involving Part 135 air carriers, 40.5 percent of the aircraft were destroyed. There was substantial damage to 58.6 percent, minor damage to 0.5 percent and no damage to 0.3 percent. (Percentages do not total 100 because of rounding.)♦

Phase of Flight in 339 Weather-related Accidents, U.S. Federal Aviation Regulations (FARs) Part 135 Operations, 1989–2000

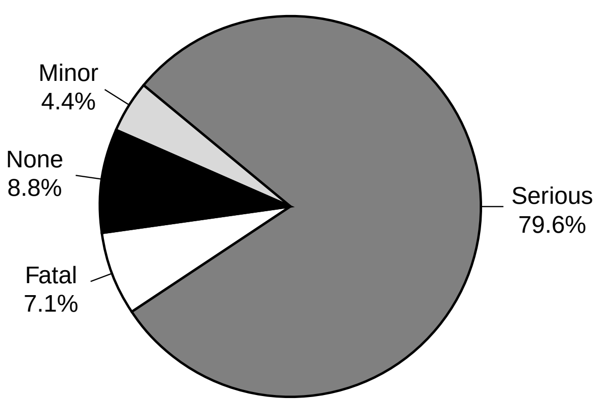


VFR = Visual flight rules

Source: U.S. Federal Aviation Administration National Aviation Safety Data Analysis Center (NASDAC) and Flight Safety Foundation

Figure 4

Injury Severity in 113 Weather-related Accidents, U.S. Federal Aviation Regulations (FARs) Part 121 Operations, 1989–2000

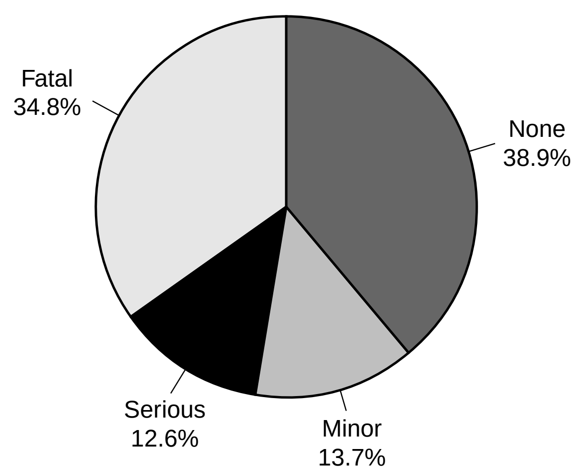


Note: Percentages do not total 100 because of rounding.

Source: U.S. Federal Aviation Administration National Aviation Safety Data Analysis Center (NASDAC) and Flight Safety Foundation

Figure 5

Injury Severity in 365 Weather-related Accidents, U.S. Federal Aviation Regulations (FARs) Part 135 Operations, 1989–2000



Source: U.S. Federal Aviation Administration National Aviation Safety Data Analysis Center (NASDAC) and Flight Safety Foundation

Figure 6

Publications Received at FSF Jerry Lederer Aviation Safety Library

Report Questions Feasibility of Small-aircraft Transportation System Concept

The Transportation Research Board of the U.S. National Research Council found no indication that using small aircraft in low-traffic airspace would offer a practical means of business travel and personal travel.

FSF Library Staff

Reports

Future Flight: A Review of the Small Aircraft Transportation System Concept. National Research Council (NRC). Transportation Research Board (TRB), Committee for a Study of Public-sector Requirements for a Small Aircraft Transportation System. TRB special report 263. 2002. 122 pp. Figures, tables. Available from Transportation Research Board.*

The National Academy of Sciences is a private, nonprofit, quasi-government organization created by the U.S. Congress to advise the government on scientific and technical matters. The NRC is its principal operating agency. The TRB, a division of the NRC, is charged with promoting innovation and progress in transportation. The Small Aircraft Transportation System (SATS) program was established by the U.S. National Aeronautics and Space Administration (NASA).

A key part of the SATS concept, according to the report, is a vision of small aircraft being flown between small airports in airspace that currently is lightly used. This would provide an increasingly larger share of the nation's intercity personal and business travel. Such a program, if successful, would alleviate some of the capacity pressures on airports and air transportation facilities. The committee conducted an analysis of the plausibility and desirability of the SATS concept.

The report provides an overview of the SATS vision and program plan and reviews the characteristics of the U.S. civil aviation fleet, airports and airways usage. It describes air transportation challenges, such as the sources and magnitude of congestion and air service to small cities. Key findings of the NRC committee were that:

- There is no indication to suggest that SATS aircraft can be made affordable for use by the general public;
- SATS has minimal potential to attract users if it does not, as conceived, serve the nation's major metropolitan areas;
- SATS promises to have limited appeal to price-sensitive leisure travelers, who make most intercity trips;
- Infrastructure limitations and environmental concerns at small airports are likely to present large obstacles to SATS deployment;
- Many technical and practical challenges await the development and deployment of SATS technologies; and,
- SATS has the potential for undesirable outcomes.

The committee did not find justification for SATS, pointing out that NASA's strength is in technology research and development, and not in defining, developing and promoting new transportation systems. The committee recommended that NASA, to better understand aviation needs, join with other relevant government agencies, led by the U.S. Department of Transportation, to undertake forward-looking studies of civil aviation needs and opportunities and to work with the U.S. Federal Aviation Administration, the U.S. National Transportation Safety Board and other agencies with operational and technological expertise.

***Blueprint for NAS Modernization: 2002 Update*.** U.S. Federal Aviation Administration (FAA) Office of System Architecture and Investment Analysis. October 2002. 76 pp. Figures, illustrations, photographs, appendixes. Available on the Internet at <www.nas-architecture.faa.gov/cats> or from FAA.**

In the report, the U.S. National Airspace System (NAS) is described as "a complex network of interconnected systems, as well as the people who operate, maintain and use the systems and detailed procedures and certifications. The NAS includes more than 1,900 airports, 750 air traffic control (ATC) facilities and about 45,000 pieces of equipment that operate unceasingly to provide safe and efficient flight services for users. The NAS spans the country, extends into the Atlantic, Pacific and Arctic Oceans, and interfaces with neighboring ATC systems for international flight." *The NAS Architecture*, the aviation community's plans for improving the NAS over the next several years, is no longer available in a print version. Instead, FAA is making comprehensive architecture information available at a special Internet site. The Internet site, <http://www.nas-architecture.faa.gov/cats>, continually updates and adjusts the architecture data. This 2002 update publication, available in a print version, provides an overview of the current NAS architecture and updates the modernization efforts first described in the 1999 "Blueprint for NAS Modernization."

The Effects of Practice and Coaching on the Air Traffic Selection and Training (AT-SAT) Test Battery. Heil, Michael C.; Detwiler, Cristy A.; Agen, Rebecca; Williams, Clara A.; Agnew, Brandy O.; King, Raymond E. U.S. Federal Aviation Administration (FAA) Office of Aerospace Medicine (OAM). DOT/FAA/AM-02/24. December 2002. 13 pp. Figures, tables, references, appendix. Available on the Internet at <www.cami.jccbi.gov> or from NTIS.***

FAA recently developed the Air Traffic Selection and Training (AT-SAT) test battery, a computerized selection test to screen air traffic control specialist (ATCS) applicants. Scores determine which applicants will be hired by FAA and sent to its academy for training. The report said that improved test scores resulting from practice and coaching may influence hiring decisions.

For this study, 150 individuals who were not ATCSs, but who met the basic requirements for an ATCS position, completed the test battery. Some participants took the tests multiple times (defined in this report as practice) so that test takers became more familiar with the test format each time they repeated the test. Instead of practice, other participants received coaching, which included helpful suggestions on the test-taking process and familiarization with the test format.

The report said that composite AT-SAT scores used for hiring decisions increased with repeated testing, with the greatest increase occurring after coaching. Nevertheless, the researchers questioned whether offering candidates the benefit of coaching would upgrade anything other than their test-taking skills.

"In terms of selection decisions, it is conceivable that coaching could move an individual from a failing status into a passing status and even from the qualified category into the well-qualified category, without improving their ability to perform on the job," said the report.

Books

Challenger's Shadow: Did Government and Industry Management Kill Seven Astronauts? Macidull, John C.; Blattner, Lester E. Coral Springs, Florida, U.S.: Llumina Press, 2002. 139 pp. Tables, illustrations, photographs, appendixes.

As the Presidential Commission on the Space Shuttle Challenger Accident began its investigation a few weeks after the Jan. 28, 1986, accident, John Macidull, an accident investigator assigned by the U.S. Federal Aviation Administration to the commission staff, offered this written suggestion: "Although there is a natural tendency to focus on the most obvious physical cause of the accident, and all are encouraged to provide input in that direction, a complete investigation requires uncovering and addressing all aspects, and to include or eliminate all possibilities that could either have contributed to the accident or could influence future practices, lines of communication and hardware design."

Sixteen years later — reviewing the commission's final report and comparing it with other accounts of the Challenger accident — Macidull and aerospace journalist Lester Blattner conclude in this book that the commission devoted excessive attention to hardware performance, especially to the "O-rings" that sealed joints in segments of two solid-rocket motors during launch. The authors believe that this attention resulted in a correct determination of physical causes but failed to determine adequately either the latent causes (such as institutional/political pressures) or the causality of pre-launch decisions by the responsible teams and individuals. Macidull concludes, "The real cause of the accident was the group of people involved in the decision to launch [Challenger] under untried environmental conditions with a known defect."

The authors use testimony and data from the commission's final report, interviews with participants, responses from federal government agencies received under the Freedom of Information Act, Macidull's experience during the investigation and information from other sources to support the following allegations: criteria for selection of commission members and the 120-day period allotted for the commission's investigation were inadequate; interests of astronauts were not represented adequately in the launch-decision process; the relationship of the U.S. National Aeronautics and Space Administration (NASA) to the commission unduly influenced the independence of the investigation; investigators at times were obstructed in their inquiry because requested information (e.g., crew checklists, photographs, audio recordings, motion-picture films and flight data) was withheld by NASA; insufficient follow-up questioning of witnesses occurred during public hearings and misrepresentation of some technical information was not challenged; data-driven judgments of engineers were overruled by managers who were influenced by commercial pressures, power relationships and cultural differences among professions; errors were identified and the commission did not assign responsibility for wrongdoing to individual decision-makers; errors were made in assigning relative "criticality" status to some shuttle components; and facts about the final minutes of life for the astronauts killed in the accident (including the possibility of astronauts surviving such an explosion with an additional crew-escape system) were suppressed.

The book includes the 1986 plan of investigation and operating procedures suggested by Macidull; Macidull's comments on people, methods and problems encountered in the commission investigation and while writing the final report; a brief history of NASA's manned-space-flight programs; civilian objectives and military purposes for the space shuttle program; the state of technical knowledge of O-ring performance among NASA managers and contractors before the accident; participants' decisions during approximately 22 hours preceding the Challenger launch; and a transcript of communications, with annotations by the authors, during the three minutes and 15 seconds preceding the Challenger explosion.

Regulatory Materials

Altitude Reporting Equipment and Transponder System Maintenance and Inspection Practices. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 43-6B. Aug. 14, 2002. Tables, appendixes. 18 pp. Available from GPO.****

Altitude-reporting equipment and transponder systems are essential for the safe operation of aircraft within the U.S. national airspace system and many other countries. This AC contains information about acceptable methods of testing altimeters, static systems, altitude encoders and air traffic control transponder systems. The material provides means of testing to be used at the time of original installation, after performing repairs and during scheduled recertification.

[This AC cancels AC 43-6A, Automatic Pressure Altitude Encoding Systems and Transponders Maintenance and Inspection Practices, dated Nov. 11, 1977, and AC 43-203B, Altimeter and Static System Tests and Inspections, dated June 20, 1979.]

Issuance of Repair Station Certificates to Foreign Approved Maintenance Organizations Under the Maintenance Implementation Procedures of a Bilateral Aviation Safety Agreement. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 145-7A. Sept. 23, 2002. Appendixes. 30 pp. Available from GPO.****

The need to maintain aircraft and aircraft components outside national geographic and certification boundaries is addressed by maintenance inspection procedures (MIPs) under the auspices of a Bilateral Aviation Safety Agreement (BASA). Because FAA and certain other national aviation authorities (NAAs) have extensive inspection, surveillance, evaluation and certification programs for their respective repair facilities, the countries executed an agreement, BASA, a system to promote aviation safety and eliminate duplicate activities.

This AC provides information and guidance to any approved maintenance organizations (AMOs), approved by an NAA, that want to obtain, renew or amend a U.S. Federal Aviation Regulations (FARs) Part 145 repair station certificate. The certificate is obtained under provisions of the MIPs. The MIPs are based on an FAA and NAA evaluation of Parts 43 and 145 and the country's national regulation governing AMOs. The AMO seeking the certificate must be located in a country with which FAA has concluded a BASA/MIP.

Appendixes include FAA special conditions contained in MIPs; a sample FAA supplement to a maintenance organization manual; comparison charts of FAA Part 145 repair-station ratings and Joint Aviation Authority-approved maintenance organization ratings; and a sample FARs/Joint Aviation Regulations (JARs) regulatory comparison chart.

[This AC cancels AC 145-7, *Issuance of Repair Station Certificates to JAA-approved Maintenance Organizations Under the Maintenance Implementation Procedures of a Bilateral Aviation Safety Agreement*, dated May 11, 1998.]♦

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2101 Constitution Avenue, NW
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http://www.TRB.org

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Office of System Architecture and Investment Analysis
NAS Architecture Branch
ASD-110
800 Independence Avenue, SW
Washington, DC 20591 U.S.

*** National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161 U.S.
Internet: <http://www.ntis.gov>

**** Superintendent of Documents
U.S. Government Printing Office (GPO)
Washington, DC 20402 U.S.
Internet: <http://www.access.gpo.gov>

Accident/Incident Briefs

Airplane Damaged After Entering Turbulence, Hailstorm

The accident report said that the crew's preparations for the flight were "partly inadequate" because they did not review all relevant information about en route weather conditions.

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

Hailstones Crack Windshields, Damage Radome

McDonnell Douglas DC-9-81. Minor damage. No injuries.

During descent to land at an airport in Finland after an afternoon flight from Sweden, the airplane entered a cumulonimbus (CB) cloud at about 15,200 feet and encountered turbulence and hailstones — some as large as five centimeters (two inches) in diameter. The crew heard thunder and selected the weather radar, but a radar image was not generated because the radar antenna had been damaged by hail. Windshields in front of the captain and the first officer cracked. The ground-proximity warning system (GPWS) provided two "terrain" warnings, and the autopilot disconnected.

The accident report said that the two GPWS warnings were a result of "the radio altimeter starting to measure distance from the hailstones, which were abundant in the cloud." When the warnings occurred, the airplane was about 12,600 feet above the area minimum altitude.

The crew turned the airplane 180 degrees to avoid another CB cloud. Soon afterward, the autothrottles disconnected. Several minutes later, the crew declared an emergency, told air traffic control (ATC) that the windshields had cracked and requested radar vectors to the destination airport. The airplane was landed nine minutes later.

The captain told passengers over the public-address system that the airplane had entered a hail shower and "that it had been unpleasant but not dangerous."

Examination of the airplane revealed hail damage to the radome, engine-inlet cowlings and leading edges of wings and stabilizers.

An investigation revealed that the crew had arrived at the departure airport early to plan the flight and had reviewed routine aviation weather reports, airport forecasts, notices to airmen and company circulars. The accident report said that they did not review the significant weather chart or take a copy of the chart with them. (The report said that the chart showed occasionally high CB clouds embedded in other clouds along the intended route.) The captain said later that they had taken extra fuel because "there [were] some CB clouds and rain showers." Her briefing of the cabin crew for the flight did not include a discussion of weather conditions.

The report said that the crew had used airborne weather radar during the first 10 minutes of the flight and then selected the unit "OFF." They flew the airplane above clouds in clear weather and unrestricted forward visibility; the captain said, however, that the boundary between the clouds and clear sky was obscured because of moisture in the atmosphere.

The report said that a SIGMET (a message on significant meteorological observations) was distributed eight minutes after the airplane entered the CB cloud.

Analysis of weather radar images showed that there was a thunderstorm covering a distance of about 15 kilometers by 50 kilometers (nine statute miles by 31 statute miles) at the accident site. The primary radar display used by ATC at the time of the accident did not show the CB clouds.

The report said that the probable cause of the accident was that "flight preparation was partly inadequate, in respect [to] en route weather, and the pilots did not form a correct picture of the weather conditions in flight so that the airborne weather radar would have been used to avoid the CB cloud."

The report said that a contributing factor was "that the … SIGMET was prepared too late, considering the development of weather conditions."

Uncontained Engine Failure Damages Leading-edge Flaps

Boeing 767-200. Substantial damage. No injuries.

While flying the airplane through Flight Level 110 (approximately 11,000 feet) during a flight from Australia to New Zealand, the flight crew heard a loud bang and felt the airplane move right, and then yaw left. They determined that the left (no. 1) engine had failed, and they shut down the engine.

The captain declared an emergency and received radar vectors from air traffic control for a return to the departure airport. The flight crew observed that there had been damage to the engine nacelle and the leading-edge flaps.

The preliminary report said, "In consideration of the flap damage, the crew elected to carry out the approach without using the leading-edge flaps and using only partial extension of the trailing-edge flaps. Late in the final approach, the first officer made a 'brace' call to the passengers and cabin crew using the public-address system. The aircraft approach and landing was uneventful."

An inspection of the airplane revealed a "large rupture" of the outboard core cowling and "severe gouging and scoring of the outboard side of the engine strut" above the damaged cowling. The report said that the first-stage high-pressure turbine disk had failed and had released part of the disk rim and outer web, the engine casing around the disk had been severed and the central shaft had broken between the first-stage high-pressure turbine disk and the second-stage high-pressure turbine disk. Further examination revealed that the turbine disk had fractured because of fatigue cracking that originated at the bottom of a turbine-blade dovetail slot.

At the time of the failure, the turbine disk had accumulated 12,485 cycles since new and 4,579 cycles since the last complete inspection. The accident investigation was continuing.

Wing of Taxiing Airplane Strikes Parked Aircraft's Window

Antonov An-124-100. Minor damage. No injuries.

After a midday flight from Ukraine to England, the flight crew was told by air traffic control (ATC) to taxi the airplane on Taxiway Charlie. On the taxiway, the captain moved the airplane slightly right of the centerline to avoid a building near the left side of the taxiway. He then moved the airplane slightly left of the centerline to avoid a parked airplane near the right side of the taxiway.

As the airplane was taxied past the parked airplane, ATC told the crew that their airplane's right wing apparently had struck the parked airplane.

The captain, who had been taxiing the airplane, said that his attention had been divided between taxiing and following directions from ground personnel and the first officer. An examination revealed damage to the fairing on the An-124's right wing and a broken window on the parked airplane.

ATC information and airport information say that the An-124's wingspan of 73.3 meters (240.5 feet) requires that the airplane be towed — not taxied — on Taxiway Charlie.

After the accident, ATC management distributed a memo to controllers to remind them of the towing requirement.

Icing Conditions Forecast Before Fatal Flight

Cessna 421C Golden Eagle. Destroyed. One fatality.

Instrument meteorological conditions prevailed for the on-demand cargo flight in the United States. Before a series of evening and night flights, the company dispatcher told the pilot that icing conditions were possible and asked the pilot to obtain more detailed weather information to determine whether the flight should be conducted in a different airplane.

A preliminary report said that the pilot told the dispatcher that "weather would not be a problem." About half an hour later, the dispatcher told the pilot that the flight would include an additional segment; he observed the pilot at the weather station computer and on the telephone before the pilot again said that the weather "should still not be a problem," although there might be "a little problem" during departure from the airport where the fourth flight segment was to begin.

Weather at the destination airport, 25 nautical miles (46 kilometers) northwest of the accident site, at 1956 included wind from 340 degrees at six knots; visibility of 10 statute miles (16 kilometers); few clouds at 800 feet, scattered clouds at 2,500 feet and an overcast at 4,200 feet; temperature three degrees Celsius (C; 37 degrees Fahrenheit [F]); dew point minus one degree C (30 degrees F); and the altimeter setting 30.11 inches of mercury (1019.64 hectopascals). Rain had ended at 35 minutes past the hour, and mountains were obscured, northeast to southeast. During the next hour, scattered clouds formed at 600 feet and dissipated at 2,500 feet, and the wind shifted to 010 degrees at seven knots.

The pilot completed the first two flight segments and began the third flight segment at 1950 local time. The estimated flight time was 50 minutes. The last contact between air traffic control (ATC) and the pilot — who was receiving visual flight rules flight-following services — was recorded at 2030. At 2126, ATC told the company dispatcher that a loss of radar contact with the airplane had occurred.

The wreckage was found on upsloping rocky terrain at 9,125 feet.

Door Separates From Airplane During Flight

Lockheed L188C Electra. Minor damage. No injuries.

The airplane was being flown through 4,000 feet after a late-afternoon takeoff from an airport in France when the flight crew heard a loud bang and the airplane shook and depressurized. The crew began to return to the departure airport and declared mayday, a distress condition. The airplane was landed without further incident.

An examination of the airplane, which had been converted for cargo operations, revealed that the crew-emergency-exit door was missing. The only damage to the airframe involved the door's forward hinge. The accident report said that the missing door (which was not recovered) had not been placarded or marked to indicate the "LOCK/CLOSED" handle position and the "UNLOCK/OPEN" position. There were no entries in the airplane's technical log involving the "door unsafe" warning system.

The airplane had been loaned to the operator by another company because maintenance was being performed on the airplane usually flown by the crew. That airplane was equipped with a different type of "door unsafe" warning system.

After the accident, the operator and maintenance organization affixed placards to the door lock/hook tensioning handle to depict the "LOCKED/CLOSED" position and the "UNLOCK/OPEN" position of the handle. They also safety-wired the handle to indicate its movement, added a preflight check of the handle position and published a notice to crews about correct operation of the handle.

Landing Gear Collapses During Rollout

Beech Super King Air 200. Substantial damage. No injuries.

Visual meteorological conditions prevailed for the afternoon takeoff from an airport in the United States. After takeoff, the flight crew moved the landing-gear lever to retract the landing gear, but the landing gear did not retract fully.

The crew conducted the emergency checklist, but they could not correct the problem. To consume fuel, the captain decided to continue the flight to the destination airport. The crew asked controllers at the air traffic control tower of an en route airport to observe the landing gear, but the controllers said that they could not determine whether the landing gear was extended and locked in position.

The crew landed the airplane at another airport closer to the destination airport. During the landing rollout, the two main landing gear collapsed.

Airplane Rolls Off End of Runway During Landing

Cessna 551 Citation II. Substantial damage. No injuries.

After an instrument approach, the airplane was landed with a light tail wind on a wet runway at an airport in France. As the airplane slowed to about 80 knots, the pilot said he was experiencing braking problems.

The airplane continued off the end of the runway onto soft ground, and the nose landing gear collapsed.

Other General Aviation

Airplane Strikes Terrain During Landing Approach in Gusty Winds

Cessna 182B. Destroyed. One fatality, one serious injury.

After a visual flight rules flight of about 2.5 hours, the pilot flew the airplane at 500 feet above ground level (AGL) over a relative's property, located near the destination grass airstrip in Australia. The relative had been asked in advance by the pilot to cancel the search and rescue time cited in the flight plan.

After observing the airplane over the property, witnesses watched as the airplane was flown into the traffic pattern at the nearby airstrip.

The accident report said, "The airstrip was aligned approximately 305 degrees. The aircraft was observed to turn left onto final approach at about 50 [feet] to 80 feet AGL. All turns were reportedly made using about 45 degrees angle of bank. Witnesses also observed the aircraft to be buffeted by gusting winds."

Winds were described as "strong and blustery" from the west and northwest.

Witnesses observed that, while on final approach, the airplane entered a climbing steep turn to the right, then descended rapidly and struck the ground in a 60-degree to 80-degree nose-down attitude, with the left wing low, about 300 meters (984 feet) east-northeast of the airstrip's threshold.

Examination of the wreckage revealed that the flaps were retracted fully and that the engine was capable of normal operation before the impact. The accident investigation was continuing.

Activated Circuit Breaker Prevents Landing-gear Extension

Cessna 210 Centurion. Minor damage. No injuries.

After takeoff from an airport in Northern Ireland where avionics maintenance had been completed on the airplane, an electrical problem occurred and the pilot observed that the autopilot did not function.

The pilot told air traffic control that he wanted to return to the airport. On final approach, the pilot selected 10 degrees of flaps and selected the landing-gear handle "DOWN." He said that he believed that he had observed illumination of the green landing-gear indicator light and that when he looked out the left window, he had observed that the left-main landing gear had extended. He heard no sound from the landing-gear warning horn when he retarded the throttle. After touchdown, the underside of the fuselage contacted the runway.

An examination of the airplane revealed that, although the landing-gear handle was in the "DOWN" position, the landing gear had not locked in that position.

The landing gear are extended and retracted by hydraulic actuators, and hydraulic pressure is generated by an electrically controlled pump assembly. The pump motor is activated by a pressure switch when pressure in the pump delivery line reaches specified levels. Two circuit breakers — one for the indication circuit and the control circuit and the other for the pump motor — provide electrical power. When the battery master switch is on and the two circuit breakers are functioning properly, the pump assembly operates automatically; if either circuit breaker fails, the pump assembly does not operate.

The landing-gear handle in the cockpit is a hydraulic changeover valve. When the pilot moves the handle to select the "UP" or "DOWN" position, the pressure-delivery line from the pump assembly is connected to the three landing-gear actuators and the two main-landing-gear downlock actuators.

The accident report said, "On the approach to land … when the landing gear was selected to 'DOWN,' it would have released the gear from the 'UP' position, where [they] had been held by locked-in hydraulic pressure. Because the hydraulic-unit pump-motor circuit breaker had tripped [opened] and, as a result, the hydraulic system could not be pressurized, the main-landing-gear legs would have trailed at a position of equilibrium in the airstream."

The accident report said that the airplane's landing-gear-indication system includes one green light that illuminates when all three landing gear are locked down and one amber light to indicate when all three landing gear have been retracted fully. When the landing gear is in transit or if one landing gear is not at its full-limit position, there is no indicator light. The system also includes a warning horn that sounds if the landing gear is not locked down when the throttle is moved beyond a specific low-power position.

Pilot Cites Distraction as Cause of Landing Accident

Jabiru SP. Substantial damage. No injuries.

The pilot was conducting takeoff and landing practice at an airport in South Africa. On the fourth landing, the airplane bounced and then touched down on its nosewheel. The nose landing gear collapsed, and the airplane flipped forward onto its back.

The pilot said that he had been distracted before the touchdown by a tractor that was being used to mow grass next to the runway.

Rotorcraft

Pilot Reports Bird Strike Before Off-field Landing

Rotorway Executive 90. Minor damage. No injuries.

The helicopter was being flown on an afternoon flight in England when the pilot told an airport radio operator that he had little remaining fuel and requested clearance to the airport refueling area. Ramp personnel asked the pilot to confirm the type of fuel required, but the radio operator received no response to subsequent calls to the helicopter pilot.

The pilot of an aircraft departing from the airport observed the helicopter in a field next to a runway threshold.

The pilot and witnesses on the ground said that birds had been flying over fields near the runway. Soon after the pilot observed the birds, there was a loud bang, and the helicopter began to vibrate and then yawed left. The pilot conducted an autorotation and landed in the field. Later, he said that the tail rotor was struck by a bird. Rescue personnel said that they saw no bird remains, and no bird remains were found during repairs to the tail rotor, which received mechanical damage.

Tail Boom Breaks During Takeoff in Gusty Winds

Bell 206L-4 LongRanger IV. Substantial damage. No injuries.

Visual meteorological conditions and gusty winds prevailed for the takeoff from an offshore platform in the Gulf of Mexico. The pilot said that he waited for the winds to subside, then began to reposition the helicopter on the platform before the planned takeoff. After he started the engine, the helicopter lifted off the platform, and the pilot turned the helicopter 180 degrees into the wind. After a sudden gust of about 30 knots, he landed the helicopter on the platform; when the gusts subsided to about 20 knots, he began the takeoff again.

The pilot said that during the takeoff, the helicopter "immediately started to bounce uncontrollably and [slide] to the left (south)." The pilot lowered the collective and closed the throttle. The helicopter stopped on the platform's safety fence.

An examination of the helicopter revealed that the tail boom had broken.

Baggage Door Opens During Flight

Aerospatiale AS 350BA. Destroyed. Four minor injuries, one uninjured.

Visual meteorological conditions prevailed for the afternoon flight in the United States. At 800 feet, during the initial descent to the landing site, the pilot felt a "sudden hard shudder" and heard a noise. A passenger observed that the right baggage door was "open and flapping."

The helicopter yawed left, and the pilot said that his input on the tail-rotor pedals had no effect. The pilot increased power to gain altitude, but the helicopter entered a spin to the left. The pilot began an autorotation, and the helicopter struck water and remained upright. The pilot and all four passengers exited the helicopter; they were rescued by the crew of a fishing boat.♦

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