ASRS Directline

Issue Number 6

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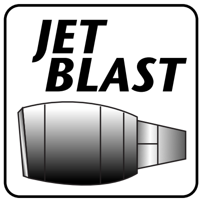
August 1994

Here is issue six of ***ASRS Directline***. Our previous issue of ***Directline*** featured two articles that were adaptations of research papers that were presented at the Ohio State University (OSU) 7th International Symposium on Aviation Psychology. This issue contains two more: *"Emergency 911—The Story of EMS Helicopter Operations,"* and *"Lost Com,"* an investigation of the factors involved in loss of communication. We also have an excellent examination of jet blast problems, and, for the second time, a review of ASRS Database Statistics. Don't forget—we like to hear from you; if you have suggestions or comments, kindly drop us a line. Here are the articles in this issue:

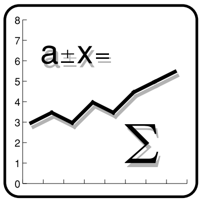
Ground JET BLAST Hazard by Rowena Morrison **4**
Rowena Morrison, Editor of ASRS' award-winning CALLBACK publication, takes a look at ground jet blast hazards. Although the aviation industry has made great strides in reducing these hazards, Rowena finds that jet blast remains a safety concern. Read along as she takes a fresh look at ground jet blast hazards and passes along some time-tested and new suggestions for dealing with the problem.



Emergency 911—EMS Helicopter Operations by Linda Connell and Marcia Patten **12**
Do you, or someone you know, owe your lives to the pilots and medical team of an Emergency Medical Service (EMS) helicopter crew? The pressures that EMS crews face, and the conditions under which they must operate, are examined in this excellent adaptation of the paper presented at OSU by Linda Connell. Even if you fly a 747, you will have a heightened appreciation of the men and women in EMS operations the next time that you hear the callsign "Lifeguard" on the radio.

Lost Com by Charles Drew, Andrew Scott, and Bob Matchette **19**
Ever since we started relying on radios for communication and control in aviation, we have had loss-of-communication problems. This article examines the how and why of loss-of-communication events, then takes a further look at why there is often a delay in pilot recognition in lost com. The article sums up with some advice from our pilot and controller analyst staff on how to prevent, or recover from *"Lost Com."*

ASRS Database Statistical Information compiled by Loren Rosenthal **26**
We first published a summary of ASRS Database statistics in Issue Number 4 of *ASRS Directline* (June 1993). Here is an updated version that includes data through the end of 1993; we intend to provide these data on a yearly basis. Who reports to the ASRS, and what kind of events are they experiencing? After you take a look at this section, drop us a line and let us know how you use this information, and what statistical data you might like to see in future issues.



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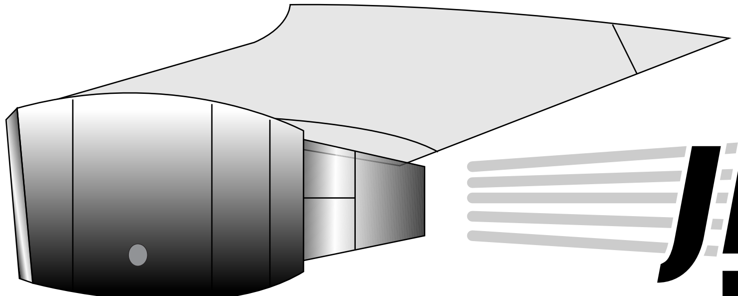
.... **Charles Drew, *ASRS Directline* Editor**



Ground JET BLAST Hazard

by Rowena Morrison

"During taxi out…we were informed on the Ground frequency by Air Carrier B that one of their passengers deboarding behind us was "blown down and injured" by our jet blast while departing the ramp. All three engines were running as I anticipated a short taxi. No more than idle thrust was required nor used as we were very light…I made approximately a 45-degree right turn toward taxiway before being released from guide person. We could not see, nor were we informed, of any boarding operation behind us. I believe Air Carrier B was remiss for allowing a deboarding operation behind a jet whose engines were running." (ACN 79190)

"…Widebody was cleared for takeoff, and we [commuter twin] were cleared into position and hold. The Captain called for the controls unlocked and runway checklist. While on [taxiway] approaching the runway, just after the hold line, the jet blast hit the airplane. The Captain applied the brakes, however the jet blast lifted the right wing and the right main gear off the ground. The jet blast blew the aircraft into the blast fence at the approach end of Runway 31L." (ACN 145186)

Jet Blast Data

Almost every commercial jet operating manual has one—a single page with the matter-of-fact title, "Jet Blast Data." On this page is a diagram of the aircraft's jet blast "damage profile," as measured from the tail and with engines at low RPM settings (usually 35 to 40 percent N_1). This profile extends in line from the outboard wing-mounted engines to more than 200 feet behind some larger aircraft. Within this area, jet engines can generate hurricane-level exhaust forces approaching 100 knots.

The potentially dire results? Before a crew can say "powerback," jet engine blast can up-root trees, flatten building structures, shatter windows, lift and propel heavy objects, weathercock braked airplanes, blow over lift trucks, shift unbraked baggage carts, and create other havoc on airport ramps, taxiways, and runways. Although the diagrams don't say so, jet blast can also injure or kill crew and passengers who happen to cross its path.

The fact that few serious jet blast incidents and accidents occur during millions of ground operations annually is a tribute to the training and professionalism of air carrier flight and ground crews, and to the continual care they exercise in ground operations. When we looked at ASRS data, we found that ground jet blast incidents (fifty-one reports) represented only a tiny fraction of the total incidents reported. Yet even this small number of jet blast reports contained some surprises:

& Almost half of the jet blast incidents reported to ASRS occurred on taxiways, in run-up areas, and adjacent to or on runways—all relatively uncongested airport areas. The other half occurred on ramps, where many more such incidents might be expected because of close aircraft parking and tight maneuvering conditions;

& Incidents of jet blast damage that occurred on ramps were invariably associated with sharp *turns* of the aircraft during an engines-on pushback, powerback, taxi-out, or taxi into a gate. Use of a tug or tractor did not prevent such incidents if the aircraft was turned sharply during the pushback or taxi-in maneuver;

& Eighty-five percent of the damage inflicted by jet blast was to the wings, props, flaps, and rudders of other aircraft, especially to light aircraft weighing five-thousand pounds or less. Eleven percent of the damage incidents involved building structures, objects, or vehicles. Injuries to people accounted for four percent of the jet blast damage total.

What are the lessons to be learned from these ASRS jet blast incidents? We begin by briefly revisiting the sites where almost half the jet blast incidents reported to ASRS occurred—taxiways, runup areas, and areas on or immediately adjoining runways.

Taxiways and Runways: *Aim* Prevents *Blame*

Collectively, off-ramp sites accounted for forty-seven percent of the jet blast incidents reported to ASRS. These off-ramp locations were taxiways; areas on or immediately adjoining runways, and run-up areas . (See Table 1, below.)

Table 1 — Site Of Jet Blast Incident

Site of Incident	No. Rpts.	% Data
Ramp	27	53
Taxiway	10	20
Runway (Hold, Landing, Takeoff)	10	20
Runup Area	4	7
Total ▶	**51**	**100%**

The usual targets of jet blast in these locations were light aircraft weighing 5,000 pounds or less, that were unexpectedly crunched and pummeled by the blast forces from jet engines. Frequently, the jet blast damage was the result of misdirected engine run-ups and tests. This pilot's experience was typical, down to the inevitable details of a prop strike and bent wing:

> ✍ "…We taxied out and followed the taxiway east then turned southbound…After the turn had been completed, I felt the airplane being lifted from the tail and forced over to the right side. The nose, prop, and right wing struck the ground, then we started to be pushed along the taxiway in that position…It was not until I was outside of the airplane that I realized that we had been overturned by an air carrier jet that was doing a runup facing the blast fence with the jet blast directed toward the taxiway…I was told that the occupants of the jet were all maintenance [personnel]…" (ACN 226055)

Heavier aircraft were also susceptible to jet blast damage in these locations. In an incident reported by two different flight crews, a small transport aircraft (in the 5,000 to 14,500 pound weight category) played "chicken" with a widebody aircraft holding in position on a runway for a nighttime takeoff—and lost. The sense of helplessness experienced by the pilot of the small transport came through clearly in his report to ASRS:

> ✍ "The widebody was sitting in position and was not rolling and I felt I could cross behind him and taxi to park. I pushed up the power to cross and about halfway across the WDB pushed up his power to begin his takeoff roll. His jet blast blew me off the runway into a grass area…The prop tips were damaged on the taxi lights and the left wing came in contact with the ground and was bent…I was not aware that his jet blast would render an aircraft the size of mine so helpless." (ACN 253191)

The Captain of the widebody aircraft involved in this incident had several suggestions for preventing jet blast damage during night operations:

> ✍ "…I think the SMT [small transport] should have waited until our liftoff at least before crossing, or Tower should have withheld clearance for some specified distance on our takeoff roll. Remaining jet blast is very hard to estimate at night and timed or distance separation before light aircraft cross is the only solution." (ACN 253191)

Several broad themes emerged from this group of reports:

1) The danger of performing engine tests and run-ups when jet blast is directed across active taxiways and runways;
2) The need for Tower and Ground Controllers to carefully monitor jet blast hazard, specifically the *direction* of jet engine exhaust.

Both themes were dramatically evident in this controller's report of a large jet's engine run-up calamity:

> ✍ "Air carrier LGT [large transport] called Ground Control for a full power engine runup at the gate. Ground Control advised him he would have to go to the jet runup area…The heading for aircraft operating in this area is 220 degrees…Ground Control advised the heading, the LGT complied. As the LGT made his full power runup, the Ground controller observed a cloud of dust several hundred feet in the air and debris blowing on the departure end of the runway in use (up to 1500 feet). The Ground controller immediately called the aircraft to cease runup. After 2 or 3 calls the aircraft complied. When the dust and debris cleared, the damage that was done was the complete destruction of the localizer…If the county…continues to use this area for maintenance runup, they should install a blast fence…" (ACN 124003)

Several pilots admonished Ground Control for not monitoring run-ups of larger aircraft more carefully, and for failing to provide light aircraft with warnings of jet blast hazard:

> ✍ "Ground Control cleared me to taxi to my parking area. I was following my clearance to taxi and approximately 600 feet down the taxiway, my aircraft was caught in a jet blast produced by an aircraft testing its engines in a run-up area. The force of the jet blast caused excessive lateral force on the left main gear of my aircraft causing it to collapse…No warning was given me by Ground Control. The aircraft doing the run-up was in contact with Ground Control and was not asked to reduce power…Ground Control [should] instruct all aircraft in the run-up area to direct their blast away from the taxi area instead of across it…" (ACN 133597)

In a similar incident, a small aircraft performing a run-up 150 feet behind, and to the side of, an airliner holding short of the runway, experienced a wing and prop strike when the larger aircraft powered up. The pilot of the small plane had succinct advice for both the jet crew and ATC:

> ✍ "Causes: 1) the jet should not perform engine checks/run-ups on a taxiway without contacting Ground Control. 2) ATC should warn heavy aircraft about smaller aircraft behind them." (ACN 156166)

On the Ramp: *Position* Engines

Fifty-three percent of the jet blast damage incidents reported to ASRS occurred on an airport ramp during pushback, powerback, taxi-out, or taxi-in. Several different factors appeared to influence these events. The most significant was the position of jet engines in relation to gates, ground equipment, people, and other aircraft on the ramp when breakaway power was applied. Another prominent factor was the proximity of light aircraft, including commuter-type aircraft, on or near ramps with turbojet operations. A final element was ground handling procedures, including gate radio communications and disposition of baggage carts.

Power + Turns = Hazard. More than a third of the jet blast ramp incidents involved aircraft that had *engines powered* and were *turning 45 degrees or more*. In a few cases, not even the use of a tractor or tug prevented jet blast damage if engines were running, and an aircraft was in the process of making a sharp turn. This can be explained in part by the power requirements associated with ramp operations—an aircraft initiating movement from a full stop requires relatively more power to overcome inertia and tire friction than an aircraft already in motion. Additional breakaway thrust is needed if the aircraft must also turn during the initial movement. Unless carefully managed, these power applications can result in jet blast damage.

One reporter described unusually severe damage from jet blast that occurred during a hard turn, on a congested ramp not designed for larger aircraft:

> ✍ "While taxiing out, we were advised by another aircraft that due to our turn and tailpipe position, his aircraft had sustained some damage. After calling Ramp Control, we later learned we had blown out some terminal windows, knocked over a ramp truck, put the elevators of two aircraft into the full up position, and done some damage to miscellaneous air freight cargo equipment…At departure time, because of our close proximity to the terminal and the heavy weight of our aircraft, all engines were started up at the gate. After the salute, I advanced the throttles to breakaway thrust, and was directed to begin a hard right turn to clear another aircraft parked on our right. Once the aircraft was moving, I reduced power and concentrated on the signalman. The ramp at XYZ, like at many small airports, was not designed to handle LGT [large transport] and MLG [medium-large transport] sized aircraft. By attempting to maneuver around without the use of a tractor or tug, we are compromising safety…We were fortunate that no one was injured…" (ACN 57960)

Powered 180-degree-or greater turns seemed especially likely to result in jet blast damage, even when crews used "normal" or "only necessary" thrust. Several reports illustrate:

> ✍ "…A fuel truck refueling an aircraft at an adjacent gate had a ladder blown off the top…and it struck the aircraft it was refueling. My taxi out involved a 180+ degree turn. My use of thrust was normal…" (ACN 108825)

> ✍ "…Taxiing requires a hard right 180 turn to get out of gate. I used power to 3 engines to start forward, initiated hard right turn, reduced #3 to idle, and kept power on 1 and 2 to keep aircraft rolling in the turn. I used only what I felt was necessary to keep my aircraft rolling. Clearance is tight and I was concerned about missing poles, building, etc. Captain of another aircraft immediately to left of our parking spot complained that his aircraft was damaged by jet blast." (ACN 112237)

> ✍ "…As I turned into "C" area, I realized my assigned gate was a hard left turn on ramp. We asked and were cleared by Ground for a 180 degree turn. I did not see any problem so proceeded to turn left. Approaching the gate we heard someone on Ground say that we just blew over a catering truck. I went to scene and observed truck lying on left side. Truck was in "raised" mode; no stabilizing "outriggers" observed; no chocks observed…Damage to parked aircraft confined to lower portion of left rear entry door and my ego. Suggestions: all catering trucks have "stabilizers"; shut down all jet engines when making turns on ramps (get a tug!)." (ACN 170016)

The corrective suggested by several reporters is to *position* jet aircraft so that their forward thrust is directed away from gate areas, people, and ramp equipment:

> ✍ "Corrective action: push aircraft back to a position where initial taxi can be made in a forward direction." (ACN 58798)

Positioning is especially critical to safe powerback operations, which are the turbojet equivalent of "reverse gear." In a powerback operation, the flight crew deploys engine thrust reversers to direct thrust *ahead* of the aircraft, thus pushing the aircraft backwards. Concluded one reporter of a powerback incident that resulted in jet blast damage:

> ✍ "This type of damage could be avoided if aircraft are towed out of congested areas, especially when situations exist where the possibility of jet blast damage is high. At a minimum, when powering back, the aircraft should be directed into a position so that the aircraft is parallel to the centerline of the taxiway so that when forward thrust is applied, the jet blast isn't directed into the gate area." (ACN 70969)

Close Proximity of Light Aircraft. The policy of parking of light aircraft “tail-to” turbojet aircraft on ramps, or in areas adjacent to congested ramps, appeared to invite jet blast damage incidents. In a number of instances, commuter planes occupying the same ramp area as turbojets were the targets of jet blast:

> ✍ “During a wait for load advisory message, the aircraft was taxied to a position on ramp near other aircraft…The Ground controller did advise us to use minimum thrust when departing ramp. With 2 engines running, aircraft moved only 15-20 yards before slowly coming to a stop. The number 2 engine was called to be started and with all 3 running, even then slightly above idle thrust was needed to move up and around another aircraft parked in front of us…The next day the Captain was notified by company channels that a twin-engine commuter aircraft had been blown/slid into adjacent baggage carts causing some aircraft damage.” (ACN 228844)

In cases where a mixture of different aircraft sizes on the ramp could not be avoided, it appeared important that adequate space be left between turbojets and smaller commuter or corporate aircraft, and that ground crews carefully monitor boarding and deboarding operations, particularly those of the lighter aircraft:

> ✍ “Damage reported to small commuter aircraft from blast of one engine at idle power as we pulled into gate. With close proximity of small 2-engine commuter aircraft and my LGT, they reported two people fell down as a result of blast. If this is so as stated, then obviously the area between large aircraft and the small commuters is insufficient and the situation must be remedied.” (ACN 180036)

It was also clear from reporters’ comments that airports’ ramp management policies could influence the occurrence of jet blast damage incidents:

> ✍ “On taxi in to gate X…some tail damage was done to a SMA, which was parked behind our aircraft “tail to.” The close proximity of operations of turbojet aircraft and light reciprocals was a strong contributing factor. A minimum of four other incidents have occurred on this ramp involving aircraft damaged by turbojet blast.” (ACN 245389)

Ground Communication & Handling Procedures. A final factor contributing to some ramp jet blast incidents reported to ASRS was inadequate communication between pilots and ATC regarding pushback and power-up, or between flight and ground crews involved in pushback activities. At some airports, initial pushback communications are conducted on gate radio until the aircraft is released to Ground Control. For at least one reporter involved in a ramp jet blast incident, this procedure was a contributing factor:

> ✍ “…At some point during pushback, the co-pilot advised gate radio that we would need to draw power or run up an engine to start the remaining engines. This was acknowledged by gate radio. Number 4 engine was started at the gate due to an inop APU…A company mechanic plugged in a headset and advised us that a SMA had taxied in “close proximity” to our rear and had been tipped onto a wing tip. He further stated that the wing and prop had been damaged…One contributing factor in this incident is the present tower procedures which have all initial pushback communications on gate radio until “released to monitor Ground.” We (the pilots) and Ground are not aware of what each other are or might be doing. Unless gate radio advises the Ground controller of our pushback and power up needs, he may not be aware of a hazardous condition.” (ACN 81873)

More frequently, however, inadequate communications between flight and ground crews, coupled with questionable ground handling procedures, were responsible for jet blast damage incidents. In some cases the miscommunication was a result of an ambiguous or absent signal by the ground crew:

> ✍ "I made a normal departure from gate. Used normal power pull away. Ground personnel made no indication of anything abnormal. On taxi I saw a small aircraft had been blown over…" (ACN 50621)

In several other incidents, ramp agents or ground personnel did not warn the flight crew of transient light aircraft in the vicinity of the pushback:

> ✍ "We had been directed away from the ramp. Ramp agent was not aware of [small] aircraft behind us." (ACN 86732)

Several pilots suggested that damage to baggage carts by jet blast could be prevented by improved ground crew vigilance and cart handling:

> ✍ "Baggage cart drivers/any vehicle drivers [should] not pass [behind] aircraft at any time because they are unable to judge how much power is presently applied or could be applied on the jet engines ahead of them." (ACN 194755)

> ✍ "Baggage cart brakes didn't work and cart was not in proper parking area." (ACN 237246)

Sources and Types of Jet Blast Damage

Because of the small size of the ASRS study set (fifty-one reports) and the absence of make/model information in database records examined, it was impossible to conclusively identify the aircraft types that were primary sources of jet blast damage. Several interesting findings emerged, however.

Large (LGT) aircraft weighing between 150,001-300,000 pounds, such as the B-727, B-757, and A320, were the most frequent source of jet blast damage by nearly a two-to-one margin, accounting for 45 percent of the damage incidents reported to ASRS. In comparison, medium-size transports (MLGs) weighing 60,001-150,000 pounds, including aircraft such as the DC-9, BA-146, MD-80, and B-737, were the source of jet blast damage in 25 percent of the incidents. In another 24 percent of incidents, widebody aircraft (WDB) weighing over 300,000 pounds, such as the DC-10, L-1011, B-747, and B-767, were the source of jet blast. (See Table 2.)

Table 2 — Source Of Jet Blast

Aircraft Type		No. Rpts.	% Data
LGT	(Large Transport)	23	45
MLG	(Medium Large Transport)	12	25
WDB	(Widebody Transport)	13	24
HVT	(Heavy Transport)	1	2
MDT	(Medium Transport)	1	2
LTT	(Light Transport)	1	2
	Total ▶	**51**	**100%**

The finding related to LGT aircraft was not completely unexpected: the aircraft types that comprise ASRS's LGT weight category—especially the B-727—account for significantly more worldwide commercial jet operations than other aircraft types. Thus ASRS data may simply reflect these real-world proportions. We also anticipated that there might be fewer jet blast incidents involving the widebody (WDB) category of aircraft, since many air carrier companies prohibit maneuvering widebody aircraft in confined spaces such as ramps.

When we classified the types of jet blast damage, we found that other aircraft—particularly light aircraft—were the primary targets of jet blast damage in 85 percent of the study incidents. Usually aircraft were damaged because of a direct "hit" from jet exhaust, or because objects such as ladders and baggage carts were blown into them. Many of these incidents were preventable, either through safer handling procedures for large jets departing and arriving at ramps; or through stricter ATC separation criteria between large jets and light aircraft in other areas of the airport, coupled with explicit jet blast warnings to pilots of both large jets and light aircraft.

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Summary and Conclusions

In the high-pressure, quick-turnaround environment of most scheduled air carrier operations, flight crews of turbojet aircraft may be tempted to ignore jet blast avoidance procedures such as requesting a tug or tractor for pushback, or taxiing to a designated area on the airport to do a quick engine run-up. Fortunately, the ASRS jet blast reports we reviewed contained safety suggestions that should help pilots, ground crews, airport managers, and ATC avoid jet blast incidents without causing excessive ground delays.

For Flight Crews:

- Never perform an engine check or run-up on a taxiway or near a runway without first informing ATC. This will allow ATC time to issue appropriate jet blast warnings to lighter aircraft that may be nearby, but unseen by the jet crew.
- When it is necessary to perform an engine run-up, request ATC assistance in ensuring that jet engine exhaust is directed *away* from active taxiways, runways, and other areas that may be occupied by lighter aircraft.
- If possible, avoid pushback, powerback, or taxi-in procedures that involve 180-degree-or-greater turns with one or more engines running—consider using a tug instead.
- When departing a gate, request pushback to a position where an initial taxi can be made without directing forward thrust into the gate area—or into lighter aircraft parked nearby on the ramp. If a powerback must be made, request that the guide person direct the aircraft to a position that is *parallel to the centerline of the taxiway*, before applying forward thrust.
- Before engine start and pushback on a ramp where both turbojets and lighter commuter aircraft are parked, ask ground personnel to inform the flight crew of any boarding or deboarding operations by lighter aircraft that may be in progress close behind jet aircraft. If a potential hazard exists, flight crews should delay their engine start and pushback procedure until the area behind them is clear. Be aware that even small air carrier and corporate jets can produce potentially deadly blast.

For Ground Crews:

- Always visually check the ramp and taxiways behind a turbojet before and during a pushback/powerback for the presence of transient light aircraft that may be caught in the jet blast.
- Give decisive hand signals and/or verbal warnings to the flight crew during a pushback or powerback if you see a hazardous situation developing.
- Avoid driving baggage carts between turbojets on the ramp; it is often impossible to know whether aircraft engines are running, or whether power might be applied suddenly by the jet's crew.
- Position baggage carts in the areas designated on the ramp—make sure the cart brakes have been applied.

For Airport Managers

- Ensure that adequate distance buffers are maintained on the ramp between commuter and turbojet boarding and deboarding operations.
- Avoid parking light aircraft "tail-to" turbojets on airport ramps; light aircraft may be damaged during jets' power-up and initial taxi. Make sure that any light aircraft left on ramps overnight, or during daytime operations, are properly secured.
- Encourage owners of light aircraft in parking areas adjacent to taxiways used by turbojets to make sure that their planes are properly tied down, with gust locks engaged or attached when possible.

For ATC:

- When a turbojet requests a maintenance run-up or engine check, direct the aircraft to an airport area designated for this activity, *or* turn the aircraft to a heading where jet exhaust will not be aimed across active taxiways, run-up areas, and runways. *Require one of the aircraft crew members to be on a headset during the run-up procedure so that communications between the tower and aircraft will not be disrupted.* Otherwise, the ear-splitting noise of revving jet engines may drown out ATC instructions on cockpit speakers.
- *Always* warn light aircraft of jet blast hazard if they are near a turbojet that is initiating or performing an engine run-up. This warning is especially important to light aircraft taxiing near a turbojet run-up at dusk or night.
- Before clearing a turbojet into position on the runway, consider warning the jet crew of the presence of lighter aircraft directly behind them, or in close proximity (on an adjacent taxiway or in a run-up area, for example). The jet crew may be unaware of the lighter aircraft. This warning is particularly important when "immediate takeoff" instructions are issued.
- Before clearing a light aircraft to cross a runway where a large turbojet aircraft has just departed, issue a jet blast warning and consider applying time or distance separation between the light aircraft and the residual jet blast. These safeguards may be especially important *at night*, when pilots lack the visual cues that help them judge residual jet blast.

Emergency 911

EMS Helicopter Operations

by
Linda Connell
and
Marcia Patten

"We were on an air ambulance flight…picked up a team of organ removal surgeons in XYZ…and flew them to ABC to remove the heart from a donor. The weather was clear and forecast to remain so. We understood… [that] the heart has a very short lifetime between removal from the donor and installation in the recipient, so when the recovery team arrived back at the ABC airport it would be necessary to expedite as much as possible…The F/O…[and I] readied the aircraft for the return leg and then went into the FBO to wait…Shortly before the medical team's departure from the airport…the fog began to roll into the area. Upon [their] arrival, the visibility was down to 4000 RVR…[but] our operations specifications call for minimum 5000 RVR for departure. I felt it was necessary to depart below minimums based on our medical emergency…I felt the decision to depart below minimums was the only one available to me under the circumstances. If we had waited for improved visibility, the heart would have been ruined, and the receiving patient may have died." (ACN 221023)

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Welcome to EMS Operations

The flight described above is hardly the sort a pilot wants to face everyday. Fortunately, most helicopter Emergency Medical Service (EMS) calls are not nearly so dramatic. However, the operational aspects of EMS calls can be the ultimate test of a helicopter pilot's skills. The "scene" calls that may have contributed to the victim's injuries—a vehicle accident, a near-drowning or serious fall at a rocky beach, a backwoods hunting accident, or an aircraft forced-landing in mountainous terrain—also contribute to the risk associated with the EMS flight. Yet these are precisely the situations in which a helicopter may be the most expeditious, or even the only, means of getting medical assistance to the victim and getting the victim to a medical facility.

The first hour following a serious injury is the most time-critical period, during which the patient mortality rate can be reduced by as much as 50 percent if immediate and appropriate medical care can be provided. The benefits of immediate treatment by medical personnel at an on-scene emergency and rapid transport of the patient, especially within this "golden hour," have been well-documented. Hospitals and medical centers have recognized the value of pairing medical crews and helicopters for reaching critically-injured or seriously-ill patients. As a result, the number of hospital helicopter programs has increased dramatically over the last ten to fifteen years.

During the years 1978-1986, this increased use of helicopters for emergency medical and air ambulance services came at a high price. In a study of 59 EMS accidents during this period, the NTSB found that the accident rates for EMS helicopter operations were approximately 3.5 times higher than for other non-scheduled Part 135 Air Taxi helicopter operations. Human error, directly or indirectly, was attributed as the cause of the majority of these accidents. To the credit of the EMS industry, these accident rates decreased significantly following the NTSB report and recommendations.

A recent study undertaken by NASA and the Aviation Safety Reporting System (ASRS) looked at 81 incident reports submitted from 1986 to 1991 involving EMS helicopters. The purpose was to identify and describe the operational aspects of these incidents, and to assess the contribution of human factors to these occurrences.

This article will focus on the human factors most commonly cited: communication interactions, time pressure, distraction, and workload.

Can We Talk…?

Communication and information transfer difficulties were pervasive, and repeatedly emerged as a major contributor to the chain of events leading to the reported incident (78 percent). The most common difficulties were reported as miscommunication during pilot contact with ATC and unsuccessful attempts by a pilot to contact ATC. Further, pilot communications with other pilots, hospital dispatchers, and ground personnel (i.e., police, firefighters, paramedics, park rangers, etc.) were also cited as additional interactions which sometimes interfered with ATC communication:

> ✍ “I was coordinating with dispatcher, medic command (flight following/status reports), and emergency vehicle on scene, and broadcasting position reports and intentions on Unicom. Approach advised (me) that I entered his airspace and did not properly coordinate with his controller… I was working four frequencies and receiving conflicting coordinates from the ground while searching for the landing zone.” (ACN 181754)

Communications problems played a major role in reports of both airspace violations and near mid-air collisions (NMACs), which occurred most frequently in Class D airspace during early- to mid-afternoon (1201-1800 hours). This is a reflection of the complex, controlled-airspace environment found in the areas that can support major medical centers, and also the time of day when air traffic is generally heavy and inter-facility patient transfers are most likely to take place.

In 50 percent of airspace violations and 59 percent of NMACs, the EMS pilot was in radio communication with at *least* one ATC facility at the time of the incident. Frequency congestion, misunderstanding of ATC instructions or clearances, busy ATC personnel, and lack of common understanding of the “Lifeguard” call sign priority were cited as problems affecting the information transfer process, and contributing to the reported incident. (See sidebar).

Airspace violations frequently occurred during the takeoff phase of flight and were often due to poor radio reception or transmission associated with the low altitudes used by helicopters. In some instances, poor radio communications were attributed to landing sites surrounded by obstructions, usually the hospital or other buildings:

> ✍ “After takeoff from local hospital, which is out of radio contact with Tower but near their control zone, (I attempted to contact Tower). By the time contact was made, the airspace had been entered. A procedure needs to be established for helicopter operators to take off from areas within an ARSA where radio contact is not possible until after takeoff.” (ACN 126017)

> ✍ “I was unable to contact Tower or Approach from the hospital helipad. It [helipad] is down in a hole surrounded by buildings. I departed without clearance into ARSA/Control Zone and immediately contacted Approach…He told me to stay clear of the ARSA until radar contact (had been) established. The problem is that I was already in the ARSA/Control Zone on the pad at the hospital.” (ACN 142201)

NMACs occurred frequently in airspace that requires radio communication, specifically, in Class B, C, and D airspace. However, many NMACs were also reported in uncontrolled (Class G) airspace. Helicopters often fly in uncontrolled airspace, usually at low altitude. Several reporters indicated that due to frequent communication problems and delays encountered in Class B, C, and D airspace, they, and apparently many other small GA aircraft (which were usually the other parties in the reported NMACs), remained low-level in uncontrolled airspace, not talking to ATC.

The NTSB found that in-flight encounters with weather at low altitude were the single most common factor in fatal EMS accidents, with most accidents occurring at night. All 15 in-flight weather-related accidents occurred at low-altitude and in uncontrolled airspace, and 10 of those occurred at cruise speed. In the ASRS study, in-flight weather encounters were cited in 14 percent of the reports. Pre-flight weather briefings had been obtained in 80 percent of these incidents, but 75 percent of the briefings did not match the actual weather conditions the pilots encountered. The captain of a 2-pilot crew, both IFR-rated and current, flying an IFR-certified aircraft, described, the potential hazards of inaccurate weather forecasts:

> ✍ "The biggest safety problem I see is lack of accurate weather forecasting from a facility with weather reporting. This is the third time I have been inbound with a patient and have been caught by unforecast weather conditions—not just a little off, but all the way from VFR to low IFR. The last time this happened they reported clear and 10 (miles visibility) when in fact they were 300 (ft ceiling) and 1/2 (mile visibility), and went to 0-0 within an hour. Unexpected IFR or IMC can cause confusion and possibly even an accident with an experienced crew, much less an inexperienced pilot in a VFR small aircraft." (ACN 138253)

Time Trap

Time pressure was cited as an frequent contributor to incidents—the patient's critical condition led to a sense of urgency about the flight, which often resulted in inadequate pre-flight planning. Reporters cited such oversights as not stopping for refueling; failure to obtain or review correct charts; overflying scheduled aircraft maintenance; inadequate or less-than-thorough weather briefings; and inadequate evaluation of weather briefings preceding the go/no-go decision. Patient criticality was reported as a major contributor to time pressure in 44 percent of the reports. Time pressure associated with the patient's condition seemed to be present regardless of whether the patient was already on-board the aircraft or the pilot was en-route for patient pick-up.

Recommendations have been made to try to isolate the EMS pilot from the overall medical situation and the patient's condition. However, the pilot is well-aware that his or her services would not have been requested unless a serious medical situation existed. It is a normal human emotion to respond to an emergency. Given the sense of urgency that seems to be inherent in an EMS operation, and the potential for both verbal and nonverbal expressions of the necessity for speed, that attempt at isolation may be unrealistic or impossible to achieve. In numerous reports of airspace violations and inadvertent IMC encounters, pilots belatedly recognized their lack of separation from the medical circumstances.

> ✍ "[This is] another exercise in getting involved in the medical situation at the scene and how it can affect a pilot's judgment. We can never let the medical necessity override our good judgment and prevent us from being safe." (ACN 141232)

> ✍ "I was involved in patient care when I should have been totally involved in flying." (ACN 146594)

> ✍ "…High risk delivery, mother in distress. I allowed patient's condition to influence my decisions. Got above layer, had to descend IFR in a non-certified but well-equipped aircraft." (ACN 58837)

In crystal-clear 20/20 hindsight, many pilots seem to have come to similar conclusions:

> ✍ "Pilots, especially those in my line of work, should never let the circumstances around them dictate the way they would normally fly. If a flight has to be delayed in order to safely fly that mission, then so be it. No flight is so important that the lives of the flight crew should be jeopardized due to incomplete or inaccurate pre-flight planning." (ACN 100727)

> ✍ "…Quick EMS helicopter responses, numerous interruptions during start-up, added pressure of a dying person, causing pilot to make emotional decisions instead of safe ones and the pilot allowing this to happen. Most likely a pilot would not fly unless under excessive pressure to do so— not by anyone (else), but self-imposed." (ACN 118240)

Distraction

Distraction from the primary task of flying the aircraft was reported in many incidents. Distraction was often cited in terms of external influences—noise interference from medical equipment, aircraft equipment problems or malfunctions, traffic avoidance in high-density traffic areas, interruptions, monitoring of multiple radio frequencies, radio frequency congestion, poor visibility, marginal weather, and impending low-fuel situation. There were also a number of internal sources of distraction, including personal and family concerns, lack of familiarity with the area, involvement in patient condition, confusion about procedure, and misunderstandings about duty delegation.

Up to Your Empennage in Alligators

Workload as such was not cited as a major contributor to EMS incidents. However, workload is a complex concept and is subject to a variety of influences that can lead to activity overload, shedding of tasks, fatigue, and ultimately to incidents such as those reported. An unexpected finding was that cruise flight, when cockpit activity might be expected to be low, appeared to be a magnet for EMS safety incidents. Both airspace violations and NMACs were reported as most frequently occurring in cruise flight and in VFR weather. In-flight weather encounters were also reported as occurring most often in cruise flight. Although cruise is not usually a time of intense aircraft-handling activity (as might be during takeoff or approach), it is a time when the EMS pilot might be attending to tasks inside the cockpit—providing position reports to dispatch, coordinating with the medical center, programming navaids, or communicating with other EMS personnel—rather than specifically watching for conflicting traffic, a cloud layer, or airspace boundaries.

Aircraft equipment can also play a vital role in pilot workload. Although many EMS helicopters are not IFR-certified, most come very well-equipped. This is a double-edged sword for many pilots. The abundance and quality of equipment provides a level of confidence about the pilot's ability to handle inadvertent IMC. However, the complexity of some modern IFR-equipped aircraft can require more than one set of hands and eyes to be used to maximum advantage. A few EMS helicopters are equipped with autopilots. Even 2-pilot crews who might comfortably handle such a well-equipped aircraft may find themselves defeated in legally completing their missions because their aircraft is not IFR-certified.

> ✍ "It is frustrating to have an aircraft that is so well equipped with twin engine reliability and can't even legally depart to VFR on top or to make a simple ILS or LOC/DME approach to conservative minimums." (ACN 58837)

Several accounts indicated that having an IFR rating with currency and following pre-arranged procedures can be literal lifesavers when encountering inadvertent IMC. One fortunate reporter had everything in his favor when he encountered unforeseen weather conditions.

> ✍ "On climbout, I lost all ground references at 400 feet.…Landed in farm field about 1/2 mile from airport. Although fully equipped, aircraft was not IFR certified. This situation had been previously addressed and rehearsed. An instrument rating, planning for inadvertent IFR, and current approach plates kept a bad situation from ending in disaster." (ACN 169746)

Summary and Recommendations

Many of the human factors considerations cited in the EMS incident reports are known to have a significant impact in other aviation environments, and are ongoing topics of human factors research. The pilots themselves recognized some of these considerations and often had suggestions for resolving the problems they encountered.

- There appears to be a need for more concise, less frequent communication between EMS pilots and ATC. Some pilots have recommended that EMS aircraft be assigned discrete transponder codes while operating in airspace requiring ATC communication. In theory, this would allow a pilot to make the initial ATC contact and state his or her intentions, then be tracked on radar with minimal additional radio calls. Other pilots seem to feel that standardization of the "Lifeguard" callsign (see sidebar on "Priority Handling" and "Lifeguard") would go a long way in facilitating EMS flights through some types of airspace. One approach might be for EMS pilots to arrange a friendly discussion with the Tower supervisors in the areas where Lifeguard flights frequently occur. This might provide a mutual understanding of the responsibilities and expectations of both pilots and controllers in Lifeguard radio communications. Another recommendation is to obtain Letters of Agreement (LOAs) with the local ATC facilities most frequently contacted. Many pilots find that an LOA can define routes, altitudes, reporting points, and other operational information that helps to streamline the communication process for both pilots and controllers. This can be especially helpful when a hospital helipad in located within controlled airspace.

  Associated with improvements in ATC communication are improvements in crew communication. Crew Resource Management (CRM) is not just for major airlines or big companies. Clear, assertive communications among all EMS team members—pilots, flight nurses, paramedics, doctors, administrators, dispatchers, and on-scene personnel—are vital if the EMS flight team is to perform its duties efficiently and successfully.

- Another aspect of CRM and Aeronautical Decision Making (ADM) is the concept of task management and delegation. Many incidents were reported as occurring when and where they were least expected—in day VFR, during cruise flight. In two-pilot operations, tasks need to be delegated such that one pilot is always "outside" the aircraft, looking for that potential NMAC or IMC encounter. In single-pilot operations, on-board personnel may need to take an active role in all phases of the EMS operation.

- A recommendation that is often repeated by both EMS pilots and human factors researchers is the need for the pilot to be isolated as much as possible from the patient's condition. There have been many attempts to do this, and the situation continues to improve. Pilots are rarely greeted anymore with a heart-wrenching request to "save a dying child." Typically, the question is simply put to the pilot: "Can we get there and back?" with no mention made as to the nature of the emergency or the patient's condition. This helps remove some of the emotional pressure, and encourage the pilot to make an objective decision about whether the flight can reasonably be completed safely.

- Finally, many of the pilot reporters indicated that an instrument rating and currency were very helpful, if not invaluable, in encounters with unforecast weather. Since most EMS helicopters are IFR-equipped even if they are not IFR-certified, an instrument rating and currency at least provide a pilot with options in case of an in-flight weather encounter.

All efforts need to proceed towards developing solutions and preventive mechanisms within the National Airspace System and the EMS team. Each individual involved in these important emergency operations needs to become a part of the larger effort to improve communication, decrease distraction, decrease time pressure to realistic levels, and assist in workload management.

Lifeguard & Priority Handling

In our survey of the 81 EMS incidents reported to the ASRS, it became evident that "Lifeguard" and "Priority Handling" are phrases in need of clarification. Some EMS pilots seem unclear about the degree of preferential treatment provided by the "Lifeguard" call sign and how this situation compares to "Priority Handling." Similarly, some controllers seem unaware of pilots' operational expectations when "Lifeguard" is used. An ASRS report illustrates the expectation by a pilot that "Lifeguard" call sign will provide immediate priority, and also suggests that the controller had difficulty prioritizing this "Lifeguard" flight:

> ✍ "When requesting departure clearance and using 'Lifeguard' call sign, the controller ignored my transmissions for nearly 4 minutes. I could have departed safely and expeditiously in several directions completely away from the flow of fixed wing traffic." (ACN 159931)

◆

FAA Air Traffic Control Handbook

The FAA Air Traffic Control handbook, Order 7110.65J, provides for "operational priority" for civilian air ambulance flights. It states in paragraph 2-4, Operational Priority:

> "Provide air traffic control service to aircraft on a 'first come, first served' basis as circumstance permit, except the following…
> a.) Provide priority to civilian air ambulance flight (LIFEGUARD). When verbally requested, provide priority to military air evacuation flight (AIR EVAC, MED EVAC) and scheduled air carrier/air taxi flight. Assist the pilot of air ambulance/evacuation aircraft to avoid areas of significant weather and turbulence conditions. When requested by a pilot, provide notifications to expedite ground handling or patients, vital organs, or urgently needed medical materials. 2-4a) Note—Air carrier/taxi usage of "LIFEGUARD" call sign, indicates that operational priority is requested."

Airman's Information Manual

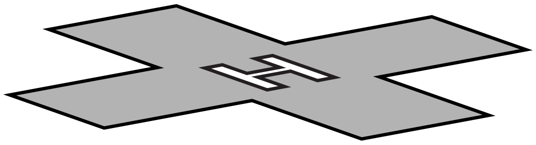
In contrast, the *Airman's Information Manual* offers no guidance as to the nature or degree of "priority" afforded the "Lifeguard" flight. This lack of information, and the possibility of variable controller interpretations of FAA Order 7110.65J when faced with different situations, may create unrealistic expectations for both pilots and controllers.

FAA Air Traffic Procedures Division

In a response to an inquiry from ASRS, the FAA Air Traffic Procedures Division offered the following expanded interpretation of "Lifeguard" and "Priority Handling" terminology.

> "The use of the term 'Lifeguard'…provide[s] priority…Even the expeditious movement of Presidential aircraft or other special air operations are listed behind air ambulance priority in Order 7110.65…

Lifeguard & *Priority Handling*



> "It is a fine line between normal operations and emergency operations, both for the medical personnel as well as for the controllers. While an emergency in the air traffic control world generally means that an aircraft (and therefore its occupants) are endangered, this distinction blurs significantly in air ambulance operations, in which the aircraft is fine but the occupant(s) may be endangered.
>
> "Order 7110.65 requires the controller to "…give first priority to separating aircraft and issuing safety alerts as required in this order. Good judgment shall be used in prioritizing all other provision of this order…In conjunction with paragraph 2-4, therefore, any aircraft that identifies itself as a 'Lifeguard' flight…will and in fact, does, receive a very high priority in the air traffic system."

"Lifeguard" can be confused with another commonly used aviation term, "Priority Handling," which is further explained by FAA Air Traffic Procedures Division:

> "The term and usage of 'Lifeguard' must be contrasted sharply with the term and usage of 'Priority Handling.' 'Priority Handling' means that the pilot requests priority handling, and has no other connotation. Unless the pilot further specifies or clarifies that request, it means nothing more than any other request…Given the ambiguity inherent in the term 'priority handling' and with no other indication or rationale for the request, it is unlikely that the controller would provide service reserved for air ambulance flights.
>
> "Good communications between pilot and controller provides a safer and more efficient operation for all concerned. Awareness of an emergency or near-emergency situation provides the latitude for both the pilot and controller to effectively perform the task at hand…Controllers share with emergency medical personnel a high degree of awareness of the value of human life: it is a natural alliance."

The following table summarizes the information provided concerning the terms "Lifeguard" and "Priority Handling":

Lifeguard	***Priority Handling***
■ Is indicated by including the term "Lifeguard" in the aircraft call sign (e.g., "**Lifeguard** Medic Flight 246").*	■ Is a request, usually following the aircraft call sign (e.g., "Medic Flight 246, requesting priority handling").
■ Indicates that *human life is endangered* to some degree, regardless of other wording in the aircraft call sign.	■ Is treated like any other request until the pilot states the reason for the priority, at which time the controller can provide appropriate assistance.
■ Air ambulance aircraft will receive very high priority when they are identified in the air traffic system.	■ Is not, in itself, justification for an aircraft to receive special handling from the air traffic system.

*As noted by the FAA Procedures Division, "In many locations the actual call sign of air ambulance aircraft can vary widely. Examples are 'DUSTOFF,' 'LIFE FLIGHT,' or 'MEDIC' and often with an associated number such as 'Dustoff one.' These kinds of call signs and air ambulance operations are normally accompanied by excellent communication between the operators and air traffic control, both in the form of recurrent visits/briefings, and Letters of Agreement."

Lost Com

by
Charles Drew,
Andrew Scott, &
Bob Matchette

The key to any good relationship, whether in marriage, at the office, or between pilot and controller is communication. Pilots and air traffic controllers know that the safe and efficient movement of air traffic requires good voice communication between air traffic control facilities and aircraft, yet most pilots and controllers have experienced a loss of communication at least one time or another, for a variety of reasons.

A Near Thing

The following event, reported to ASRS by several participants, illustrates the problems that can arise when communication is not possible. A Center facility had jurisdiction over two air carrier aircraft, both at flight level 350 and on a nearly head-on converging course. The Captain of air carrier X writes:

> ✍ "…We were given a routine radio frequency change…We tried to check-in on the new frequency several times, but were blocked by other transmissions. The Controller on this frequency was extremely busy…While waiting for a break to check-in, my First Officer called out traffic to me at the 2 o'clock position. The traffic, a wide body [jet], was in my blind spot (behind a windscreen post). When I saw the aircraft I watched for approximately 10 seconds and determined we were on a collision course. I initiated an immediate descent out of 35,000 feet." (ACN 187551)

The First Officer of air carrier X adds:

> ✍ "…I figure we missed by 800 feet vertical separation. He went directly over us. I'm sure we would have collided had I not seen this aircraft." (ACN 187556)

And a Controller provides the conclusion:

> ✍ "This near-miss occurred because air carrier Y didn't maintain a radio watch over the whole northern hemisphere while on a…[trans-Atlantic] flight, and another aircraft was not retrieved from a wrong frequency by a supervisor working radar— because of human error…Air carrier Y never saw air carrier X." (ACN 189213)

Several communications-related problems occurred here, including the flight crew of air carrier Y not maintaining a listening watch on frequency, and aircraft X being sent to the wrong frequency by ATC—perhaps with insufficient time for a recovery. How many ways can you lose your com (and your calm). Well…

Lost Com

There Must Be 50 Ways…

There must be at least fifty ways to lose communication and here are just a few:

- misset the aircraft audio panel
- set the aircraft radio volume too low
- assign an incorrect frequency to an aircraft
- experience an electrical system failure
- forget to turn on the aircraft alternator
- have a "stuck mike"
- tune the wrong frequency on the aircraft radio
- have an ATC facility radio failure
- get frequency blockage due to radio congestion
- fall asleep
- forget to switch to a new frequency
- try to communicate on the wrong radio.

Sound familiar? Perhaps you can think of thirty-eight more. Given the potential hazards, a review of the causes and effects of interruptions to communication sounds like a pretty good idea. An initial investigation, using ASRS records, examined the causes and effects of loss of communication events. A follow-up study looked at the principal human-factors issues involved in del*ayed* lost communication recognition on the part of pilots who experienced this problem. Here are the six most interesting findings of these two studies:

❶ Causes for Communication Interruption

Misset Radios

As can be seen in Figure 1, pilots' inadvertent missetting of aircraft radios or audio selectors accounted for over half of all interruptions to communication. Notes a pilot:

> ✍ "We were experiencing loud noise over the radio, and so we tried switching radios while getting the ATIS at the destination airport…and in turn left Approach [Control] on the radio, but on the wrong side (plane is equipped with flip/flop radios). After several minutes of radio silence, we noticed what had happened and switched Approach back on and called them. The Controller was upset and announced we had delayed 7 other aircraft due to our mistake." (ACN 189101)

Radio Problems

An aircraft radio problem or failure was the next most commonly noted cause for loss of communication, but pilots of general aviation (GA) aircraft (specifically light single-engine types) were more likely to experience loss of communication through aircraft radio failure than were operators of other aircraft types. The following report from a general aviation pilot illustrates not only the potential problems with general aviation aircraft electrical systems, but also a reasoned response by the reporter, and the invaluable employment of a hand-held portable transceiver:

> ✍ "…In a single instant, the electrical system failed. The off flags on the navigation receivers dropped, all LCD [liquid crystal] displays disappeared, and there was no reply light on the transponder. I attempted radio contact anyway, but there was no sidetone in my headset so I doubted I was transmitting. I heard no other radio traffic. I was IMC at the time and squawked 7700. I knew that the destination area was VFR. However, I was transient and therefore unfamiliar with the area. It took me a moment to realize that I carry a portable transceiver for this

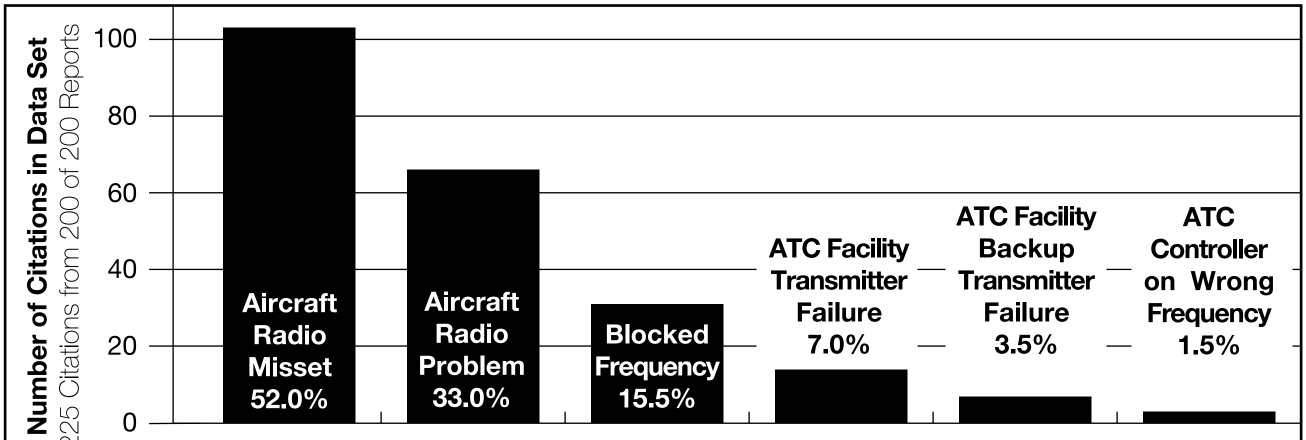


Figure 1 — Causes of Loss of Communication, Percentage of Data Set

> very situation. I pulled it out, connected the headset, and attached it [the radio] to the external antennae cable. Unfortunately, I could not monitor the primary Center frequency. That information was locked in the memory of the now inoperative radio panel. I had fallen into the trap of not manually logging on paper the assigned frequency…I attempted contact on 121.5 but got no response.
>
> "I navigated as best as possible, and soon broke out into VMC. I headed for the first airport I saw. Some quick dead-reckoning and the VFR chart I had been using to monitor flight progress led me to believe, correctly, that it was Scottsdale. I changed the hand-held frequency to Scottsdale Tower and was able to make contact." And after a safe landing… "Maintenance examined the aircraft the next day and determined that the [aircraft] battery had shorted; at least one cell was dry." (ACN 156291)

Blocked Frequency

A "stuck mike" (in which a microphone, radio transmitter, or audio selector panel failed in the transmit mode) was known to be the cause in about 60 percent of blocked frequency incidents. ATC facility transmitters and combined weather conditions/frequency overlap each accounted for less than 10 percent of occurrences. The following report is typical of stuck mike incidents:

> ✍ "Shortly after switching to Washington's final Approach Controller, an aircraft began broadcasting on the frequency with a stuck mike. The aircrew maintained a steady stream of conversation not pertinent to their flying duties…effectively jamming the frequency while we were awaiting further vectors for sequencing into Washington National during the afternoon rush. Fortunately, the alert Controller managed to announce an alternate frequency and regained control of the situation." (ACN 173930)

And in another classic stuck mike event:

> ✍ "…After three minutes of radio silence I had begun to wonder if I had lost communications with the Radar Controller. My instincts were right—we had lost radio contact…In the cockpit I had a few choice words to say about my aircraft and radios which should not have been said at any time."

And later, when asked to contact the Facility Supervisor on the telephone:

> "He [the Supervisor] said 'Now how are your blank-blank radios doing?…We have everything on tape, everything! We had to go to a backup frequency because of your language. You apparently had a hot mike.' " (ACN 153914)

❷ Duration of Lost Com

Figure 2 shows the average (mean) duration of the loss of communication, which ranged from a low of 30 seconds to a high of 1 hour. When various causes for loss of communication were combined, the average duration was 7.6 minutes.

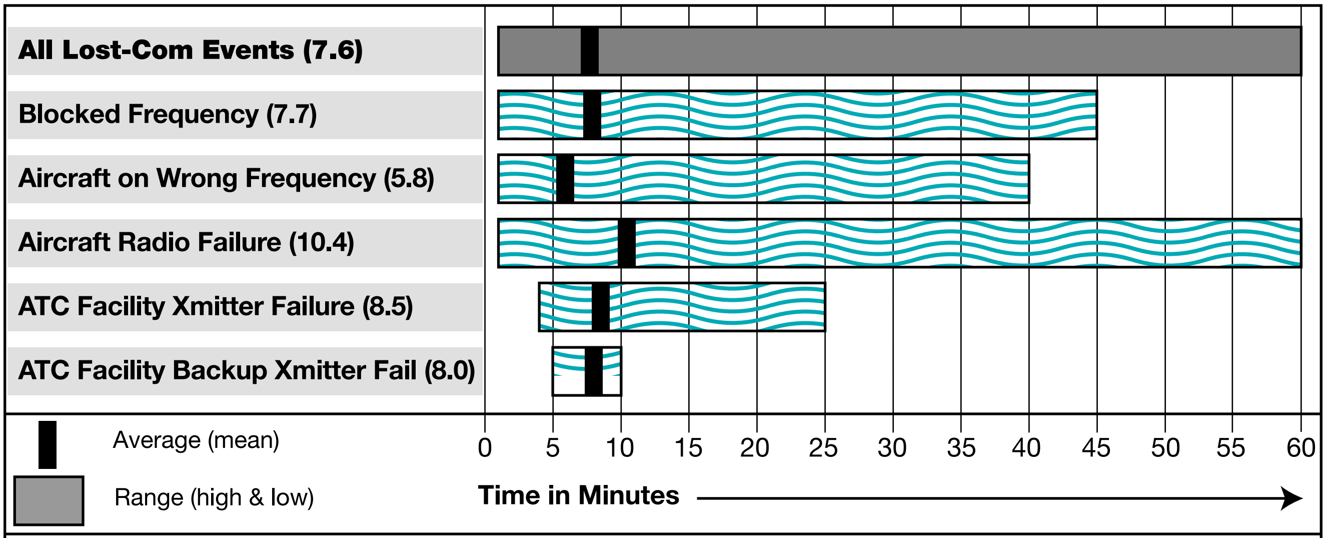


Figure 2 — Range and Mean Duration of Communication Interruption

❸ Phase of Flight

In what phase of flight are pilots most likely to experience a loss of communication? The answer differs depending on whether the operator is an air carrier or general aviation. (See Figure 3.)

Air Carrier = Cruise

According to the McDonnell Douglas 1992 Commercial Jet Transport Safety Statistics review, air carrier aircraft spend an average of 64 percent of total flight time in cruise, thus it is not surprising that air carrier pilots experience the majority of event occurrences in the cruise phase, but we found that there may be additional factors. On long distance routes, and while in cruise, it is generally accepted that air carrier flight crews will experience lowered levels of attention due to reduced stimulation from cockpit management duties, which may lead to a reduction in pilot monitoring of radio traffic. From an air carrier pilot:

> ✍ "…either we missed a frequency change call, or Center failed to pass us to the next sector. Although all three flight crew members were eating, I am reluctant to believe we all missed the repeated calls ATC states they made to us directly and through other aircraft…But, through inattention or subconscious reliance on a call from Center to start descent, we continued on at flight level 350. We were nearly at ATL [destination] when we recognized the problem. After a rush to reestablish communication, I made contact with ATL Center and reported overhead ATL at 35,000 feet…" (ACN 188575)

GA = Approach and Landing

Combined approach and landing phases provided the greatest number of events for pilots of light single and twin GA aircraft. Why? Well, for one thing GA pilots, when all types of operations are considered, probably spend less time in cruise than do air carrier flight crew. For another, they usually have significantly less cockpit automation and often a single-pilot operation, therefore a general aviation pilot may be required to devote greater attention to positional and situational awareness while in cruise, which may result in he*ightened* levels of awareness. However, a general aviation pilot on an instrument approach and landing usually has fewer and less sophisticated system and navigational devices, less total and recent experience, and less opportunity for task sharing when operating single-pilot. He or she often has to cope with a higher individual workload than their airline counterpart, and the opportunity for task overload is enhanced. Of course, sometimes a pilot makes his or her own problems, as in the following report by a flight instructor:

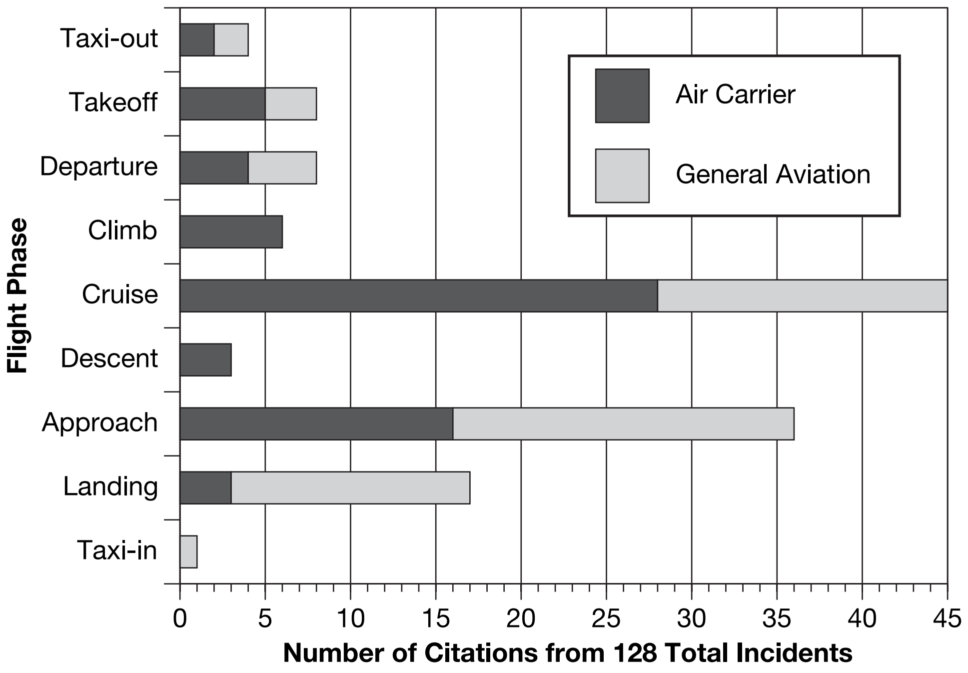


Figure 3 — Flight Phase and Type of Operation

✍ "While we were landing at SJC in a light aircraft (X)…the Tower advised us of light aircraft Y making a right cross-wind departure. I reported looking for him…then continued looking for [other] reported traffic. No sighting. Many calls at the same time to other aircraft by Tower. Turned off speaker switch to tell student to descend to pattern altitude…"

And after the reporter had spent some time in the now quiet environment…

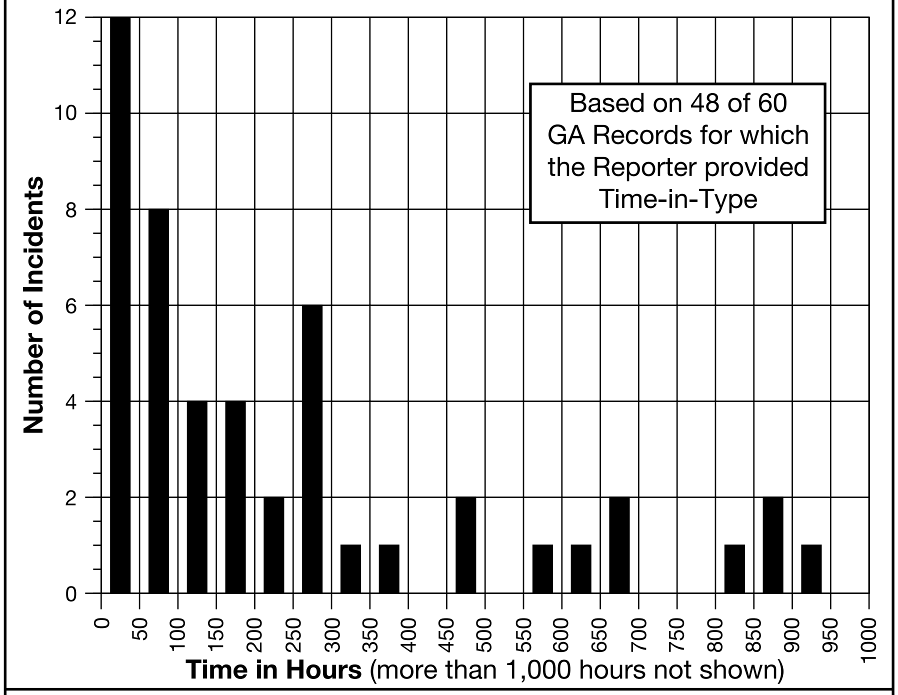
"What's wrong? No speaker! Darn. Switch on! …Tower called…'Where have you been? We've been calling you for the last five minutes.' " (ACN 157097)

Figure 3 shows the flight phases in which air carrier and general aviation pilots experience their communications problems.

❹ Low Experience = More Loss of Com Events

There is a significantly increased opportunity for lost com occurrences when one or more of the flight crew is low time on the aircraft type—this is particularly true for general aviation pilots. Figure 4 provides the frequency of lost communication events vs. time-in-type for GA pilots. (A similar, but less pronounced pattern was revealed for air carrier pilots.)

Times in Figure 4 are in 50 hour segments from 1 hour to 50, 51 to 100, and so on. The "spike" noted in the 251 to 300 hour segment is probably a result of "rounding" by reporters. (A reporter with 276 hours, or 310 hours for example, may tend to round his experience to 300 hours.)



Based on 48 of 60 GA Records for which the Reporter provided Time-in-Type

Figure 4 — GA Pilot Time in Type vs. Event Frequency

Lost Com

➎ Delay in Recognition

Preoccupation or distraction with tasks in high workload situations was commonly noted in delayed recognition of loss of communication. Note the following report:

> ✍ "Upon change over from approach to tower frequency, new F/O failed to move COM selector head switch to new frequency; we called on wrong frequency for landing and call was covered by another aircraft transmission. I thought we had called on tower frequency and were cleared to land, but we were distracted at this time by performing the final landing checklist…" (ACN 182606)

At the opposite end of the causal spectrum, loss of awareness or lowered levels of awareness was also a significant contributor to delayed recognition of com loss:

> ✍ "While in cruise, the captain, acting as pilot-not-flying, was given a frequency change to Chicago Center, I believe. I do not remember a reply to his call on frequency. Sometime thereafter I noticed there was no one on frequency talking. I said it sure is quiet. He said 'Yeah,' so I called center for a radio check—no reply. So I switched back to previous frequency. Controller stated he had been trying to reach us, gave us a new frequency. I feel it was due to fatigue that we had not caught the apparent wrong selection of a new frequency…" (ACN 189021)

➏ Recognition of Com Loss

Most commonly, flight crew discover their communication loss when they made a normal attempt to communicate with ATC:

> ✍ "…Had a…mike switch which stuck in the transmission mode. ATC said that had been that way for 15 miles. I had not heard from ATC for some time and it was about time for a frequency change. I attempted to call ATC and then discovered the sticking switch…" (ACN 179290)

The next most common reason for communications recovery was intervention by the controlling facility on another frequency, or through company or ARINC channels as illustrated in the following report:

> ✍ "…Center read a clearance so fast that neither my FO nor I had a chance to copy it, nor were we sure if that clearance was for us. I called Center back and said that if that clearance was for us, we did not copy it…I called again and still no response…About 5 minutes later an air carrier flight called us on 118.15 (our ATC frequency) and advised us that Center wanted us to immediately climb to 31,000 and turn to 180 degrees…" (ACN 156274)

Observations and Recommendations

Let's see if there may be some useful recommendations for reducing the frequency, duration and severity in lost communication events.

General Considerations

- ✔ As noted, the most common reason for a misset radio is inadvertent pilot mis-selection of a frequency. The best solution to this problem is the old solution—proper attention to detail and good cockpit management and monitoring on the part of the flight crew.
- ✔ Pilots should be aware that there is a significantly increased opportunity for a lost communication event when pilot experience in the aircraft type is low. Continued emphasis on the value of situational awareness will help.
- ✔ Pilots often experienced difficulty in returning to an original frequency if there was an error in selection or clearance to a new frequency. A simple and effective aid for pilots is to write down assigned frequencies; should a loss of communication occur at the point of a frequency change, the pilot may easily return to the previous frequency.
- ✔ One reporter, as a final thought in his misset frequency report, suggested that facility frequencies be reproduced on **enroute** navigation charts. This could be either the primary sector frequencies, or perhaps a "general" frequency shared by a number of sectors within a facility through which a recovery could be effected.
- ✔ The seriousness of "stuck mike" events could be significantly reduced by the use of transmitter "time-out" devices that terminate transmission after a reasonable time period.

✔ Military aircraft, in addition to their normal radio package, are usually fitted with radios that receive on “Guard” frequencies 121.5 and 243 MHz. The volume of these emergency radios cannot be reduced, and in-coming transmissions on this radio will override other communications. If all aircraft operating in the ATC system were fitted with such radios, recovery of aircraft with misset radio and blocked frequency problems could be effected more readily.

GA Pilots

✔ Loss of situational awareness in high workload situations, and problems with aircraft radios or electrical systems were commonly noted problems for GA pilots. Thorough pre-flight planning can help reduce the impact in high workload situations. GA pilots should know their electrical system, and should constantly monitor the electrical system in flight and should consider terminating the flight at the first signs of system problems.

✔ Where high cockpit workloads contribute to loss of communication such as during Approach and Landing, adherence to cockpit disciplines (such as the sterile cockpit), and maintenance of positional awareness should serve to reduce delays in event recognition.

✔ A number of ASRS reports from general aviation operators note the use of hand-held portable aviation radio transceivers—as backup to aircraft mounted radio equipment. In 4 incidents the “hand-held” can be credited with a communications “save,” and there are additional reports among those reviewed for this study that cite effective use of these portable communications radios.

Transport Pilots

✔ Review of pertinent records indicates that pilot recognition of interrupted communication in the Cruise phase, (notable for a low workload environment and a point where ATC communication and chatter are minimal), may be facilitated by the motherhood and apple pie solution of constant situational and positional awareness.

✔ For high altitude flight, noting the location of ARTCC Facility boundaries as marked on charts should serve to alert pilots to required hand-offs.

Controllers

✔ Controller intervention through use of company or ARINC frequencies is effective when used.

✔ Those incidents wherein an ATC facility used an alternate communications process to “recover” an interrupted-communication aircraft showed good success. Use by facilities of alternate communications procedures such as company frequency, aircraft relays, SELCAL, ARINC, and ACARS tends to be effective.

✔ It is suggested that ATC facilities review alternate communications possibilities in the event of frequency blockages, including periodic resting of the battery-operated Gonset radios.

STATISTICS

Introductory Note Regarding ASRS Database Statistics

ASRS codes descriptive characteristics of every report it receives and places that information in a computerized database. We code the function of the person who submitted the report; the place and time of the reported incident; and the descriptive nature of the occurrence. Following are 13 pages of graphs and statistics portraying these and other data.

Time Frame

The data presented are for two specific time periods—a **1-year** period from January 1993 through December 1993, and a **7-year** period from January 1987 through December 1993. The reader will see that, with few exceptions, the 1-year and 7-year data are remarkably similar, with few changes in percentages.

Relationship of ASRS Data to All Aviation Incidents

ASRS reports are voluntarily submitted and are not obtained through a statistically valid sampling process. Thus, the ASRS cannot specify the relationship between its database and the total volume of aviation safety incidents that occur, nor can it say with certainty that this relationship has remained fixed over time. This is known as the ***self-reporting bias*** problem.

However, the ASRS can say with certainty that its database provides definitive lower-bound estimates of the frequencies at which various types of aviation safety events actually occur. For example, 29,434 altitude overshoots were reported to the ASRS from January 1987 through December 1992. It can be confidently concluded that at least this number of overshoots occurred during the 1987-92 period—and probably many more. Often, such lower-bound estimates are all that decision makers need to determine that a problem exists and requires attention.

Known Biases

We are aware of two prominent factors that bias ASRS statistical data. The first is the relatively high number of reports received from pilots (currently about 96 percent of ASRS report intake) versus controllers (roughly 3 percent). This imbalance causes the ASRS database to have many more records describing pilot errors (altitude deviations, runway transgressions, etc.) than controller errors (operational errors, coordination failures, etc.).

The second biasing factor is the computerized error detection capabilities at FAA Air Route Traffic Control Centers (ARTCCs). These are very effective at capturing altitude and track deviations that result in a loss of aircraft separation. Thus, the ASRS receives disproportionately large numbers of reports describing these kinds of events, mostly from pilots.

Number of Reports vs. Number of Incidents

Many incidents are reported by more than one individual. For example, an incident may be reported by a pilot and a controller, several pilots and several controllers, the entire flight crew of a given aircraft, and pilots of more than one aircraft. **In 1993, ASRS received 30,303 reports describing 24,348 unique incidents; thus, 5,955 reports were "secondary," in that they described incidents which had already been reported to the ASRS.**

Hypothetical Example Table

	1993		Jan '87 through Dec '93	
Data category	**Incidents**	**% of Incident Base**	**Incidents**	**% of Incident Base**
Category A	22	13%	1,207	12%
Category B	39	24%	2,945	29%
Category C	83	50%	5,352	52%
Total Unique Incidents	**127**	**77%**	**7,698**	**75%**
Inapplicable or Unknown	**38**	**23%**	**2,509**	**25%**
Incident Base	**165**	**100%**	**10,207**	**100%**

Total and Percent Distributions

Multiple entries are permitted in many of the data fields coded by ASRS analysts. For example, an altitude bust that resulted in a loss of standard separation would be coded in the Anomaly field as an altitude deviation, an airborne conflict, and an ATC clearance violation. While this is the most accurate way of coding events, it means that incidents do not fall into neat, mutually exclusive categories that always add up to 100 percent. Moreover, it is not unusual for selected data fields to be left blank during coding, either because needed information is not available, or because the field is not deemed relevant to a particular report. This presents an added complication when incidents are totalled and percent distributions are calculated.

The first chart in the following pages shows the number of **unique incidents** reported to the ASRS over the past 7 years. This provides a baseline for interpreting data in succeeding charts which characterize the time, location, and other aspects of the reported incidents. The data in these latter tables are presented in a consistent format that provides for unknown or inapplicable data, and for cases in which more than one category applies. An example is shown above in the hypothetical table.

In this example, incident records are categorized as A, B, or C. Any incident may be placed in one, two, or even three of these categories. If categories A, B, and C are simply added together, incidents that are recorded in more than one category will be double-counted in the "Total Row." Since double-counting is usually unwanted in summations, the totals have been adjusted to eliminate double-counted events. The results are presented in the row entitled ***Total Unique Incidents***.

Thus, in the Hypothetical Example Table, a total of 165 incidents were reported during the current time period. This is the ***Incident Base*** for that period. Out of the Incident Base, 127 unique events fell into categories A, B, or C, or some combination of these categories. The remaining 38 incidents did not fit any of the categories, or there was insufficient data to classify them. These are shown in the ***Inapplicable or Unknown*** row.

Because the number of Total Unique Incidents varies from table to table, we decided to use the Incident Base to calculate percent distributions for all data sets. By calculating the percentages in this matter, we created a common yardstick which can be used to compare the data presented in the various charts.

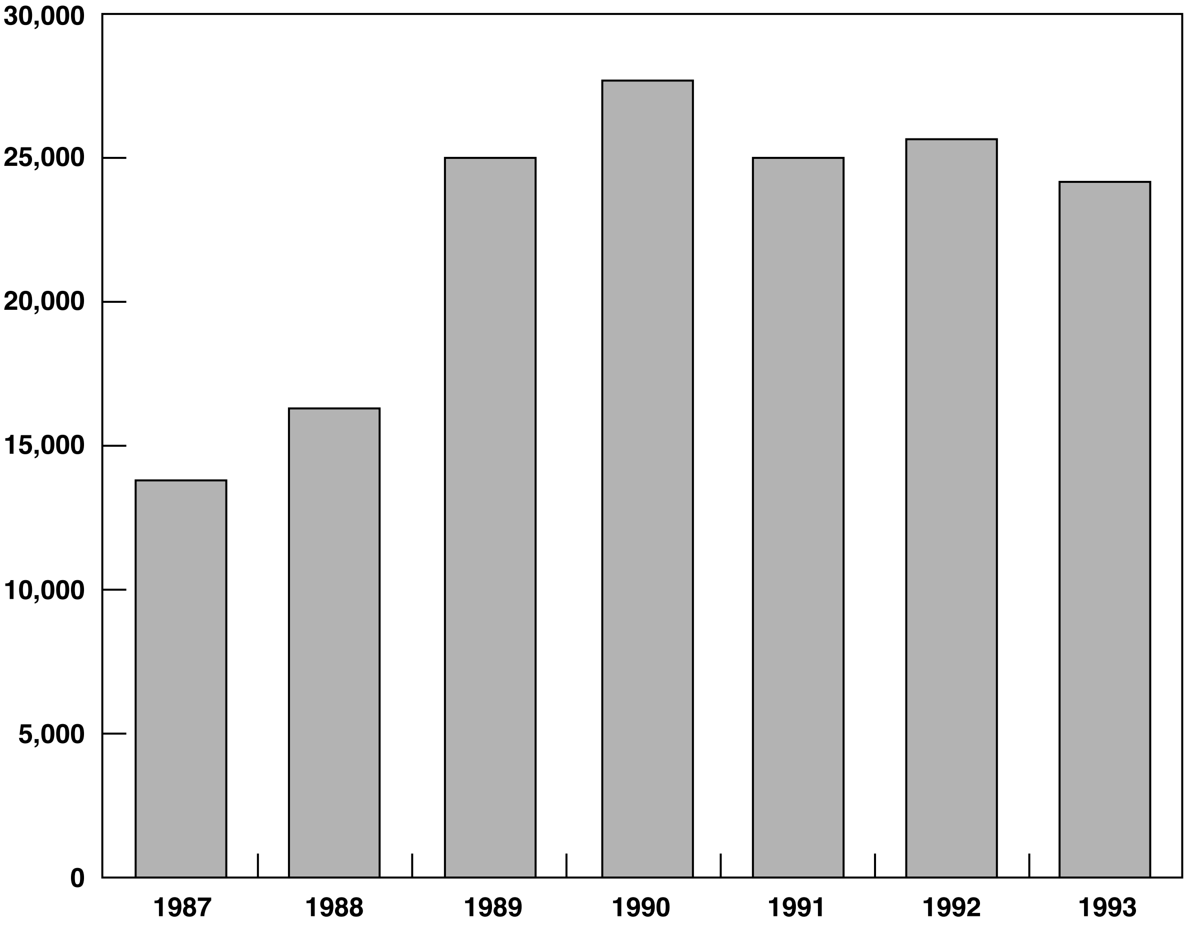
Finally, all of the percentages shown were rounded to whole numbers. In those cases where the number of relevant incidents is very small (less than one-half of one percent) the percentages round down to, and are presented as, zero percent. Similarly, in those cases where the number of reports in a category exceed 99.5 percent of the Incident Base, the result was rounded up to, and is presented as, 100 percent.

Data Listing

Statistical Data **Page**

Reported Incidents

Year of Occurrence

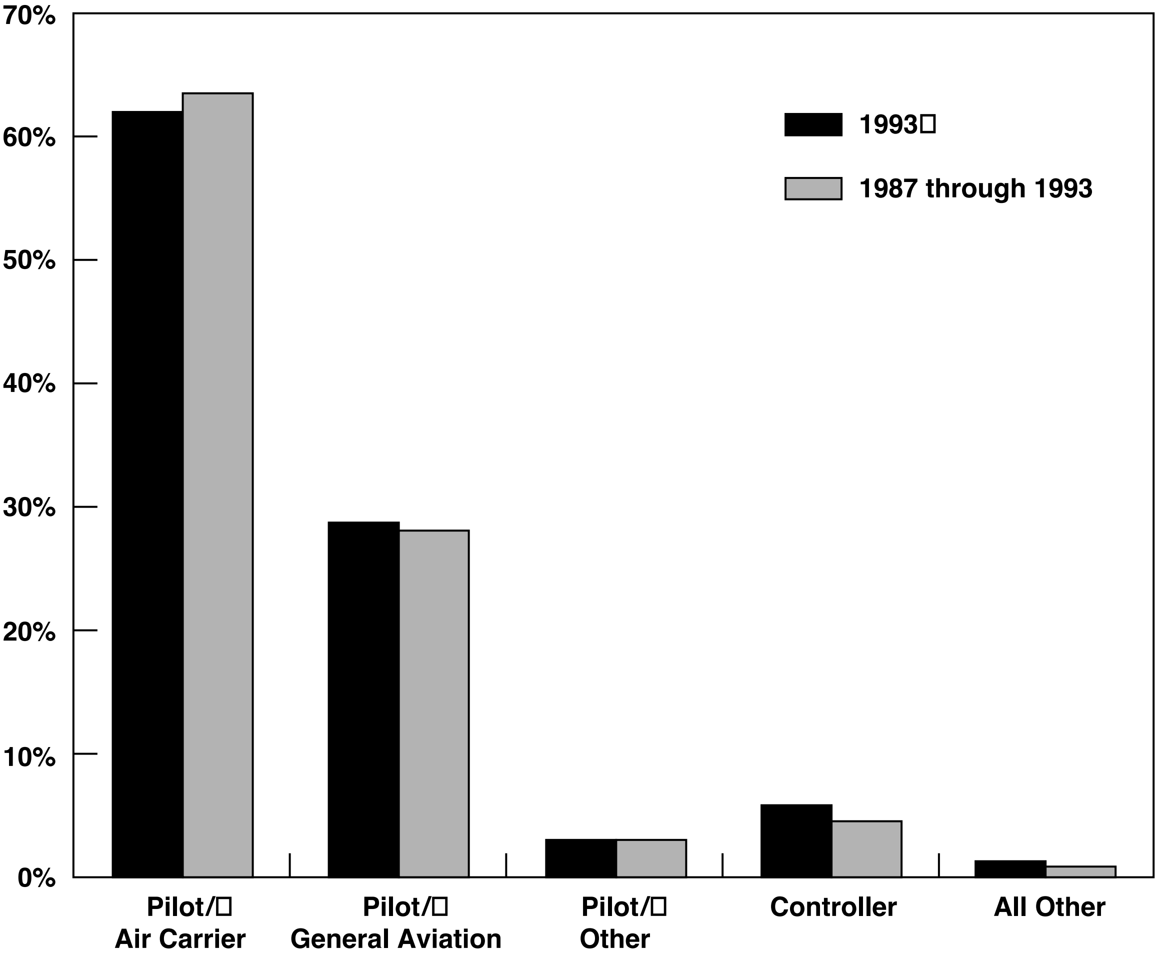


Period of Occurrence	Reported Incidents	
	Year Total	*Cumulative*
1987	13,612	13,612
1988	16,381	29,993
1989	24,953	54,946
1990	27,728	82,674
1991	25,034	107,708
1992	25,865	133,573
1993	24,349	157,922

◄—— Incident Base

Reported Incidents

Reporting Sources

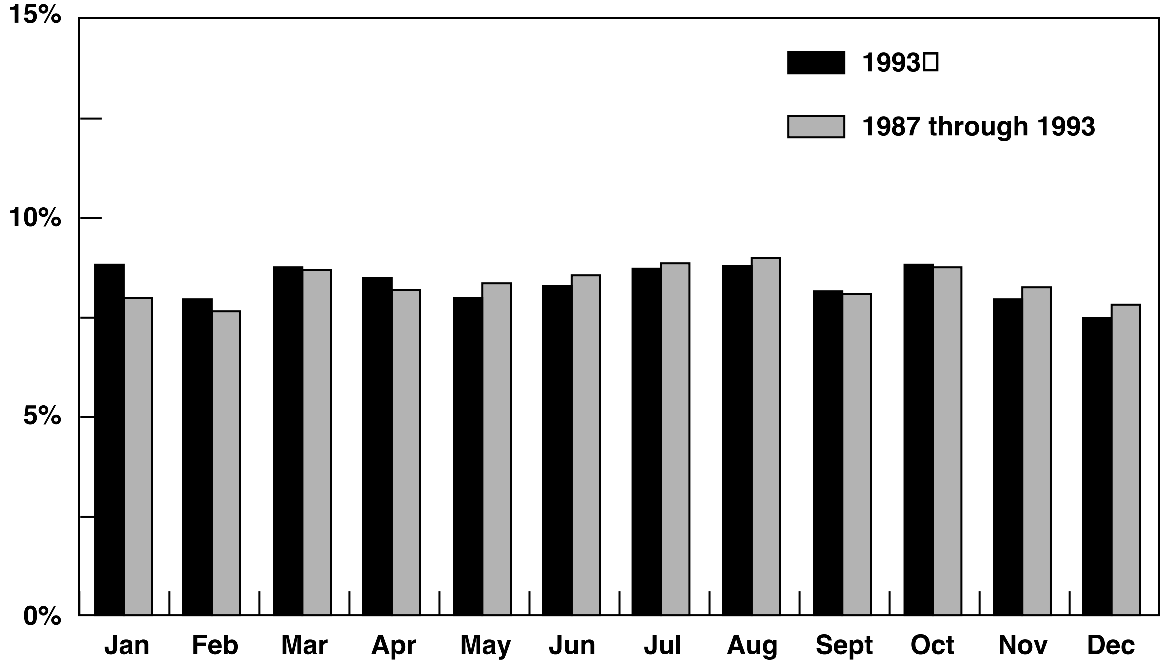


Reporters	1993		1987 through 1993	
	Incidents	% of Incident Base	Incidents	% of Incident Base
Pilot/Air Carrier	15,215	62%	100,538	64%
Pilot/General Aviation	6,953	29%	44,942	28%
Pilot/Other	843	3%	5,465	3%
Controller	1,214	5%	6,552	4%
All Other	242	1%	1,039	1%
Total Unique Relevant	**24,310**	**100%**	**157,765**	**100%**
Irrelevant or Unknown	**39**	**0%**	**157**	**0%**
Incident Base	**24,349**	**100%**	**157,922**	**100%**

Note: Roughly 20 percent of these events were reported by more than one person, but the secondary reporters were usually involved in the same incident, e.g., two pilots reporting the same NMAC.

Reported Incidents

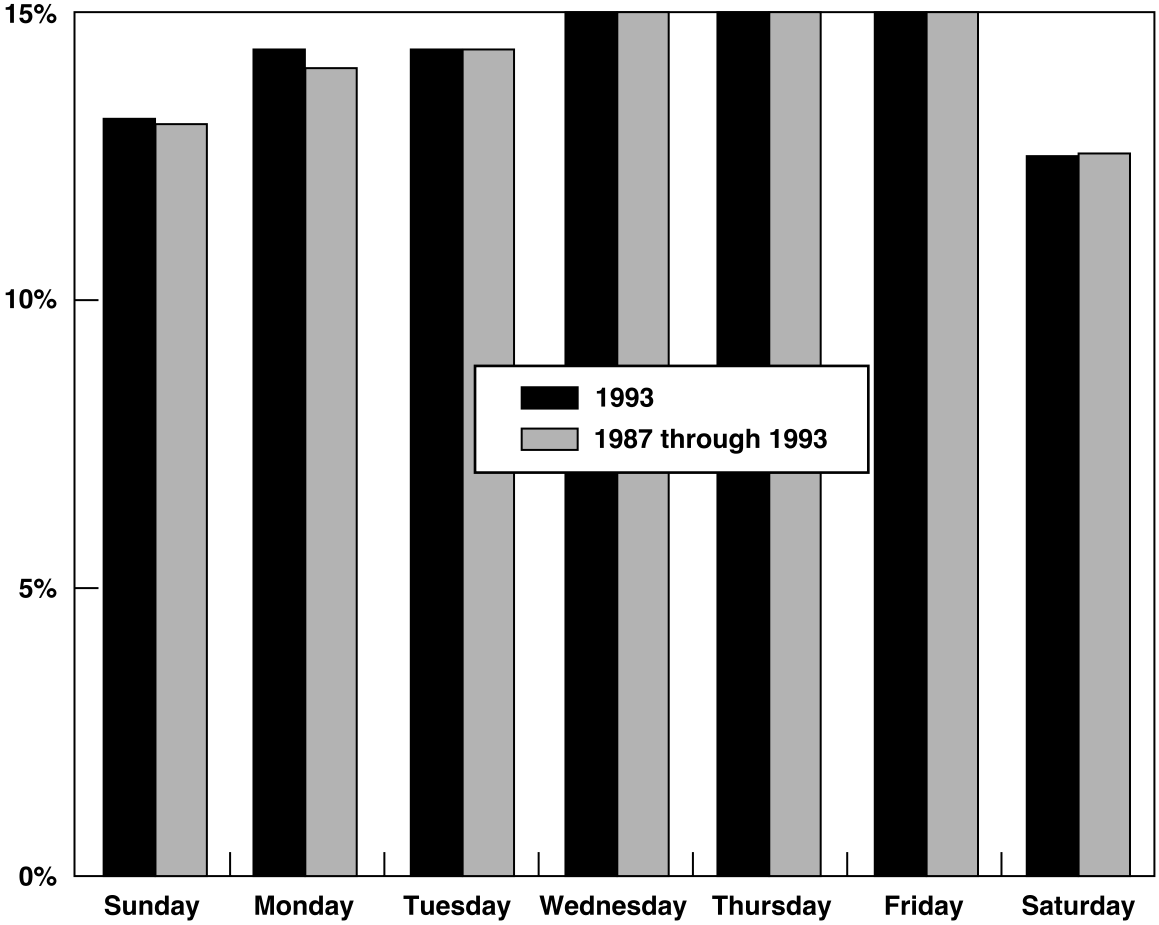
Month of Occurrence



	1993		1987 through 1993	
Month	**Incidents**	**% of Incident Base**	**Incidents**	**% of Incident Base**
January	2,145	9%	12,508	8%
February	1,927	8%	12,041	8%
March	2,131	9%	13,693	9%
April	2,068	8%	12,892	8%
May	1,946	8%	13,125	8%
June	2,018	8%	13,531	9%
July	2,121	9%	13,934	9%
August	2,138	9%	14,161	9%
September	1,987	8%	12,851	8%
October	2,148	9%	13,877	9%
November	1,937	8%	12,979	8%
December	1,783	7%	12,330	8%
Total Unique Relevant	**24,349**	**100%**	**157,922**	**100%**
Irrelevant or Unknown	**0**	**0%**	**0**	**0%**
Incident Base	**24,349**	**100%**	**157,922**	**100%**

Reported Incidents

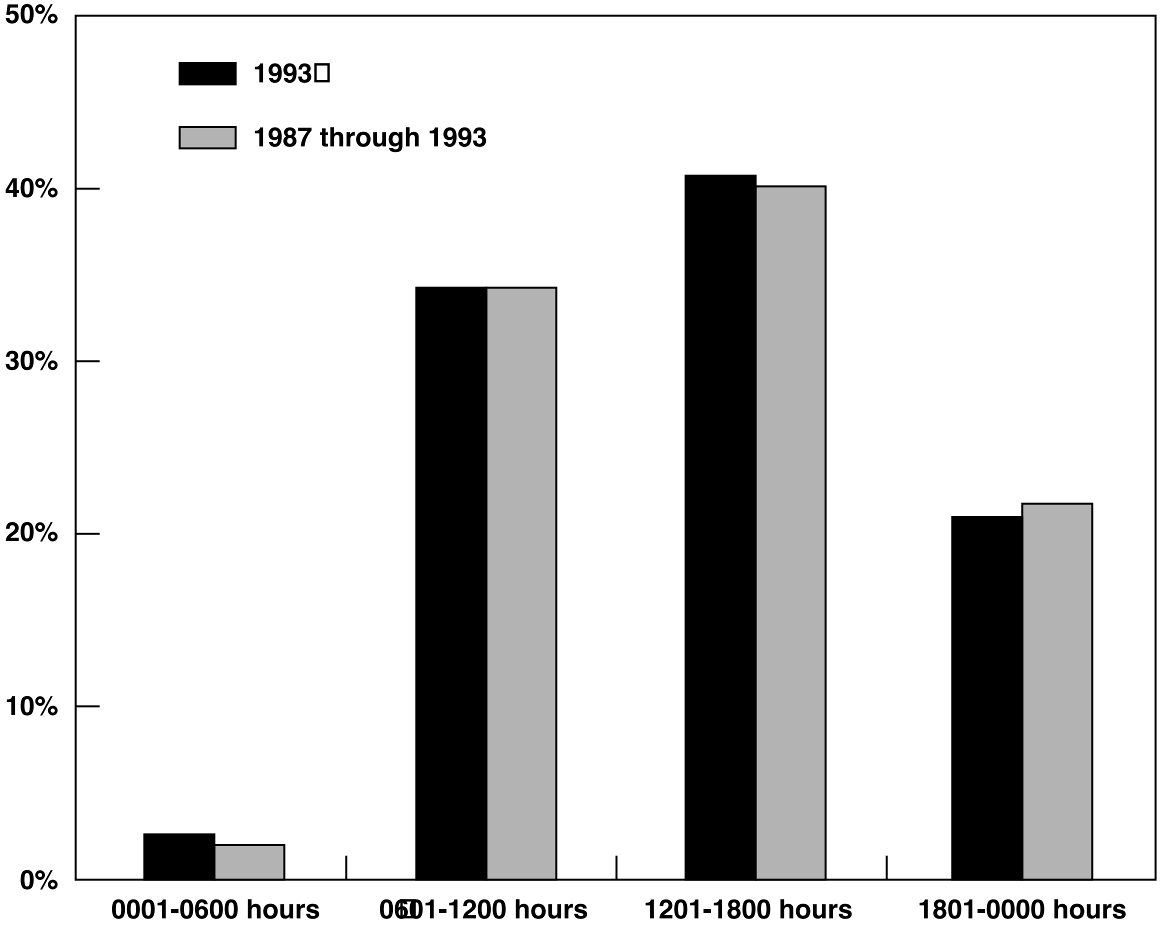
Weekday of Occurrence



	1993		1987 through 1993	
Weekday	**Incidents**	**% of Incident Base**	**Incidents**	**% of Incident Base**
Sunday	3,235	13%	20,867	13%
Monday	3,522	14%	22,251	14%
Tuesday	3,491	14%	22,607	14%
Wednesday	3,689	15%	23,673	15%
Thursday	3,715	15%	24,259	15%
Friday	3,681	15%	24,443	15%
Saturday	3,010	12%	19,614	12%
Total Unique Relevant	**24,343**	**100%**	**157,714**	**100%**
Irrelevant or Unknown	**6**	**0%**	**208**	**0%**
Incident Base	**24,349**	**100%**	**157,922**	**100%**

Reported Incidents

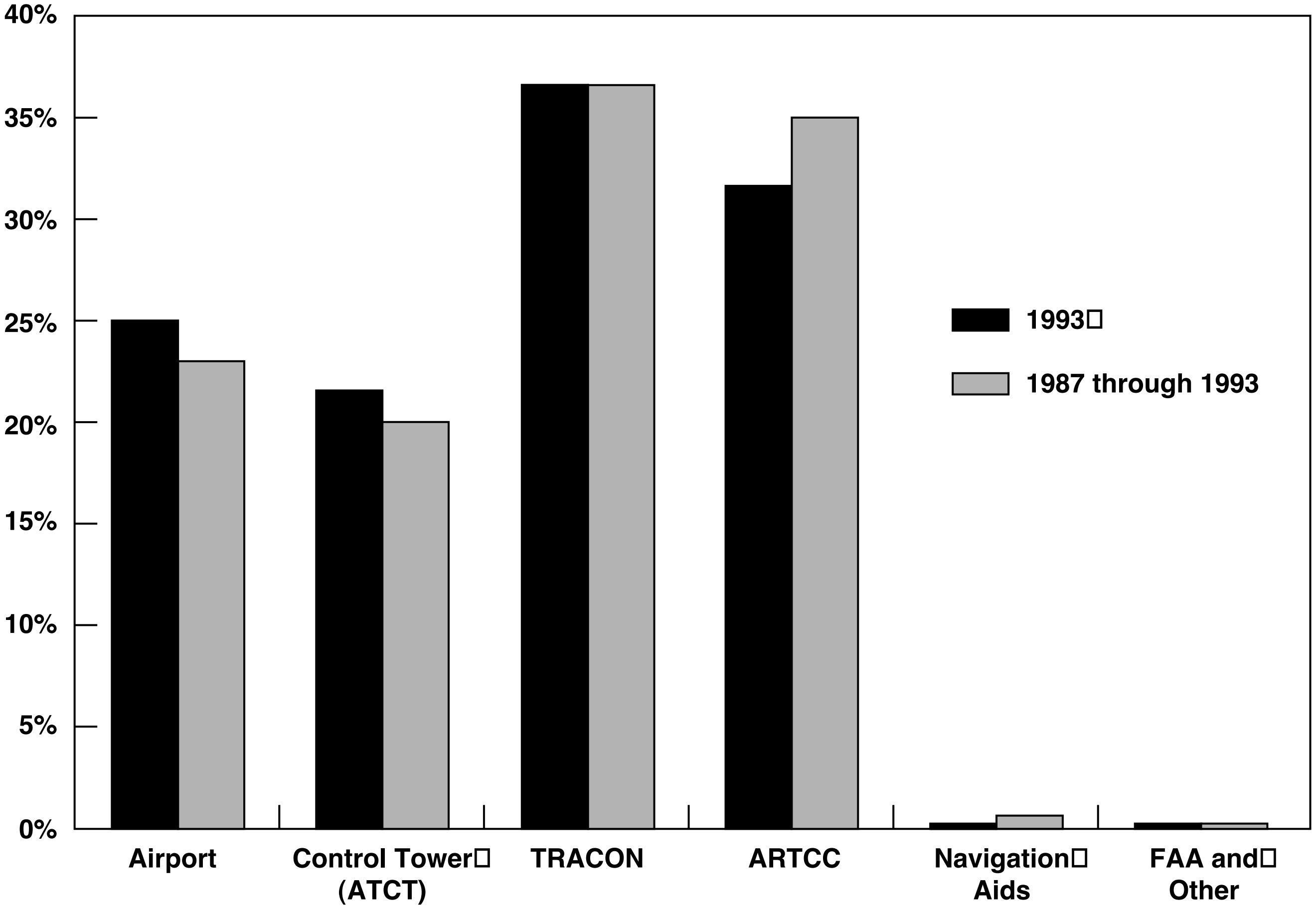
Time of Day of Occurrence



Time of Day (Local Time)	1993		1987 through 1993	
	Incidents	% of Incident Base	Incidents	% of Incident Base
0001-0600 hours	616	3%	3,499	2%
0601-1200 hours	8,376	34%	54,333	34%
1201-1800 hours	10,034	41%	64,731	41%
1801-0000 hours	5,228	21%	34,609	22%
Total Unique Relevant	**24,254**	**100%**	**157,172**	**100%**
Irrelevant or Unknown	**95**	**0%**	**750**	**0%**
Incident Base	**24,349**	**100%**	**157,922**	**100%**

Reported Incidents

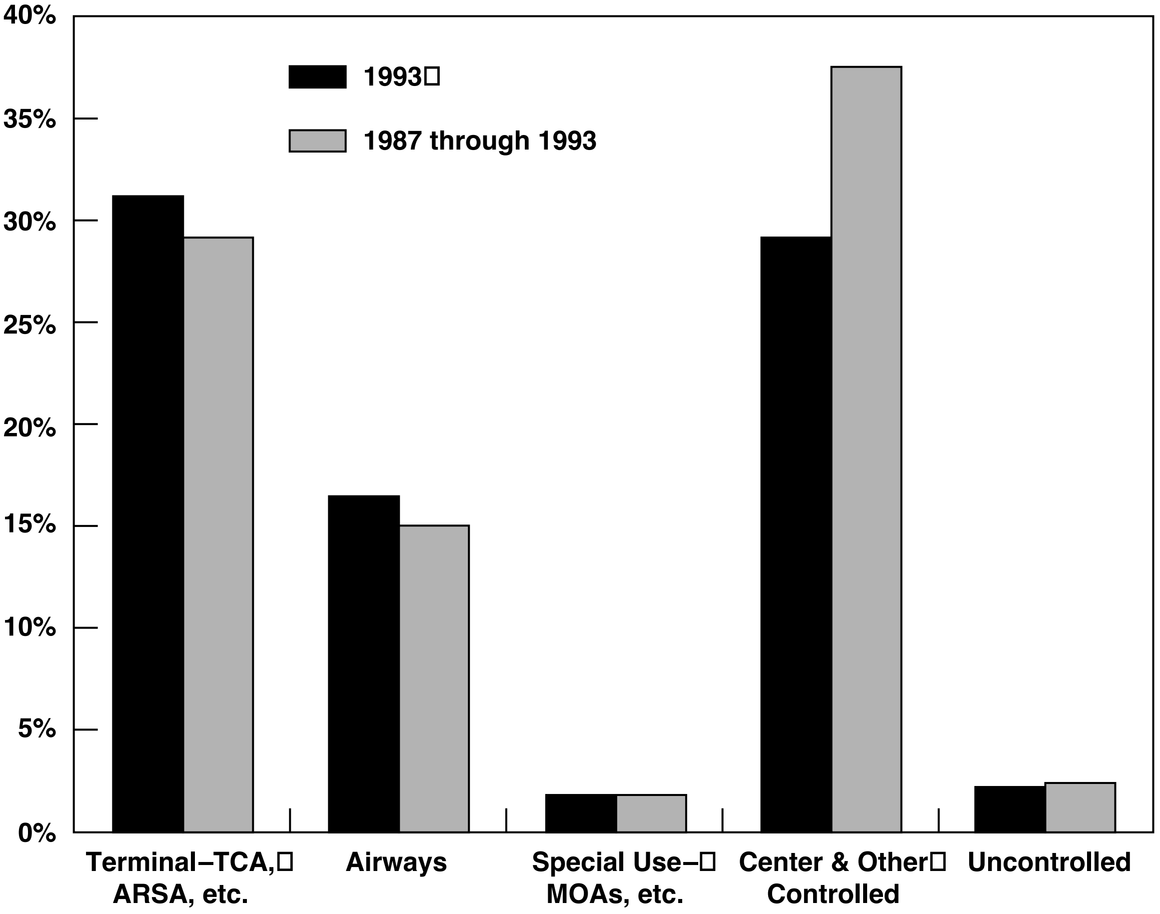
Involved Facilities



Involved Airspace	1993 Incidents	1993 % of Incident Base	1987 through 1993 Incidents	1987 through 1993 % of Incident Base
Airport	6,119	25%	37,042	23%
Control Tower (ATCT)	5,333	22%	31,803	20%
TRACON	8,910	37%	58,564	37%
Center (ARTCC)	7,838	32%	55,292	35%
Navigation Aids	21	0%	206	0%
FSS and Other	125	1%	666	0%
Total Unique Relevant	**24,286**	**100%**	**157,022**	**99%**
Irrelevant or Unknown	**63**	**0%**	**900**	**1%**
Incident Base	**24,349**	**100%**	**157,922**	**100%**

Reported Incidents

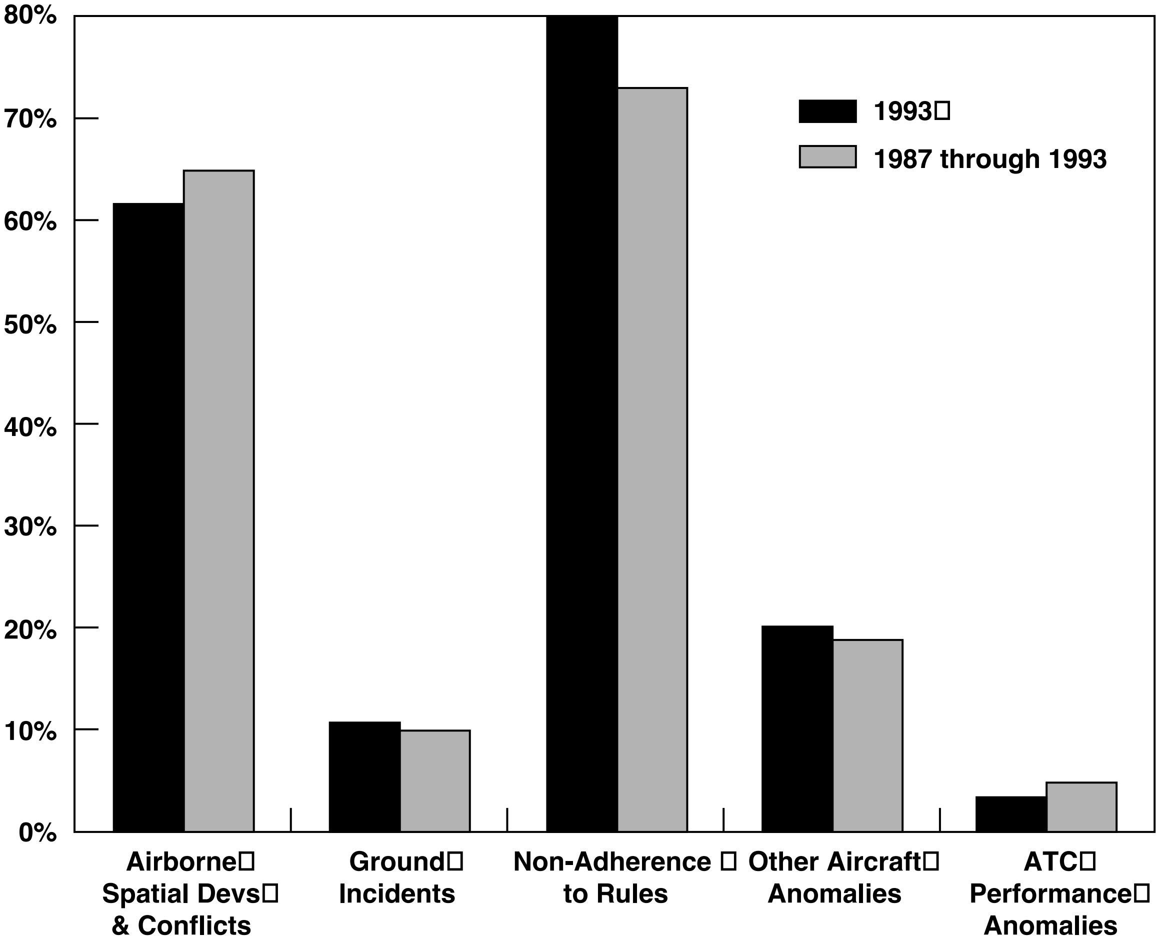
Involved Airspaces



Involved Airspace	1993		1987 through 1993	
	Incidents	**% of Incident Base**	**Incidents**	**% of Incident Base**
Terminal–TCA, ARSA, etc.	7,515	31%	45,150	29%
Airways	4,129	17%	23,849	15%
Special Use–MOAs, etc.	368	2%	2,236	1%
Center & Other Controlled	7,175	29%	58,983	37%
Uncontrolled	485	2%	3,225	2%
Total Unique Relevant	**19,367**	**80%**	**129,404**	**82%**
Irrelevant or Unknown	**4,982**	**20%**	**28,518**	**18%**
Incident Base	**24,349**	**100%**	**157,922**	**100%**

Reported Incidents

Anomalies (Top Level Categorization)

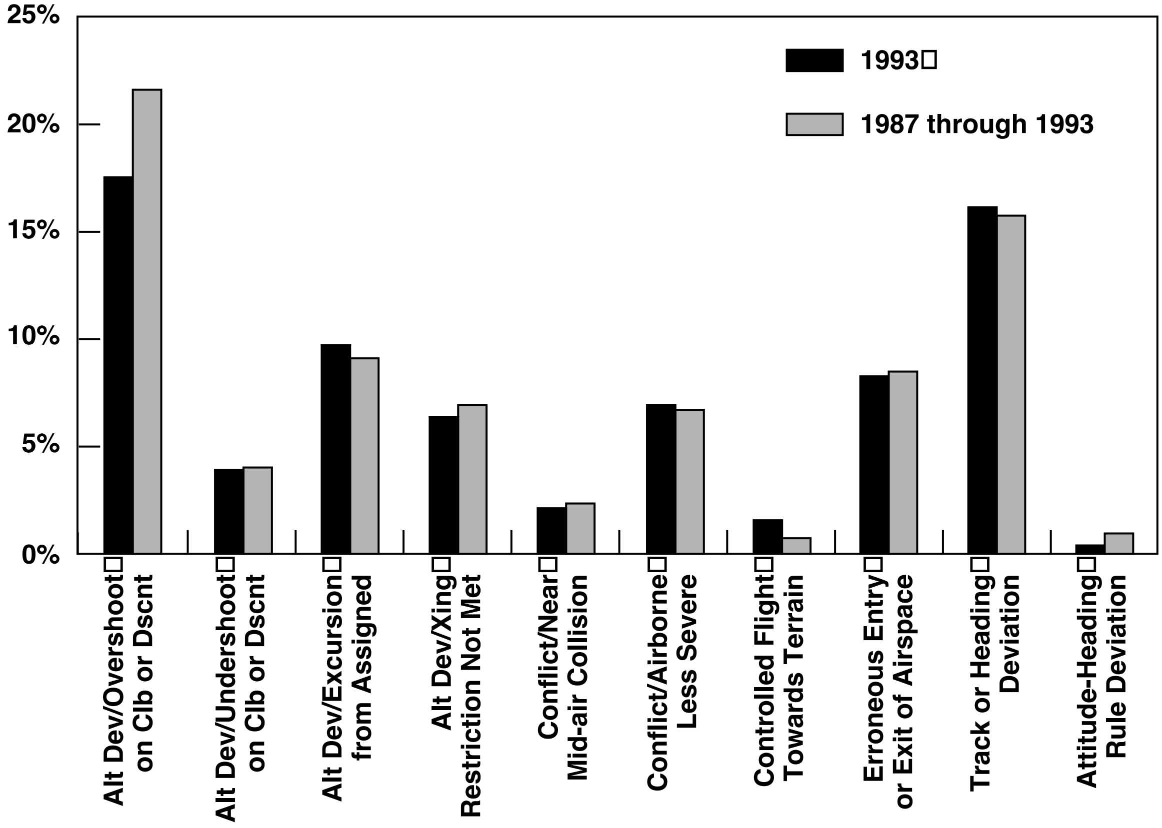


Type of Anomaly	1993 Incidents	1993 % of Incident Base	1987 through 1993 Incidents	1987 through 1993 % of Incident Base
Airborne Spatial Devs & Conflicts	15,081	62%	102,944	65%
Ground Incidents	2,562	11%	15,287	10%
Non-Adherence to Rules	19,421	80%	115,460	73%
Other Aircraft Anomalies	4,906	20%	28,884	18%
ATC Performance Anomalies	821	3%	7,449	5%
Total Unique Relevant	**22,885**	**94%**	**146,707**	**93%**
Irrelevant or Unknown	**1,464**	**6%**	**11,215**	**7%**
Incident Base	**24,349**	**100%**	**157,922**	**100%**

Note: See the cautionary remarks regarding reporting biases in the Introductory Note.

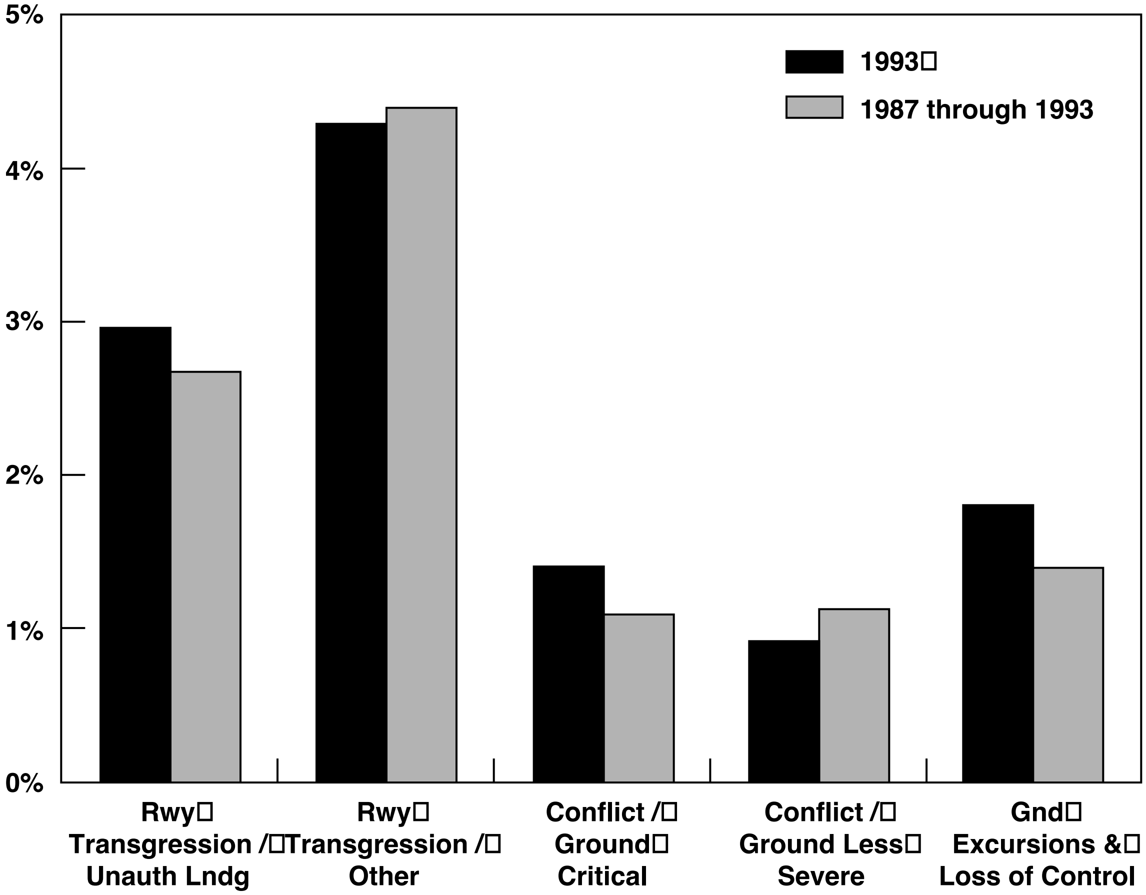
Reported Incidents

Airborne Spatial Deviations & Conflicts



	1993		1987 through 1993	
Spatial Deviation or Conflict	**Incidents**	**% of Incident Base**	**Incidents**	**% of Incident Base**
Alt/Dev/Overshoot on Clb or Dscnt	4,218	17%	33,656	21%
Alt Dev/Undershoot in Clb or Dscnt	956	4%	6,310	4%
Alt Dev/Excursion from Assigned	2,390	10%	14,711	9%
Alt Dev/Xing Restriction Not Met	1,539	6%	10,323	7%
Conflict/Near Mid-air Collision	516	2%	13,586	2%
Conflict/Airborne Less Severe	1,610	7%	10,277	7%
Controlled Flight Towards Terrain	277	1%	992	1%
Erroneous Entry or Exit of Airspace	2,058	8%	13,456	9%
Track or Heading /Deviation	3,876	16%	24,730	16%
Altitude-Heading Rule Deviation	53	0%	501	0%
Total Unique Relevant	**15,081**	**62%**	**102,944**	**65%**
Irrelevant or Unknown	**9,268**	**38%**	**54,978**	**35%**
Incident Base	**24,349**	**100%**	**157,922**	**100%**

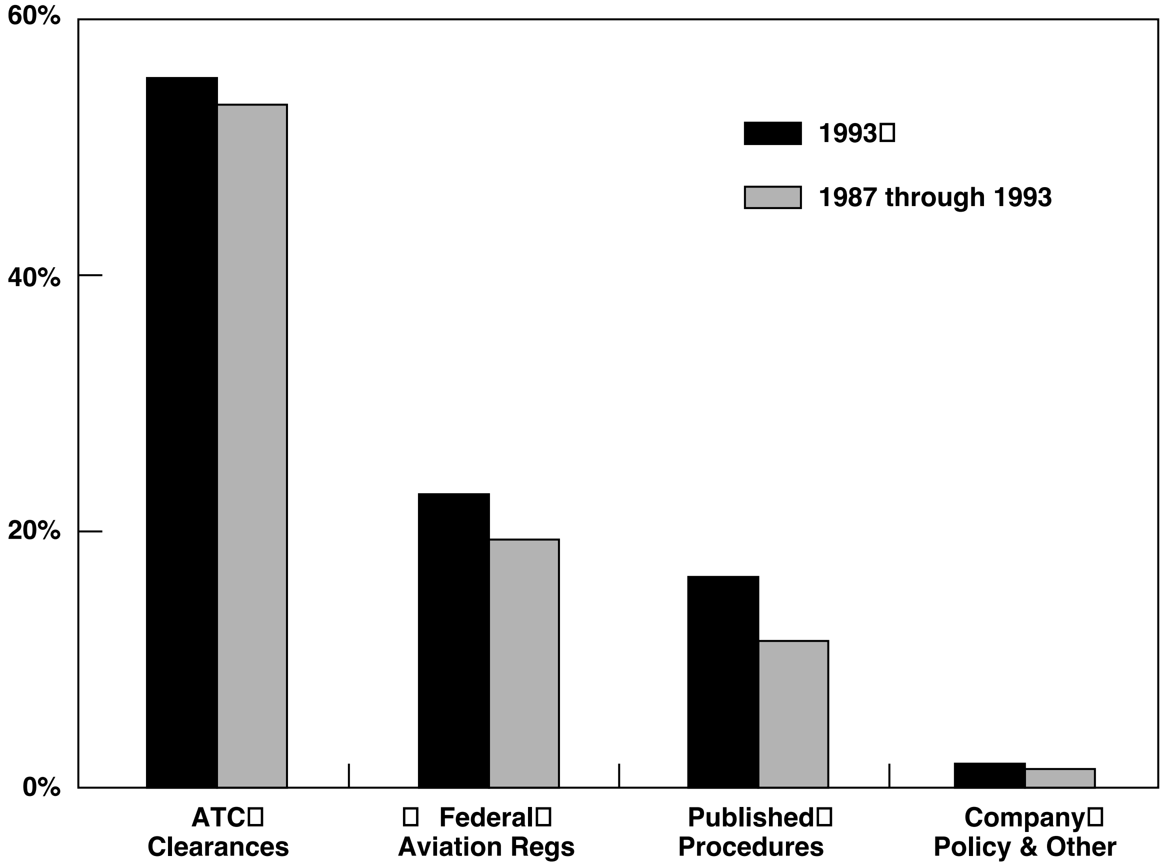
Ground Incidents



Ground Incidents	1993 Incidents	1993 % of Incident Base	1987 through 1993 Incidents	1987 through 1993 % of Incident Base
Rwy Transgression / Unauth Lndg	723	3%	4,134	3%
Rwy Transgression / Other	1,048	4%	6,838	4%
Conflict / Ground Critical	334	1%	1,718	1%
Conflict / Ground Less Severe	228	1%	1,777	1%
Gnd Excursions & Loss of Control	436	2%	2,193	1%
Total Unique Relevant	**2,562**	**11%**	**15,287**	**10%**
Irrelevant or Unknown	**21,787**	**89%**	**142,635**	**90%**
Incident Base	**24,349**	**100%**	**157,922**	**100%**

Reported Incidents

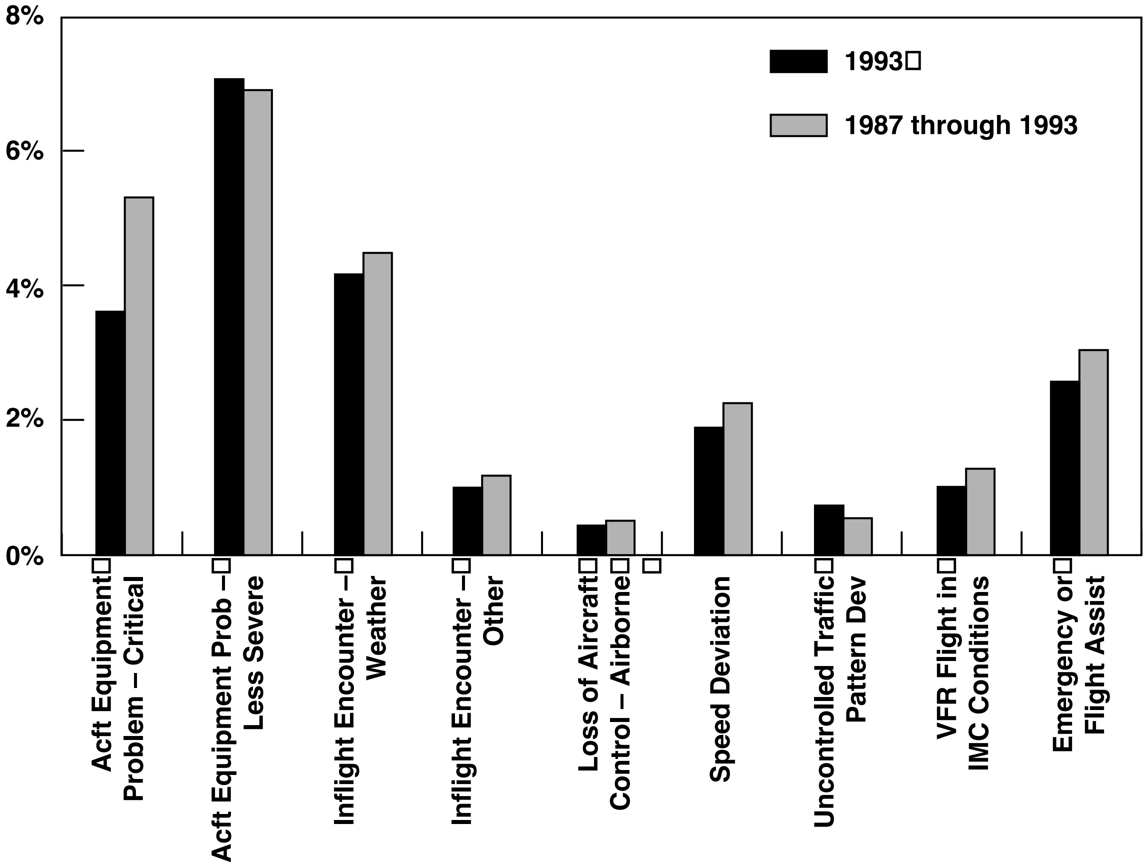
Non-Adherence to Rules & Requirements



Non-Adherence to...	1993		1987 through 1993	
	Incidents	% of Incident Base	Incidents	% of Incident Base
ATC Clearances	13,440	55%	82,299	52%
Federal Aviation Regs	5,682	23%	30,940	20%
Published Procedures	4,069	17%	18,951	12%
Company Policy & Other	399	2%	2,067	1%
Total Unique Relevant	**19,421**	**80%**	**115,460**	**73%**
Irrelevant or Unknown	**4,928**	**20%**	**42,462**	**27%**
Incident Base	**24,349**	**100%**	**157,922**	**100%**

Reported Incidents

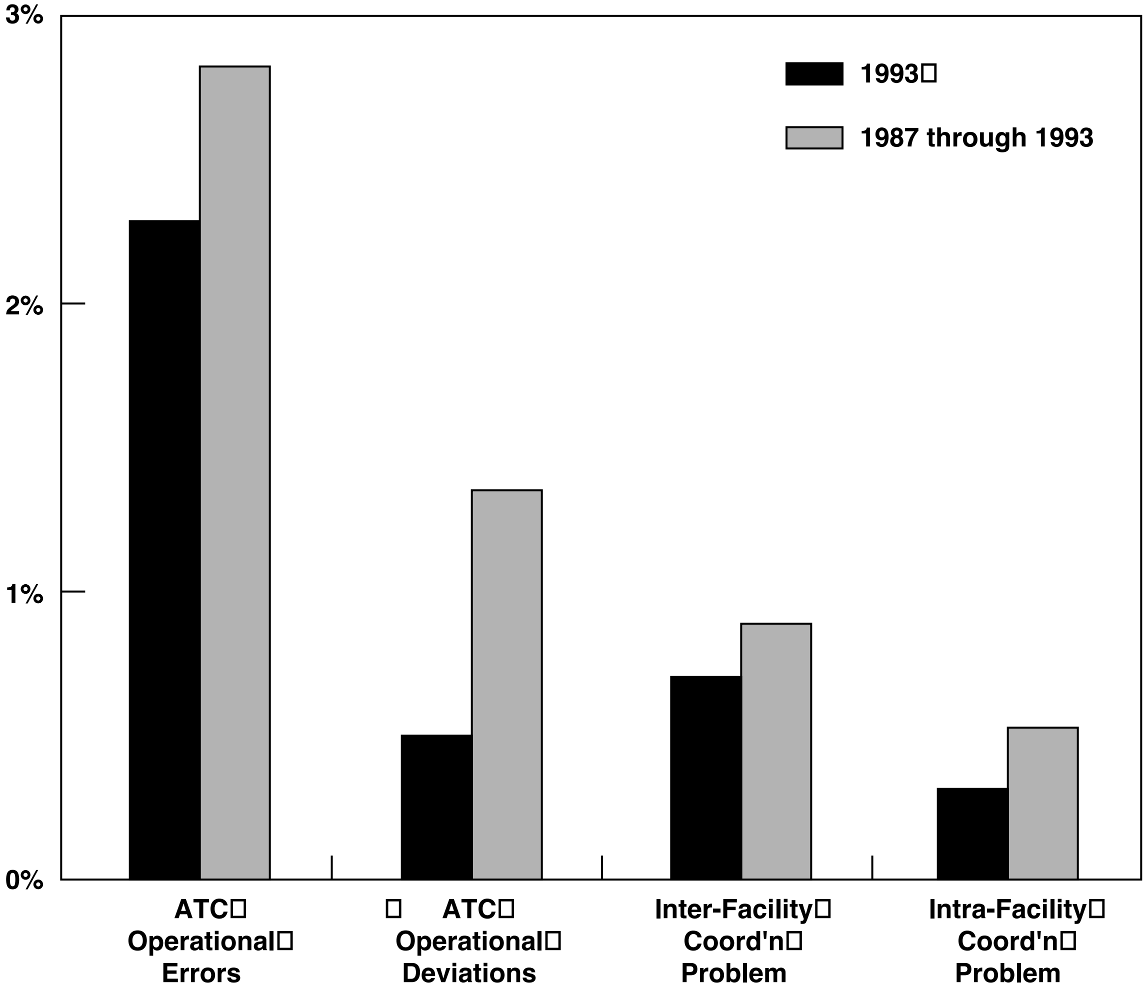
Other Aircraft Anomalies



Other Aircraft Anomlay	1993		1987 through 1993	
	Incidents	**% of Incident Base**	**Incidents**	**% of Incident Base**
Acft Equipment Problem – Critical	1,297	5%	5,765	4%
Acft Equipment Prob – Less Severe	1,702	7%	11,281	7%
Inflight Encounter – Weather	1,050	4%	6,402	4%
Inflight Encounter – Other	252	1%	1,428	1%
Loss of Aircraft Control – Airborne	92	0%	525	0%
Speed Deviation	518	2%	3,055	2%
Uncontrolled Traffic Pattern Dev	129	1%	999	1%
VFR Flight in IMC Conditions	254	1%	1,435	1%
Emergency or Flight Assist	721	3%	3,851	2%
Total Unique Relevant	**4,906**	**20%**	**28,884**	**18%**
Irrelevant or Unknown	**19,443**	**80%**	**129,038**	**82%**
Incident Base	**24,349**	**100%**	**157,922**	**100%**

Reported Incidents

ATC Handling Anomalies



ATC Performance Anomaly	1993		1987 through 1993	
	Incidents	% of Incident Base	Incidents	% of Incident Base
ATC Operational Errors	560	2%	4,453	3%
ATC Operational Dev	133	1%	2,149	1%
Inter-Facility Coord'n Prob	169	1%	1,356	1%
Inter-Facility Coord'n Prob	90	0%	891	1%
Total Unique Relevant	**821**	**3%**	**7,449**	**5%**
Irrelevant or Unknown	**23,528**	**97%**	**150,473**	**95%**
Incident Base	**24,349**	**100%**	**157,922**	**100%**