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AN INVESTIGATION OF REPORTS OF CONTROLLED FLIGHT TOWARD TERRAIN (CFTT)

by

Richard F. Porter and James P. Loomis

April 6, 1981

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AN INVESTIGATION OF REPORTS OF CONTROLLED FLIGHT TOWARD TERRAIN (CFTT)

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SUMMARY

This report describes a study of reports in the files of the Aviation Safety Reporting System (ASRS) which are relevant to the hazard of flight into terrain with no prior awareness by the crew of impending disaster.

Some 258 reports, from the more than 23,000 documents in the ASRS data base, were found to be relevant to the general problem area. These were examined in detail to identify the human and system factors which are conducive to CFTT events and to safe recovery from such incidents when they occur.

The results of this study indicate that human error was a casual factor in 64% of the incidents in which some threat of terrain conflict was experienced. Approximately two-thirds of the human errors were attributed to controllers, the most common discrepancy being a radar vector below the Minimum Vector Altitude (MVA). Errors by pilots were of a much more diverse nature and include a few instances of gross deviations from their assigned altitudes.

The Ground Proximity Warning System (GPWS) and the Minimum Safe Altitude Warning (MSAW) equipment were the initial recovery factor in some 18 serious incidents and were apparently the sole warning in six reported instances which otherwise would most probably have ended in disaster.

INTRODUCTION

The early 1970's were marked by a dramatic series of Controlled-Flight-Into-Terrain (CFIT)* fatal accidents. On December 1, 1974, TWA Flight

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*Those accidents in which an aircraft, under the control of the crew, is flown into terrain (or water) with no prior awareness on the part of the crew of the impending disaster.

514, a Boeing 727 inbound to Dulles from Columbus, Ohio, struck a mountain, after prematurely descending below a safe enroute altitude, due to ambiguities in the pilot-controller communication terminology and navigation charts. This accident served as a watershed for important accident prevention developments. One of these was an amendment to Federal Aviation Regulation Part 121 to require that all large turbine-powered aircraft be equipped with a Ground Proximity Warning System (GPWS). Another was the initiation of the Aviation Safety Reporting System (ASRS) of which this report is a part.

The years following 1974 have been marked by a widely recognized reduction in CFIT-type accidents, at least in scheduled air carrier service. Notwithstanding controversy over the "false alarm" problem, some believe these improvements are attributable to GPWS and the Minimum Safe Altitude Warning (MSAW) system later installed in the ARTS-3 terminal area radar systems.

An examination of ASRS reports relating to reported hazards involving terrain and/or obstacles is of significant interest. First, it offers an opportunity to identify new or recurrent problem areas which may pose a hazard to flight. Further, it offers a most interesting chance to review the impact of GPWS and MSAW implementation on the CFIT accident regime.

OBJECTIVE

The objectives of this research task were to (1) identify those human and system factors which facilitate the occurrence of CFTT events and which preclude their termination as an accident, and (2) to understand the impact of the introduction of Ground Proximity Warning Systems (GPWS) and Minimum Safe Altitude Warning (MSAW).

APPROACH

The earliest reports in the ASRS data bases date from July of 1976. In order to extend the study back as close to the height of the CFIT problem era, the search for appropriate ASRS reports was focused on the period from July 1976 through October 1980. This data base contained approximately 23,000 reports.

In developing a strategy for identifying appropriate reports, it was necessary to broadly define the type of situations and/or occurrences being sought. In general, three broad categories were sought:

- Actual occurrences in which, except for an intervention that occurred or by chance, it is believed that the aircraft would have come in contact with terrain, bodies of water, or obstacles such as towers, tanks, smokestacks, or buildings
- Situations which are believed to be conducive to an aircraft inadvertently coming into contact with terrain, bodies of water, or obstacles
- Actual occurrences in which a GPWS or MSAW system issued a false or inappropriate alarm.

While the third category above did not directly relate to controlled flight toward terrain, it was judged important because false alarms stand to influence the credibility of alarms or create new hazards (e.g., loss of aircraft control due to distraction).

As a first step toward getting insight into the CFTT arena, it was planned that the selected reports would be classified into whatever categories the data might suggest. The descriptive statistics of each category would then be developed and studied. Finally, it was intended that a more qualitative analysis would be undertaken to better understand the hazards involved and the related event sequences and recovery factors.

RESULTS

Initially, the data base search described above yielded some 383 reports describing some 363 unique* situations/occurrences. An analysis of the substance of these reports forced a refinement of the definition of the CFTT study scope and resulted in the discard of some reports. Examples of situations/occurrences excluded from this initial document set include the following:

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* Multiple reports are sometimes received describing a specific occurrence or situation.

- There were quite a few reports where the reporter was describing unstabilized final approaches resulting from poor vectoring procedures or pilot technique. These were excluded because the threat of collision with terrain pertains to loss of control rather than a situation where there is no awareness of an impending collision with terrain
- There were several incidents in which an acute awareness of terrain, and efforts to stay clear of it, led to other problems such as a near mid-air collision with another aircraft
- There were some incidents where either turbulence aloft or windshear on the final approach course brought the aircraft dangerously close to terrain
- There were yet other reports describing low flying aircraft which were deemed to have been illegally low or otherwise flying hazardously.

Classification of CFTT Reports

The final document set retained for study consisted of reports describing 258 unique situations/occurrences. An examination of the document set suggested that it would be useful to classify the reports into the six categories defined in table 1.

A word of explanation is in order concerning types I and II. These are situations/occurrences in which the overall responsibility for what went wrong is alleged to lie with a flight crew member or a controller, respectively. This does not mean that there may not be other underlying causes for what transpired. Further, the selection of these six categories does not preclude the examination of phenomena that may involve more than one of these categories (e.g., incidents in which a GPWS prevented collision with terrain).

Descriptive Statistics

Figure 1 shows the histograms of reporting frequency for all of the six types defined in table 1.

TABLE 1. DEFINITION OF THE TYPES OF SITUATIONS OR OCCURRENCES USED

Designation	Description
I.	Problems arising from flight crew errors involving navigation, altitude control, or aircraft configuration
II.	Problems arising from inappropriate ATC vectors or clearances, or deviation from standard procedures
III.	Problems with charts concerning altitude retrictions, or qualifications in case of loss of communications, configuration of airspace, or established procedures
IV.	Problems connected with unlighted or unmarked towers, tanks, etc., or obstacles ineffectively lighted or marked
V.	Problems arising from inadequate or unreliable approach aides, enroute aides, or use thereof
VI.	Problems arising from false or believed inappropriate activation of GPWS or MSAW devices.

There is no obvious reason for the noticeable peak in reports received in early 1978. In fact, both 1977 and 1978 exhibit significantly greater numbers of reports than do 1979 and 1980. Aside from this anomaly, the average number of CFTT reports received each month has stabilized at about 4.5 reports per month. There has been no significant trend in the last two years which would suggest either an increase or decrease in the rate at which CFTT reports are received by the ASRS.

Table 2 shows both the number of unique reports for each of the six categories and a breakdown of report frequency by type of reporter. As shown, the greatest number of reports occurred in category II where ATC vectoring or clearances were alleged to be the main problem. The next most reported category was V where the problem involved landing aids. Overall, flight crew members were the most frequent reporters, accounting for about 68 percent of

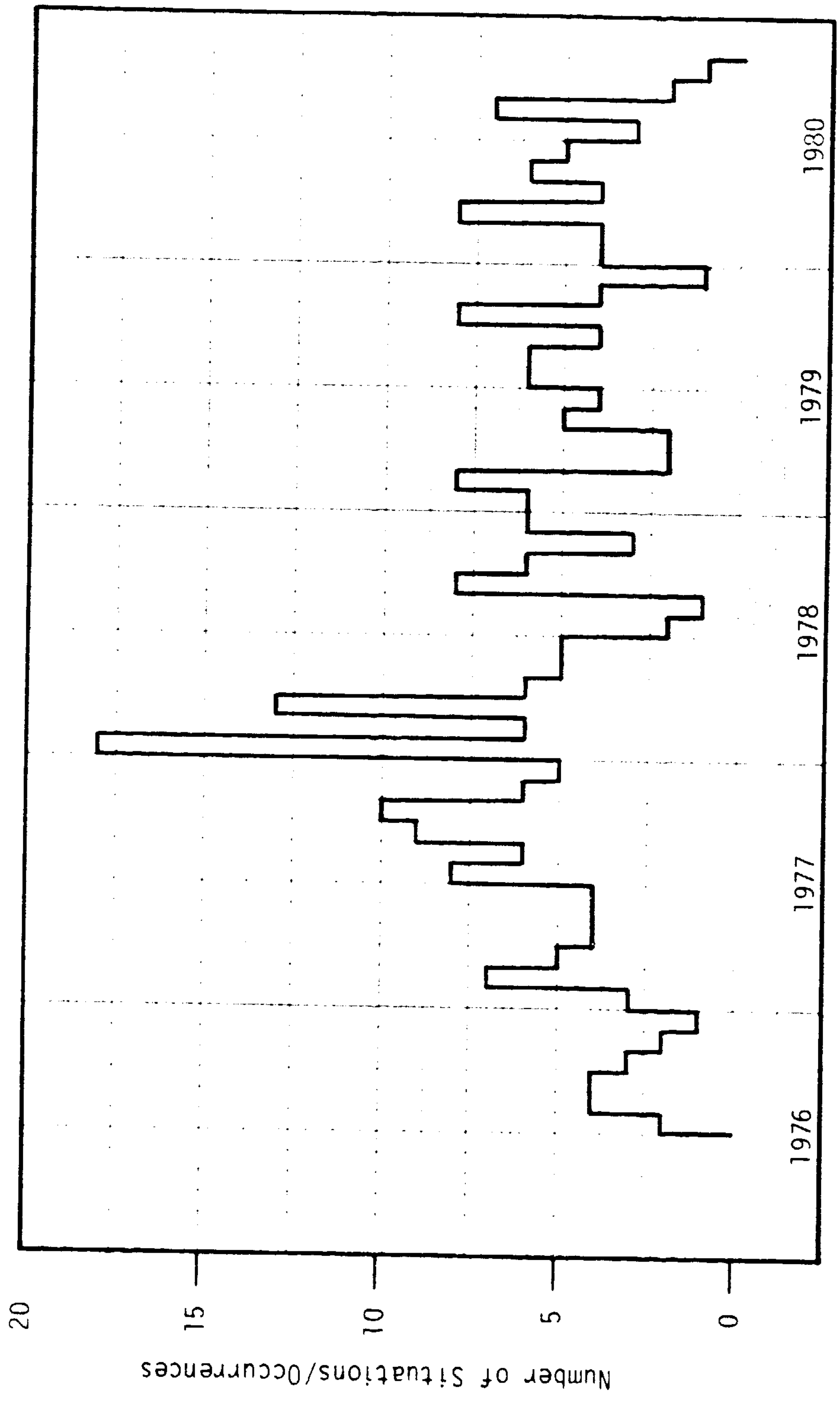

FIGURE 1. DISTRIBUTION OF REPORTED SITUATIONS OR OCCURRENCES BY CALENDAR MONTH

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TABLE 2. REPORTED SITUATIONS OR OCCURRENCES BY TYPE AND REPORTER

Type of Situation/ Occurrence	Total	By Reporter		
		Pilot or Crew Member	Controller	Other
I.	43	28	15	0
II.	83	48	31	4(a)
III.	27	13	12	2(b)
IV.	24	22	1	1(b)
V.	52	37	14	1(b)
VI.	29	24	4	1(a)
Totals	258	172	77	9

(a) US Air Force HATR Reports.
(b) Unknown.

the reports. Only for category III (problems with charts, etc.) did controllers report as often as pilots.

Each report of a situation or occurrence has implications regarding hazards to flight in one or more flight regimes. For example, in a case such as an unlighted tower near an active airport, both the climb (departure) and initial approach flight regimes might logically be affected. Table 3 traces these hazards to the various flight regimes by type of situation/occurrence. Since more than one flight regime may be affected, 332 flight regime impacts exist as a consequence of the 258 situation/occurrence reports.

It was naturally of interest to examine statistics relating to type of aircraft, number of engines, type of aircraft operator. However, it was concluded that such statistics would be both meaningless and misleading for "situations" vis-a-vis "occurrences." For example, if the pilot of a particular type of aircraft relates a concern about ambiguous minimum altitude information contained on a chart and there is no evidence that he was involved

TABLE 3. FLIGHT REGIMES AFFECTED BY THE REPORTED SITUATIONS/OCCURRENCES EXAMINED

Type of Situation/ Occurrence	Affected Flight Phase				
	Climb	Cruise	Descent	Initial Approach	Final Approach
I.	8	3	5	14	24
II.	22	17	17	24	10
III.	9	10	5	6	9
IV.	18	7	1	10	17
V.	3	3	2	7	48
VI.	1	1	4	5	22
Totals	61	41	34	66	130

in an incident revolving around this observation, then the type of aircraft is not relevant. Accordingly, descriptive statistics on aircraft and operator were developed for only occurrences. Of the 258 reports of situations/ occurrences, some 188 were judged to be occurrences. Table 4 shows the statistics developed.

Type I Reports

As described in table 1, Type I reports deal with CFTT incidents arising from apparent flight crew errors involving navigation, altitude control, or aircraft configuration. All of these reports describe a specific occurrence, as opposed to a broader hazardous situation.

Type I Statistics. Type I reports, 43 in number, comprise about 17% of the total study document set. Most (75%) were submitted by the pilot while the remainder were submitted by controllers.

The distribution of Type I reports, by year, is given in table 5.

TABLE 4. DESCRIPTIVE STATISTICS ASSOCIATED WITH 188 OCCURRENCES

Type of Occurrence	No. of Occurrences	Number of Engines					Category of Operator					
		1	2	3	4+	UNK	Personal	Business/ Corporate	Air Taxi	Air Carrier	Military	UNK
I	43	7	11	16	6	3	4	2	-	30	-	7
II	83	24	32	15	5	7	17	6	5	33	14	8
III	9	2	2	2	1	2	3	-	1	4	-	1
IV	7	3	1	-	-	3	1	-	-	-	-	6
V	17	-	3	8	1	5	-	2	-	10	-	5
VI	29	-	9	11	1	8	-	-	-	23	1	5

TABLE 5. DISTRIBUTION OF TYPE I REPORTS BY YEAR

Year	No. of Reports
1976 (last six months)	1
1977	4
1978	15
1979	10
1980 (first ten months)	13

The frequency of these reports has not changed significantly in the last 3 years, averaging slightly more than one report per month over the 36-month period.

No significant correlation is evident between the number of occurrences and the geographical location, if consideration is given to the relative traffic volumes at various sites. No individual location accounted for more than three of the 43 occurrences, which, in total, were distributed among 34 separate locations which were identified.

Most of the incidents of Type I occurred at the destination of the flight, with 68% occurring either during the Initial Approach or Final Approach flight phases. Problems occurred with lesser frequency in the Climb (16%), Descent (10%), and Cruise (6%) flight phases.

Air Carrier aircraft were involved in 70% of the reported Type I occurrences. The remainder described an incident involving a General Aviation aircraft. Of the 14 General Aviation reports, the pilot experience level is available in six, and the data indicate that these pilots were relatively experienced. Only two had less than 1000 hours, while the most experienced had 20,000 hours.

Almost all of the incidents (92%) occurred while the aircraft was on an IFR flight plan, although the event occurred in VMC in about 40% of all cases. Table 6 provides the distribution of the reports by lighting and meteorological conditions. Two of the 43 reports are not represented in table 6 since they did not specify these factors.

TABLE 6. DISTRIBUTION OF TYPE I REPORTS BY LIGHTING AND METEOROLOGICAL CONDITIONS

	IMC	VMC	Mixed	UNK	Totals
Day	9	12	3	0	24
Night	3	5	0	1	9
UNK	0	3	1	4	8
Totals	12	20	4	5	41

Nature of Occurrences. The nature of the Type I occurrences, as categorized by the immediate cause of the potential conflict with terrain, is given in table 7.

Each of the categories of table 7 is discussed in the following paragraphs.

Altitude error - non-precision instrument approach: Nine of the Type I occurrences (21%) were characterized by altitude discrepancies during non-precision instrument approaches. The nine incidents may be segregated into three sub-groups:

(1) Four cases in which the final approach descent was initiated prematurely,

(2) Three cases in which the descent was initiated properly but continued below the minimum descent altitude (MDA) without proper visual contact with the airport, and

(3) Two cases in which the initial approach altitude was below the published limit.

One of the premature descent incidents was apparently instigated by an anomalous radiation pattern from a fan marker. A general aviation pilot reported an erroneous aural signal, one mile before actually crossing the fix, during a localizer back-course approach in IMC. He initiated the descent but then noticed a second, strong aural signal during actual passage.

Force of habit contributed to the premature descent of another general aviation pilot flying a localizer approach at a strange airport. The

TABLE 7. NATURE OF TYPE I OCCURRENCES

Immediate Cause	No. of Incidents Air Carrier	Gen. Av.	Totals
Altitude Error - Non-precision Approach	5	4	9
Altitude Error - Precision Approach	9	0	9
Deviation on Visual Approach	5	0	5
Lateral Deviation on Approach	3	1	4
Violation of IFR Altitude Clearance	4	0	4
Unsafe Altitude - Visual Flight	0	3	3
Wrong Heading	1	2	3
Improper Flap Setting	2	0	2
Totals	30	13	43

usual procedure at his home base was to be vectored to the localizer at a relatively high altitude. Then, when the localizer was captured, a descent would be initiated to the LOM crossing altitude. In the case at hand, he was vectored to the localizer at the LOM crossing altitude. At this point, his Pavlovian response caused him to begin a descent to some undefined lower altitude several miles outside of the marker. He caught his own mistake 300 feet below the proper altitude.

The apparent cause of the remaining two premature final descent incidents was an error in identifying passage of the Final Approach Fix. Both incidents took place in IMC.

One was in daylight over relatively flat terrain with ground contact through scattered clouds. In this incident, the First Officer, flying a localizer approach, incorrectly identified a position fix and prematurely descended to an altitude 900 feet below the published altitude restriction for his actual position. The Captain, handling the radio communications, did not perform an adequate position check. The deviation triggered an MSAW alert.

The final incident in this sub-group occurred in IMC at night. The report, by a controller, describes a near-disaster involving an air carrier aircraft flying a localizer back-course approach:

> "...Weather was poor (low ceiling, restricted visibility). Aircraft was approximately 8-1/2 miles final (2-1/2 from FAF of Steve) when low altitude alert sounded. Aircraft descended rapidly from 1700 ft. to 600 ft. and was still descending when alerted by PHF tower after I alerted them. Final Approach Fix altitude is 1700 feet. Aircraft immediately began to climb back up and crossed Steve at 1700 feet...it appeared they may have thought they were at the FAF (Steve) when they actually had only crossed Ripps Intersection inbound."

The second sub-grouping of non-precision approach errors is concerned with improper descent below the MDA. Of the occurrences, two were reported by the pilots and allow insight into the underlying causes. For example, this report by a general aviation pilot flying a practice NDB approach over unlighted terrain, at night, tells it all:

> "...Had a Private Pilot with 50-100 hrs. experience with me as check pilot. During the approach descended below the MDA, (1) because I forgot the correct altitude, (2) because I couldn't see the chart (flood lighting inadequate), (3) because the check pilot didn't correct me. Not being an IFR pilot he didn't know the critical variables to watch, and at night in New Mexico it is quite dark. There was a clear horizon, but the dark uninhabited surface was difficult for him to see until the landing light hit it (50 feet!!). ..."

In less dramatic fashion, an air carrier pilot on a localizer back-course approach reported that he descended to the MDA after passing the FAF but, because of improper flying technique, overshot the descent sufficiently to trigger an MSAW alert.

The last non-precision MDA violation was reported by a controller, whose vigilance most probably prevented a major catastrophe. The aircraft was a 4-engine heavy transport flying an NDB approach in IMC.

"Aircraft was cleared for an 10R approach. ...He crossed Grandview at 2800 and began descent to minimums for Runway 10R (1300 MSL). I observed his altitude readout at 1100 MSL approximately 3 mile final. The low altitude alarm failed to work. I immediately advised the tower, who advised the aircraft at once. ...Ground witnesses say that the aircraft missed the Historical Society building by about 100 feet..."

The failure of the MSAW to provide a warning signal in the preceding report was alleged to be caused by maintenance personnel turning off the system without notice.

The remaining two non-precision approach occurrences concerned aircraft flying the initial approach below the published altitude. Neither may have presented an actual hazard since they occurred in daylight in VMC. Nevertheless, after radar service had been terminated and the aircraft was off frequency, a controller observed a twin piston-engine air carrier aircraft 1800 feet below the minimum safe altitude for the NDB approach for which it had been cleared. In the other incident, a general aviation pilot, flying a practice VOR approach, misinterpreted the approach plate and descended below the minimum outbound altitude. A controller observed the Mode C read out and alerted the pilot through the FSS.

Altitude error - precision approach: Precision approach errors provided as many Type I reports (9) as did the non-precision incidents. All of the reports in the precision approach sub-group pertain to air carrier aircraft.

Three of the reports described altitude errors during the initial approach phase, prior to crossing the outer marker. A controller reported one of these, which occurred in daylight VMC. When advised that they were 700 feet below the glide slope altitude at the approach fix, the crew asked for, and received a clearance for a visual approach. The cause of the incident was not reported. In the second occurrence, a perpendicular intercept of the localizer was too demanding for a First Officer with little recent experience. He lost excessive altitude during the turn and crossed the marker 500 feet below the proper altitude. The third initial approach occurrence was attributed to a high cockpit workload, primarily caused by two changes in the assigned runway. As a result, the aircraft was allowed to overshoot its descent by 600 feet. The first warning came from the GPWS, although the aircraft was clear of clouds at the time.

The remaining six incidents in this subgroup were deviations below the glide slope inside of the outer marker, and three of these were caused by erroneous indications from flight directors.

In one of the flight director malfunctions, the error was detected almost immediately by the non-flying pilot, presumably by cross-checking with raw glide slope information. In the other two incidents, no such cross-check was evident, and the situations deteriorated until the crews were warned by the GPWS and by an alert controller, respectively. Both of the latter incidents were in VMC, but the GPWS warning came during a night approach over water.

In another occurrence involving an equipment failure, the autopilot of a 3-engine wide-body aircraft failed to lock onto the glide slope, possibly because of an expedited descent for vertical separation from another aircraft. The failure was observed immediately, but the aircraft descended 800 feet below the published altitude before a manual recovery was made. The altitude deviation also caused a low alert on the approach controllers equipment.

One incident occurred in daylight in excellent visibility. In fact, the good weather was a contributing factor. The distraction of looking for other aircraft, in response to numerous traffic advisors, caused the pilot to drop somewhat low on the glide slope during an approach to LAX on a beautiful Saturday afternoon.

The final occurrence in this subgroup concerned a last minute change in runway assignment at night in VMC. A relatively inexperienced First Officer forgot to retune the ILS, but somehow managed to fly a complete approach using the flight director. The GPWS alert was ignored as a false alarm. The report, by the errant pilot, implies that the Captain was fully aware of the blunder but did not interfere since the runway was in sight and the approach was satisfactory.

Deviation on visual approach: Five Type I incidents occurred during visual approaches, and all involved air carrier aircraft. Three of these were created directly by an altitude deviation; one was caused by a visual navigation error in the airport environment; and one was caused by a combination of mountainous terrain, other traffic, and a night-time environment.

The first altitude deviation case was created by a communication dysfunction between a controller and the flight crew of a wide-body transport. While ten miles from the airport, and over water, the crew were told by Approach Control that they were cleared for a visual approach. What they were not told, either by the controller or the current ATIS message, was that the glide slope was out of service. Since company policy required the use of all available aids, and since no flags were showing, the copilot used erroneous glide slope indications to descend in VMC with restricted visibility. At this point, to quote from the report--"...I became aware of high rise buildings coming into view and the GPWS sounded off. ..."

A non-standard instrument panel contributed to the second occurrence. In daylight, with good visibility, the pilot relied entirely on the runway and his projected touchdown point for visual interpretation of azimuth and vertical profile. The flight director was not monitored because it was nonstandard and wasn't located where he was accustomed to looking for glide slope information. As a result, he drifted below the electronic glide slope sufficiently to trigger the GPWS. The approach was continued and the landing was made without difficulty.

In the remaining low-altitude occurrence, the pilot of a four-engine wide body violated his altitude clearance within the Airport Traffic Area while being vectored downwind for a visual approach. No reason for the altitude discrepancy was given in the report by a controller.

The remaining two cases in this sub-group were incidents of genuine peril, wherein the pilots lost sight of the airport after accepting visual approach clearances. The first occurred in hazy daylight in a major metropolitan area:

> "Aircraft was being vectored to an ILS final for Runway 21 Left. When he was on base leg Northeast of the airport, the aircraft reported the airport in sight and requested a visual approach. The Approach Controller issued the visual approach clearance and changed the aircraft to tower frequency. The aircraft turned southbound and

did not call the tower. The tower controllers noticed the aircraft on radar with the low altitude alert... the aircraft was observed at 1700 MSL 1-1/2 miles north of the WJR radio antenna, 1311 MSL. At this time the aircraft called the tower. Went in descent to 1400 MSL and flight radar target touched the radar marking of the antenna. Aircraft then climbed to 3000 feet and was vectored for an ILS approach."

The radio antenna mentioned in the preceding report is directly abeam of the runway, but nearly 7 nautical miles to the left of the centerline. It seems clear that the crew either did not have visual contact when they requested the clearance; or, if they did, they lost contact and did not admit their problem.

The final case could have been categorized as a Type II incident because of questionable controller judgment; nevertheless, it is included in Type I because it would have been prudent for the reporting pilot to refuse a visual approach under the conditions which existed:

"...Approach called to advise we were No. 3 behind Aircraft B on 15 mile final. The approach turned us to a heading of 020 degrees. I couldn't see where No. 1 was. ...I saw Aircraft B but didn't know it was him. He had his ground flood lights on. So did I, but Aircraft C didn't. As we came closer and closer, I began to realize what a bad call Approach had made. Our heading had taken us behind a 7000 ft. mountain... Approach cleared us for a visual with Aircraft B about 2 miles in front of us. So here we were headed up a mountain pass with a 10,000 ft. mountain in front of us, a 9,000 ft. mountain to our right and (the 7,000 ft. mountain) about a quarter mile to our left. I knew where I was because I grew up in (the area) and learned to fly in that mountain pass. We couldn't see the mountains. It was very dark. There was no moon and not even a cloud deck to reflect the city lights onto the hills...I told the copilot to start a turn to the left. At that time, we crossed the center line to Runway 26. B had just been there. We hit his vortex, and in his configuration... it tossed us around violently. We were in a 30 degree bank to the left when we hit it. The copilot had started a descent. I told him to hold 8,000 ft. and called approach and asked him how far we were behind B. Approach answered '2 miles'. I asked what our speed was in relation to B and was told we were 30 knots faster. I told the copilot to put us on a heading of 190 degrees. Again (the 7,000 ft. mountain) was off to our left, but I felt a little better this time because all we had in front of us was valley. After another 180 degee turn to the right followed by a 90 degree turn to the left, we landed on Runway 26 just as B cleared the runway... ."

Deviation from departure procedure: Pilot errors during instrument departures led to four Type I incidents. In one, a general aviation pilot in IMC was cleared direct to a VOR after takeoff but mistakenly flew the reciprocal course toward high terrain. An alert controller caught the error.

The three other cases consisted of failure of air crews to adhere to the proper published departure procedures. One report, by a controller, describes a wrong turn by the pilot of a light turboprop transport which placed the aircraft in proximity to high terrain. The controller promptly advised the pilot of the error and provided vectors to re-establish the proper departure course.

Both of the remaining incidents involved three-engine wide-body aircraft departing from San Francisco. A controller reported that one of these started to fly a Shoreline 5 departure, a VMC procedure, with stratus clouds in the area, instead of the assigned SF2 standard departure. The erroneous turn was observed and corrected by the Departure Controller.

In the remaining case, the Miami-based Captain's report suggests that a post-midnight departure from San Francisco created a sufficient disturbance to the crew's circadian rhythm to induce a serious lack of mental alertness. As a consequence, the First Officer delayed an assigned right turn after takeoff until he was reminded by the Captain. The late turn brought them into proximity to San Bruno Mountain, but neither crew member was aware of the hazard until the Departure Controller advised them of an altitude alert (MSAW).

Lateral deviation on approach: Pilot errors contributed four instances of gross lateral deviation from the localizer path during ILS approaches.

Only one of these occurrences involved an air carrier aircraft. Exceptionally high winds of unknown magnitude caused the aircraft to drift toward high terrain while attempting to capture the localizer, following a non-standard holding pattern maneuver. The first warning was a GPWS alert which prompted the pilot to initiate an immediate climb and turn. Along with the basic cause, which was the high velocity wind, were the associated factors of an inadequate crew briefing on non-standard actions, inadequate information or alerts on the winds aloft, and a low experience level of the First Officer.

Another serious incident in this sub-group occurred during an improperly flown missed approach by a corporate jet crew. Tower visibility at the time was 1/8 of a mile. The RVR was 3400 feet in freezing drizzle, light snow and fog. Perhaps the only favorable circumstance was that it happened in daylight. A controller reported the occurrence as follows:

> "...On a very short final, pilot advised missed approach. I issued 'Fly runway heading, maintain 2500 feet.' At this time we heard a very loud jet engine noise coming from the East side of the tower, when the runway is West of the tower approximately 250-300 yards. ...An aircraft waiting for departure told a controller later that he had observed the aircraft about 300 East of the runway and '...it just missed hitting the tower.'"

The pilots perspective of this incident would be interesting, but no pilot report was received by the ASRS. It seems probable that high cockpit workload was a factor, but there is no information to reveal when the situation began to deteriorate.

An inexperienced instrument pilot, in a small single-engine aircraft, overflew the localizer on a published transition route and continued into an area of high terrain. With no radar coverage, the hazard became known only when the pilot informed the controller. The controller immediately cleared the aircraft for a climb above the overcast and suggested maintaining VFR until oriented.

Another general aviation pilot was observed by a Center controller to be tracking a localizer course, but displaced 5 miles to the side near mountainous terrain. Using the airport tower controller to relay communications, the alert Center controller suggested a revised heading. The pilot later claimed that he was receiving erroneous information from his instruments.

Violation of IFR altitude clearance: Three of the four IFR altitude clearance violations involved a misunderstanding of the assigned altitude, while the fourth was caused by distraction. All cases in this subgroup involved air carrier aircraft.

The largest error, a blunder of no less than 24,000 feet, occurred during a night departure from Salt Lake City. The copilot copied the clearance altitude as 7000 feet (the number left in the altitude alerter from the arrival) instead of the correct value of 31,000 feet. The Captain, who had been busy on another radio when the departure clearance was received, did not question the clearance. After takeoff, the Captain became concerned and queried the controller, whereupon the mistake was discovered. Immediately after initiating a climb, the GPWS sounded a terrain warning, caused by an island in the Great Salt Lake with a peak near 6650 feet.

Another flight crew accepted what they thought was a clearance to 4000 feet during a descent to Albuquerque--a questionable figure in view of the fact that the field elevation is 5352 feet. The captain put 4000 in the altitude alert window and the First Officer read back the clearance to 4000 feet. The read-back was not challenged by the controller, who had actually assigned 14,000 feet. The problem became apparent when the flight emerged from clouds in time to take evasive action to avoid Sandia Peak.

In another case, the flight crew of a 4-engine wide-body aircraft climbed to 1700 feet while departing JFK, instead of the assigned 17000 feet. The pilot reported level at 1700 and questioned the assignment, whereupon the misunderstanding was corrected.

In the remaining altitude violation, a pilot was distracted from his flying duties by making a P.A. announcement to his passengers. As a consequence, he strayed 1000 feet below a crossing altitude restriction during descent in mountainous terrain. The incident occurred at night in VMC.

Unsafe altitude--visual flight: There were three reports of real or potential hazards caused by insufficient altitude in visual flight. These reports were submitted by general aviation pilots.

One report described a genuinely hazardous situation brought about by extreme fatigue:

> "I was flying for a cargo outfit at the time. I had been averaging 12 hours a day duty time. We...also do all our own loading and unloading. I had been on duty since 1 a.m. the previous night, flying around 7 hours. ...was flying back to our home base empty. I was the only one in the airplane on a 15 mile leg. ...I unconsciously began a descent for MIC airport. Before I realized what altitude I was at, I broke my stare and began a fast angle of climb to gain altitude, for I had dipped down to around 500 feet or so. ..."

The second occurrence could have been very serious in IMC. The pilot of a small single-engine aircraft, in mountainous terrain in clear weather, observed that his true altitude was much lower than the altimeter would have him believe. Furthermore, his airspeed and rate-of-climb readings were erratic. Later examination revealed that there were, indeed, bugs in the aircraft's system--specifically, two or three small wasp-like creatures in the pitot/static fixture.

The last report in this subgroup described a relatively benign event which serves to illustrate that a pilot operating VFR is totally responsible for his own altitude discipline. Following the tower's instructions to fly a right traffic pattern instead of the left pattern he had expected, the pilot found himself over rising terrain that reduced his altitude above the ground to 500 feet or less.

Wrong heading: In three instances, pilots flew incorrect headings while operating IFR, creating a potential conflict with terrain.

An air carrier crew found themselves flying toward high terrain at their assigned altitude of 13,000 feet. When the Center asked if they were proceeding as filed, the pilot discovered he was tracking the wrong VOR radial and had deviated substantially from his intended airway, which passed over lower terrain. An immediate clearance was given to 15,000 feet.

During descent in IMC, an erroneous ADF indication prompted the pilot of a light twin to fly a heading which could have led to a terrain conflict. An alert center controller detected the track deviation and provided radar vectors to the destination airport.

Radio communication difficulties figured prominently in the last case in this subgroup. A corporate aircraft in IMC had only intermittent and garbled contact with the reporting controller. In the confusion, the aircraft flew a heading intended for another aircraft with a somewhat similar tail number. The aircraft also descended 1700 feet below nearby terrain. Fortunately, another ATC facility was able to regain contact with the aircraft.

Improper flap setting for landing: Two instances were reported by pilots who experienced GPWS warnings on final approach because of improper flap configuration. In one case, the pilot assumed the alert was a false alarm, since his VASI indication appeared normal. In the other, the Captain of a wide-body aircraft correctly identified the problem when the GPWS was activated at 500 feet during a visual approach in haze. He immediately selected the proper flap setting and an uneventful landing followed.

Type II Reports

Type II reports cover CFTT incidents arising from apparent controller errors, in the opinion of the reporter, in the form of inappropriate ATC vectors or clearances, or deviations from standard procedures.

Nature of occurrences. The Type II occurrences are categorized in table 9 according to the nature of the problem as perceived by the reporter.

Each of the categories of table 8 are discussed in the following paragraphs.

Cleared below minimum legal altitude: More than half of the Type II reports (45) describe occurrences in which an aircraft was assigned an

TABLE 8. NATURE OF TYPE II OCCURRENCES

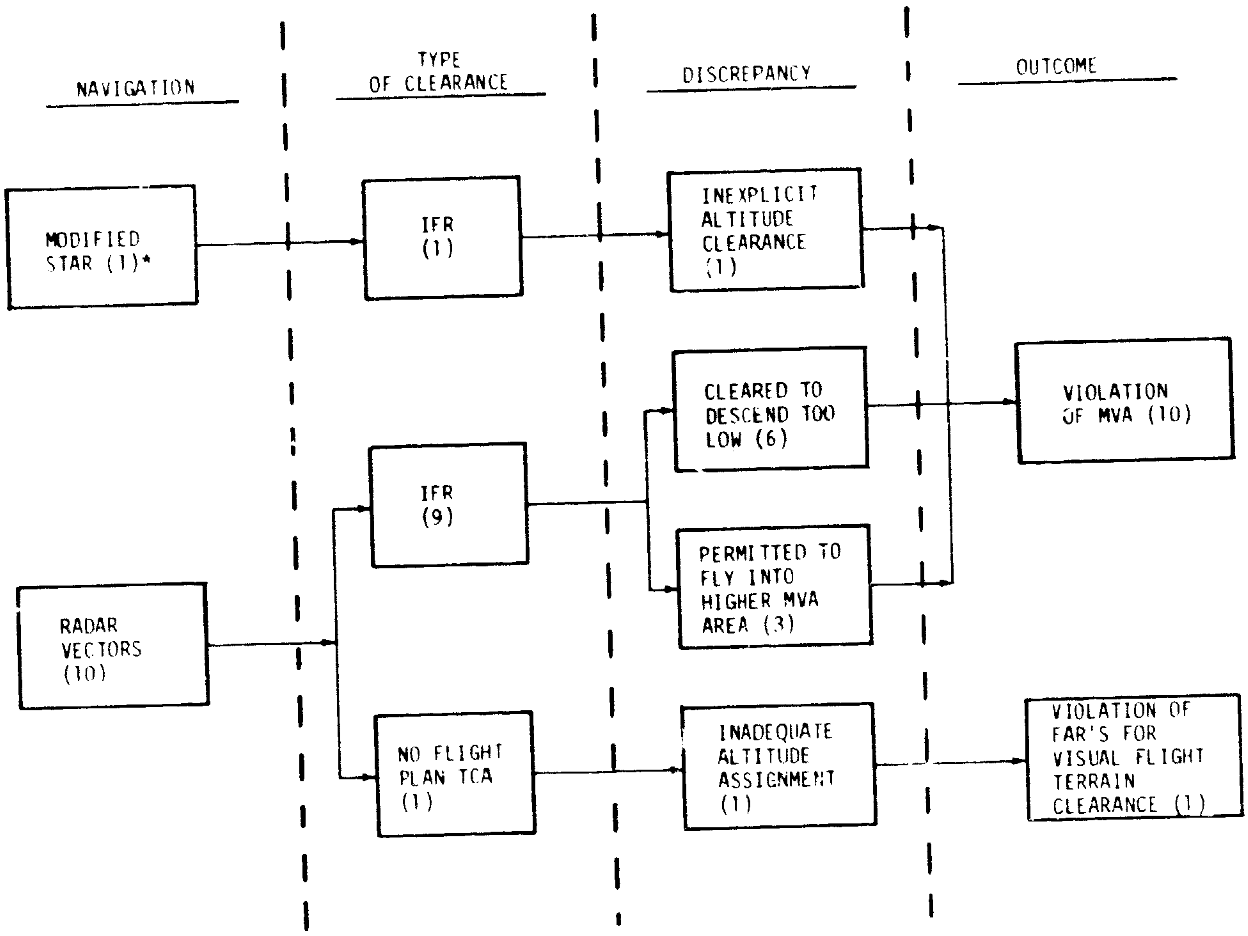
Immediate Cause	No. of Incidents Air Carrier	Gen. Av.	Military	Totals
Cleared Below Minimum Legal Altitude	15	21	9	45
Neglected While On Radar Vectors	0	5	4	9
Given Ambiguous Clearance	5	3	0	8
Given Legal But Disconcerting Clearance	6	2	0	8
Given Heading Toward Higher Terrain	3	2	0	5
Cleared With Impaired ILS	4	1	0	5
Miscellaneous	0	2	1	3
TOTALS	33	36	14	83

altitude below the minimum required by the Federal Air Regulations or by the standards of the Air Traffic Control System. Most of these reports (26) were submitted by controllers.

In 40 of the 45 incidents, the aircraft were on IFR flight plans; while in the remaining five cases, the aircraft were receiving headings and altitude assignments within a Terminal Control Area (TCA).

The lighting and meteorological conditions are given in table 9.

Eleven incidents in this category occurred during the initial approach phase. These events are outlined in figure 2. All but one of the aircraft were being radar vectored at the time of the incident. In the singular case, a military fighter was flying a published STAR approach when instructed by the controller to discontinue and descend to 3000 feet. The clearance was later amended to return to the STAR profile, but the correct altitude was not restated by the controller. As a result, the aircraft flew through an area 1000 feet below the MVA.



* Numbers in parenthesese are number of occurrences.

FIGURE 2. OUTLINE OF INITIAL APPROACH INCIDENTS IN WHICH THE AIRCRAFT WAS CLEARED BELOW A MINIMUM LEGAL ALTITUDE

TABLE 9. LIGHTING AND METEOROLOGICAL CONDITIONS FOR INCIDENTS IN WHICH THE AIRCRAFT WAS CLEARED BELOW THE MINIMUM LEGAL ALTITUDE

	IMC	VMC	Mixed	UNK	Totals
Day	13	15	2	3	33
Night	5	2	1	1	9
Dusk	0	2	0	1	3
Totals	18	19	3	5	45

While all of the remaining initial approach incidents in this group involved aircraft on radar vectors, one of these concerned a 5300-hour general aviation pilot operating with no flight plan in a TCA. He reported being assigned an altitude only 700 feet above a congested area and 200 feet over open land while complying with radar vectors. The other nine incidents were in violation of the Minimum Vector Altitude (MVA) requirement for IFR traffic. In six of these, the aircraft were simply given an inadequate altitude assignment; while in three, the aircraft was permitted to fly into a higher MVA area through faulty planning by the controller.

The reason for the inadequate altitude assignment was not given in three cases. An air carrier aircraft was vectored 800 feet below the MVA over a large metropolitan area in IMC at night before the controller realized the error. Similarly, a military transport, being vectored for a GCA approach at night in VMC, was told to descend 1500 feet below the MVA. The controller caught his mistake when the aircraft was only 300 feet above the erroneously assigned altitude. The final unexplained error in this sub-group was primarily an error in the positioning of a fighter aircraft being vectored for a GCA approach in IMC in mountainous terrain:

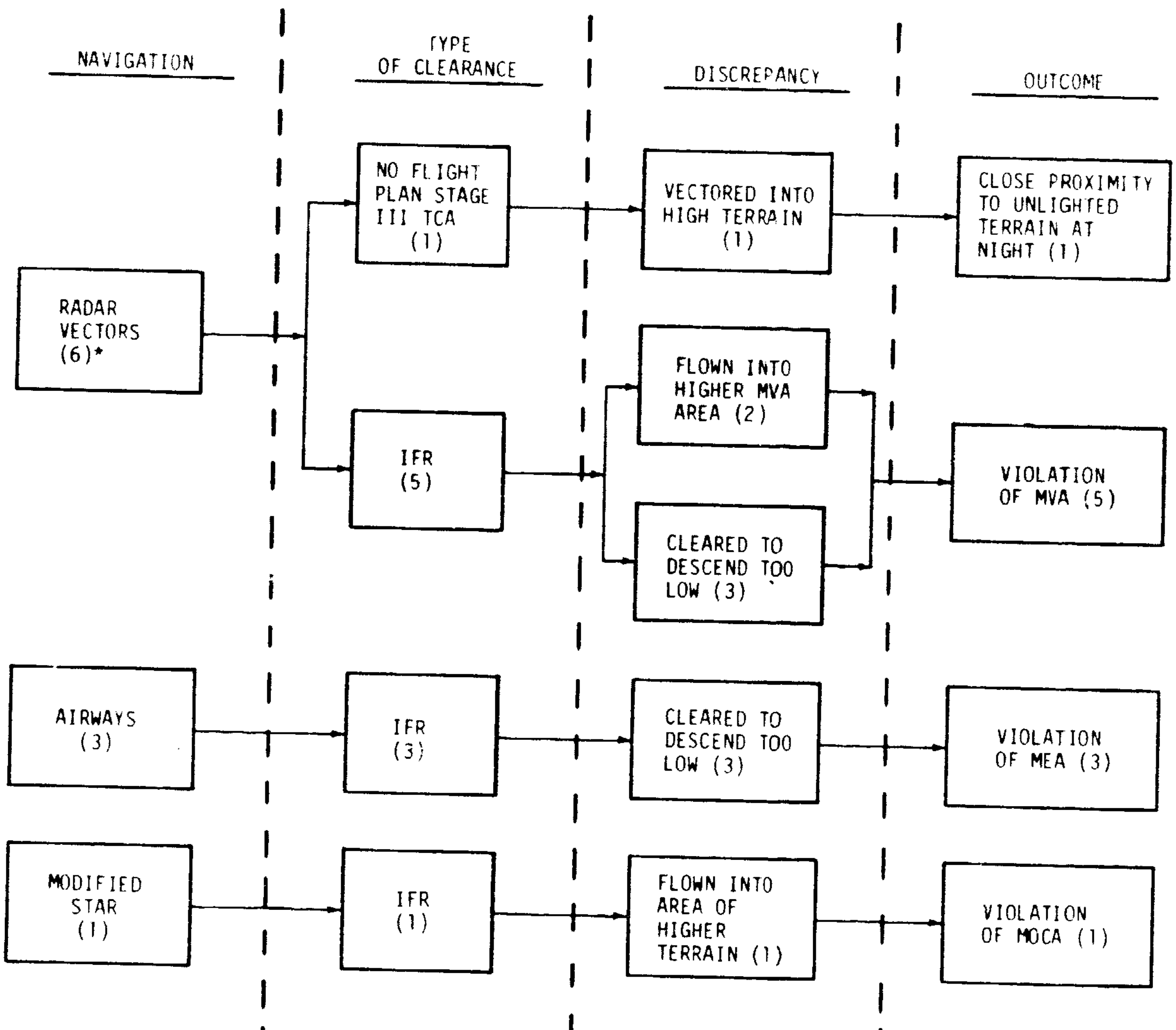
> "...descent to 4100 MSL directed by Approach Control. Pilot elected to maintain 4800 MSL, being west of course. Pilot reported passing within 3000 feet laterally of 4314 foot spot elevation with 4108 foot spot elevation 3 miles at 12 o'clock to ground track..."

In three incidents, a reason for the altitude clearance discrepancy is either explicitly stated or implied. In one case, a controller trainee transposed the numbers in an altitude clearance, descending an air carrier aircraft to 2300 feet instead of 3200 and generating an MSAW alert. In another, a controller confused two radar targets at a facility with no ARTS or MSAW capability, thereby vectoring a corporate aircraft over mountains below the MVA and at the same altitude as the peaks. The incident happened at dusk in unspecified meteorological conditions. The third case took place at night in restricted visibility. The narrative speaks for itself:

> "...We were being vectored to the final approach course. Our flight was told to turn left to a heading and descend to 3000. Clearance was acknowledged. Then a new voice gave us a further turn to the left and to maintain 2000. This clearance was acknowledged by reading back the heading and altitude. At approximtely 2500 feet MSL, this new voice, which was very deep and seemed to be mumbling into the microphone, said something to our flight, but the only thing any of us in the cockpit understood was the words 'altitude alert'. I then levelled the aircraft immediately...After two attempts the controller spoke a little clearer and told us we were only cleared to 3000 feet...He apparently had just come on the midnight shift and was very tired..."

As outlined in figure 2, three of the initial approach incidents in this category were initially assigned a proper altitude but were inadvertently vectored into an area with a higher MVA. In one of these, a controller was distracted by radio communications and allowed an air carrier aircraft to violate a 7300 foot MVA area while at 7000 feet. The crew reported a GPWS alert, but the controller did not realize his error until the aircraft was out of the hazardous area. In a similar incident, a military trainer in VMC was kept too wide and violated a 9000 foot MVA at 7000 feet. In the last initial approach incident, a controller underestimated the radius of turn of a fighter aircraft, permitting a transgression 2000 feet below a neighboring MVA and triggering an MSAW alert. A contributing factor in this case was a late hand off to the reporting controller.

Ten incidents in this category occurred while the aircraft was in the descent phase. These are outlined in figure 3.



* Numbers in parenthesese are number of occurrences.

FIGURE 3. OUTLINE OF DESCENT INCIDENTS IN WHICH THE AIRCRAFT WAS CLEARED BELOW A MINIMUM LEGAL ALTITUDE

All but one of the aircraft were on IFR flight plans. The sole exception was following Stage III radar vectors in a TCA at night. He complained of being directed into mountainous terrain at an unsafe altitude.

As seen in figure 3, five of the IFR aircraft were on radar vectors and each case culminated in an MVA violation. Three were simply cleared to too low an altitude. One of these incidents was caused by the controller's confusion of two military aircraft with similar call signs; while in another, the flight crew transposed the numbers given for heading and altitude. The crew read back the garbled clearance but were not corrected by the controller. In two cases, a descending aircraft was given radar vectors into a region of higher terrain. In one instance, a controller committed an error in judgement in turning an air carrier aircraft for traffic separation, setting off both a GPWS and MSAW alert. No explanation of the error was given in the other report.

Three aircraft were cleared to descend below the MEA on airways, as shown in figure 3. All three incidents were reported by the erring controllers themselves, one of whom "misoriented myself to the area". Another descended an air carrier aircraft below the 18,000 foot floor of a jet airway, thinking there was a Victor airway underneath, which there was not. The third controller descended a general aviation aircraft prematurely because of confusion over MEA boundaries.

The remaining descent incident in this category concerns an air carrier aircraft which was following a published descent profile in mountainous terrain:

> "...Our arrival was via the (name) STAR. We were given a discretionary descent to descend to and maintain 13,000 feet. During the descent, we were recleared "Direct (name) VOR'. This placed us inbound on the 281 radial. We arrived at 13,000 feet at approximately 33 DME. The flight conditions were IFR with the tops at 14,000 feet MSL. At approximately 30 DME, the GPWS activated a Mode 2 Excessive Closure Rate. We heard 'Terrain-Terrain-Pull Up'. I immediately climbed the aircraft through 14,000 feet to about 14,300. ...Upon checking a WAC chart, I discovered the terrain altitude peak was 11,918 feet. This ground proximity (1082 feet) coupled with

mountainous terrain, suggests that the GPWS Mode 2 operated correctly."

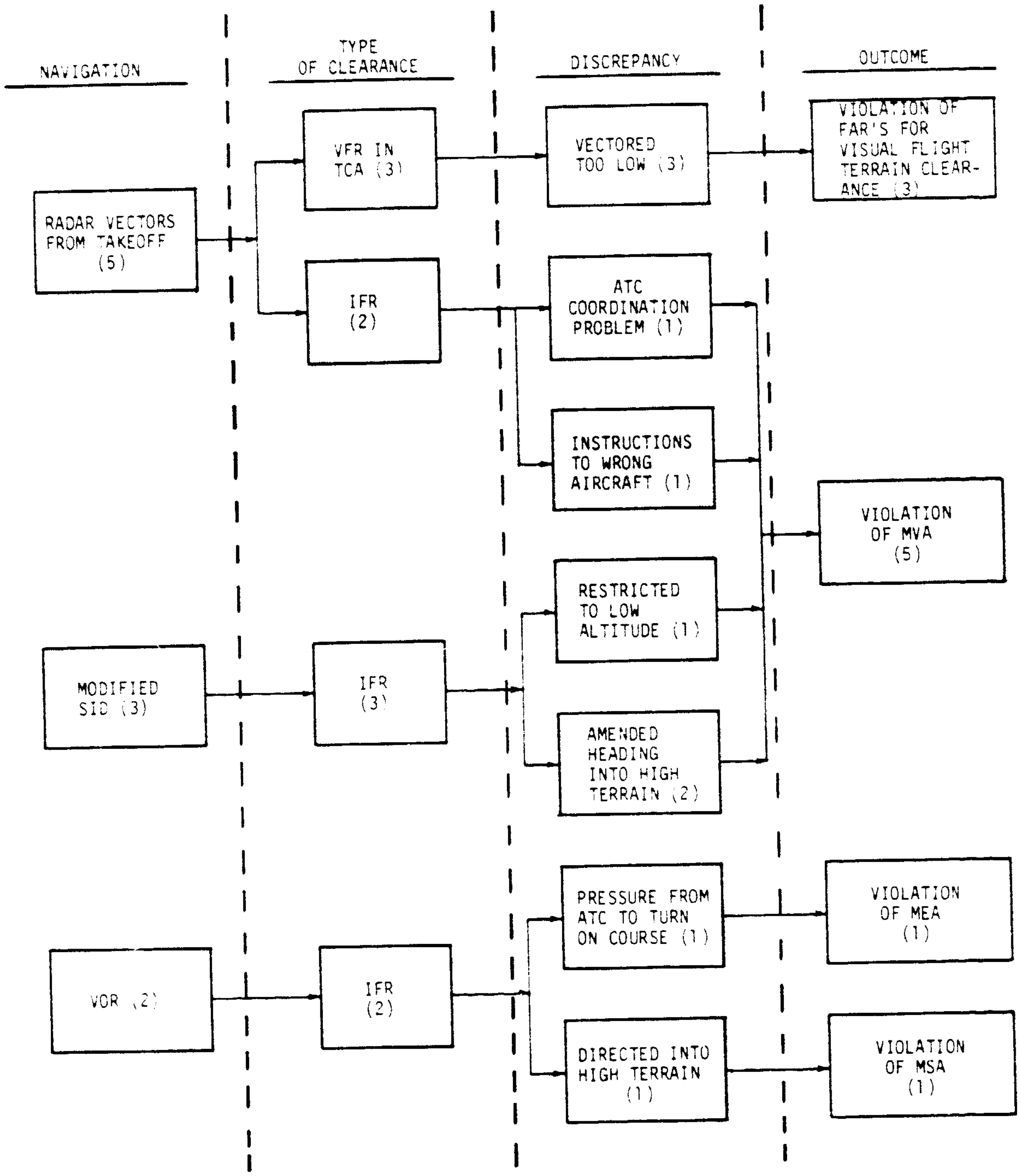
Ten reports in this category described unsafe altitude clearances during the departure phase. These incidents are outlined in figure 4.

Half of the events occurred while the aircraft were on departure radar vectors from takeoff, and three of these were departing VFR in a Terminal Control Area. In each of these three cases, the reporting general aviation pilot complained of an unsafe altitude assignment. Specifically, they reported being vectored as low as 200 feet AGL and 400 feet over towers and in one case, having radar service terminated at 1500 feet in a hazy metropolitan area with 1349 foot towers in the vicinity.

Two of the departure radar vector incidents involved aircraft operating IFR. Both occurrences resulted in MVA violations. In one, an air carrier aircraft was given a non-standard departure route over two other major airports, instead of the usual SID. In the confusion, communication with the aircraft was minimal and it flew 500 feet below the MVA directly over a large city at night in IMC. In the other incident, the pilot of a general aviation aircraft was given a clearance intended for a different aircraft. This resulted in the aircraft flying 500 feet below the MVA in IMC.

Three occurrences began with Standard Instrument Departures (SID's) which were modified, in flight, by the controllers. In one of these incidents, a tower controller reported that he temporarily restricted a departing light aircraft to an altitude below the MVA to provide visual separation with another aircraft with which he could not communicate. In another case, a general aviation pilot reported that a controller amended his SID clearance to a heading which put the aircraft within 300 feet of a mountain peak and 200 feet from an antenna tower. The MSAW alert was triggered, but no action was suggested to the pilot. Fortunately, the event took place in VMC which permitted visual terrain avoidance. A very similar, but more hazardous, occurrence involved an air carrier aircraft departing on a SID in mixed meteorological conditions:

> "...departure plate includes maintaining VFR until passing the 342 degree radial. After takeoff while beginning our right turn, the tower advised us to roll out heading 350 degrees and contact Departure Control. This put us on a heading for the hills northwest of



* Numbers in parenthesese are number of occurrences.

FIGURE 4. OUTLINE OF DEPARTURE INCIDENTS IN WHICH THE AIRCRAFT WAS CLEARED BELOW A MINIMUM LEGAL ALTITUDE

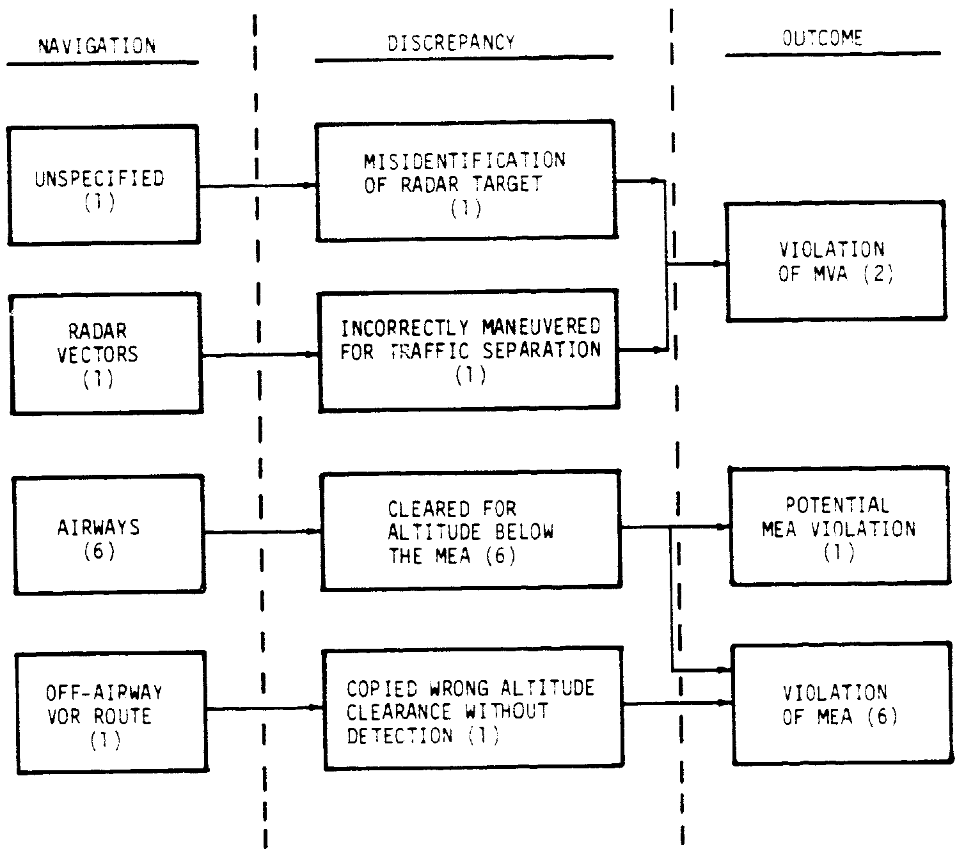
the airport, which at that time were obscured by clouds above 1000 feet. Departure Control was busy with another aircraft so there was a short delay in making contact. Just as they said 'radar contact', we entered the clouds, clearing the hills by about 500 to 600 feet. ...I would never have accepted such a clearance from the ground up, but in the mid-point of a turn in a congested area, plus communication saturation, there are virtually no alternatives."

The remaining two departure occurrences took place as the aircraft were proceeding, as cleared, from the runway to a VOR. In one case, the tower controller transposed left and right in his clearance to turn after takeoff. As a consequence, the aircraft came within 1000 feet of sharply rising terrain in VMC. In the other, the reporting pilot complained to pressure from a center controller to violate an MEA restriction:

"...the field elevation is 1483 feet and the MEA for first segment is 6000 feet. Since I was piloting an aircraft with limited climb performance, I intended to enter a holding pattern at the VOR and gave my intentions to the tower. Halfway to the VOR I switched over to the Center and I was instructed to turn on course. I came back on the radio in protest, stating my intentions to reach the MEA first. At this point the controller demanded that I turn on course. Being a rookie instrument pilot and since I had some visual contact with the ground in light snow showers, I went along with him. ...This area does not have any sort of ASR radar. ..."

Nine incidents in this category occurred during cruise flight under IFR clearances. These are outlined in figure 5. In one unusual case, an apparently spurious radar target was identified by the controller as a light aircraft enroute through his sector. When the target subsequently disappeared, the controller called the aircraft and determined that it was 15 miles from the position he had identified and was below the MVA as well. Another MVA violation was reported as a result of radar vectors to ensure separation. Both aircraft were directed into terrain without proper ground clearance.

Six of the cruise incidents occurred while the aircraft was flying on airways; and in four of these, the controller failed to climb the aircraft to an altitude compatible with the next segment. For example, a controller was



* Numbers in parenthesese are number of occurrences.

FIGURE 5. OUTLINE OF CRUISE INCIDENTS IN WHICH THE AIRCRAFT WAS CLEARED BELOW A MINIMUM LEGAL ALTITUDE

distracted in trying to locate a lost aircraft and permitted a general aviation aircraft to enter the next sector 1000 feet below the MEA. A faulty data strip marking contributed to another incident; the controller mistakenly believed the aircraft to be VFR on top. In a third case, a military trainer flew at dusk only 500 feet above mountain peaks because an amended clearance, relayed through a Flight Service Station, did not reach the aircraft in time. The fourth failure to climb was attributed to a lack of sector coordination.

In a totally different situation, a military helicopter pilot questioned an airways altitude assignment 1000 feet below the published MEA. His protest was to no avail, the controller insisting the MEA was lower. The resourceful pilot requested and received radar vectors to make his operation legitimate.

In the last airways incident, the data strip for a light aircraft did not contain the usual notation that the assigned altitude was inadequate for a particular segment of the route. Nevertheless, an alert controller recognized the discrepancy and climbed the aircraft before it penetrated the higher MEA area.

The final cruise occurrence in this category involved a charter flight flying an off-airways route. The crew apparently copied an altitude clearance intended for a different flight and flew a substantial portion of the trip below the MEA before the discrepancy was noted.

The final approach phase provided three occurrence reports in this category. On two consecutive VOR approaches to a major hub airport, the controller cleared an air carrier aircraft below the published minimums prior to the pilot having the runway in sight. Both attempts ended in missed approaches. In another case, a general aviation pilot was observed three miles east of course while attempting an NDB approach at night in IMC. Approach Control requested that the tower issue a missed approach, but the tower refused and vectored the aircraft to final 600 feet below the MVA. In the third case, a commuter pilot was requested to perform a 360 degree turn for spacing on final approach. On radar vectors, the turn was extended into an area with a higher minimum altitude requirement.

Two incidents in this category occurred during missed approaches. In one, a 400 hour general aviation pilot complained of being vectored 200 feet below the MVA in IMC because the controller wanted 1000 feet of separation with overhead traffic. Traffic was also a factor in the other incident. A military transport on short final from an NDB approach requested a 360 degree turn and vectors for an ILS approach. Because of traffic, he was assigned a heading and an altitude which put him 1000 feet below the MVA.

Neglected while on radar vectors: There were nine reports of incidents in which an aircraft was forgotten, ignored, or otherwise left without proper guidance while on radar vectors. Seven of these reports were from pilots while two were from controllers. In five of the cases, controller workload was mentioned as a contributing factor.

No air carrier aircraft were involved--five were general aviation, while four were military. All were on IFR flight plans except one which was operating with no flight plan in a TCA.

The lighting and meteorological conditions are given in table 10.

TABLE 10. LIGHTING AND METEOROLOGICAL CONDITIONS FOR INCIDENTS IN WHICH THE AIRCRAFT WAS NEGLECTED WHILE ON RADAR VECTORS

	IMC	VMC	Mixed	Totals
Day	2	4	2	8
Night	0	1	0	1
Totals	2	5	2	9

Four of the nine incidents occurred as the aircraft were being vectored during the initial approach phase. In the most hazardous of these, a disaster was averted only because the crew of a military transport were properly aware of their position relative to high terrain, even though they were in solid clouds. At 5000 feet, their assigned heading was directly toward a 5696-foot peak. After repeated attempts to contact Approach Control, all thwarted by frequency congestion, the pilot took evasive action on his own authority. The evasive maneuver was initiated only three to five miles from the peak, according to a post-flight analysis.

In the other three initial approach incidents, the aircraft were fortunate to be clear of clouds. This was particularly true in the case of a reporting flight instructor:

> "While on an IFR training flight (actual clearance) we received a vector which would have flown us into a mountain since the controller apparently forgot us. ...continued flight would have impacted the aircraft approximately 200-300 feet below the ridge top. After crossing the ridge we asked for a freqency change and returned to the base airport."

In one instance, the controller realized the situation in time to advise a "sharp" right turn just one or two minutes from terrain conflict, after vectoring a U.S. Government civil aircraft past the final approach course. In this case, the pilot was aware of the hazard, having just broken out of an overcast.

The last initial approach incident involved a forgotten fighter pilot who steadfastly flew 38 miles on an assigned vector, among peaks in VMC, before jogging the controller's memory.

Two incidents were reported of having been forgotten during the departure phase. In one case, a flight of two fighters was given a clearance to climb to 7000 feet on an assigned heading. After a period of being distracted by other traffic, the reporting controller remembered them in time to suggest a "good rate of turn" less than a mile from a 9000 foot MOCA area. The other departure occurrence concerned a general aviation pilot complying with radar vectors while departing a TCA with no flight plan. His narrative reflects his frustration at being placed in a "no-win" situation:

> "...assigned heading 180 degrees and altitude 3500 feet. Unable to establish contact with Departure/Approach controller on multiple (at least 4-5) attempts. Was about 500 feet AGL with approaching higher terrain. Became apparent I would either have to (1) chance it on being able to climb over the approaching mountains, (2) change heading drastically, or (3) make an unauthorized climb. Chose last

choice because I could hear controller clearing plan just ahead of me to 6000 feet. I climbed to 4500 feet -probably violation of TCA. Departure controller then immediately came on frequency with reprimand for climb and indicated inbound plane passed 1/4 mile away at 4000 feet - Did not see plane..."

Two pilots reported having been forgotten while on radar vectors during cruise flight. A Navy helicopter was on a vector toward rising terrain in IMC when the controller left the frequency for an unexplained reason. After some delay communication was re-established on the guard frequency.

In the other cruise incident, an air taxi pilot reported flying almost 50 miles in marginal VMC at an altitude below the MEA's of nearby airways. The report gives no reason for the cavalier treatment alleged in the narrative:

> "...IFR clearance as follows: ATC clears (flight) to the (name) airport via radar vectors, maintain 2500 feet. ...Tower instructed the flight to contact (name) center on 127.1 (still within 1 n.m. of the airport). The flight reported on frequency passing 2000 feet. It was so confirmed. Approximately 15 n.m. west of the airport, center was reminded that the flight was still at 2500 feet (our filed request was 4000). That was greeted with a 'Roger'. Having experienced a similar situation twice in the past 8 months, the crew elected to continue on the runway heading at 2500 feet to see where our 'Radar Vector' would take us. ...by the time we were 2 miles past our destination we again called center. When the controller realized he did not know the position of an aircraft he was working on an IFR clearance, his confusion was easy to understand. ..."

In the final occurrence in this category, a controller acknowledged his error in permitting a corporate jet to descend into an 8000 foot MVA area at 7000 feet at night. In his own words: "As I was busy, I did not notice that he was turning a little wider than usual and let him stray into the 8000 MVA."

Given ambiguous clearance: The eight reports in this category pertain to instances in which the clearance issued by ATC contained an important but unspoken restriction, or which left the flight crew in a state of uncertainty with regard to their proper course of action. In each case, the ambiguity of the clearance could have led to a conflict with terrain.

All eight reports were submitted by pilots. Five of these were air carrier pilots, while the remaining three were general aviation. All were on IFR flight plans.

The lighting and meteorological conditions are listed in table 11.

TABLE 11. LIGHTING AND METEOROLOGICAL CONDITIONS FOR INCIDENTS IN WHICH FLIGHT CREWS WERE GIVEN AMBIGUOUS CLEARANCES

	IMC	VMC	Mixed	Unk	Totals
Day	0	2	1	0	3
Night	1	1	0	0	2
Dusk	1	0	1	0	2
Unk	0	0	0	1	1
Totals	2	3	2	1	8

Unless the aircraft is established on a segment of a published route or instrument approach procedure, FAR 91.116 (f) requires that, when an approach clearance is received, a pilot shall maintain his last assigned altitude unless a different altitude is assigned by ATC. Nevertheless, four reports were received of instances in which the aircraft were simply "cleared for the approach" from radar vectors or while otherwise in a position without a published transition to the Final Approach Fix. Perhaps significantly, two of these cases occurred outside of the United States.

One incident occurred during an approach by an air carrier aircraft to an airport in Turkey. It was at dusk with heavy haze and the aircraft was in a holding pattern over an area where the MEA is 4500 feet. When cleared for the approach, the pilots looked at the approach plate and decided they could descend at their discretion to 3000 feet. The report was submitted by the Captain who expressed his appreciation for the alertness of the Flight Engineer, who requested that they level off at 4500 feet until established on the glide slope.

Another report by an air carrier pilot described a situation at an airport of entry in Canada.

> "...Several times at (name) airport, I have been on a vector for an ILS approach at an assigned altitude and cleared for the approach before intercepting the localizer. It was impossible to make an instrument approach unless I left my assigned altitude for the minimum glide slope intercept altitude before I was established on the localizer. Most of the times a lower altitude was given, when requested by me, from Approach Control. Today (mid-1978) we were being vectored...at an assigned altitude of 4000 feet. While south of the localizer, we were cleared for the approach. We requested a lower altitude (2400 feet cleared) but the controller would not issue us another altitude but only said that we were cleared for the approach. To say the least, we were a little high when we broke out of the overcast..."

While foreign controllers are not bound by the U.S. Federal Air Regulations, controllers in the United States certainly are. Nevertheless, a similar incident was reported by an air carrier pilot at an airport in the midwest. The scenario began in exactly the same manner as the preceding narrative. We join the story just as the controller has repeated his "cleared for the approach" over the objection of the pilot:

> "...I then told the controllers..we would have to stay at 6000...and we would be too high to complete a safe approach and landing. His reply was to the effect that we were cleared to 2600 feet then. ...we began a rapid descent and made a successful landing. The field was VFR or we would not have attempted such a descent so close in...".

A general aviation pilot, in IMC at dusk, reported being cleared for an ILS approach from an airway intersection with no published route for transition. Rather than confront the issue, he requested clearance to a nearby VOR and a VOR approach from that fix.

In another incident, Center turned over a corporate pilot to a VFR tower, with no approach clearance. Since the tower had no authority to issue an instrument approach clearance, the pilot was forced to revert to VFR. The weather was, in fact, VMC-presumably known to the center controller but not discussed with the pilot.

The remaining three cases in this category concern clearances with an unspoken restriction of vital concern to the pilot. In one of these, an air carrier aircraft on a SID at night in IMC was told to turn right "when able" for radar vectors while at 7000 feet:

> "...According to the SID instructions, a right turn was not to be made until passing (name) intersection and 9500 feet, presumably because of high terrain to the west. None of the cockpit crew members had ever heard the phrase "when able" with respect to a heading change. So we queried the controller about the clearance and the terrain (which could not be seen). He replied in an irritated and arrogant tone with 'Sir, that is a legal clearance'. While the clearance may have been legal, it was ambiguous to us and potentially dangerous. Certainly we were able to make the turn, but such a heading might have taken us dangerously close to high terrain. Somewhat perplexed, I replied that we were 'unable' and continued to fly the published SID. ..."

Another air carrier aircraft, flying a STAR profile at night, was cleared to descent to 10,000 feet "at pilot's discretion":

> "...Upon inspection of the STAR, we discovered that at our position on the STAR the MEA was 16,500 feet. I think that this is a potentially dangerous situation, especially for people who do not fly this part of the country on a regular basis. I do not think that most pilots realize their responsibility to review MEA's when given a clearance like the one we were given. ..."

In a call-back, the reporter stated that they if they had begun their descent when cleared they would have reach 10,000 feet while still in the 16,500 MEA area. The controller apparently assumed that the pilot would adjust his descent profile accordingly.

In the final incident of this category, a 3000 hour general aviation pilot objected to being cleared "after takeoff turn left 200 degrees", noting that such a heading was directly toward a high ridge in close proximity to the airport. When queried, the controller replied that he meant to turn at the pilot's discretion after maintaining runway heading to a sufficient altitude.

Given legal but disconcerting clearance: The eight reports (seven incidents and one situation) in this category are peculiar in that no actual error or FAR violation is evident. Yet, each describes circumstances which were disconcerting enough to the reporting pilots to warrant the submission of an ASRS report.

All of the reporters were professional pilots, six of them employed by air carriers, while two are Air Taxi pilots. All of the report described occurrences on IFR flights.

The lighting and meteorological conditions for the seven incidents in this category are given in table 12.

TABLE 12. LIGHTING AND METEOROLOGICAL CONDITIONS FOR INCIDENTS IN WHICH FLIGHT CREWS WERE GIVEN LEGAL BUT DISCONCERTING CLEARANCES

	IMC	VMC	Unk	Totals
Day	0	3	0	3
Night	3	0	0	3
Unk	0	0	1	1
Totals	3	3	1	7

Three of these incidents arose because of an information gap between controllers and pilots with regard to minimum altitude limits. In particular, pilots are generally unfamiliar with minimum vector altitudes and may feel uncomfortable when vectored, quite properly, below the minimum altitude displayed on the charts available to them. In one case, an FAA check pilot, riding with the reporting pilot, demanded a climb to the published minimum altitude. In another, an air carrier pilot's confidence was even further shattered when the GPWS went off on radar vectors over hilly terrain after descending 700 feet below the Jepp chart minimum altitude. As the controller had intended, the aircraft was actually 100 feet above the MVA. On the third, but somewhat different instance, a perplexed air carrier pilot found himself trying to resolve three diverse minimum altitude restrictions at night in IMC:

> "I requested and was given a route from my position on V-45 airway (which has an MEA of 2000 feet) direct to the outer locator (which has a procedure turn minimum altitude of 2100 feet). However, the minimum safe terrain altitude is 2600 feet..."

An air carrier pilot reported being disturbed by a GPWS alert while crossing a ridge at 10,500 feet, even though the weather was VMC in daylight. The radar altimeter showed a 1500 foot clearance, a legal margin since the aircraft was on radar vectors.

Two other reporting pilots expressed concern over radar vectors in mountainous terrain. One, a 5000-hour air taxi pilot objected to two instances of radar vectors off airways at night in IMC:

> "In both instances, weather was solid IMC...We were given radar vectors...and were not told the purpose...nor was there much communication from that time on. ...This procedure is ambiguous at best and takes the aircraft close to (mountain). In both instances I repeatedly asked the controller when we would be turned back toward the airway or VOR because of the length of time between communications and in both instances I felt as though I had been forgotten..."

In another report, the Captain of a wide-body air carrier aircraft made a strong plea for the implementation of SID's and STAR'S to replace the extensive radar vectoring at a particular site in mountainous terrain:

> "...Upon arrival at (name) on the first flight, I was appalled to find that so much faith was placed upon the radar vector as an arrival and departure handling technique, and the attendant necessity for continuous radio communication. After several flights I 'learned' the arrival and departure patterns of radar vectors and it is their consistency which causes me to submit this report...It would be criminal to allow a crash to occur just because communications were interrupted."

In a very detailed report, another air carrier pilot took exception to a last-minute change to an impromptu off-airway clearance at night which he found very disconcerting:

"...The weather was poor with rain, low ceilings, turbulence, isolated embedded thunderstorms, gusty surface winds. ...As we were cleared for takeoff, the tower advised us to 'turn right to heading 180 degrees, maintain 6000 feet'. I didn't like this last minute change to our clearance as it, in my judgement, negated our previous routing without providing us with any new definitive routing to our destination airport. However, I accepted it because of the pressure of the takeoff. ...departure control advised us to report receiving the (name) VOR satisfactorily for 'direct'. This was not part of our original clearance route. ...I questioned the adequacy of the 6000 foot altitude assignment because I noted an 8000 foot MEA to our left and 5687 foot terrain on the area chart. ...I was in no position at the time (dark, rain, turbulence, on instruments) to be plotting a course on the chart to determine compliance with FAR 91.199(a)(2)(i). I felt uneasy...so I asked the coast controller if we were in radar contact. He muddled some reply...so I specifically asked him if 6000 feet was adequate for our assigned route. He then fell silent whereupon I began to feel very uncomfortable. After a couple of attempts to raise him, I said that I either wanted a radar vector or I would take necessary action (i.e., a climb to 8000 feet without a clearance). He responded by 'turn right to a heading of 250 degrees for a vector to... . It was apparent to me that I was neither 'fish nor foul'... I wasn't on an actual radar vector but I was assigned an off-airway route at ATC's request. ...I am confident, in retrospect, that my altitude and route assignments were safe and in compliance with the requirements of FAR 91. But I also know that I was in no position at the time to determine the adequacy of the route and altitude when it counted, and I had the feeling the controllers didn't really know either...".

In the final incident in this category, the pilot of another air carrier aircraft objected to the tower's routing while circling to land after a runway conflict developed while he was on a 2-1/2 mile final. Although the weather was VMC in daylight, the guidance provided by the tower required several abrupt turns at low-altitude. The pilot observed that while the maneuver was within the parameters of safety, it was well outside the limits of comfort for all concerned.

Given a heading toward higher terrain: The five incidents in this category have in common the receipt of an ATC IFR clearance which, in the opinion of the reporter, could have placed the aircraft in a position without adequate terrain clearance. In no case did the aircraft actually enter the potentially hazardous area. In three of the cases, the pilot refused the clearance; while in the remaining two, the flight path was altered by ATC before the suspected hazard was encountered.

Three of the reports were by air carrier pilots, one from a general aviation pilot, and one from a controller. The lighting and meteorological conditions are given in table 13.

TABLE 13. LIGHTING AND METEOROLOGICAL CONDITIONS FOR INCIDENTS IN WHICH FLIGHT CREWS WERE GIVEN A HEADING TOWARD HIGHER TERRAIN

	VMC	IMC	Totals
Day	3	1	4
Night	1	0	1
Totals	4	1	5

In one instance, a general aviation pilot on radar vectors under daylight VMC conditions, became concerned that his vector would impact terrain a few miles ahead. The controller disagreed, insisting the altitude was safe. The pilot, unconvinced but now within about two miles of the ridge, requested and received a heading change.

An air carrier pilot, on a published departure route in IMC, received a suggestion to turn to a heading which would permit an inbound aircraft to make a straight-in approach, but which would also lead into mountainous terrain. When asked if he could guarantee terrain clearance, the controller only promised to do his best. Unsatisfied with this warranty, the pilot refused the new heading and continued on the published route.

Another air carrier pilot, departing in daylight VMC conditions from an airport in a "bowl", was concerned about the hot-day performance of his aircraft. He refused a clearance to maintain runway heading after takeoff because such a course was directly toward a 4000 foot mountain. Unable to get a modified IFR clearance from the controller, he took off VFR to provide his own navigation out of the area.

In the sole report by a controller, a situation was reported wherein a particular published departure, at his facility, is frequently amended to maintain 6000 feet while approaching an intersection with a crossing restriction of 7000 feet. The departure controller apparently issues the altitude restriction for initial traffic separation, with the intention of lifting the restriction later. The reporting controller objected to this practice because a delay in communication could result in an aircraft penetrating high-terrain airspace below the MEA.

In the final report of this category, an air carrier pilot objected to radar vectors below nearby mountains at night:

> "...cleared from 11,000 feet to 9000 feet on heading of 240 degrees, which would cause aircraft to meet high terrain 9300 feet and 9200 feet southwest of the airport. Controller said they used this procedure all the time during VMC conditions. We didn't know we were operating under VMC conditions nor were we given lost communications instructions."

Cleared with impaired ILS: Five reports described instances whereby, in the opinion of the reporter, pilots were not adequately warned about an impairment of the ILS system or in which the localizer was rendered erratic because of aircraft on the ground.

In the worst case of an information failure, a general aviation pilot reported being cleared in "hard" IMC for an ILS approach while the system was out of service according to a current NOTAM.

Two air carrier pilots objected to the use of the terminology "cleared for ILS approach" where the glide slope is out of service, apparently having encountered instances in which neither the terminal controller nor the ATIS message provided a warning.

The remaining two reports in this category described situations in which aircraft were permitted into critical areas on the ground while other aircraft were on final approach using the ILS system. One of these reports was from a tower controller whose efforts to stop the practice, on a particular night, were over-ruled because no actual system deviation was occurring (not Category II). A similar situation report eloquently expressed the feelings of an air carrier pilot:

> "...During a recent three week period, I have conducted five approaches below Cat. I limits, typically 100 obscured and RVR's ranging from 1600 to 2200 feet. ...In four of five, there was localizer displacement or waffling at low altitudes caused, apparently, by other aircraft on the ground disturbing the localizer. Some specific examples follow. (Date and place), daytime, 1600 RVR...saw lights at approximately 170 feet, some localizer waffling at about 300. (Date and place), night, 100 obscured, 2200 RVR...at about 300 feet, severe swinging of the localizer started, causing 15 degree banks to each side...very nearby ended upon the lights. ...(Date and place)...100 obscured, RVR 1600...the localizer became erratic again at about 300 feet...took a missed approach. On the second approach, ...tower cleared another aircraft to depart and he was rolling as we passed about 600 feet, which again caused the localizer to swing...As far as I'm concerned, there is little or no margin for error during these low visibility approaches, coupled with an apparent feeling of complacency by nearby everyone. ...It is sheer madness to clear an aircraft for take-off when there is someone on approach inside the outer marker. ...A corollary problem is the fuzzy area between Cat. I and Cat. II approaches. It is very common for

the visibility to be up and down frequently, crossing the border between the two realms. ...there are sterile areas on all Cat. II airports wherein aircraft are not permitted during Cat. II operations, but where they are permitted during Cat. I operations... throwing in an erratic localizer really loads up the crew..."

Miscellaneous: Two singular cases were reported. One involved a general aviation aircraft which lost radio contact with ATC for an extended period in mountainous terrain, but the aircraft was apparently in VMC, so no serious terrain hazard existed. In the other instance, a mulitary trainer was given an erroneous altimeter setting during descent, which resulted in an unsafe initial approach altitude in IMC.

Type III Reports

The reports in Type III are those in which a reporter alleges that the design of airspace, air traffic and aircraft procedures or published information relating thereto is deficient and presents the hazard of collision with terrain or obstacles.

Some 27 unique situation/occurrences are in this group. This represents approximately 10 percent of the total number of reports in the CFTT study document set. Of these, only nine are classifiable as discrete occurrences; while 18 report situations. Unlike other types examined in this study, the reporters are almost evenly divided among pilots and controllers.

With one exception, there appears to be no particular geographic correlation with the number of Type III reports. The exception is the state of Alaska, with eight reports - five of these from the Anchorage area. It appears that a reason for the higher frequency of Alaskan reports may be the unusually rugged terrain combined with, in some cases, relatively large distances between navigational aids.

Over the 52-months covered in this study, 1978 was the peak year for Type III reports, providing 12 of the 27 reports.

For the most part, the problems reported in the Type III classification are of such a nature that the fix, if appropriate, is unique to a specific location. For this reason, these reports will not be treated in as much individual detail as in the preceding Type I and Type II incidents.

The distribution of reports, with respect to the general type of problem, is given in table 14.

TABLE 14. GENERAL NATURE OF PROBLEMS DESCRIBED IN TYPE III REPORTS

Problem Area	Number of Reports
Design/Configuration	
Airspace	5
ATC Procedure	6
Aircraft Operational Proced.	1
Subtotal	12
Published Information	
Ambiguous	8
In Error	2
Absent	5
Subtotal	15
Total Problems	27

Situation reports. The specific deficiencies reported in general situations of Type III are summarized in table 15.

Occurrence reports. Nine of the Type III reporters described specific instances to support their points of view. For example, an air carrier pilot observed that a particular approach plate notation should be made more prominent.

> "...There was a line of thunderstorms in the area...I looked at the 36L Approach Plate. I did not see the small print in the right center...As we got closer to the VOR...the line of thunderstorms seemed to fill in and be intensifying and was in the shape of a horseshoe with us in the center...We were level at 2000 feet and the controller told us to turn right to 210 degrees. I looked at the

TABLE 15. SUMMARY OF ALLEGATIONS IN TYPE III SITUATION REPORTS

- Published procedure doesn't provide terrain clearance
- Proposed profile descent procedure ambigious
- Chart shows inaccurate MEA
- Published missed-approach procedure could lead to terrain conflict
- Chart ambigious on COP's and MEA gaps
- Departure procedure could lead to terrain with communication failure
- Pilot ignorance of MVA's leads to blind clearance acceptance
- Published departure procedure gives low performance aircraft a terrain problem
- MEA too high, leads to steep approaches
- Company flight operations manual doesn't provide for safe operation at airport
- Published procedure ambigious in regard to minimum altitude
- Pilots on IFR flight plans cruise below MEA when VFR on top
- Local procedure requires tower controller to clear aircraft below MVA
- Radar video map lacks critical points
- Charts don't show 500 foot offshore drilling rigs
- ATIS doesn't mention cranes near runway
- Airway dimensional tolerances invalid in Alaska
- Ship-in-channel procedure will lead to go-arounds

radar and told the controller...210 degrees looked the worst and I asked if I could head 180 degrees for 5 or 6 minutes then turn left...He said 'approved'. As we were going through the line the First Officer told the controller we were heading Southeast...and the controller asked if we saw the towers at 12 o'clock. We looked up and saw the towers through the rain at our immediate left front. Both I and the First Officer pulled back on the yolk and climbed to 2500 feet..."

A general aviation pilot misread his chart, picking up the altitude for initiating a turn which was for the opposite direction runway. He suggested that the altitude restriction should be a specific part of the departure clearance.

In another case, a complicated SID contributed to a foreign air carrier aircraft being discovered by a controller at 5000 feet in a 6700 foot MVA area.

A controller reported that an aircraft made an approach below minimums at his facility, but there was some uncertainty regarding what the correct minimums were. Components of the ILS system had been out of service for nine months, but the approach charts had not been changed to reflect the impaired system.

An air carrier pilot objected to initial approach radar vectors over mountainous terrain where the MVA is sufficiently low that his GPWS was activated.

The pilot of a floatplane observed an uncharted obstruction, in the form of telephone wires across a river, just in time to avoid collision by making a hard landing on the water.

One occurrence report presented convincing evidence that the MVA in one locale was not adequate. In fact, the MVA had been raised since the reported incident occurred. There can be little doubt but that the GPWS prevented a catastrophe in this incident:

> "...on a radar vector to (name) the GPWS actuated with a red light and 'Whoop-Whoop Pull Up'. At this time we were...at an assigned altitude of 11,000 feet. ...radio altimeter was observed to pass 2500 feet rapidly and power was initiated, climb attitude established. The radio altimeter passed through 800 feet and gradually started up during the climb. ...there was a deep low (trough) aloft, and...the aircraft was 1400 feet lower than indicated..."

At the time of the incident, the MVA was intended to provide a 1000-foot margin. In the reporter's opinion, even a revised 2000-foot margin was not entirely adequate.

An air taxi pilot in Alaska reported a controller informed him that he was 10 miles off the center of an airway when his VOR indicator was centered. He felt that an MEA below the minimum reception altitude was dangerous because of high terrain on both sides.

In the final Type III occurrence, a controller admitted being unable to answer a pilot's question regarding the proper flight segment altitude for a published departure route. The pilot selected an alternate route instead. The culprit was the unusually complex and detailed information necessitated by the terrain surrounding the Alaskan site.

Type IV Reports

Type IV reports are those in which it is alleged that inadequate, nonexistent, or misleading lighting and/or marking of obstructions posed a hazard to aerial navigation.

There were 24 reports of this type, or approximately 9 percent of the total CFTT study document set. Of these, 7 are classified as occurrences while the remaining 17 are classified as situation reports. These reports were submitted almost exclusively by pilots.

While it may not be statistically significant, the San Francisco Bay area provided three of the 24 Type IV reports, more than any other geographical area.

The reporting frequency of Type IV reports is very peaked. None were received in 1976. The greatest number (50 percent) were received in 1977. The remaining 50 percent were spread fairly evenly over the next three years. This characteristic is true for both the situation and the occurrence reports.

Situation reports. Although all Type IV reports are very site-specific, there is a commonality among a few reports which permits some grouping into generic classes. For the situation reports, the generic classes of problems are listed in table 16.

TABLE 16. PROBLEMS DESCRIBED IN TYPE IV SITUATION REPORTS

Problem	Number of Reports
Failure to replace burned out marker lights on towers	4
Poor visibility of towers which have functioning lights	3
Towers without markings or lights	2*
Lighted objects which look like the airport environment	2
Towers whose height or location makes them a hazard	2
Unmarked wires near an airport	2
Unmarked crane operating near airport	1
Tall trees on approach course to runway	1

*One report deals with a "trap" in which an unlighted tower exists next to a lighted one.

Occurrence reports. Five of the seven Type IV occurrence reports described near-misses with radio or television towers which were lighted, but not adequately. The pilot of a corporate jet, circling to land at night, narrowly avoided a 436 foot tower just 1 1/2 miles from the airport. An observer in the cockpit spotted the tower, which was difficult to discern from a background of city lights. In another incident, a light plane pilot cruising at 1000 feet at dusk had a near-miss with towers that are 1049 feet high, six miles from an airport. Similarly, a pilot reported several instances wherein he observed light aircraft pulling up suddenly to avoid four 505 foot towers located 1.2 nautical miles from the threshold of a runway. The fourth report described a near-miss with 1031 foot television towers, also in the vicinity of an airport.

The sole report of this group by a controller described two incidents, in marginal VFR weather, which involved two separate towers in his area, each almost 2000 feet AGL:

> "...The first was an enroute aircraft who called for advisories...He was identified 1 mile from the antenna west of town, 500 feet below the top of it. He was unaware of it and was given an immediate vector to avoid impact. The second occurrence was with a VFR aircraft that departed southbound. He proceeded towards the antenna south of town and was given information and vectors to avoid it. He passed within 2 miles of the antenna without seeing it, and indicated surprise that it was there. ..."

Significantly, none of the ubiquitous antenna towers in these reports were equipped with high-intensity strobe lighting.

One report described a problem with an antenna tower whose "dim red lights" had been out of service for several months at the time the report was submitted. To make matters even worse, the obstacle was located on top of a mountain within a heavily used corridor between higher terrain and a TCA.

The final Type IV report was submitted by a reporter who claimed to be just one of ten pilots who, to his knowledge, have missed a particular smokestack by a wingspan or less. The stack was lighted by a spotlight, but was difficult to see against the background at night. The obstacle in question is located 1/4 mile from a runway and just 100 yards from the centerline.

Type V Reports

The Type V reports are those in which it is alleged that a hazard exists because of the absence, improper design, or inappropriate operation of enroute and landing aids.

Some 52 unique situation/occurrence reports were found to fit the definition above. This represents about 20 percent of the total CFTT study document set. Most of these reports (35) are descriptions of situations, while 17 are classifiable as occurrences. Approximately 70 percent were submitted by pilots, and the remainder by controllers. There is no significant correlation of the number of reports and any particular geographical location.

A majority of these reports (76 percent) described perceived hazards during the final approach flight phase.

The number of reports of this type peaked in 1977 with 38 percent of the reports submitted in that year.

Situation reports. The complaints contained in the 35 situation reports are classified in table 17.

TABLE 17. CLASSIFICATION OF TYPE V SITUATION REPORTS

Complaint	Number of Reports
Inadequate Glide Path Cues (Black Hole Effect)	
No VASI	10
VASI out of service	7
Poor quality VASI	3
VASI path too close to power lines	1
Subtotal	21
Unreliable ILS	4
Shortened Approach Lighting System	3
Miscellaneous	
Poor communication with ATC	1
Poor location of LOM	1
Unreliable ATC radar	1
Non-standard ILS/DME	1
Airport critical area being reduced	1
Adequate weather data not available	1
ATIS not informative on status of ILS	1
Subtotal	7
Total	35

As evident in table 17, two thirds of the situation reports cite the hazards associated with night approaches without adequate visual guidance in the form of a suitable VASI. Almost half of the VASI complaints were submitted by air carrier pilots.

Aside from the four reports of unreliable ILS indications and the three reports objecting to a shortening of the approach lighting system, the remaining situation reports are very site-specific.

Occurrence reports. Unlike the situation reports, the specific occurrences are weighted heavily toward hazards which occurred during ILS approaches. Reports of ILS incidents account for 13 of the 17 reports.

Four incidents were reported in which shut-downs for maintenance were not properly coordinated, at least not with the flight crews who were using the system at the time.

The pilot of a wide-body air carrier aircraft described an approach to a major airport with the ceiling reported as 700 feet, broken:

> "...approximately 2 1/2 miles from touchdown, 800 feet AGL, glide slope disappeared from both instruments on Captain's and First Officer's panel. PAFAM communicated 'Take Over', and Number 2 autopilot, which was in use for approach, dropped off. First Officer continued approach manually...After landing, tower asked if flight had lost glide slope during approach...advised that maintenance was performing ground checks..."

In a very similar incident, a maintenance technician turned off the ILS while an air carrier aircraft was on a three-mile final in heavy precipitation, causing a missed approach.

In the two other shut-down incidents, the maintenance procedure was coordinated with ATC but took place at inopportune times. In one of these cases, the weather was "indefinite ceiling zero, sky obscured, visibility one sixteenth, fog, forecast to improve".

One ILS-related occurrence report questioned the wisdom of having the localizers for different runways on the same frequency at the same airport. A wide-body air carrier aircraft was cleared for a visual approach to Runway 1L with no mention by either the controller or the ATIS that the 1L ILS was out of service. The aircraft received spurious signals from the Runway 19 localizer, which is on the same frequency. In VMC conditions, a normal landing was made despite a warning from the GPWS that the aircraft was below the glide slope.

Two cases were reported wherein erratic glide slope behavior raised havoc during coupled approaches. In the more serious of these:

"Category II approach. Autopilot followed fluctuation of glide path between 100 to 150 feet that resulted in excessive pitch down. Autopilot disconnected, power added, nose raised. Hard landing resulted barely on the threshold..."

An errant glide slope component figured prominently in three other occurrence reports. In one, an air carrier pilot in VMC flew an entire approach with the glide slope needle centered and no flags showing only to discover that the indicator remained centered all the way to the parking area. The problem was in the glide slope transmitter. In another incident, the approach coupler on a wide-body aircraft locked on to a multiple glide slope signal. The crew realized that they had not yet crossed the outer marker and initiated a go-around at 800 feet. In the third case, the glide slope indicator in another wide-body aircraft gave an obviously erroneous indication at the outer marker. The tower monitor showed no problem existing, but the monitor was later found to be incorrect.

Three other reports were concerned with ILS problems. In one, a controller reported the system inoperative, for an unspecified reason, for five minutes with three aircraft at some stage of the approach. Another controller complained that the ILS at his facility behaved erratically in heavy rain, as did the runway lights. In the last, an air carrier pilot reported executing a missed approach because of an anomaly in the localizer course as he approached minimums.

Two reports were received which complained of deficiencies in the lighting system. One of these was from an air carrier pilot:

"ILS approach to Runway 28. Sequence flashes were bright and quite a distraction when aircraft descended below the clouds on a foggy, rainy night. (Weather 300 overcast, 1 mile in rain and fog.) Requested tower to..."kill the rabbit". When he turned off the sequence flashers, the entire approach light system was extinguished. Controller was apologetic, but the only way he could turn off the SFL was to turn off the MALSR servicing the airport. ..."

The other lighting complaint was from a general aviation pilot and concerned a night landing at an uncontrolled airport:

"...Runway 36 has trees and a power line at the approach end, so I elected to make my approach to Runway 18 where there were no obstructions. When I turned final, I adjusted my descent to land on the green threshold lights. Approximately 25 feet above ground, as I was beginning to flare, I sensed something was wrong so I executed a go-around. After circling the airport, I realized what had happened. The airport had no threshold lights on Runway 18. The green lights that I had seen were the threshold lights of Runway 36 which could be seen from both directions. This, coupled with the fact that approximately one third of the Runway 18 lighting was not visible (burned out), led me to believe that I was approaching a displaced threshold on Runway 18..."

Only one occurrence report concerned enroute navigational aids. A controller described the incident, which happened at dusk in IMC.

"...I observed a target on radar approximately 18 miles west of centerline of (vector airway) on a heading which would take the aircraft to Mount (name). I established radio and radar contact and advised pilot of his position. ...He...only showed a couple miles left of course. This has happened three times in ten days to three different aircraft."

In the final Type V report, it was alleged that a reportable accident of a corporate aircraft was due, in part, to the fact that control of traffic at a particular site should be re-delegated to a different radar facility for better coverage.

Type VI Reports

Type VI reports are those in which it is alleged that a GPWS or MSAW alarm occurred under inappropriate conditions. In the opinion of the reporters, these false alarms can cause potentially serious problems in the cockpit. Moreover, they reduce the credibility of the alarm systems.

There were 29 unique occurrences, or about 11 percent of all the reports in the CFTT study document set. Some 83 percent of these were submitted by pilots, the remainder by controllers.

The false alarms occurred most frequently during the final approach flight phase (67 percent) with descent and initial approach each accounting for an additional 14 percent.

Information concerning aircraft and operator characteristics was missing from about 17 percent of the reports. Of the remainder, the reports dealt almost exclusively with air-carrier operated, transport-category aircraft.

The prevailing flight conditions are given in table 18.

TABLE 18. PREVAILING CONDITIONS IN TYPE VI REPORTS

Flight Plan	Number	Meteorological Conditions	Number	Lighting Conditions	Number
IFR	25	IMC	8	Night	5
Unk	4	VMC	12	Day	15
		Mixed	1	Both	1
		Unk	8	Dusk	1
				Unk	7

The number of reports of this type peaked in 1978, with the incidence of these reports considerably reduced in the last two years. The reporting frequency, by year, is listed in table 19.

All of the Type VI reports described occurrences, as opposed to general situation reports received in some of the other categories treated in this study. One of these was unique in that it was not truly a false alarm, but a manifestation of system damage. In this incident, a large but unfortunate bird was struck by the glide slope receiving antenna on the aircraft, causing a "Pull Up" aural GPWS alarm at low altitude on final approach.

The other 28 reports are summarized in table 20.

TABLE 19. REPORTING FREQUENCY FOR GPWS AND MSAW FALSE ALARMS

YEAR	GPWS	MSAW	BOTH	TOTAL
1976 (last six months)	5	0	0	5
1977	2	4	0	6
1978	6	4	1	11
1979	2	2	0	4
1980 (first ten months)	1	2	0	3
	16	12	1	29

TABLE 20. COMPLAINTS OF REPORTERS OF TYPE VI INCIDENTS

Reporters Complaint	Number of Reports
Distraction and loss of confidence	15
No problem indicated	5
Concern that pull-up would cause mid-air collision	4
"Low Altitude" callout as result of MSAW alarm misleading	2
Cockpit communication blocked	1
Loss of airspeed from distraction	1

While all of the reports represent a cause for concern, only two portrayed a serious occurrence where the false alarm led to some genuine difficulties. In one early incident (1976) an air carrier aircraft was on final approach with only partial flap deflection because of a flap system problem. Although the situation was well under control by the crew, the GPWS was triggered to a "pull-up" alert about two miles from the runway. In the words of the reporting pilot:

"...since the audio level is extremely high, all cockpit and tower communications were blocked at this point in time, speed call-outs, sink rate call-outs, height above runway call-outs were not possible. This, in effect, denied a coordinated crew function. ..."

In the other serious incident, a spurious GPWS warning received on short final in gusty winds caused sufficient distraction to permit a critical loss of airspeed with a difficult recovery.

DISCUSSION

In the preceding section, the 258 reports comprising the study document set have been summarized, without comment, and placed in categories intended to delineate certain common circumstances. In this regard, the previous section can stand alone as a factual account of what is contained in the ASRS files, pertinent to CFTT hazards.

For the most part, the reports must speak for themselves. While all of them can be classified by their superficial similarities, few, if any, are alike in detail. For this reason, a specific summarization of such parameters as causal and recovery factors would not only be difficult, it would be of questionable value. Instead, this section will deal primarily with general impressions obtained during the course of the study.

Human Error in CFTT Incidents

If the 29 reports of erroneous MSAW or GPWS alerts in Type VI are omitted, there were 159 discrete occurrences (as opposed to situations) in the study document set. Human error is the greatest single causal factor in these remaining CFTT incidents, producing 101, or 64% of the total number of occurrence reports.

Of the Type I incidents, in which inappropriate flight crew action precipitated the occurrence, 70% are directly chargeable to human error, primarily simple errors of execution. A very few of these, perhaps three, produced errors which can only be described as blunders. In two of the Type I set, the blunders prevailed despite the presence of other crew members and the clearance read-back to a controller.

Most of the human error incidents are of Type II, wherein unsafe clearances were issued by controllers in 81% of the occurrences. In the vast majority of those cases, the underlying reason for the error is not revealed.

The remaining human errors were reflected in the untimely and uncoordinated shut down of ILS equipment (4 cases) and the MSAW system (1 case).

The Role of GPWS and MSAW in CFTT Incidents

The GPWS or the MSAW equipment functioned properly in 24 occurrences examined in this study. Indeed, the first warning of danger came from one of these systems in 18 cases, 10 from the GPWS and 8 from the MSAW alert.

In the opinion of the authors, a disaster would have occurred in six instances, were it not for the timely warning of these systems. GPWS and MSAW each accounted for three of those probable saves. This is a conservative estimate, since the seriousness of some of the other occurrences is difficult to judge, particularly those reported by controllers in the Type II category.

Further evidence of the efficacy of the GPWS and MSAW systems was found in a separate study by the authors* of accidents in the United States, or to U.S. carriers, in which air carrier aircraft were flown into terrain with no prior awareness on the part of the crew of the impending disaster. In the years 1971-1975 (pre GPWS/MSAW), there were 17 such accidents; while in the period 1976-1980 (post GPWS/MSAW), there were two (In one of the latter, a GPWS alarm was sounded, but ignored). Employing a standard statistical test, it was concluded that the probability of this dramatic reduction being coincidental is less than seven in one million.

Several of the 29 incidents of inappropriate alarms (Type VI) imply that pilots are much more aware of the negative aspects (false alarms) of these systems than they are of their demonstrated worth. In the words of one reporting pilot "...It is my opinion that the GPWS is much more likely to cause an accident than it is to prevent one..." The results of this investigation, and the study cited above, indicate to the contrary.

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*Loomis, J. P. and Porter, R. F., "The Performance of Warning Systems in Avoiding Controlled-Flight-Into-Terrain (CFIT) Accidents", 1981 Symposium on Aviation Psychology, Columbus, Ohio, April 20-22, 1981.

At the same time, the legitimacy of the complaints, contained in the Type VI category, must be recognized. There is no doubt that frequent inappropriate alarms tend to degrade the effectiveness of the systems by reducing confidence in their veracity. It is also clear that legitimate ATC procedures, such as vectoring aircraft at or near th MVA over undulating terrain, can routinely create false GPWS alarms and that these can create crew distraction with potentially hazardous effects.

Radar Vectors and Off-Airways Routing

Some 46 reports described incidents which occurred during radar vectoring, principally during departures and arrivals in mountainous terrain. It may be inferred that pilots are not comfortable when heavy reliance is placed on controllers, often busy with other aircraft, for navigation and terrain avoidance. This attitude is supported by the ten cases of aircraft being forgotten or ignored while on radar vectors.

One report, in particular, made a strong plea for the establishment of more SID's and STAR's at a particular site. It may be significant that only three incidents were reported concerning aircraft on published SID's (all pilot errors) and no incidents on STAR's. On the other hand, six of the radar vectoring incidents occurred when controllers preempted a published transition with vectors.

While it is always the responsibility of the flight crew to mantain an awareness of position relative to surrounding terrain, it is apparent that the reporting pilots would be much more comfortable with published routes when a terrain hazard is present. Aside from the radar vector instances, this point is also forcibly presented in one particular report regarding an off-airways amended clearnace.

It should be noted that the comments promoting the value of published routes, SID's, and STAR's, support the findings of Harris (1975)*.

A contributing factor to the pilot's aversion to radar vectors is the fact that he generally does not have access to information regarding MVA's. When an altitude assignment is received which is lower than the minimum

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*Harris, R. M., "Review of Pilot and Controller ATC Responsibilities", MTR-6954, Mitre Corporation, July, 1975.

altitude indicated on his charts, he can only accept the clearance on faith - a valuable redundancy in operational safety is no long present. This system deficiency was also pointed out by Harris in 1975.

While on the subject of radar vectors, some notice must be taken of the plight of the VFR pilot operating in a TCA. Unlike his IFR colleagues, he does not enjoy the protection of the MVA, even if he knows what it is. In five instances, the pilots alleged that they were vectored at an unsafe altitude. By complying, they were presumably in violation of FAR Part 91, but the same regulations forbed them from deviating from the ATC clearance. While it is true that FAR 91.75A permits the pilot to question a clearance, clarification is not always readily obtainable on congested frequencies.

Approach Clearance Terminology

Unless the aircraft is established on a segment of a published route or instrument approach procedure, FAR 91.116(f) requires that, when an approach clearance is received, a pilot shall maintain his last assigned altitude unless a different altitude is assigned by ATC. Only two incidents were reported in the United States in which an aircraft was "cleared for the approach" without benefit of a proper transition altitude assignment. On the other hand, two other reports indicate that procedures in other countries may differ, and crews operating to foreign airports may be required to provide their own transition altitudes to the final approach fix.

CONCLUSIONS

From a review of some 258 pertinent reports in the ASRS data base, the following conclusions may be drawn concerning the observed hazards conducive to collision with terrain:

(1) Human error is the single greatest identifiable cause of CFTT incidents, being a causal factor in over 64% of the occurrences in which some threat of terrain conflict was experienced. Approximately two thirds of the human errors were attributed to controllers, the most common discrepancy being a radar vector

below the MVA. Errors by pilots were of a much more diverse nature and included a few instances of gross deviations from their assigned altitudes.

(2) Radar vectoring in mountainous terrain is particularly conducive to controller errors. Radar vectoring was the occasion of 46 specific occurrences, while only three incidents arose on SID's and none on STAR's that were not amended by radar vectors off the published profiles.

(3) A factor contributing to the aversion of many pilots to radar vectoring in IMC is that pilots do not have information on MVA's readily available. A radar vector below a minimum altitude on the pilots charts must be accepted on faith, removing a valuable safety check.

(4) There can be little doubt that the GPWS and MSAW systems have been responsible for averting several catastrophic accidents to air carrier aircraft. It seems relatively certain that a disaster would otherwise have occurred in six incidents examined in this study. In 12 other cases, one of these systems provided the first warning of danger.

(5) Many pilots are apparently unaware of the effectiveness of the GPWS and suffer from some disbelief in its credibility as a consequence of false alerts.

(6) There is some evidence that an approach clearance to a runway with the glide slope component of the ILS out of service should contain an explicit reminder of that fact. A particularly insidious situation occurs when the glide slope anomaly does not cause a flag to appear in the cockpit.

APPENDIX

APPENDIX - LIST OF ABBREVIATIONS

ADF	Automatic Direction Finder
AGL	Above Ground Level
ARTS	Automatic Radar Terminal Systems
ASR	Aircraft Surveillance Radar
ASRS	Aviation Safety Reporting System
ATC	Air Traffice Control
ATIS	Automatic Terminal Information Service
CFIT	Controlled Flight Into Terrain
CFTT	Controlled Flight Toward Terrain
COP	Change-Over Point
DME	Distance Measuring Equipment
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FAR	Federal Air Regulation
FSS	Flight Service Station
GCA	Ground Controlled Approach
GPWS	Ground Proximity Warning System
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
LOM	Locater Outer Marker
MALSR	Medium-intensity Approach Light System with Runway Alignment Indicator Lights
MDA	Minimum Descent Altitude
MEA	Minimum Enroute Altitude
MOCA	Minimum Obstruction Clearance Altitude
MSA	Minimum Safe Altitude
MSAW	Minimum Safe Altitude Warning
MSL	Mean Sea Level
MVA	Minimum Vectoring Altitude
NDB	Non-Directional Beacon
NOTAM	Notices to Airmen
RVR	Runway Visual Range
SFL	Sequenced Flashing Lights
SID	Standard Instrument Departure
STAR	Standard Terminal Arrival Route
TCA	Terminal Control Area
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VOR	Very High Frequency Omnidirectional Range Station
WAC	World Aeronautical Chart

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