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Aircraft Cargo Compartment Smoke Detector Alarm Incidents on U.S.-Registered Aircraft, 1974-1999

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technical note

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16. Abstract

This technical note documents the number of incidents of cargo compartment smoke detector alarms on U.S.-registered aircraft operating under Federal Aviation Regulations (FAR) Part 121 and Part 135 for the years 1974 through 1999. The source for the data includes the Federal Aviation Administration (FAA) Service Difficulty Report System, the FAA Accident/Incident Reports, and National Transportation Safety Board (NTSB) accident information. The incidents are tabulated by year, precautionary action taken, cause, aircraft type, and phase of flight.

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EXECUTIVE SUMMARY

Most aircraft cargo compartments either currently require fire detectors or will shortly require them. This technical note documents the number of incidents of cargo compartment smoke detector alarms on U.S.-registered aircraft operating under Federal Aviation Regulations (FAR) Part 121 and Part 135 for the years 1974 through 1999. The source for the data includes the Federal Aviation Administration (FAA) Service Difficulty Report System, the FAA Accident/Incident Reports, and National Transportation Safety Board (NTSB) accident information. The results of the database searches are tabulated by number of false alarms, unscheduled landings due to false alarms, identified causes of alarms, false alarms versus genuine alarms, ratio of false alarms to genuine alarms for successive 5-year periods, proportion of alarms between large and small airplanes, and the phase of flight in which false alarms occurred. The data show that both the number of false alarms and the ratio of false alarms to real alarms are steadily increasing. The ratio of false alarms to real alarms over the previous 5 years was 200 to 1. The data does not give an indication of the causes for the false alarms in most cases.

INTRODUCTION

PURPOSE.

The purpose of this technical note is to document the results of database searches to determine the number of cargo compartment fire detector alarms that have occurred on U.S.-registered airlines over the past 26 years.

BACKGROUND.

Federal Aviation Regulations (FAR) require fire detectors in Class B, C, and E cargo compartments. Class B compartments are accessible in flight and are found on airplanes ranging in size from commuters to wide-body aircraft operating as "combis." "Combi" is an industry term referring to the combination of a passenger cabin and a cargo compartment on the main deck of an aircraft. The size of each section on a combi can typically be varied fairly quickly to accommodate the needs of the airline. Class C compartments are generally larger, inaccessible compartments found below the cabin floor on transport category aircraft. Class E compartments are typically the main deck compartments on aircraft carrying cargo only. Class D compartments have traditionally been inaccessible, smaller cargo compartments below the cabin floor that did not require fire detectors. Class D compartments have been affected by a recent change in regulations that will require fire detection and suppression systems to be installed by March 19, 2001 [1]. This rule change is estimated to affect approximately 3000 airplanes.

Airplane flight manuals contain the approved procedures to follow for a variety of situations. In the case of a cargo compartment fire detector alarm, the typical flight manual procedure is to shut off any applicable ventilation, discharge fire suppression agent if equipped, and divert and land at the nearest suitable airport. What constitutes the nearest suitable airport is at the discretion of the flight crew. In the discussion section of the final rule for Class D cargo compartments mentioned previously, there is some discussion regarding the cost of diversions. One of the commenters to the rule estimated the costs associated with diverting to an alternate airport at $30,000 for a narrow-body airplane and $50,000 for a wide-body airplane and the Federal Aviation Administration (FAA) agreed that those estimates were probably in the correct range. In addition to the direct costs associated with a diversion, there could also be an increased safety risk due to a variety of factors such as unfamiliar airports, less effective navigational aids, inadequate maintenance facilities, shorter runways, inferior airport rescue and fire fighting (ARFF) capabilities, etc. Obviously, diversions due to false cargo compartment fire alarms are undesirable. In addition to the above reasons, a high ratio of false alarms to actual fire or smoke events can erode confidence in the detection system and possibly delay appropriate action in the event of a real smoke or fire emergency.

FAR 121.703 and FAR 135.415 require, among other things, that all incidents of in-flight fire detector alarms, whether due to real fires or false alarms are reported to the FAA by U.S.-registered airlines operating under FAR Part 121 or Part 135 regulations. These reported incidents are maintained by the FAA in the Service Difficulty Report System (SDR). The National Transportation Safety Board (NTSB) also maintains a database of all the accidents and incidents it has the responsibility to investigate. The FAA has an additional accident/incident database that contains incidents that might not be serious enough to meet the NTSB definition of an accident or incident. All three of these sources of information were used to compile the data presented in this report. There is no way to determine what percentage of the actual number of incidents that occur are captured in these databases.

The SDRs were queried in several different ways to ensure that all the incidents of interest recorded in the SDR system were returned. The incidents were searched by Air Transport Association (ATA) codes 2550—Cargo Compartments, 2610—Detection System, 2611—Smoke Detection and 2612—Fire Detection. In addition, searches were conducted using the key words smoke or fire and cargo or baggage. Each SDR consists of numerous fields of information. The fields that were of interest for this purpose were the date, aircraft model, registration number, operator code, stage of operation, precautionary procedures taken, and several lines of text for general remarks. Not all of the fields were completely filled in for all of the reports. Each report was reviewed to eliminate duplications or incidents not pertinent to this study. In many cases, the text in the remarks section described fire extinguisher activation or unscheduled landings that were not shown in the precautionary procedures field. The fields were corrected in those incidents but no other assumptions were made concerning what actions were taken. For example, some of the incidents described airplanes that are normally equipped with fire suppression systems as having a smoke warning from an inaccessible cargo compartment at cruise altitude but with no mention of activation of the fire suppression system or of an unscheduled landing. If suppression system activation or unscheduled landing was not specifically mentioned in the precautionary procedures or remarks section, it was assumed not to have occurred. In every incident of detector alarm in the SDR database, no evidence of smoke or fire was discovered. The actual smoke or fire incidents all came from the FAA accident/incident database or NTSB records.

In May 1996, a report titled "Estimated Detection System False Alarms from Cargo Compartment Fire Extinguisher Discharge Statistics," was published by the Fire Safety Section of the FAA William J. Hughes Technical Center [2]. The report used SDR data on cargo compartment fire extinguisher discharges for the years 1988 through 1990 along with some broad assumptions to estimate the number of false detector alarms that occurred in class C cargo compartments during those years. The report concluded that there was approximately one false alarm per week based on the methodology used. That estimate shows good general agreement with the actual number of reported false alarms considering the fact that this report describes incidents in all cargo compartments equipped with detectors and the previous study only looked at class C compartments.

The smoke detectors used in aircraft cargo compartments during the period reported are in actuality particle detectors. It could be argued that if particles from a source other than smoke triggered a detector alarm it should not be considered a false alarm because the detector responded as designed. However, for the purpose of this study, a false alarm is defined as any incident in which a cargo compartment smoke alarm light illuminates in the cockpit for any reason other than a cargo compartment fire.

RESULTS.

Figure 1 shows the number of reported incidents of false cargo compartment alarms for the period 1974 through 1999 [3]. These are the total number of incidents reported by U.S.-registered FAR Part 121 and Part 135 operators for each year. The requirement to report incidents was constant during this time period and there is no readily apparent reason for the drop in the number of incidents from 1989 through 1995.

Figure 2 shows the number of reported unscheduled landings for the alarms shown in figure 1. The graph clearly demonstrates that not every alarm results in an unscheduled landing. Part of the reason is that some alarms occur while the airplane is on the ground or towards the end of a flight where the intended final destination is the closest suitable airport at the time of the alarm. Another reason is that some of the alarms occurred in accessible cargo compartments. In some of those instances, the remarks section stated that the crew checked the compartment and determined that the alarm was false. The actual number of incidents like this was not tabulated because it was not always possible to determine from the remarks section of the incident if this did indeed occur. Airplanes operated as freighters can have both accessible and inaccessible cargo compartments, and there was not always sufficient detail to determine if the compartment was physically checked. There were also incidents in which suppression systems discharge and an unscheduled landing would be expected but was not reported to have occurred. These incidents were with airlines that operate traditionally configured aircraft with passenger seating above the cabin floor and inaccessible cargo compartments below the floor that reported cargo smoke alarms during cruise.

Figure 3 shows the number of incidents that were attributable to electrical sources. Electrical sources are defined here as any electrical hardware problem discovered with the detection system. Some of these include bent pins in connector plugs, broken or shorted signal wires, faulty amplifier boards, faulty detector lamps, etc. The vast majority of reports did not list a specific cause that was discovered to be responsible for the alarm.

Figure 4 shows the total number of false alarms and alarms that were determined to be due to actual smoke or fire events for the years 1974 through 1999 [4,5]. Reported smoke or fire events from within the cargo compartment are rare with none occurring during many years. The highest number of occurrences in any year was two in 1984 and again in 1998. Ironically, the source of the smoke in one of the two events in 1998 was the smoke detector itself.

The number of false alarms for each occurrence of an actual verified smoke event is shown in figure 5. Five-year intervals were chosen to ensure that there was at least one verified smoke event in each interval. Because the 26-year period that the data covered was not divisible by five, the three events that occurred in 1974 were not included. The values shown in the graph represent the total number of alarms for the 5-year period divided by the total number of actual fire or smoke events during that same 5-year period. The trend of an increasing ratio of false alarms to real events is evident.

Figure 6 shows the distribution of false alarms between traditional transport category airplanes and the smaller regional/commuter aircraft. The transport category contains all the incidents that occurred on Boeing 707/720, 727, 737, 747, 757, 767, 777; Douglas DC-8, DC-9/MD-80/

MD-90; DC-10/MD-11; Airbus A300, A310, A320/319, A330, A340; and Lockheed L-1011s. The regional category contains all of the other incidents that occurred on fixed-wing aircraft. In recent years, the greater proportion of incidents has shifted to the smaller airplanes. An attempt was made to find accurate information on the number of each airplane type operated by the U.S.-registered FAR Part 121 and Part 135 operators to determine if the changes in recent years were due only to the change in the fleet distribution. The FAA Statistical Handbook of Aviation contained that data in a useful form up to 1993. Some additional data was found up to 1996. However, useful data was not found for recent years. Information exists for the fleet makeup of each individual airline but summary data was not found.

Figure 7 gives the distribution of false alarms for the 26-year period separated by phase of flight. The SDR reports actually contain seven options for reporting the phase of flight. The phases are approach, descent, landing, climb, takeoff, cruise, and taxi. The phases approach, descent, and landing were combined on the chart into one category labeled "Descent." The phases climb and takeoff were also combined into one category labeled "Climb/TO." The highest number of alarms occurred during cruise. This would be expected since the majority of flight time is spent at cruising altitude. If the Descent and Climb/TO categories are combined, they represent almost as many incidents as those occurring during cruise. Based on the amount of time the airplane is normally in these phases of flight, this result would not normally be expected. One possible reason for this could be the increased vibrations during the high engine power settings used for takeoff and initial climb. Another possible factor is that the temperature and pressure environment within cargo compartments changes most rapidly when the airplane is changing altitude during climb and descent. Because the reasons for the false alarms in the vast majority of cases are never determined, the above possibilities are only speculation.

CONCLUSIONS

1. The number of reported false cargo compartment fire detector alarms has shown an increasing trend and, without improvements in the technology used for fire detection, should be expected to accelerate due to the addition of cargo compartment fire detectors in approximately 3000 additional aircraft by March 2001.

2. The ratio of false cargo compartment fire detector alarms to actual fire or smoke events is increasing and is currently at 200 to 1 over the previous 5 years.

3. The Service Difficulty Reports on cargo compartment false detector alarms do not give any indication of the cause for the alarm in most cases.

REFERENCES

1. Final Rule, "Revised Standards for Cargo or Baggage Compartments on Transport Category Airplanes," Amdts. 25.93 and 121.269, February 17, 1998.

2. Eklund, Thor I., "Estimated Detection System False Alarms from Cargo Compartment Fire Extinguisher Discharge Statistics," DOT/FAA/AR-TN96/56, May 1996.

3. Service Difficulty Reports, Provided by FAA Aviation Data Systems Branch, AFS-620.

4. Accident/Incident Reports, Provided by FAA Aviation Data Systems Branch, AFS-620.

5. NTSB Online Accident Synopses.

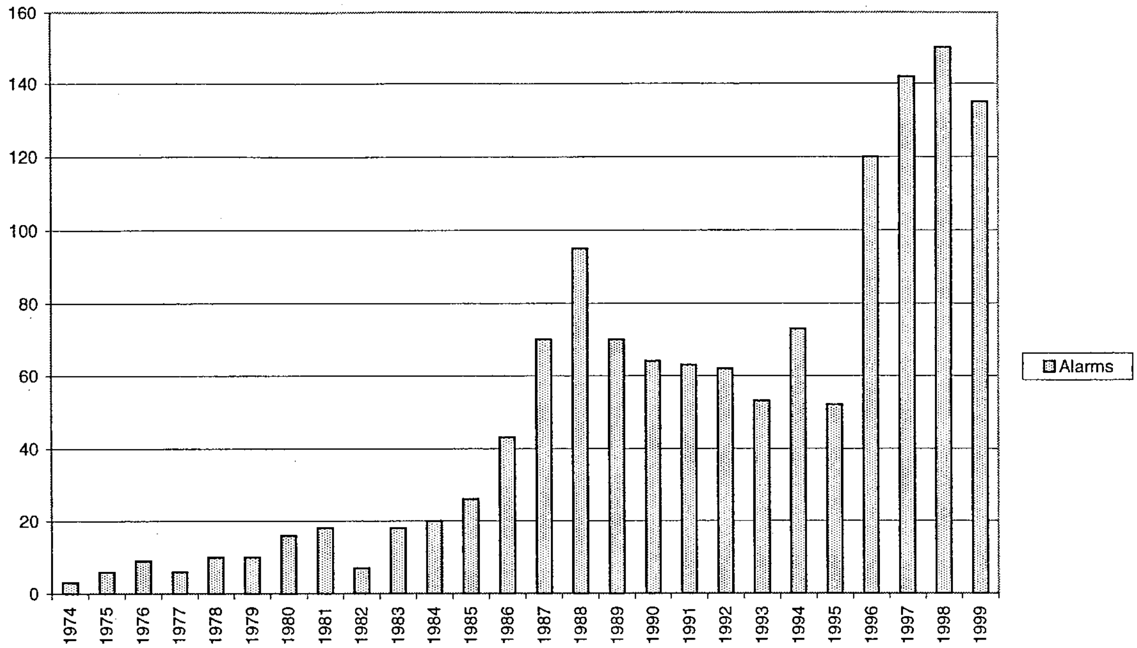

FIGURE 1. CARGO COMPARTMENT FALSE ALARMS

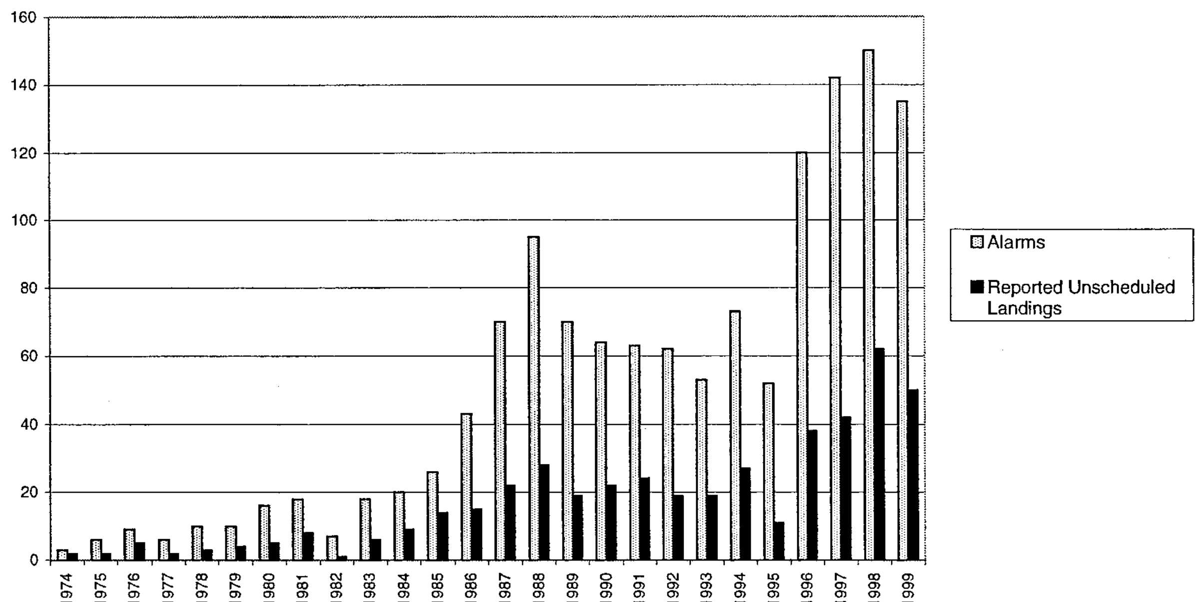

FIGURE 2. UNSCHEDULED LANDINGS DUE TO CARGO COMPARTMENT FALSE ALARMS

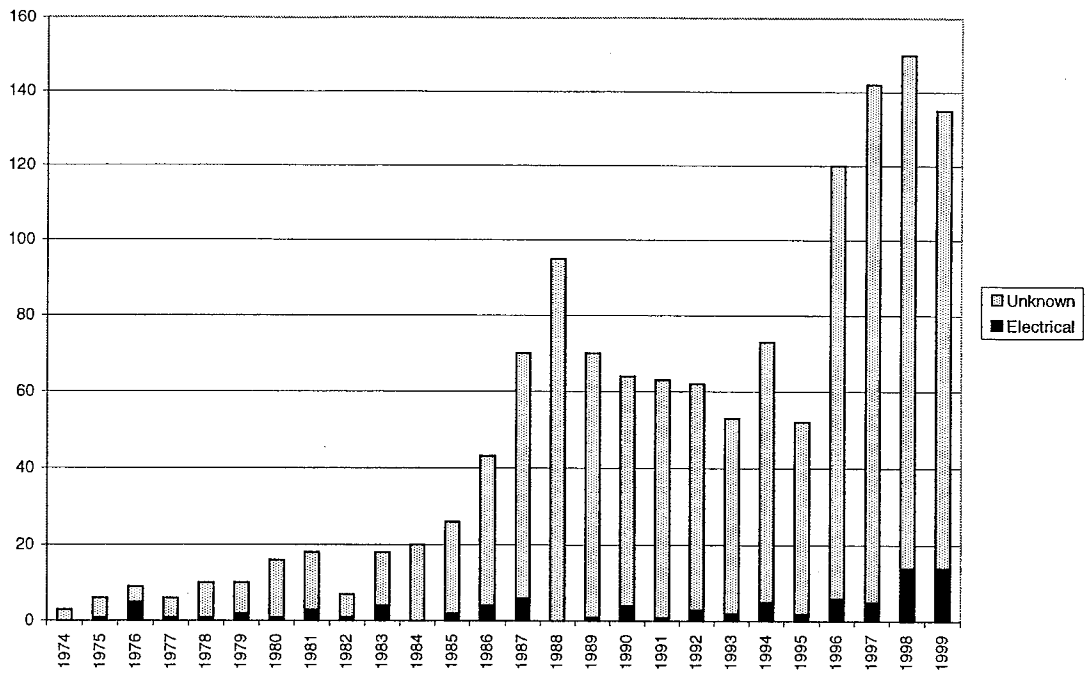

FIGURE 3. FALSE ALARMS CAUSED BY ELECTRICAL SOURCES

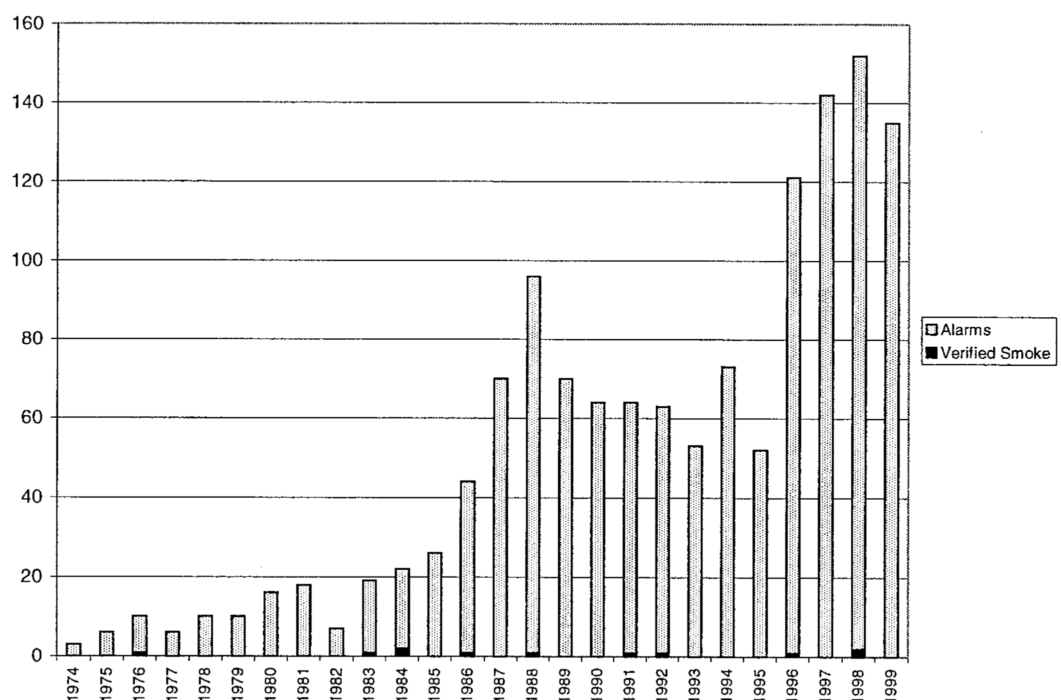

FIGURE 4. VERIFIED SMOKE EVENTS VERSUS SMOKE ALARMS

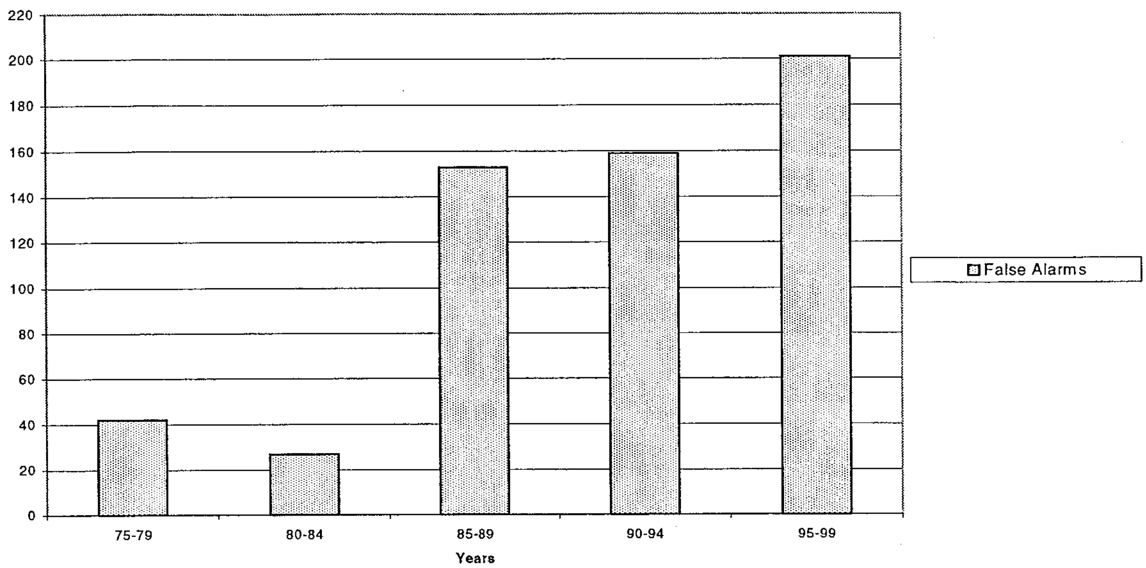

FIGURE 5. NUMBER OF FALSE ALARMS FOR EVERY ALARM DUE TO VERIFIED SMOKE SOURCE

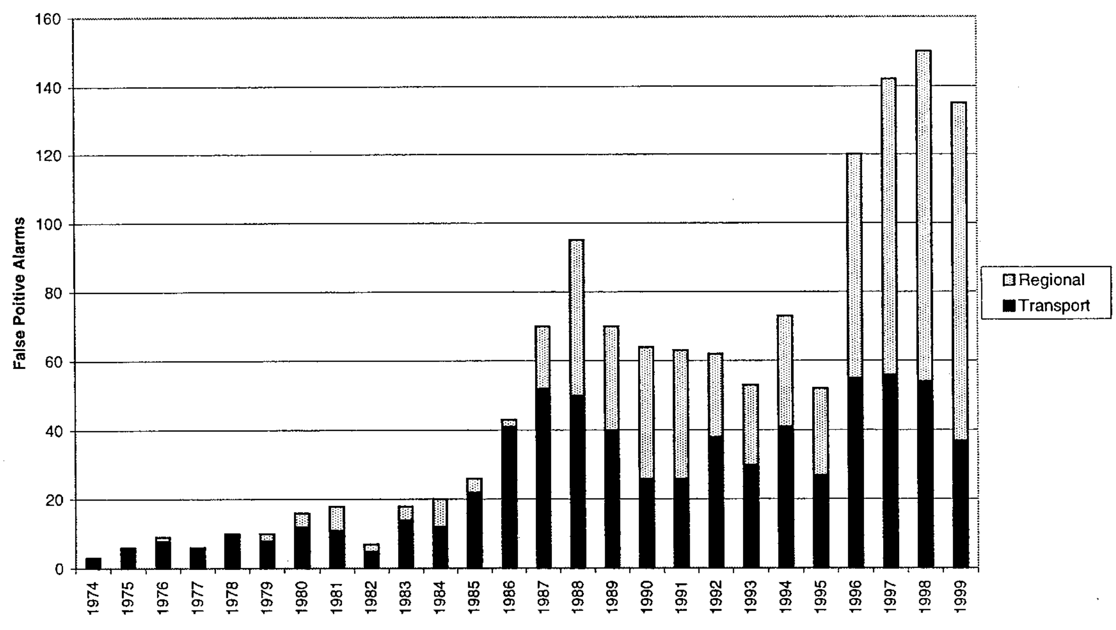

FIGURE 6. FALSE ALARMS ON COMMUTER/REGIONAL AIRCRAFT VERSUS TRANSPORT AIRCRAFT

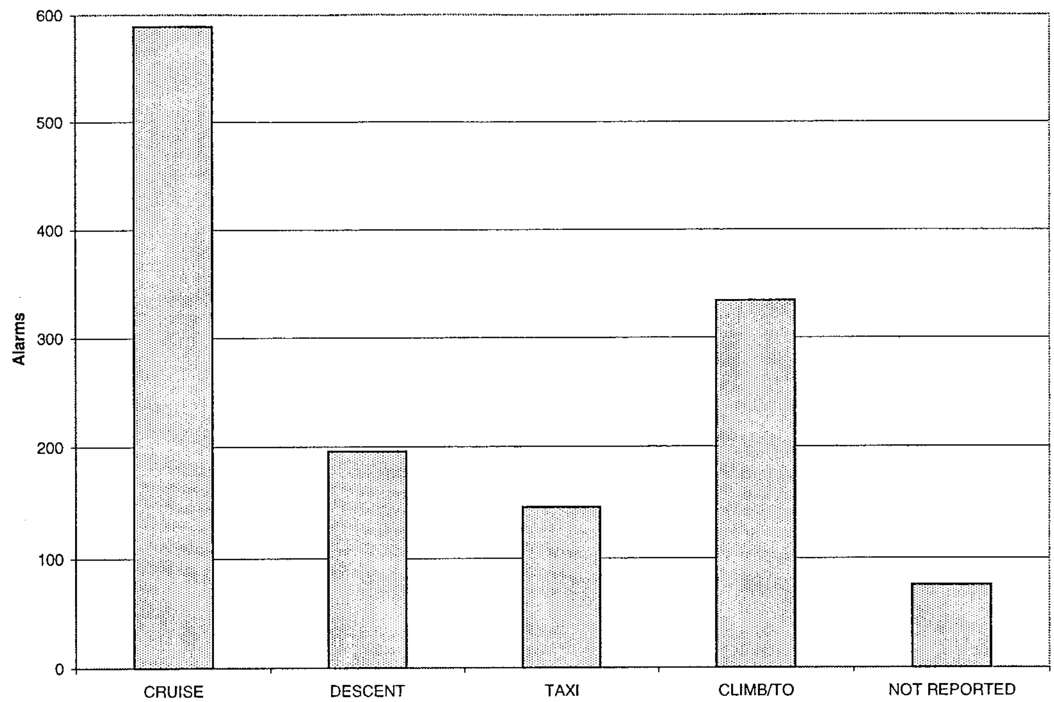

FIGURE 7. OCCURRENCES PER PHASE OF FLIGHT, 1974-1999