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Federal Aviation Administration
William J. Hughes Technical Center
Aviation Research Division
Atlantic City International Airport
New Jersey 08405

Research Into Fire, Smoke or Fumes Occurrences on Transport Airplanes

March 2017

Final Report

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U.S. Department of Transportation
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NOTICE

This research was commissioned by Transport Canada by means of the Memorandum of Cooperation regarding Civil Aviation Research and Development between the Civil Aviation Authority of the United Kingdom. This activity has been carried out in cooperation with the Federal Aviation Administration and the UK Civil Aviation Authority under the auspices of the International Cabin Safety Research Technical Group whose goal is to enhance the effectiveness and timeliness of cabin safety research.

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16. Abstract

This study has been carried out at the request of the Federal Aviation Administration (FAA) and the United Kingdom Civil Aviation Authority (UK CAA) under the provisions of a UK CAA contract.

The broad objectives of the study are to collect and analyze data relating to in-service occurrences involving fire, smoke or fumes on US registered aircraft. This involved the compilation of data into a Fire, Smoke or Fumes Occurrence (FSF) Database compiled in Microsoft Excel.

The analysis compares genuine and false occurrences by source of fire, smoke, fumes or odors and consequences (diversions, overweight landings, etc.). The data has also been analyzed to derive any likely trends in rates of occurrence. These objectives have now been achieved for data collected over the period 2002 to 2011 and are addressed in this report.

A further objective of the study is to analyze the data to determine the monetary impact of the occurrences and any trends in these impacts, which is also addressed in this report.

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LIST OF ACRONYMS

AIDS	Accident and Incident Data System (FAA)
CFR	Code of Federal Regulations
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FSF	Fire, Smoke or Fume
IATA	International Air Transport Association
MTOW	Maximum Take-off Weight
NTSB	National Transportation Safety Board (USA)
OST	Office of the Secretary of Transportation
PEEvac	Precautionary Emergency Evacuations
RTO	Rejected Take Off
SDR	Service Difficulty Reports (FAA)
UK CAA	United Kingdom Civil Aviation Authority
VSL	Value of Statistical Life

EXECUTIVE SUMMARY

This study has been carried out at the request of the Federal Aviation Administration (FAA) and the United Kingdom Civil Aviation Authority (UK CAA) under the provisions of a UK CAA contract. This report represents the Phase7 and Phase 8 deliverables as required by the UK CAA contract.

The broad objectives of the study were to collect and analyze data relating to in-service occurrences involving fire, smoke or fumes on US registered aircraft. This involved the compilation of data, covering the period 2002 to 2011, into a Fire, Smoke or Fumes Occurrence (FSF) Database compiled in Microsoft Excel.

The occurrence data analyzed was collected from the FAA Accident and Incident Data System (AIDS), the NTSB Aviation Accident Database and the FAA Service Difficulty Reports (SDRs). While these are all excellent data sources, the SDR system is often limited in the amount of information that it contains, and hence a degree of judgment is required in ascertaining the causes, location, and consequences. In some instances, it was not feasible to ascertain whether the event occurred while crew or passengers were on board the airplane or whether the data was describing an event that occurred during maintenance. Therefore, all values and rates of occurrence will be approximations rather than precise values. However, any errors in this respect are likely to be consistent over the study period and trends in rates of occurrence are likely to be reasonable reflections of the true in-service situation.

The events analyzed were all occurrences resulting from fire, smoke or fume and detector events (i.e. those that involved the operation of an onboard fire or smoke warning system) irrespective of their consequences. The concept of significant events has been introduced in order that the analysis of data could also be made on those occurrences having a more significant effect on the safety or operational aspects of airplane operations.

The analysis compares genuine and false occurrences by source of fire, smoke, fumes or odors and consequences (diversions, overweight landings, etc.). A major part of the study was to evaluate the costs of FSF events. The data used in this evaluation was derived from studies carried out by reputable sources of the following cost impacts:

- Unscheduled Landings
- Injuries to Personnel
- Fuel Jettisoning
- Airplane Damage
- Delays and Cancellations
- Emergency Evacuations

The FSF Occurrence Database has been developed to enable the database user to change the values used in the assessment of cost. Graphical presentations are contained within the FSF Occurrence Database of the annual number of occurrences, the total cost per year and the breakdown for any selected type of event.

A Summary of the primary observations from the analysis of data is contained in the next section of this report and Appendix B contains an explanation of the terms used in the study.

1. INTRODUCTION

This study has been carried out at the request of the Federal Aviation Administration (FAA) and the United Kingdom Civil Aviation Authority (UK CAA). The broad objectives of the study were to collect and analyze data relating to in-service occurrences involving fire, smoke or fumes on US registered aircraft. This involved the compilation of data, covering the period 2002 to 2011, into a Fire, Smoke or Fumes Occurrence (FSF) Database compiled in Microsoft Excel. This report represents the Phase7 and Phase 8 deliverables as required by the UK CAA contract[1].

2. OBJECTIVES

The broad objectives of the study were to

1. Collect data relating to in-service occurrences involving fire, smoke, fumes or odors on US registered aircraft.
2. Collect data relating to false warnings of fire, smoke or fumes on US registered aircraft.
3. Compile the data into an FSF Occurrence Database.
4. Compare genuine and false occurrences by source of fire, smoke, fumes or odors and consequences (diversions, overweight landings, etc.).
5. Analyze the data to derive any likely trends.
6. Analyze the data to determine the monetary impact of the occurrences and any trends in these impacts.

3. SCOPE

The airplane occurrences studied were primarily those used for the carriage of passengers or cargo and operating in accord with 14 CFR FAR 121. However to ensure that there was as large a data set of US registered aircraft as is practicable all occurrences on aircraft listed in Table 1 were collected and analyzed.

[1] United Kingdom Civil Aviation Authority Specification, Contract No. 1745 (Amendment No. 2), 17 June 2013.

Table 1. Aircraft Types/Models Included in the Study

AIRCRAFT TYPES/MODELS	Airbus Industrie A300
	Airbus Industrie A310
	Airbus Industrie A318
	Airbus Industrie A319
	Airbus Industrie A320
	Airbus Industrie A321
	Airbus Industrie A330
	ATR 42
	ATR 72
	Avro RJ
	BAe 1-11
	BAe 146
	Beech 1900
	Beech 99
	Boeing 717
	Boeing 727
	Boeing 737
	Boeing 747
	Boeing 757
	Boeing 767
	Boeing 777
	Boeing 787
	Bombardier (Canadair) CL-44
	Bombardier (Canadair) RJ100/200 Regional Jet
	Bombardier (Canadair) RJ700 Regional Jet
	Bombardier (Canadair) RJ900 Regional Jet
	Bombardier (DHC) Dash 7
	Bombardier (DHC) Dash 8
	Bombardier (DHC) DHC-6 Twin Otter
	Bombardier (Shorts) 330
	Bombardier (Shorts) 360
	Bombardier (Shorts) SC.7 Skyvan
	CASA/IPTN 212
	CASA/IPTN CN-235

AIRCRAFT TYPES/MODELS	Embraer 170
	Embraer 175
	Embraer 190
	Embraer EMB-110 Bandeirante
	Embraer EMB-120 Brasilia
	Embraer ERJ-135
	Embraer ERJ-140
	Embraer ERJ-145
	Fairchild (Swearingen) Metro
	Fairchild F-27
	Fairchild/Dornier 228
	Fairchild/Dornier 328
	Fairchild/Dornier 328 Jet
	Fokker 100
	Fokker F.27
	Fokker F.28
	General Dynamics (Convair) 580
	General Dynamics (Convair) 600
	General Dynamics (Convair) 640
	Grumman G-73T Turbo Mallard
	Gulfstream Aerospace Gulfstream I
	Jetstream 31
	Jetstream 41
	Lockheed Hercules
	Lockheed L-1011 TriStar
	Lockheed L-188 Electra
	McDonnell Douglas DC-10
	McDonnell Douglas DC-8
	McDonnell Douglas DC-9
	McDonnell Douglas MD-11
	McDonnell Douglas MD-80
	McDonnell Douglas MD-90
	Saab 340/2000

4. DATA COLLECTION

The occurrence data analyzed was collected from the following sources:

- The FAA Accident and Incident Data System (AIDS)
- The NTSB Aviation Accident Database
- FAA Service Difficulty Reports (SDRs)

While, these are all excellent data sources, the SDR system is often limited in the amount of information that it contains and a degree of judgment is required in ascertaining the causes, location and consequences. In some instances it was not feasible to ascertain whether they occurred while crew or passengers were on board the airplane, or whether the data was describing an event that occurred during maintenance. Therefore, numbers and rates of occurrence will be approximations rather than precise values. However, any errors in this respect are likely to be consistent over the study period and trends in rates of occurrence are likely to be reasonable reflections of the true in-service situation.

It is estimated that these data sources contained over 800,000 records at the time of initial data extraction. The data was filtered to eliminate those outside of the date range, 2002 to 2011 inclusive, and to eliminate rotorcraft and airplanes not included in table 1.

The textual data were then searched for the following words:

- Fire
- Smok(e)
- Fum(e)
- Odor
- Odour
- Smel(l),(t),(ling)

Occurrences not containing the above words were eliminated from the data set. All remaining data were entered into the FSF Occurrence Database described in section 5. This resulted in 17,751 records being identified over the period 2002 to 2011 inclusive that were considered likely to be relevant to the study. However, detailed analysis of these records, during the course of the study, resulted in a determination that the number of pertinent records was as shown in table 2.

Table 2. Number of Records Considered Pertinent of the Study Period

Year	Number of Occurrences
2002	1,357
2003	1,211
2004	1,314
2005	1,315
2006	1,487
2007	1,577
2008	1,428
2009	1,307
2010	1,657
2011	1,879
Total	14,532

5. FIRE, SMOKE OR FUMES (FSF) OCCURRENCE DATABASE

All occurrences meeting the selection criteria defined in section 4 were entered into a database developed specifically for this study in Microsoft Excel.

5.1 PRIMARY FIELDS

The FSF Occurrence Database contains the following primary fields.

Passenger, Freighter or Combi: This field defines whether the occurrence relates to a passenger, freighter or combi airplane.

Type of Detection: This field defines the means of detection of the FSF event. This could be a detector, which is part of a fire or smoke detection system, or by a human (crew member, ground personnel, air traffic control, etc.) or both.

Location of Detector**:** This field defines the location of the detector which is part of a fire or smoke detection system, or by a human (crew member, ground personnel, air traffic control, etc.).

Location of Fire/Smoke**:** This field defines the location in which fire smoke or fumes are located. For example the passenger cabin, equipment bay, engine etc.

Component, object or system producing fire/smoke: This field defines the source of FSF e.g. engine, air conditioning system, cargo, electrical system, etc.

False Warning: This field defines whether the indication from a detector is a false warning that was likely to have been caused by faults in the detection system.

Diversion/ Return to the Departure Airport/ Rejected Take-off**:** This field defines whether the event resulted, or was likely to have resulted in a diversion, return to the departure airport or there was a rejected take off. A “Yes” in this field indicates that the event resulted in an unscheduled landing but it is unknown whether it was a diversion or a return to the departure airport.

Emergency Evacuation: This field defines whether the event resulted in an emergency evacuation under the control or partial control of the cabin or flight crew using, or partially using the prescribed procedures.

Ground Delay*: This field defines whether the event resulted in a delay to the flight. Delays have only been considered for events that occurred before flight. The subsequent effects of an in-flight event on airplane operation have not been considered due to the sparsity of the data.

Downstream Operational Repercussions*: This field defines whether the event resulted in a significant event, or a major economic penalty on subsequent flights.

Cancellation*: This field defines whether the event resulted in a cancelation to the flight. Cancellations have only been considered for events that occurred before flight. The subsequent effects of an in-flight event on airplane operation have not been considered due to the sparsity of the data.

Fire, Smoke, Odor, Gas/Fume: This field defines the nature of the FSF event. Terms such as fumes, smoke, haze etc. are largely subjective and cannot be considered as definitive terms. Furthermore, in many instances, the magnitude of the event cannot be determined with reports as simple as “smoke in the cabin”.

Depressurization: This field defines whether the event resulted in, or was likely to have resulted in, the airplane being depressurized.

Fuel Dump: This field defines whether the event resulted in, or was likely to have resulted in, fuel being dumped, via a fuel jettison system.

In-Flight Thrust Engine Shutdown: This field defines whether the event resulted in, or was likely to have resulted in, a main thrust engine being shut down, or shutting down, as a result of failures. It includes engine shutdowns on take-off or landing.

Emergency Descent: This field defines whether the event resulted in, or was likely to have resulted in, an emergency descent in accord with prescribed procedures. It excludes descents that might be considered as normal but where the crew declared an emergency.

Emergency Declared: This field defines whether the event resulted in, or was likely to have resulted in, the flight crew declaring an emergency.

Emergency Services Deployed: This field defines whether the event resulted in, or was likely to have resulted in, the airfield emergency services being deployed.

Ground/Airplane Damage: This field defines the extent of any damage that may have been incurred by the airplane or ground installations.

Time (days) Aircraft Out of Service*: This field defines whether the event resulted in, or was likely to have resulted in, the aircraft being out of service beyond the day of the event.

Overweight Landing: This field defines whether the event resulted in, or was likely to have resulted in, an overweight landing requiring an overweight landing inspection.

Unscheduled Landing**:** This field defines whether the event resulted in, or was likely to have resulted in a return to the departure airport or a diversion. In some instances although the data suggests that there was an unscheduled landing it is unknown whether the event resulted in a diversion or a return to the departure airport.

Hidden Area**:** This field relates to FSF sources that are inaccessible in flight.

Injuries**:** This field indicates the number and extent of injuries to occupants or persons on the ground. Subject to the data being available injuries are classified in accord with the definitions suggested in reference 1. These classifications of injuries are defined in section 7.2.

Notes:
1. The majority of fields are subject to a validation process which only allows predetermined words to be entered into the FSF Occurrence Database.
2. Fields annotated with an asterisk * are especially unreliable due to the sparsity of data contained in the records.

5.2 ACCOMMODATING UNCERTAINTIES IN DATA

In many instances it was not possible to be specific about the data entry and terms such as likely and possible have been used. Probabilities have been assigned to each of these terms. For example, if a fuel dump was considered likely, it was assigned a probability of occurrence of 0.8. The cost data are not specific values but rather a range of possible values. Once again probabilities are used to randomly select over the range. The database user may select whether to use the randomly selected values or to use an average value to assess costs.

5.3 DATA SELECTION AND PRESENTATION OF DATA

The database user can select the values required for each of the fields described in section 5.1 by means of filters. Graphical presentations of number of occurrences, costs and proportion of the total costs, appropriate to the data selected are contained within the master worksheet of the database.

6. CONCEPT OF ANALYSIS OF OCCURRENCES

Data analysis is based upon a consideration of the following areas:

1. Occupied Areas
2. Engines
3. Auxiliary Power Unit (APU)
4. Inaccessible Cargo Bays
5. Accessible Cargo Bays
6. Main Deck Cargo Bays (freighter airplanes)
7. Lavatories
8. E & E Bays
9. Crew Rest Areas
10. Wheel Wells

Area 1 addresses occurrences of fire, smoke or fume events in occupied areas. Detector events (false and genuine warnings) are addressed by areas 2 to 10. Rate of occurrence and repercussions of the event are addressed for all areas.

Additionally, section 8 of this report addresses the annual number and rate of occurrence of significant events[2] in order to give a broad overview of the frequency of those significant fire, smoke or fume events and detector events having the greatest impact on in-service airplane operations.

7. COST ANALYSIS

In many instances determinations could not be made as to the precise implications of an event, hence, where feasible, probabilities of outcomes have been assigned as explained in section 5.2.

In particular there were insufficient data to determine whether the event resulted in a delay or cancellation.

Furthermore, although airplane out of service time is likely to be a significant cost factor the data were insufficient to enable cost assessments to be made.

For these reasons the cost assessments are likely to be conservative and indicative of the minimum costs incurred from fire, smoke or fume events. However, since these omissions are likely to be consistent throughout the study period the trends in costs are likely to be indicative of the rate of change of costs incurred.

For the purposes of this analysis, costs are derived at 2016 levels using an annual escalation rate of 2.5%. The FSF Occurrence Database user has the option to select alternate dates and escalation rates, for the costs displayed in the Database. No attempt has been made to round any of the cost data however it cannot be inferred that the number of significant figures reflects the level of accuracy.

7.1 UNSCHEDULED LANDINGS

Several data sources were found that contained costs for diversions but unfortunately none of these made a differentiation between diversions to an alternate airfield and return to the departure airport. Hence, the same costs are used for all unscheduled landings i.e. the ratio of diversion costs to the cost of returns to the departure airport is equal to 1. The FSF Occurrence Database has been constructed to enable this ratio to be modified by the database user.

The costs, from all data sources are believed to be inclusive of additional fuel burn but exclusive of the cost of any fuel jettisoned.

[2] – See Appendix B – Glossary.

Table 3 shows the range of Diversion Costs, in 2015 Euros, proposed by Eurocontrol in reference 2.

Table 3. Assessment of Diversion Costs Based on Eurocontrol Study

	Assessment for Cost of flight diverted			
Type of Flight	Minimum - Euros	Maximum - Euros	Minimum - US$ 2015	Maximum - US$ 2015
Regional flights - Assumed to equate to Regional Airplanes	820	5,870	935	6,692
Continental flights - Assumed to equate to Narrow Body Airplanes	1,180	8,800	1,345	10,032
Intercontinental flights - Assumed to equate to Wide Body Airplanes	5,870	64,600	6,692	73,644

1727/Cost Data/Unscheduled Landing Costs/Diversion Costs

However, other data sources suggest significantly higher diversion costs. Reference 3 assesses the cost of diversions to be US$20,000 for a Boeing 737 (narrow body airplane) at 2003 prices. This amounts to a cost per diversion, at 2016 prices, of US$27,570. In a presentation given by IATA in 2014, reference 4, the costs of Diversions were presented as being "$15,000 for a narrow-body domestic flight" and "…over $100,000 for a wide-body international flight". Escalating these values to 2016 values amounts to a cost per diversion of US$105,063[3] for a wide body airplane and US$15,759 for a narrow body airplane. Reference 5 suggests a diversion cost for an incident to a Boeing 757 (narrow body airplane) of US$67,000. Escalating these values to 2016 values amounts to a cost per diversion of US$75,804 for a narrow body airplane.

The costs from all 4 data sources are summarized in table 4.

[3] It must be stressed that the number of significant figures is not indicative of the precision of the numbers.

Table 4. Summary of Diversion Costs

Data Source	Year of Assessment	Data Source Assessment US$			Assessment at 2016 Levels US$		
		Wide Body	Narrow Body	Regional	Wide Body	Narrow Body	Regional
Reference 2 Minimum	2015	6,692	1,345	935	6,859	1,379	958
Reference 2 Maximum	2015	73,644	10,032	6,692	75,485	10,283	6,859
Reference 3	2003	-	20,000	-	-	27,570	-
Reference 4	2014	100,000	15,000	-	105,063	15,759	-
Reference 5	2011	-	67,000	-	-	75,804	-

1727/Cost Data/Unscheduled Landing Costs/Diversion Costs

The range of the costs for narrow body and wide body airplanes based on the data shown in table 4 is shown in table 5. Since only one data source was found for regional airplanes the data shown in table 5 for this airplane category is taken as the data for the narrow body airplanes factored by the ratio of the values for continental flights and regional flights shown in table 3. This is on the assumption that the continental flights, referred to in reference 2, are predominantly narrow body airplanes and the regional flights are for regional airplanes.

Table 5. Range of Diversion Costs

	Range of Data $ 2016		
	Min	Mean	Max
Regional	958	25,762	50,565
Narrow	1,379	26,159	75,804
Wide	6,859	62,469	105,063

The following observations have been derived from the FSF Occurrence Database:

Observation 1 – UNSCHEDULED LANDINGS – Passenger and Freighter Airplanes - It is assessed that approximately 70% of unscheduled landings, resulting from FSF events are returns to the departure airport.

Observation 2 – UNSCHEDULED LANDINGS – Passenger Airplanes - It is assessed that over one half of the costs incurred from all FSF events are attributable to unscheduled landings. This excludes any additional costs that might be associated with the unscheduled landing e.g. airplane damage, injuries to personnel and costs associated with emergency evacuations.

Observation 3 – UNSCHEDULED LANDINGS – Passenger Airplanes - The average cost over the ten year study period resulting from unscheduled landings is assessed to be in the region of US$11,000,000 per year.

7.2 INURIES TO PERSONNEL

Each injury, sustained in an occurrence, is assigned a fraction of VSL (value of statistical life) value as shown in table 6, in accord with reference 1. All injuries sustained by passengers, flight crew, cabin crew and ground personnel are included in the FSF Occurrence Database.

Table 6. Injury Severity Expressed as a Fraction of VSL

AIS Level	Severity	Description	Fraction of VSL
AIS 1	Minor	Superficial abrasion or laceration of skin; digit sprain; first-degree burn; head trauma with headache or dizziness (no other neurological signs).	0.003
AIS 2	Moderate	Major abrasion or laceration of skin; cerebral concussion (unconscious less than 15 minutes); finger or toe crush/amputation; closed pelvic fracture with or without dislocation.	0.047
AIS 3	Serious	Major nerve laceration; multiple rib fracture (but without flail chest); abdominal organ contusion; hand, foot, or arm crush/amputation.	0.105
AIS 4	Severe	Spleen rupture; leg crush; chest-wall perforation; cerebral concussion with other neurological signs (unconscious less than 24 hours).	0.266
AIS 5	Critical	Spinal cord injury (with cord transection); extensive second- or third-degree burns; cerebral concussion with severe neurological signs (unconscious more than 24 hours).	0.593
AIS 6	Fatal/Unsurvivable	Fatal or Injuries which although not fatal within the first 30 days after an accident, ultimately result in death.	1

Reference 6 suggests the following with regard to VSL:

> "Empirical studies published in recent years indicate a VSL of $9.1 million in current dollars for analyses using a base year of 2012. We also find that an income elasticity of 1.0 should be used to project VSL to future years. … Based on wage forecasts from the Congressional Budget Office, we estimate that there will be an expected 1.07 percent annual growth rate in median real wages over the next 30 years (2013-2043). These estimates imply that VSL in future years should be estimated to grow by 1.07 percent per year before

> discounting to present value. This guidance also includes a table of the relative values of preventing injuries of varied severity, unchanged since the 2011 guidance. We also prescribe a sensitivity analysis of the effects of using alternative VSL values. Instead of treating alternative values in terms of a probability distribution, analysts should apply only a test of low and high alternative values of $5.2 million and $12.9 million."

However, Reference 7 states the following:

> "….. we now find that these changes over the past year imply an increased VSL of $9.4 million for analyses prepared in 2015. Last year the VSL was $9.2 million. ……. We also prescribe a sensitivity analysis of the effects of using alternative VSL values. Instead of treating alternative values in terms of a probability distribution, analysts should apply only a test of low and high alternative values of $5.2 million and $13 .0 million. ….."

Using the range of values suggested in reference 7 and the annual escalation rate suggested by reference 6 the appropriate values from 2015 to 2020 are as shown in table 7. To determine injury cost these values are factored by the VSL fractions contained in table 6.

Table 7. Value of Statistical Life (VSL)

	Value of Statistical Life (VSL)		
Year	Low	Median	High
2015	5.2	9.4	13.0
2016	5.6	10.1	13.9
2017	6.0	10.8	14.9
2018	6.4	11.5	15.9
2019	6.8	12.3	17.0
2020	7.3	13.2	18.2

The year of cost evaluation, annual escalation rate and VSL levels are all variables in the FSF Occurrence Database that may be amended by the database user.

Observation 4 – INJURIES TO PERSONNEL – Passenger and Freighter Airplanes - It is assessed that approximately 7% of the costs incurred from all FSF events are attributable to injuries to personnel.

Observation 5 – INJURIES TO PERSONNEL – Passenger and Freighter Airplanes - The average cost over the ten year study period resulting from injuries to personnel is assessed to be in the region of US$4,000,000 per year. The average cost per year is approximately the same for both passenger and freighter airplanes

7.3 FUEL JETTISONING

Eighty-four confirmed occurrences of fuel jettisoning were found on the FSF Occurrence Database over the study period. Of these 21 occurred on passenger airplanes, 61 on freighters and 2 could not be confirmed as to whether they were passenger or freighter airplanes.

Data was found in 20 records where the fuel dump weight was recorded. All 20 of these occurrences were on freighter airplanes and of these 18 were on wide body airplanes and just 2 on narrow body airplanes. Not surprisingly no occurrences were found on regional airplanes. Of the 18 wide body occurrences 3 were associated with diversions and 15 were likely to have been associated with the airplane returning to the departure airport. Hence the only substantive data regarding fuel dump weights is associated with wide body airplanes returning to the departure airport. The cumulative distribution of these fuel dump weights is illustrated in figure 1.

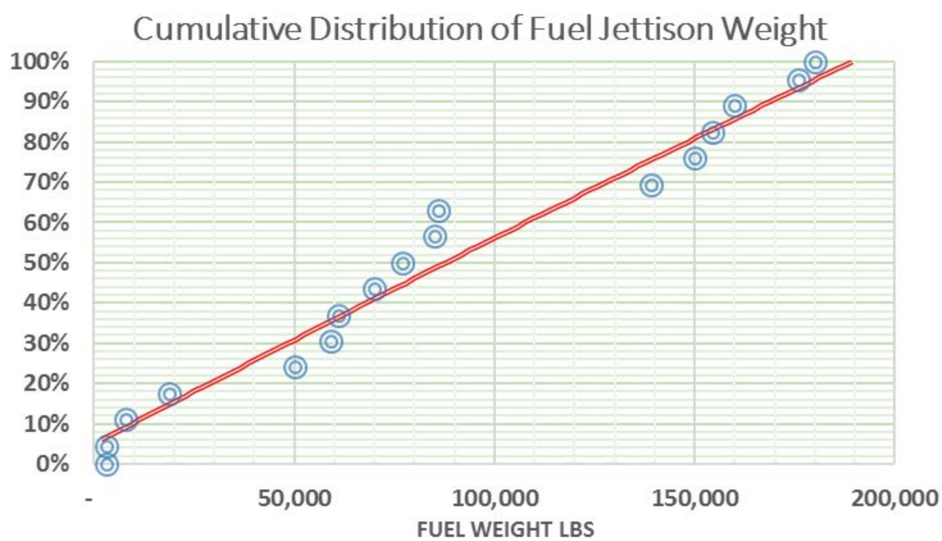

Figure 1. Cumulative Distribution of Fuel Jettison Weight for Wide Body Airplanes – Return to the Departure Airport

Since there are limited data related to diversions on wide body airplanes and only two values for narrow body airplanes the distribution shown in figure 1 is factored to derive the cumulative distributions shown in table 8. The factors used are based on the average values of the fuel jettison weight data that are available. For example, the average weight of fuel jettisoned on narrow body airplanes returning to the departure airport was found to be 5,700 pounds compared to approximately 86,000 pounds for a wide body airplane. Hence, the ratio used was 5,700 ÷ 86,000 = 0.066. The ratios assumed to derive the values shown in table 8, may be changed by the FSF Occurrence Database user.

Table 8. Cumulative Distribution of Fuel Jettison Weights (lb.)

Cumulative Probability	Wide Body Airplane		Narrow Body Airplane	
	Return to Departure Airport	Diversion	Return to Departure Airport	Diversion
0.0%	3,000	2,447	198	161
4.5%	3,000	2,447	198	161
11.0%	8,000	6,526	527	430
17.5%	18,700	15,254	1,233	1,006
24.0%	50,000	40,786	3,296	2,689
30.5%	59,000	48,127	3,889	3,173
37.0%	61,000	49,759	4,021	3,280
43.5%	70,000	57,100	4,614	3,764
50.0%	77,000	62,810	5,076	4,140
56.5%	85,000	69,336	5,603	4,571
63.0%	86,000	70,151	5,669	4,624
69.5%	139,000	113,384	9,163	7,474
76.0%	150,000	122,357	9,888	8,066
82.5%	154,324	125,884	10,173	8,298
89.0%	160,000	130,514	10,547	8,604
95.5%	176,000	143,566	11,602	9,464

It is assumed that the weight of fuel jettisoned is similar for both passenger and freighter airplanes.

Algorithms within the FSF Occurrence Database randomly select on the appropriate weight distribution to derive an estimated weight for all fuel jettison occurrences. The derived weights are then converted to a fuel cost per occurrence based on an assumed fuel cost of US$1.29 per US gallon (US$ 0.19 per lb.). This value can be changed by the database user from within the FSF Occurrence Database.

Observation 6 – FUEL JETTISONING – Passenger and Freighter Airplanes - It is assessed that between 0.1% and 0.2% of the costs incurred from all FSF events are attributable to the cost of fuel jettisoned.

Observation 7 – FUEL JETTISONING – Passenger and Freighter Airplanes - There were only 84 confirmed FSF events resulting in fuel jettisoning over the ten year study period.

Observation 8 – FUEL JETTISONING – Passenger and Freighter Airplanes – The weight and cost of fuel jettisoned approximates to 600,000 pounds or US$120,000 per year.

7.4 AIRPLANE DAMAGE

Over the study period 33 occurrences were identified where airplane damage was incurred. Airplane damage is assumed to be related to airplane value at the time that the damage is incurred. Arbitrary ranges of the proportion of the airplane value are assigned based on the values contained in table 9. These values may be changed by the FSF Occurrence Database user.

Table 9. Assumed Proportion of Airplane Value incurred by Damage

	Low	Median	High
Airplane Minor	1%	10%	20%
Airplane Substantial	20%	50%	80%
Airplane Destroyed	100%	100%	100%

Table 10 shows the estimated value, in millions of US$, at the time of initial delivery and at the time of occurrence for each of the 33 airplanes identified as incurring damage. The value at time of delivery is an estimate, based on, where available, data published by the airplane manufacturer. This value is depreciated to an estimate of the value at the time of the occurrence based on the airplane age and an annual depreciation rate. The depreciation rate is taken as a nominal 8% per year. As with all other values the data are standardized to 2016 prices. Both the 8% value, and the year to which the values are standardized, may be varied by the FSF Occurrence Database user.

Within the FSF Occurrence Database, algorithms will randomly select on the appropriate values shown in table 9. These values are then multiplied by the standardized airplane value, at the time of the occurrence, to derive an estimate of the cost of the airplane damage.

Table 10. Occurrences involving Airplane Damage showing Estimated Value at Time of Initial Delivery and at Time of Occurrence

Airplane Damage	Date of Occurrence	Airplane	Category	Registration	Delivery Date	Estimated List Price at Time of Delivery US$ Millions	Age	Estimated Value at Time of Occurrence US$ Millions 2016
Minor	02 March 2002	Boeing 727	Passenger	[N519DA]	Jan 1978	20.0	24.2	2.7
Minor	31 March 2002	McDonnell Douglas MD-11	Freighter	[N809DE]	Jun 1993	145.0	8.8	69.7
Minor	29 May 2002	Airbus Industrie A320	Passenger	[N435UA]	Sep 1996	43.0	5.7	26.7
Minor	07 October 2002	Bombardier (Canadair)	Passenger	[N411SW]	May 1995	22.0	7.4	11.9
Minor	22 August 2002	McDonnell Douglas DC-9	Passenger	[N8908E]	Sep 1966	42.5	36.0	2.1
Minor	24 September 2002	Embraer ERJ-145	Passenger	[N851MJ]	Mar 2002	12.0	0.5	11.5
Destroyed	27 April 2004	Fokker F.27	Freighter	[N715FE]	Dec 1989	7.5	14.4	2.3
Substantial	27 April 2004	Boeing 757	Freighter	[N405UP]	Oct 1987	37.0	16.5	9.3
Minor	06 December 2004	McDonnell Douglas DC-10	Freighter	[N304WL]	Oct 2001	110.0	3.1	84.9
Minor	29 December 2004	Boeing 747	Freighter	[N858FT]	Dec 1970	100.8	34.0	5.9
Minor	11 June 2005	McDonnell Douglas DC-9	Passenger	[N7536A]	Oct 1990	52.0	14.6	15.3
Minor	04 July 2005	Boeing 747	Freighter	[N714CK]	Apr 1981	139.4	24.2	18.5
Destroyed	07 February 2006	McDonnell Douglas DC-8	Freighter	[N748UP]	Dec 1967	50.0	38.1	2.1
Minor	09 June 2006	McDonnell Douglas MD-90	Passenger	[N907DA]	Oct 1995	43.0	10.7	17.6
Minor	10 February 2007	Airbus Industrie A320	Passenger	[N648JB]	Dec 2006	67.0	0.2	66.0
Minor	26 February 2007	Boeing 777	Passenger	[N786UA]	Apr 1997	120.0	9.9	52.5
Minor	30 April 2007	McDonnell Douglas DC-10	Freighter	[N309FE]	Jul 1986	110.0	20.8	19.5
Substantial	28 September 2007	McDonnell Douglas DC-9	Passenger	[N454AA]	Mar 1988	51.0	19.5	10.0
Minor	02 November 2007	McDonnell Douglas DC-8	Freighter	[N880UP]	Jun 1969	50.0	38.4	2.0
Minor	16 March 2008	Bombardier (DHC) Dash 8	Passenger	[N815EX]	Apr 1993	5.3	15.0	1.5
Substantial	28 June 2008	Boeing 767	Freighter	[N799AX]	Jul 1986	38.0	22.0	6.1
Minor	14 July 2008	Boeing 747	Freighter	[N746SA]	Dec 1976	120.0	31.6	8.6

Airplane Damage	Date of Occurrence	Airplane	Category	Registration	Delivery Date	Estimated List Price at Time of Delivery US$ Millions	Age	Estimated Value at Time of Occurrence US$ Millions 2016
Minor	27 July 2008	Boeing 747	Freighter	[N710CK]	May 1975	117.0	33.2	7.4
Substantial	28 February 2009	Bombardier (Canadair)	Passenger	[N830AS]	May 1998	25.0	10.8	10.2
Minor	03 June 2009	Embraer ERJ-145	Passenger	[N664MS]	Jan 2004	14.0	5.4	8.9
Minor	10 June 2009	Boeing 757	Passenger	[N570UA]	Nov 1992	57.0	16.6	14.3
Minor	11 January 2010	ATR ATR72	Passenger	[N434AT]	Nov 1994	10.0	15.1	2.8
Minor	24 July 2010	Airbus Industrie A320	Passenger	[N331NW]	Jun 1992	38.0	18.1	8.4
Minor	26 August 2010	Airbus Industrie A320	Passenger	[N590JB]	Jun 2004	63.0	6.2	37.7
Destroyed	03 September 2010	Boeing 747	Freighter	[N571UP]	Sep 2007	300.0	3.0	234.5
Minor	05 April 2010	Airbus Industrie A320	Passenger	[N409UA]	Mar 1994	42.0	16.1	11.0
Minor	28 May 2011	McDonnell Douglas MD-88	Passenger	[N941DL]	Jul 1989	45.0	21.9	7.3
Minor	30 September 2011	Bombardier (Canadair)	Passenger	[N256PS]	Jul 2004	32.0	7.2	17.6

Observation 9 – AIRPLANE DAMAGE – Passenger and Freighter Airplanes - It is assessed that between 60% and 65% of the costs incurred from all FSF events are attributable to airplane damage. However, this is largely weighted by the UPS freighter accident in 2010. This proportion reduces to between 20% and 30% for passenger airplanes.

Observation 10 – AIRPLANE DAMAGE – Passenger Airplanes - The average cost over the ten year study period, resulting from airplane damage, is assessed to be in the region of US$5,500,000 per year.

7.5 DELAYS AND CANCELLATIONS

Delays and cancellations have only been considered for events that occurred before flight. The subsequent effects of an in-flight event on airplane operation have not been considered due to the sparsity of the data. Generally, determinations as to whether an event might have resulted in a delay or cancellation were for the most part unreliable. Many reports simply made statements such as smoke in the cabin and it often could not even be determined whether the event occurred prior to flight, during flight or at the end of the flight. However, since it is likely that delays and cancellations will result in significant costs an attempt has been made to evaluate their significance in relation to FSF events.

Many studies have been carried out to attempt to evaluate these costs and it is evident that many factors will significantly affect the magnitude of the costs incurred. The size of airplane is an obvious factor in the magnitude of the cost. Hence, as with diversions, a range of costs has been used for wide body, narrow body and regional airplanes. No data were found for freighter airplanes, hence it is assumed that the costs incurred are similar to passenger airplanes.

Observation 11 – DELAYS AND CANCELLATIONS – Passenger and Freighter Airplanes - Delays and cancellations have only been considered for events that occurred before flight. The subsequent effects of an in-flight event on airplane operation have not been considered due to the sparsity of the data.

Observation 12 – DELAYS AND CANCELLATIONS – Passenger and freighter airplanes – Generally, determinations as to whether an event might have resulted in a delay or cancellation were for the most part unreliable. Many reports simply made statements such as smoke in the cabin, and it often could not even be determined whether the event occurred prior to flight, during flight or at the end of the flight. However, since it is likely that delays and cancellations will result in significant costs an attempt has been made to evaluate their significance in relation to FSF events.

7.5.1 Flight Delays

The cost analysis is based on FSF occurrences prior to the flight, which result or were likely to have resulted in the flight departing later than the scheduled time. Consequential delays or delays resulting from an in-flight occurrence are not assessed. In this respect the cost estimates for delays are likely to be conservative.

The data shown in table 11 is based on the Westminster University study (reference 8). This study also suggests that the costs attributable to a delay are a function of the square root of the airplane MTOW. These factors have been taken into account in making the assessments shown in table 11. Once again it should be stressed that the number of significant figures is not indicative of the precision of the numbers.

Table 11. Flight Delay Costs

	Delay Costs Euros 2010			Delay Costs US $ 2016		
	Low	Mean	High	Low	Mean	High
Wide	960	18,885	66,110	1,269	24,967	87,401
Narrow	410	8,054	30,950	542	10,648	40,917
Regional	200	2,900	9,710	264	3,834	12,837

It may be seen that these data suggest a very wide range of costs attributable to delays. The average cost of a delay based on these data, for the entries in the FSF Occurrence Database, is approximately US$7,000 for a passenger airplane.

Observation 13 – DELAYS – Passenger and Freighter Airplanes - It is assessed that between 2.5% and 3% of the costs incurred from all events are attributable to flight delays. However, these percentages are heavily weighted by the high costs associated with the UPS freighter accident in 2010 and if only passenger airplanes are considered this proportion increases to between 5% and 6%.

Observation 14 – DELAYS – Passenger Airplanes – While likely to be conservative, it is assessed that the average cost over the ten year study period resulting from flight delays is in the region of US$1,100,000 per year.

7.5.2 Flight Cancellations

The data shown in table 12 is based on the EUROCONTROL study (reference 2). Once again, it should be stressed that the number of significant figures is not indicative of the precision of the numbers.

Table 12. Cancellation Costs

	Cancellation Costs Euros 2014			Cancellation Costs US $ 2016		
	Low	Mean	High	Low	Mean	High
Wide	31,979	78,400	114,500	38,302	93,901	137,138
Narrow	6,200	15,200	23,600	7,426	18,205	28,266
Regional	2,529	6,200	9,626	3,029	7,426	11,530

The average cost of a cancellation based on these data, for the entries in the FSF Occurrence Database, ranges between US$14,000 and US$16,000 for a passenger airplane. This may be compared with the Average cost suggested by the EUROCONTROL study (Reference 2) of €17,600 which equates to approximately US$20,000 at 2016 levels.

Observation 15 – CANCELLATIONS – Passenger and Freighter Airplanes - It is assessed that between 1% and 2% of the costs incurred from all events are attributable to flight cancellations. However, these percentages are heavily weighted by the high costs associated with the UPS freighter accident in 2010 and if only passenger airplanes are considered this proportion increases to between 3.5% and 4%

Observation 16 – CANCELLATIONS – Passenger Airplanes – While likely to be conservative, it is assessed that the average cost over the ten year study period, resulting from cancellations is in the region of US$800,000 per year.

7.5.3 Emergency Evacuations

Emergency evacuations can lead to high costs being incurred due to the replacement of escape slides. The evacuations will often also result in injuries, the cost implications of which are addressed in section 7.2.

Reference 5 describes an occurrence to a Boeing 757 airplane which suggests that the cost incurred for the event totaled $131,000. Reference 5 also contains the following statement:

> *Even without four slides being repacked, under the same conditions, it is still a $67,000 event.*

It may be inferred from this that the cost of the slides being repacked was US$131,000 minus US$67, 000 = US$ 64,000, or US$16,000 per pack. Escalating this from 2011 prices to 2016 prices at 2.5% per year amounts to approximately

US$17,700 per slide pack

Reference 9 contains the following statement:

> *Airline data also indicated that the additional cost of replacing emergency escape systems, combined with the loss of revenue associated with PEEvac[4]-related maintenance, was $1.0 million per year*

It was also determined from reference 9 that over the 106 month study period there were 130 incidents where the slides were deployed. Therefore, the cost per incident would amount to:

US$ $(1 \times 10^6\}$ x $(106 \div 12) \div 130$

[4] Precautionary Emergency Evacuations

Which approximates to US$ 68,000 per incident.

From the data contained in the FSF Occurrence Database, it was assessed that the average number of slides fitted to passenger airplanes equipped with escape systems was in the region of 4.3 per airplane and on average two-thirds were deployed during an emergency evacuation. Therefore, it might be expected that the cost of replacing a slide and the loss of revenue associated with PEEvac related maintenance would be in the region of:

$$US\$\ 68{,}000 \div (4.3 \times 2/3)$$

Which approximates to US$ 23,700 per slide pack.

Escalating this value from 1992 to 2016 prices at 2.5% per year amounts to approximately

US$42,900 per slide pack

The data from reference 9 includes the out of service time associated with the slide pack replacement. The data from reference 5 is thought to be relevant to only slide pack replacement. This probably explains the large variation in costs. Since on occasions the airplane might not need to be taken out of service, due to the slide pack replacement being carried out during overnight maintenance, and since nowhere else in the cost assessment is out of service time taken into account the range of costs is considered to be reasonable. Hence, the computations carried out within the FSF Occurrence Database are based on a cost of slide replacement ranging between US$17,700 and US$42,900.

It is assumed in the cost analysis derived from the FSF Occurrence Database that emergency evacuations carried out on freighter airplanes result in no more than one escape slide being deployed.

Observation 17 – ESCAPE SLIDES – Passenger and Freighter Airplanes - It is assessed that approximately 1% of the total costs incurred from FSF events are attributable to the removal and replacement of escape slides. For passenger airplanes this increases to approximately 3%.

Observation 18 – ESCAPE SLIDES – Passenger Airplanes – It is assessed that there were in the region of 130 emergency evacuations as a result of FSF events involving escape slides on passenger airplanes over the study period, and, on average, two thirds of the exits with escape slides were used. The average cost over this period, of the removal and replacement of escape slides is assessed to be in the region of US$600,000 per year.

8. TRENDS IN SIGNIFICANT EVENTS

Significant events are defined in Appendix B of this report. Of the 14,532 occurrences that were considered valid in the study approximately 38% were considered significant events. The number of significant events to the US fleet per year is shown in figure 2 and the rate of occurrence per million flights in figure 3. These data include all categories of passenger and freighter airplanes and serve only to give an indication of the trend in FSF occurrences experienced on in-service airplanes.

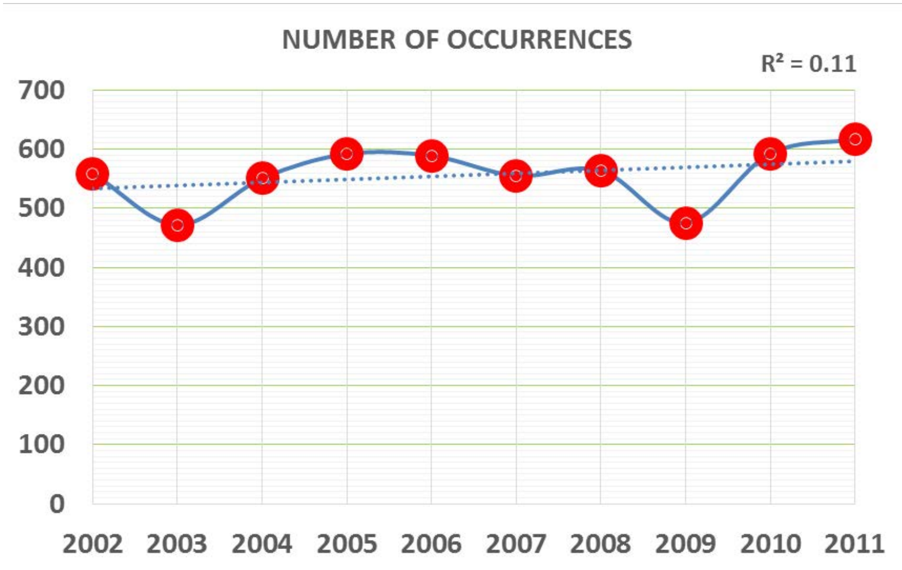

Figure 2. Significant Events - Total Number per Year

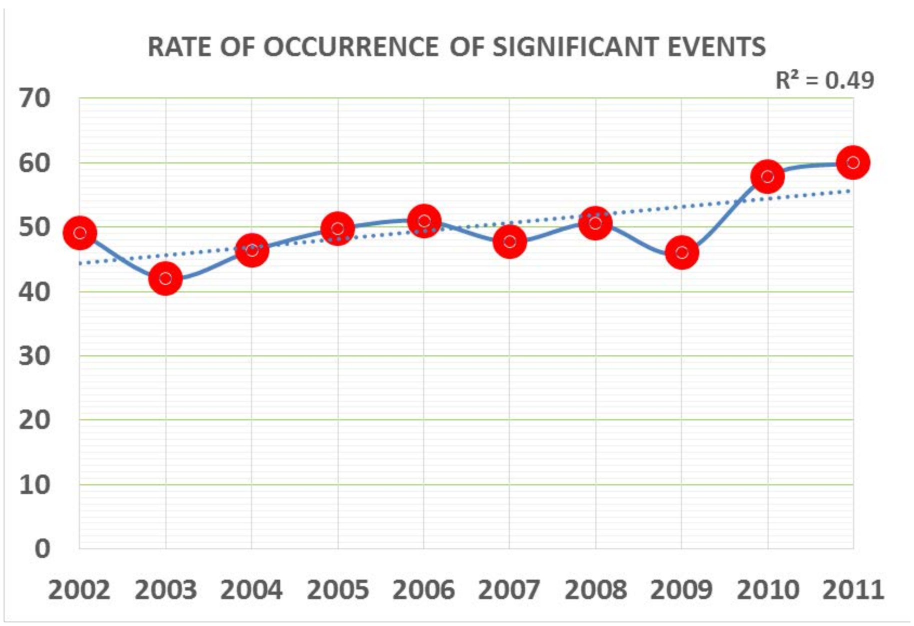

Figure 3. Significant Events - Rate of Occurrence per Million Flights

Observation 19 – SIGNIFICANT EVENTS – Passenger and Freighter Airplanes - Over the study period, there appears to be no reduction, and perhaps some increase, in both the annual number of significant events and the rate of occurrence per million flights. The average number of significant events per year is approximately 560 and the average rate of occurrence is in the region of 50 per million flights.

9. FIRE, SMOKE OR FUME (FSF) EVENTS IN OCCUPIED AREAS

9.1 ANNUAL NUMBER OF FSF EVENTS – PASSENGER AIRPLANES

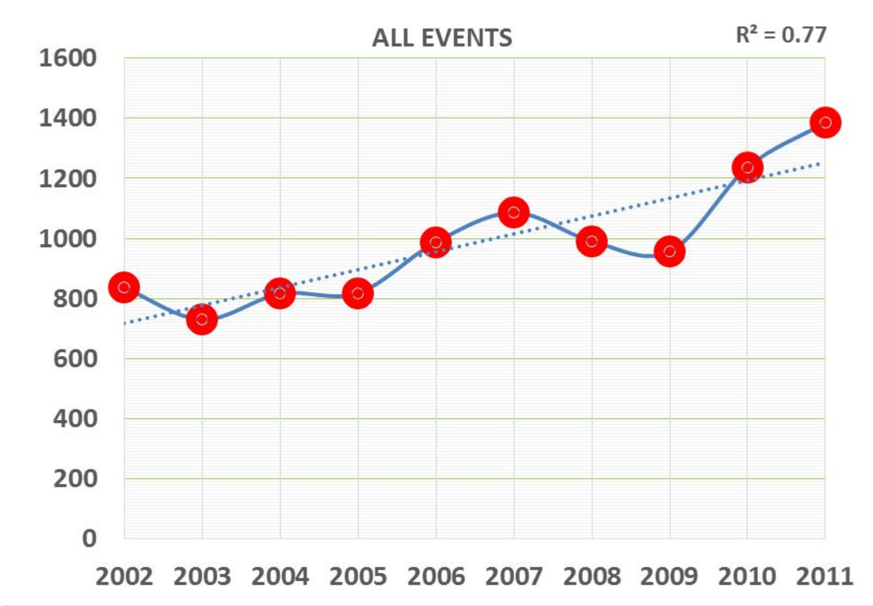

Figure 4. – Occupied Areas - Annual Number of All FSF Events in Passenger Airplanes

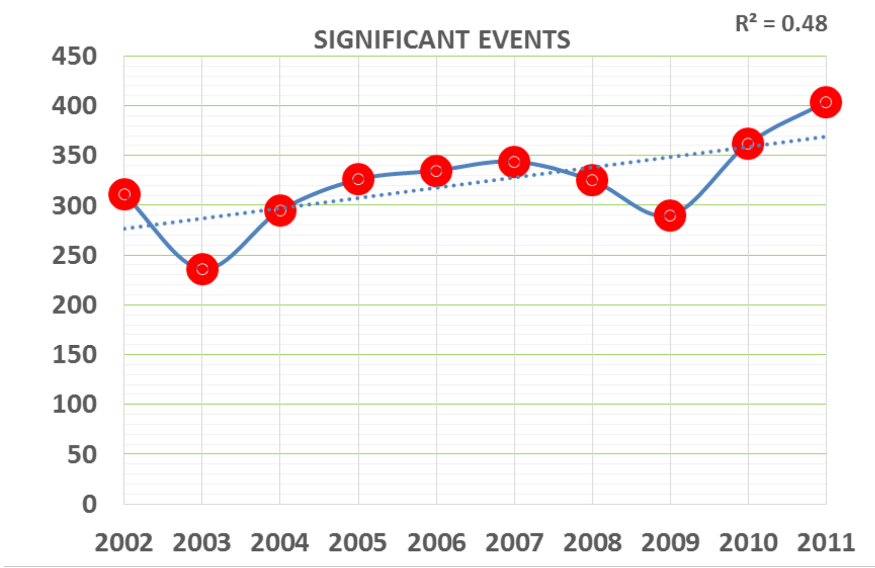

Figure 5. Occupied Areas - Annual Number of Significant FSF Events in Passenger Airplanes

Observation 20 – OCCUPIED AREAS – Passenger Airplanes - Over the study period, there appears to be an increase in the annual number of all fire, smoke or fume events in occupied areas with an average occurrence rate of approximately 1,000 per year. This increase is also apparent for significant events.

9.2 ANNUAL NUMBER OF FSF EVENTS – FREIGHTER AIRPLANES

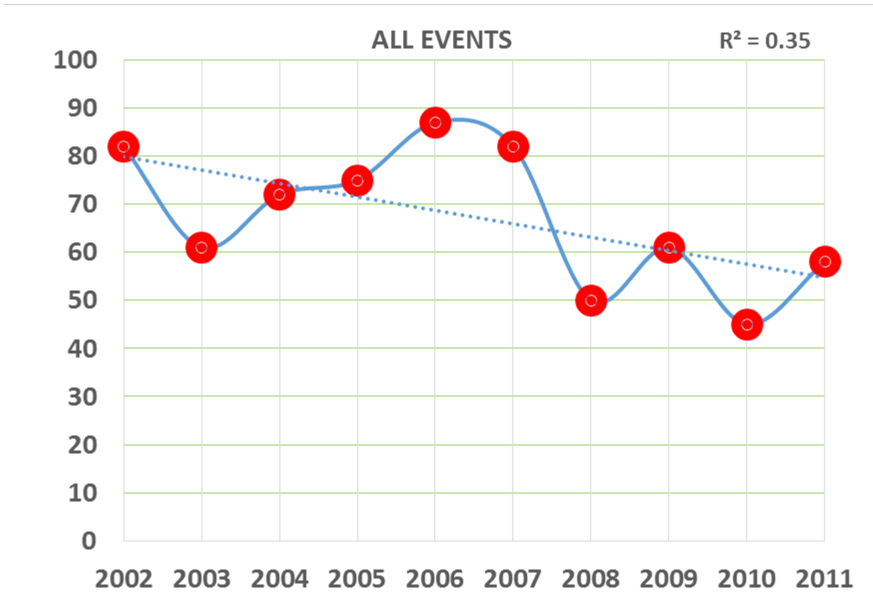

Figure 6. Occupied Areas - Annual Number of All FSF Events in Freighter Airplanes

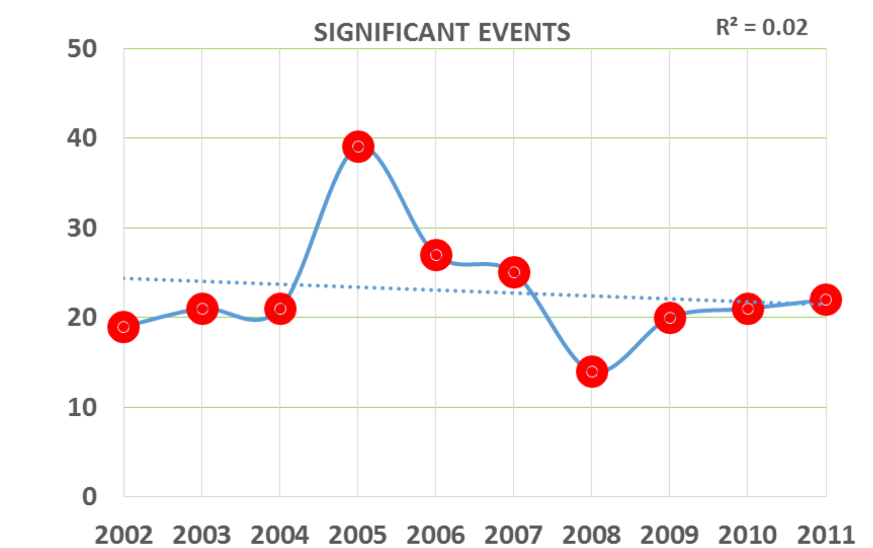

Figure 7. Occupied Areas - Annual Number of Significant FSF Events in Freighter Airplanes

Observation 21 – OCCUPIED AREAS - Freighter Airplanes - Over the study period, there may be a modest reduction in the annual number of fire, Smoke or fume events in occupied areas, with an average rate of occurrence, for all events, which is slightly less than 70 per year.

9.3 RATE OF OCCURRENCE OF FSF EVENTS

9.3.1 Passenger Airplanes

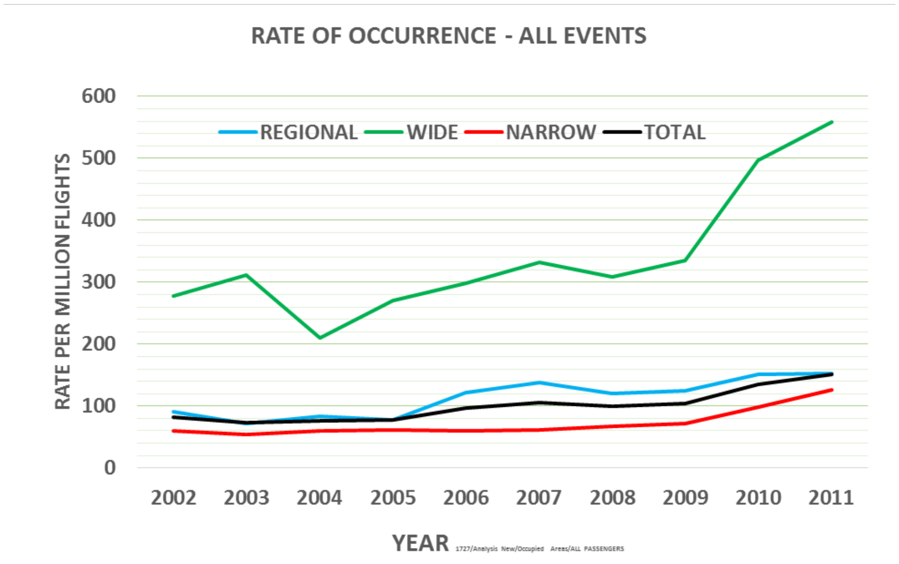

Figure 8. Occupied Areas - Rate of Occurrence of All FSF Events – Passenger Airplanes

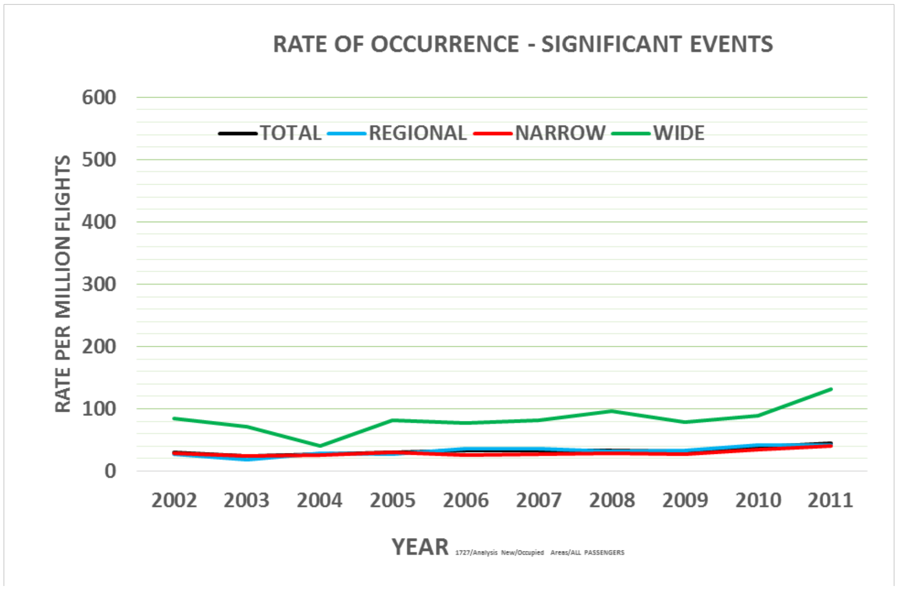

Figure 9. Occupied Areas - Rate of Occurrence of Significant FSF Events – Passenger Airplanes

Observation 22 – OCCUPIED AREAS – Passenger Airplanes - Over the study period, there appears to be an increase in the rate of occurrence per million flights of all fire, smoke or fume events in occupied areas with an average rate of occurrence in the region of 100 per million flights for all aircraft categories. Wide body airplanes exhibit a rate of occurrence that is significantly higher than narrow body and regional airplanes. Wide body airplanes also seem to exhibit a rate of occurrence of all FSF events that is increasing faster than on smaller passenger airplanes.

An increase is also apparent when considering only significant FSF events with an average rate of occurrence for regional and narrow body airplanes of approximately 30 per million flights and for wide body airplanes of approximately 80 per million flights.

The higher rate of occurrence on wide body airplanes is likely to be associated with the longer flight time and the greater number of passengers with a consequential increase in the number of potential fire, smoke or fume sources. If the rates of occurrence are derived on a flight hour basis, wide body airplanes exhibit a rate of occurrence that is similar to all passenger airplanes with regional airplanes showing the higher rates. Narrow body airplanes exhibit the lowest rates of occurrence on both a per flight and per hour basis. The rates of occurrence increase over the study period for all airplane categories irrespective of whether they are derived on a per flight or per hour basis.

9.3.2 Freighter Airplanes

The trend in the rate of occurrence of fire, smoke or fume events in occupied areas of freighter airplanes for all and significant events is shown in figure 10.

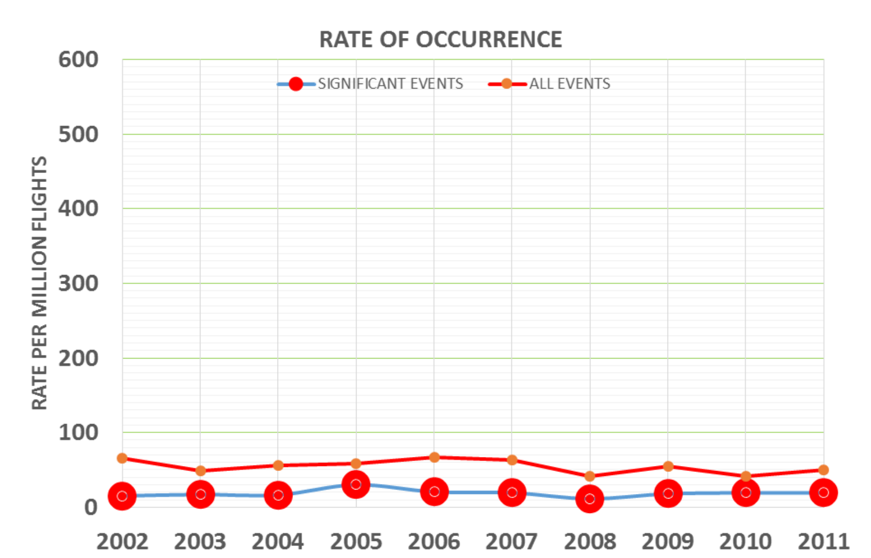

Figure 10. Occupied Areas - Rate of Occurrence of All and Significant FSF Events – Freighter Airplanes

Observation 23 – OCCUPIED AREAS – Freighter Airplanes - There appears to be no discernible trend in the rate of occurrence per million flights for both all and significant events of fire, smoke or fume events in occupied areas. Over the study period, the average rate of occurrence is approximately 55 per million flights for all events and approximately 20 per million flights for significant events.

9.4 FSF EVENTS BY SOURCE

The sources of fire, smoke or fume events in occupied areas are shown in figure 11, figure 12, figure 13 and figure 14 for regional passenger, narrow body passenger, wide body passenger and Freighter airplanes respectively. This breakdown of fire, smoke and fumes sources is for the entire period analyzed in the study.

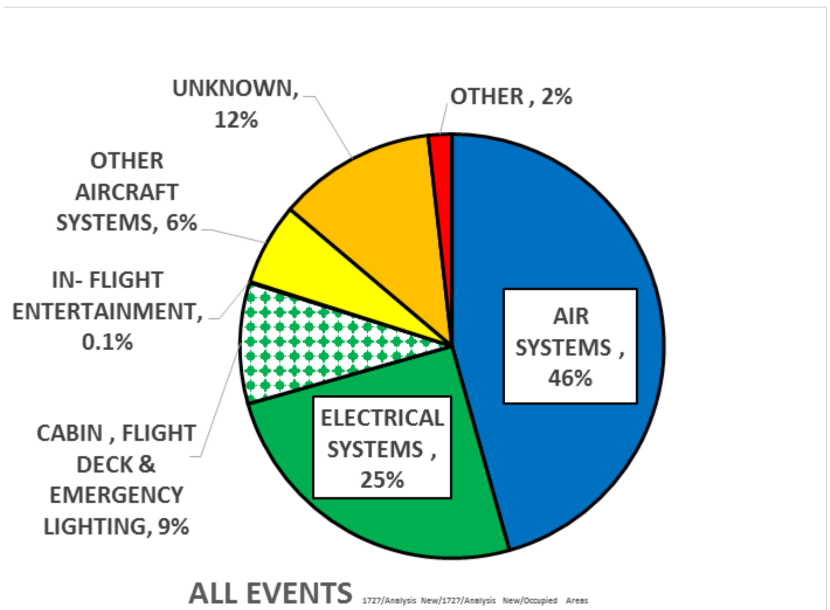

Figure 11. Occupied Areas - Sources of FSF in Regional Passenger Airplanes

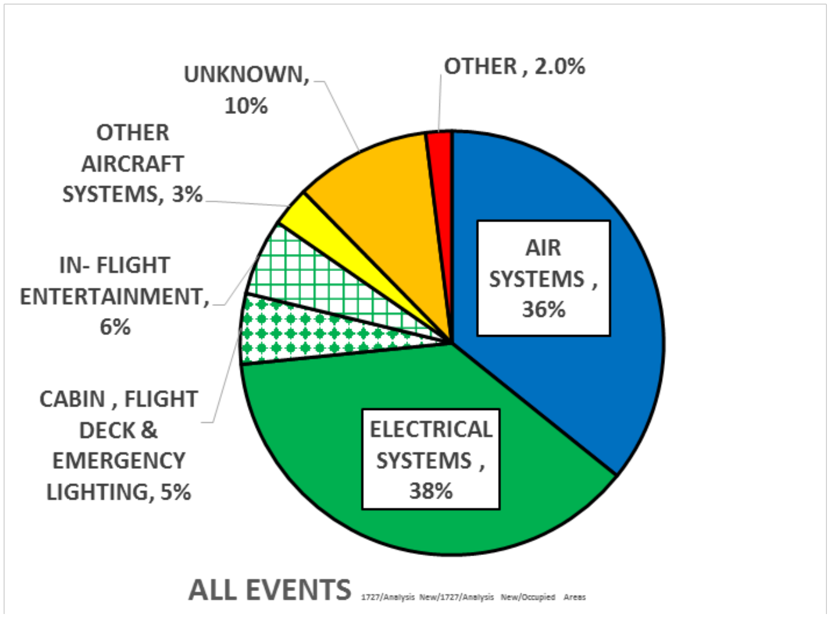

Figure 12. Occupied Areas - Sources of FSF in Narrow Body Passenger Airplanes

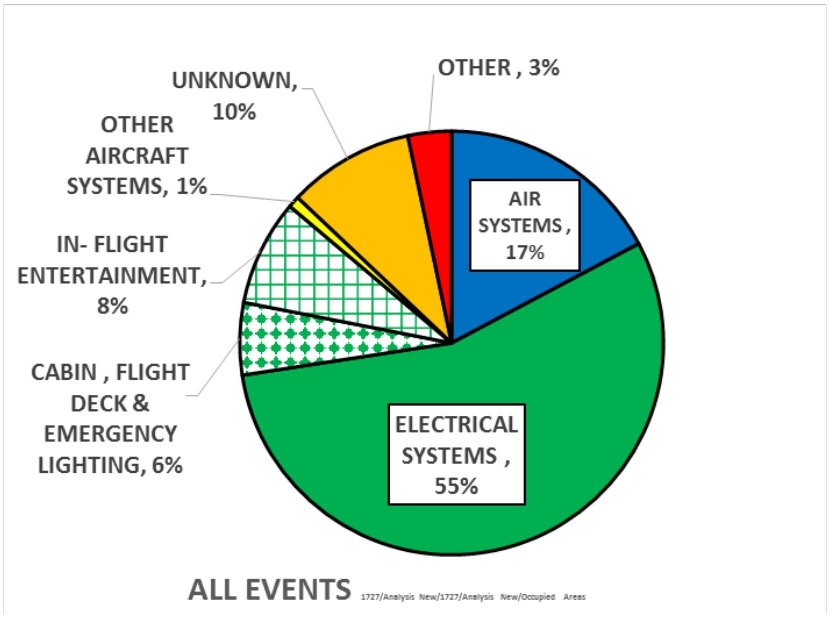

Figure 13. Occupied Areas - Sources of FSF in Wide Body Passenger Airplanes

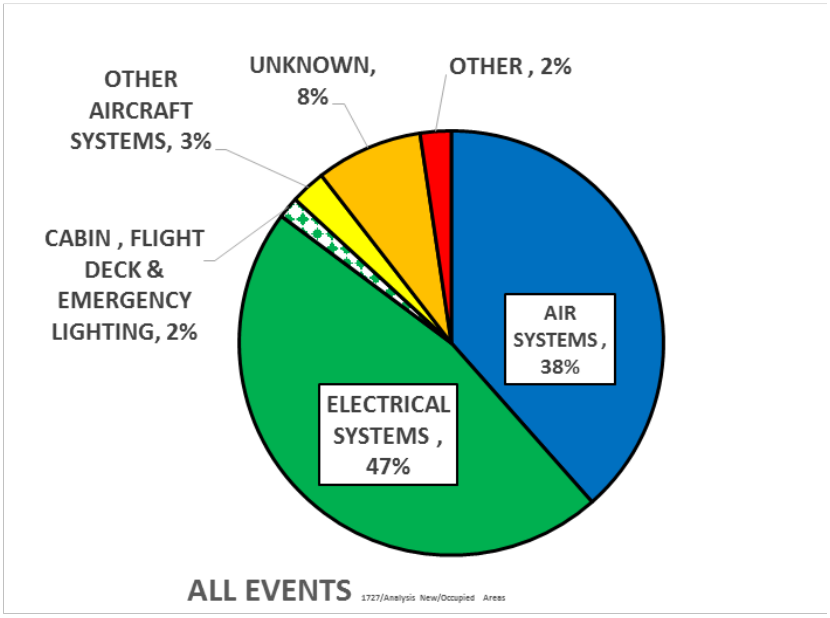

Figure 14. Occupied Areas - Sources of FSF in Freighter Airplanes

Observation 24 – OCCUPIED AREAS – Passenger and Freighter Airplanes - Air systems (engines, APU, bleed system and air conditioning systems) figure largely in the sources of fire, smoke and fume events in occupied areas of both passenger and freighter airplanes. However, electrical systems are perhaps the most frequent source of FSF with approximately two thirds of occurrences being attributable to this source on wide body passenger airplanes when lighting and in-flight entertainment systems are taken into account.

9.5 FSF EVENTS BY LOCATION

The location of fire, smoke or fume events in occupied areas are shown in figure 15, figure 16, figure 17, figure 18 and figure 19 for regional passenger, narrow body passenger, wide body passenger, all passenger and freighter airplanes respectively. Significant events are used since the data are likely to be more reliable than for all events. This breakdown of fire, smoke and fumes sources is for the entire period analyzed in the study.

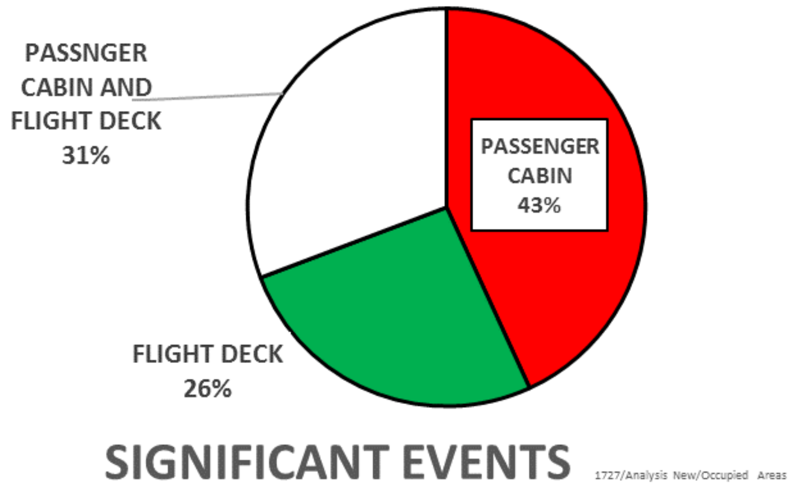

Figure 15. Occupied Areas - Location of FSF in Regional Passenger Airplanes

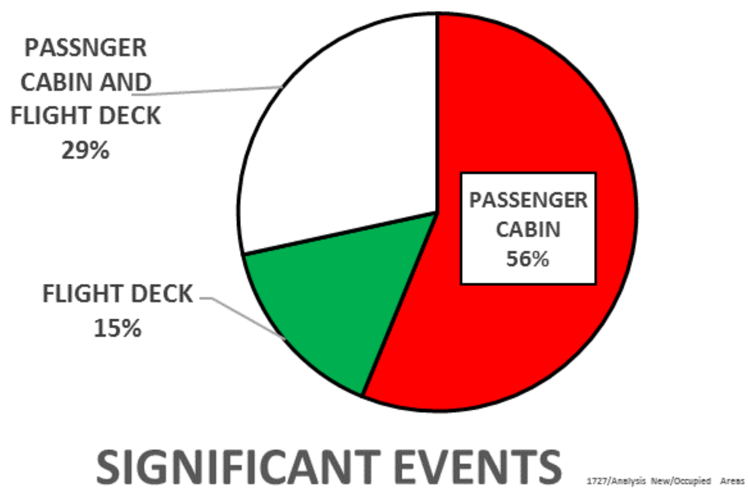

Figure 16. Occupied Areas - Location of FSF in Narrow Body Passenger Airplanes

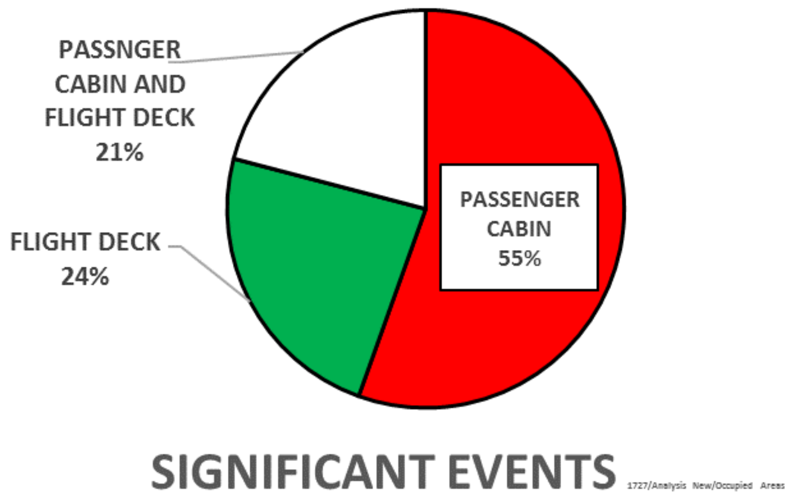

Figure 17. Occupied Areas - Location of FSF in Wide Body Passenger Airplanes

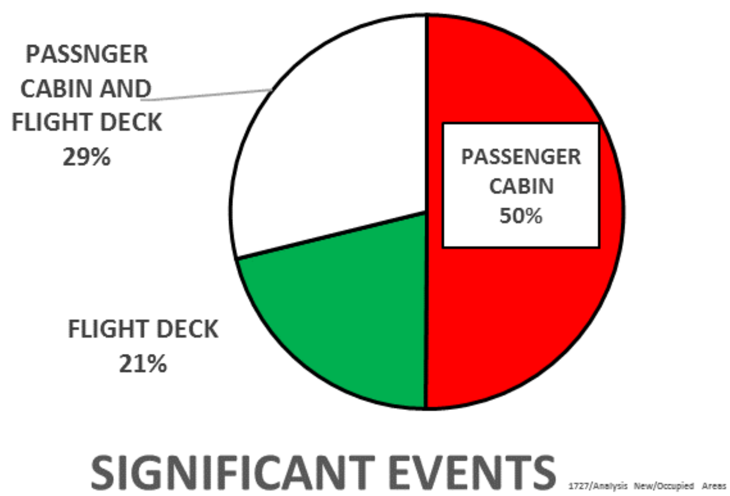

Figure 18. Occupied Areas - Location of FSF in All Passenger Airplanes

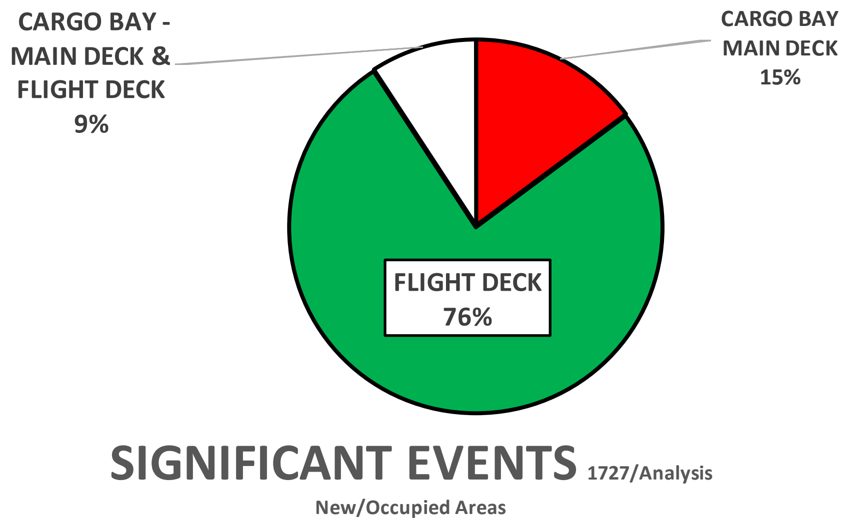

Figure 19. Occupied Areas - Location of FSF in Freighter Airplanes

Observation 25 – OCCUPIED AREAS – Passenger and Freighter Airplanes - The location of fire, smoke or fume events on all passenger airplanes suggests that approximately 80% of events result in FSF within the cabin and 50% of the events result in FSF on the flight deck. The proportion of FSF events occurring solely in the cabin on regional passenger airplanes is less than on the larger passenger airplanes presumably due to the fewer number of potential sources (cabin lighting, in-flight entertainment systems, etc.,) in this location. For freighter airplanes, the majority of FSF events are reported as being on the flight deck - not surprisingly since the main deck cargo bay would not normally be occupied in flight and there are fewer potential FSF sources than on passenger airplanes.

9.6 PROPORTION OF FSF EVENTS CAUSING FLIGHT DISRUPTIONS

The proportion of fire, smoke or fume events that are significant is shown in table 13 for passenger airplanes and table 14 for freighter airplanes.

Table 13. Occupied Areas - Proportion of FSF Events that are Significant – Passenger Airplanes

	Proportion of Events That Are Significant		
	Passenger Cabin	Flight Deck	Passenger Cabin and Flight Deck
Regional Passenger Airplanes	32%	30%	29%
Narrow Body Passenger Airplanes	39%	41%	46%
Wide Body Passenger Airplanes	20%	35%	35%

1727/Analysis New/Occupied Areas

Table 14. Occupied Areas - Proportion of FSF Events that are Significant – Freighter Airplanes

	Proportion of Events That Are Significant		
	Cargo Bay Main Deck	Flight Deck	Cargo Bay Main Deck & Flight Deck
Freighter Airplanes	42%	33%	43%

1727/Analysis New/Occupied Areas

Table 15. Occupied Areas - Proportion of All FSF Events resulting in Unscheduled Landings or Rejected Take-Offs

	All Fire, Smoke or Fume Events	Number of Unscheduled Landings	Unscheduled Landing Proportion	Number of Rejected Take-offs	Rejected Take-off Proportion
Regional Passenger	5149	1244	24%	86	1.7%
Narrow Body Passenger	3728	1298	35%	30	0.8%
Wide Body Passenger	1227	268	22%	5	0.4%
All Passenger Airplanes	10104	2810	28%	121	1.2%
All Freighter Airplanes	710	194	27%	12	1.7%

1727/Analysis New/Occupied Areas

Observation 26 – OCCUPIED AREAS – Passenger and freighter airplanes - Typically, around 25% to 30% of all FSF events result in an unscheduled landing for both passenger and freighter airplanes. The proportion of fire, smoke or fume events in occupied areas, that result in rejected take-offs, is as might be expected small – between 1% and 2% for both passenger and freighter airplanes.

10. ENGINES

10.1 ANNUAL NUMBER OF DETECTOR EVENTS

It appears that the annual number of all detector events for engines, genuine and false warnings, has decreased over the study period as illustrated in figure 20. This chart shows the total number of all detector events for all airplanes (passenger and freighters). It relates to all annunciations on the flight deck irrespective of the cause or its consequences. However, no firm conclusions may be reached regarding the reasons of this apparent downward trend. Comparisons between passenger and freighter airplanes are best addressed by comparison of the rates of occurrence of detector events. This issue is addressed in sections 10.2 and 10.4.

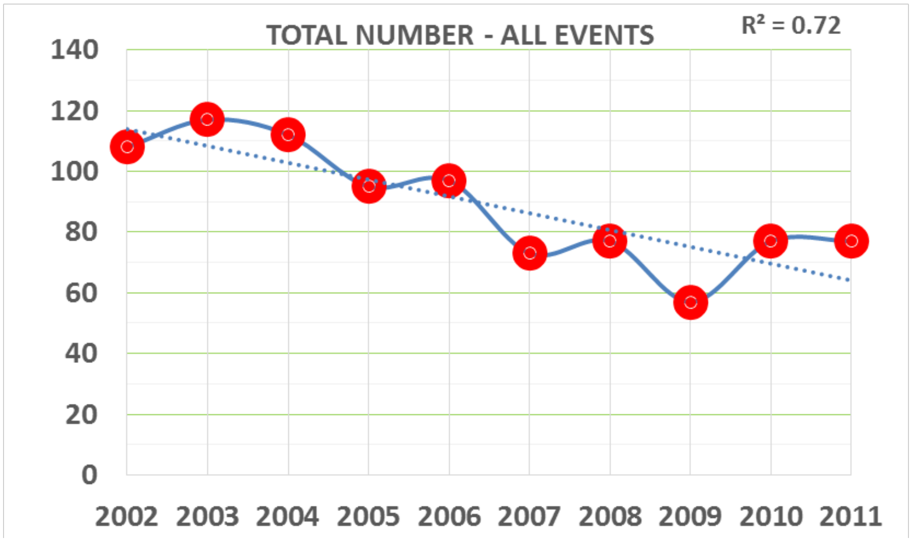

Figure 20. Engine – All Detector Events per Year

Observation 27 – ENGINE – Passenger and freighter airplanes - Over the study period the annual number of all detector events for engines - genuine and false warnings, appears to have shown some reduction with an average rate of approximately 90 per year.

10.2 RATE OF OCCURRENCE OF DETECTOR EVENTS – ALL AIRPLANES

It would be inappropriate to express engine detector events in terms of airplane flights since this would not reflect the number of engines installed on an airplane. Therefore, all rates are expressed in terms of engine flights, i.e.; the number of flights accumulated by an airplane type multiplied by the number of engines. The rate of occurrence of all detector events for all airplanes (passenger and freighter) is shown in figure 21 and for significant events in figure 22.

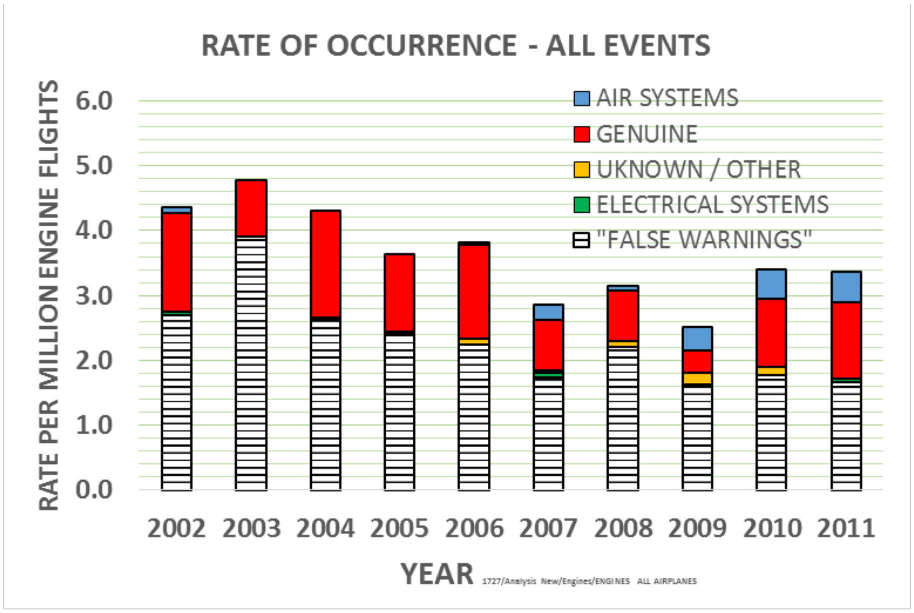

Figure 21. Engine - Rate of Occurrence of All Detector Events for All Airplanes

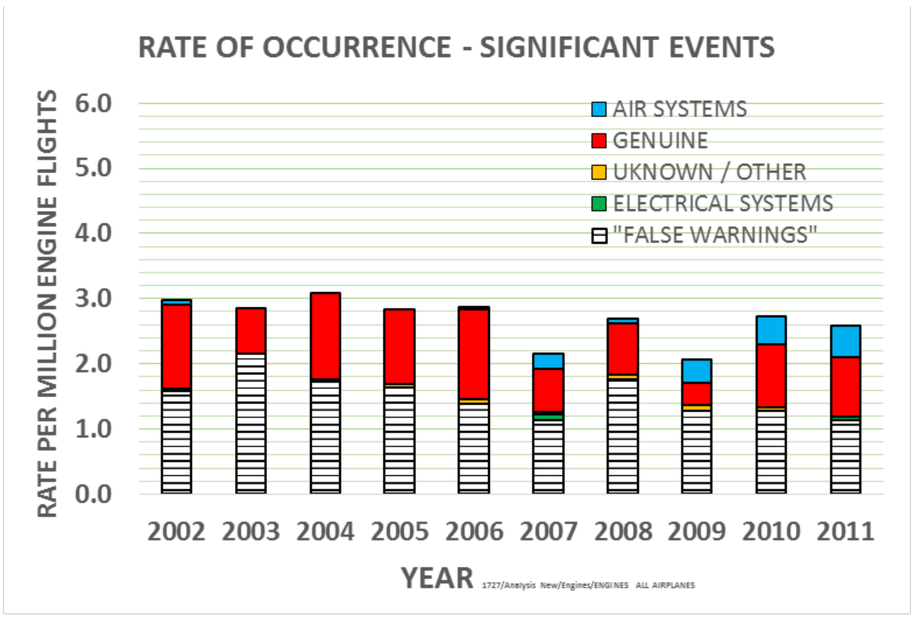

Figure 22. Engine - Rate of Occurrence of Significant Detector Events for All Airplanes

Observation 28 – ENGINE - Passenger and freighter airplanes - Over the study period the rate of occurrence per engine flight of detector events for engines - genuine and false warnings, appears to have shown some reduction, with an average rate of occurrence of approximately 3.6 per million engine flights for all events and 2.7 per million engine flights for significant events.

10.3 DETECTOR EVENTS BY FIRE, SMOKE OR FUME SOURCE

The breakdown of causes of all and significant detector events for engines installed on passenger and freighter airplanes is shown in figure 23 and figure 24 respectively.

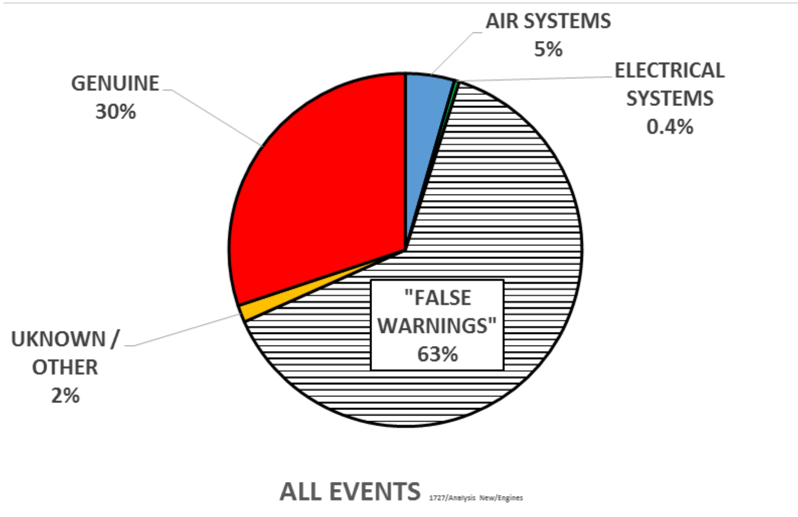

Figure 23. Engine - All Detector Events – by FSF Source

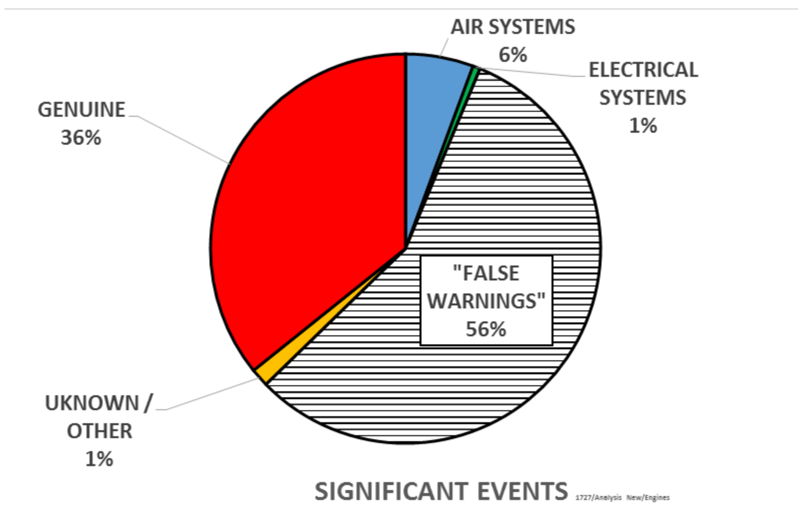

Figure 24. Engine - Significant Detector Events – by FSF Source

Observation 29 – ENGINE - Passenger and freighter airplanes - Over the study period, the proportion of all detector events for engines that were genuine annunciations was in the region of 30% with approximately 63% being false warnings. The remaining detector events were largely associated with aircraft systems – primarily air systems (bleed system). Considering significant detector events the proportion that are false warnings reduces slightly (56%), presumably due to the flight crews requiring confirmation from other sources before executing a flight interruption.

Table 16 and table 17 show the proportions of genuine and false warnings for regional passenger, narrow body passenger, wide body passenger and freighter airplanes.

Table 16. Engine - Proportion of Genuine and False Warnings for All Detector Events

All Events	Regional Passengers	Narrow Body Passengers	Wide Body Passengers	All Freighters
False Warnings	79%	52%	63%	61%
Genuine	18%	39%	34%	32%

1727/Analysis New/Engines/ENGINES ALL AIRPLANES

Table 17. Engine - Proportion of Genuine and False Warnings for Significant Detector Events

Significant Events	Regional Passengers	Narrow Body Passengers	Wide Body Passengers	All Freighters
False Warnings	73%	65%	65%	57%
Genuine	23%	32%	32%	36%

1727/Analysis New/Engines/Engine Small Airplanes

Observation 30 – ENGINE – Passenger and freighter airplanes - For all detector events, regional passenger airplanes appear to exhibit a larger proportion of false warnings - 79% compared to between approximately half and two thirds for freighter and narrow and wide body passenger airplanes. This situation is similar for significant events with approximately three quarters of engine detector events being attributable to false warnings on regional airplanes compared with approximately two thirds on the larger passenger airplanes.

10.4 TRENDS IN FALSE WARNINGS

The cumulative rate of occurrence per engine flight of all false warning detector events is shown in figure 25 and in figure 26 for significant events. The cumulative rates are derived by dividing the total number of events experienced from 2002 by the cumulative number of engine flights over the period.

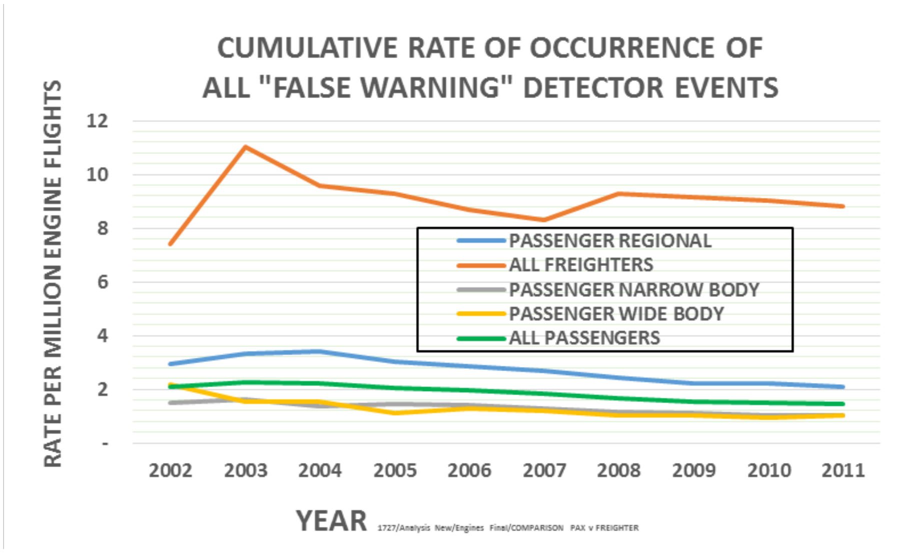

Figure 25. Engine - Cumulative Rate of Occurrence of All False Warning Detector Events per Year for Freighter and Passenger Airplanes

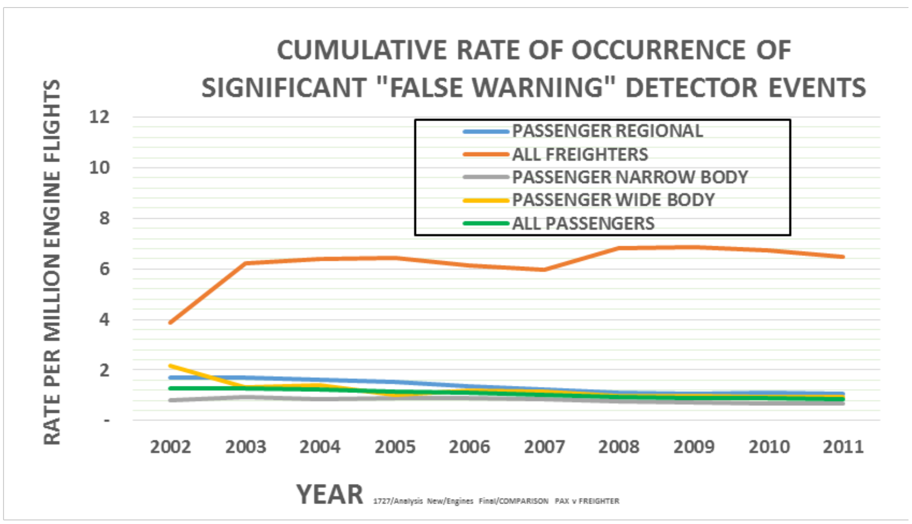

Figure 26. Engine - Cumulative Rate of Occurrence of Significant False Warning Detector Events per Year for Freighter and Passenger Airplanes

Observation 31 – ENGINE - Passenger and freighter airplanes - The rate of occurrence per engine flight of false warnings appears to be significantly higher on freighter airplanes than on all categories of passenger airplanes.

Observation 32 – ENGINE - Passenger and freighter airplanes - There appears to be no significant change in the rate of occurrence per engine flight of false warnings over the study period.

Observation 33 – ENGINE – Passenger airplanes – all false warnings on regional passenger airplanes have an occurrence rate that is approximately twice that of narrow body and wide body passenger airplanes, which have similar rates.

Observation 34 – ENGINE - Passenger airplanes - significant false warning detector events for all passenger airplanes have a remarkably similar rate of occurrence in the region of one per million engine flights.

10.5 PROPORTION OF FALSE WARNINGS CAUSING FLIGHT DISRUPTIONS

Table 18 shows the proportion of false warnings that resulted in an unscheduled landing or a rejected take-off.

Table 18. Engine - Proportion of False Warnings Resulting in Unscheduled Landings or Rejected Take-offs

	All False Warning Detector Events	Number of Unscheduled Landings	Unscheduled Landing Proportion	Number of Rejected Take-offs	Rejected Take-off Proportion
Regional Passenger Airplanes	182	55	30%	13	7%
Narrow Passenger Airplanes	107	52	49%	2	2%
Wide Passenger Airplanes	26	22	85%	1	4%
All Passenger Airplanes	315	129	41%	16	5%
All Freighter Airplanes	234	94	40%	11	5%

1727/Analysis New/Engine/Flight Disruptions Not FSF

Observation 35 – ENGINE - Passenger and Freighter Airplanes - The data analysis suggests that approximately 40% of false warnings result in an unscheduled landing for all passenger airplanes and freighter airplanes. However, there is significant variation among passenger airplane categories (regional, narrow body and wide body). It is to be expected that events on the shorter flight time airplanes are less likely to result in an unscheduled landing due to the close proximity of the destination airfield. Typically, around one quarter of these unscheduled landings were diversions and three quarters were return to the departure airport. Approximately 5% of engine false warnings resulted in a rejected take-off.

11. AUXILIARY POWER UNIT (APU)

11.1 ANNUAL NUMBER OF DETECTOR EVENTS

It appears that the annual number of detector events for APUs has shown some decrease over the study period as illustrated in figure 27. This chart shows the total number of detector events for all airplanes (passenger and freighter). It relates to all annunciations on the flight deck irrespective of the cause or its consequences. However, no firm conclusions may be reached regarding the reasons or significance of any annual trends since problems associated with a particular airplane type and even an individual airplane can significantly affect the number of events recorded.

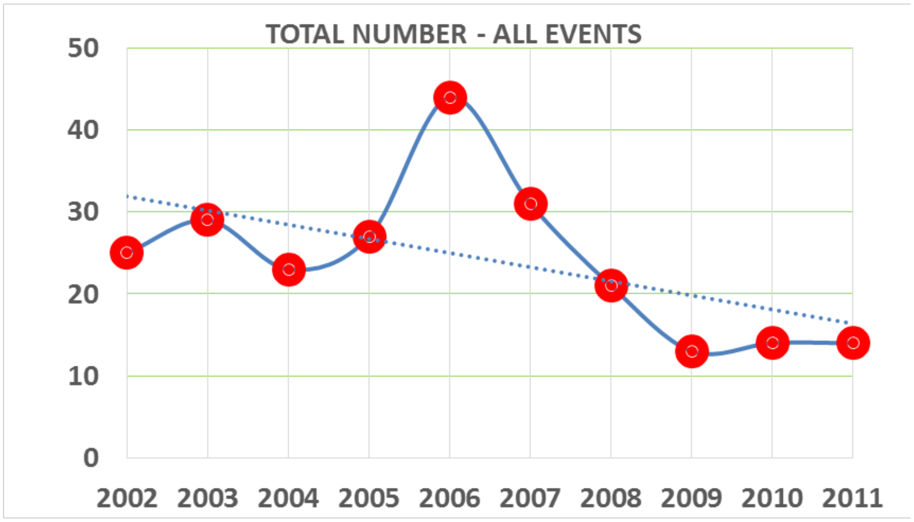

Figure 27. APU - Number of Detector Events per Year

Observation 36 – APU - Passenger and Freighter Airplanes - It appears that the annual number of all APU detector events, for all airplanes (passenger and freighter), has shown some decrease over the study period with the average number being approximately 25 per year.

11.2 RATE OF OCCURRENCE OF DETECTOR EVENTS – PASSENGER AIRPLANES

The rate of occurrence of all APU detector events for passenger airplanes is shown in figure 28. The average rate over the study period was in the region of 2 per million flights for all events.

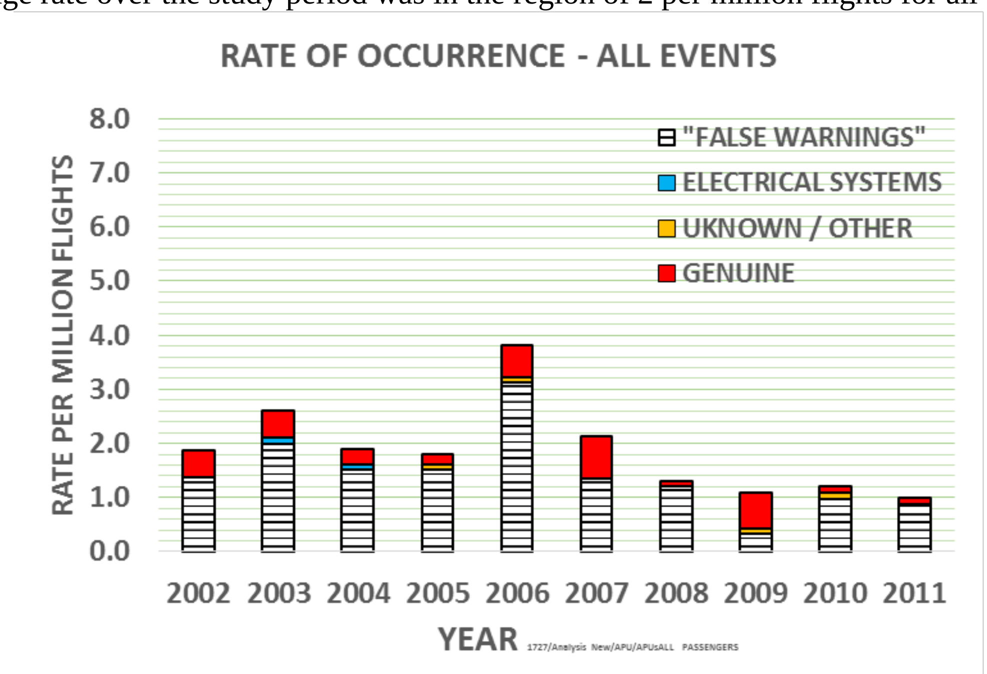

Figure 28. APU - Rate of Occurrence of All Detector Events for Passenger Airplanes

Observation 37 – APU – Passenger Airplanes - Over the study period, the rate of occurrence per flight of all APU detector events on passenger airplanes appears to have shown some improvement with the average rate being approximately 2 per million flights.

11.3 RATE OF OCCURRENCE OF DETECTOR EVENTS – FREIGHTER AIRPLANES

The rate of occurrence of all detector events for freighter airplanes is shown in figure 29. The average rate over the study period was in the region of 4 per million flights for all events.

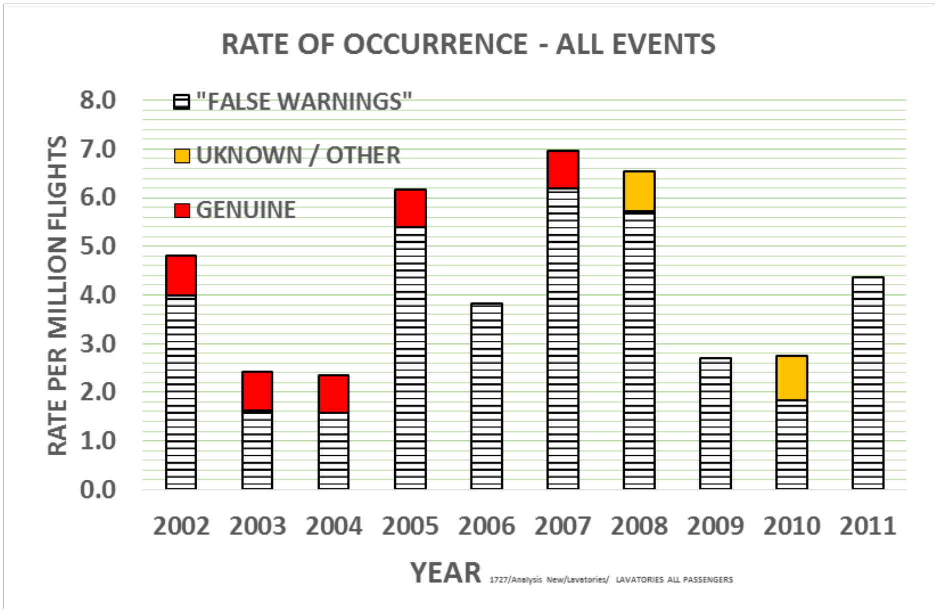

Figure 29. APU - Rate of Occurrence of All Detector Events per Year for Freighter Airplanes

Observation 38 – APU – Freighter Airplanes - Over the study period, the rate of occurrence per flight of all APU detector events on freighter airplanes is in the region of twice that on passenger airplanes with an average rate of occurrence of approximately 4 per million flights. There is no discernible trend in the rate of occurrence.

11.4 DETECTOR EVENTS BY FIRE, SMOKE OR FUME SOURCE

The breakdown of causes of all detector events for APUs installed on passenger and freighter airplanes is shown in figure 30 and for significant events in figure 31.

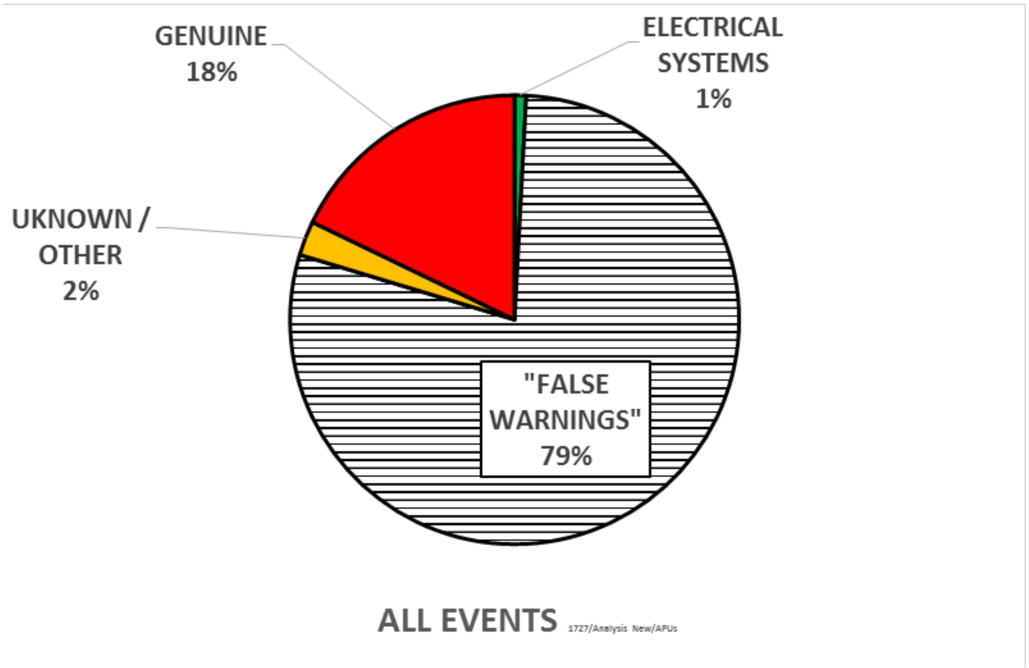

Figure 30. APU All Detector Events – by FSF Source

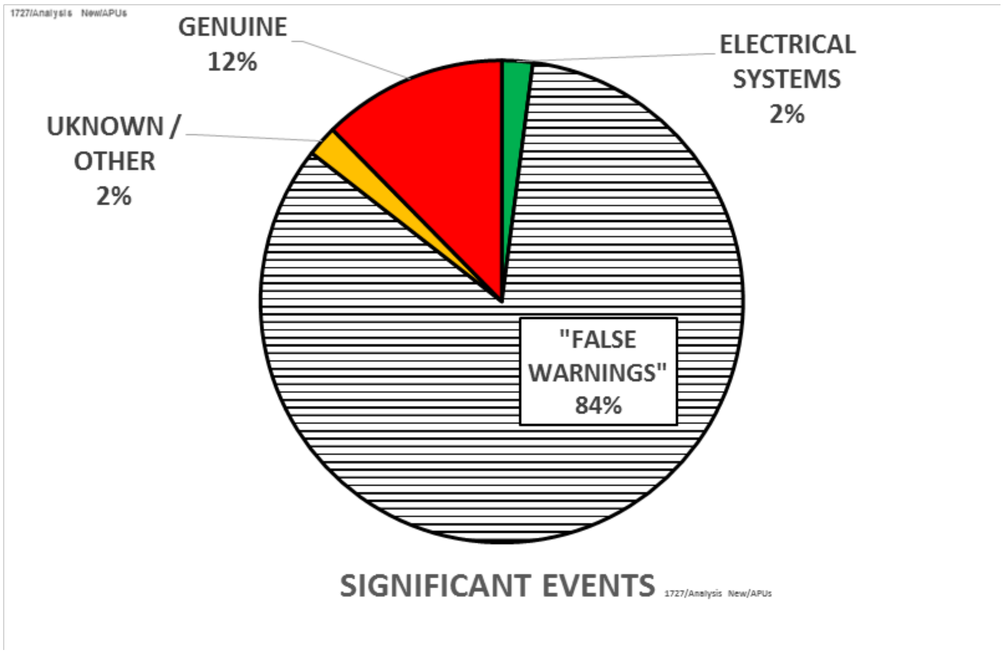

Figure 31. APU Significant Detector Events – by FSF Source

Although there is some variation among the airplane categories, presumably due to the differences in the APUs installed and their detection systems, typically around 80% of detector events are false warnings.

The proportion of false warning APU detector events by airplane category for all and significant events is shown in table 19 and table 20 respectively.

Table 19. APU - Proportion of False Warning for All Detector Events

All Events	Regional Passengers	Narrow Body Passengers	Wide Body Passengers	All Freighters
False Warnings	67%	85%	91%	87%
Genuine	30%	11%	9%	9%

1727/Analysis New/APUs Final/All Airplanes

Table 20. APU - Proportion of False Warning for Significant Detector Events

Significant Events	Regional Passengers	Narrow Body Passengers	Wide Body Passengers	All Freighters
False Warnings	62%	89%	100%	89%
Genuine	29%	7%	0%	11%

* Note only 2 APU significant detector events were found for wide body passenger airplanes 1727/Analysis New/APUs/APUs all airplanes

Observation 39 – APU – Passenger and Freighter Airplanes - While there are variations among airplane categories, typically around 80% of detector events may be considered as false warnings.

11.5 TRENDS IN FALSE WARNINGS

Observation 40 – APU – Passenger and Freighter Airplanes - The analysis of data did not reveal any discernible trends in the rate of occurrence of false warnings for APUs, suggesting no significant improvement in the false warning rate over the study period. The average rate of occurrence of APU false warnings was found to be approximately 3.8 per million flights for freighter airplanes and 1.4 per million flights for passenger airplanes.

11.6 PROPORTION OF FALSE WARNINGS CAUSING FLIGHT DISRUPTIONS

Table 21 shows the proportion of false warning APU detector events that resulted in an unscheduled landing or a rejected take-off to passenger and freighter airplane.

Table 21. APU - Proportion of False Warnings Resulting in Unscheduled Landings or Rejected Take-offs

	All False Warning Detector Events	Number of Unscheduled Landings	Unscheduled Landing Proportion	Number of Rejected Take-offs	Rejected Take-off Proportion
Regional Passenger	60	4	7%	1	2%
Narrow Passenger	73	41	56%	0	0%
Wide Passenger	10	1	10%	1	10%
All Passengers	143	46	32%	2	1%
All Freighters	46	10	22%	2	4%

1727/Analysis New/APU

Observation 41 – APU – Passenger and Freighter Airplanes - The data analysis suggests that approximately 32% of false warnings result in an unscheduled landing for all passenger airplanes and 22% for freighter airplanes. However, there is significant variation among passenger airplane categories (regional, narrow body and wide body). Typically, around one quarter of these unscheduled landings were diversions and three quarters were returns to the departure airport. Only four occurrences were found of APU false warning detector events that resulted in a rejected take-off.

12. INACCESSIBLE CARGO BAYS

12.1 ANNUAL NUMBER OF DETECTOR EVENTS

It appears that the annual number of detector events for inaccessible cargo bays has decreased over the study period as illustrated in figure 32. This chart shows the total number of detector events for all airplanes (regional, narrow body, wide body and freighter airplanes). It relates to all annunciations on the flight deck irrespective of the cause or its consequences. However, no firm conclusions may be reached regarding the reasons or significance of this apparent downward trend. Comparisons between passenger and freighter airplanes are best addressed by comparison of the rates of occurrence of detector events. This issue is addressed in sections 12.2 and 12.3.

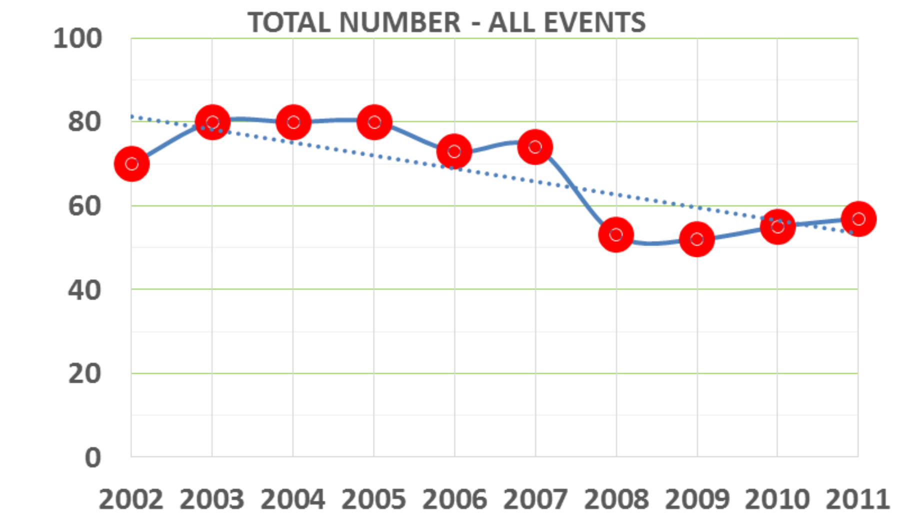

Figure 32. Inaccessible Cargo Bay - Number of Detector Events per Year

Observation 42 – INACCESSIBLE CARGO BAY – Passenger and Freighter Airplanes - The annual number of detector events for inaccessible cargo bays has decreased over the study period with the average number being in the region of 70 per year.

12.2 RATE OF OCCURRENCE OF DETECTOR EVENTS – PASSENGER AIRPLANES

It is perhaps more pertinent to analyze only narrow and wide body passenger airplanes rather than regional airplanes, since these larger airplane categories will be almost totally configured with inaccessible cargo bays whereas regional airplanes will vary markedly in their cargo bay configuration. The rate of occurrence of all detector events for narrow and wide body passenger airplanes is shown in figure 33 and for significant events in figure 34. The average rate over the study period was in the region of 3 per million flights for all events and 2 per million flights for significant events.

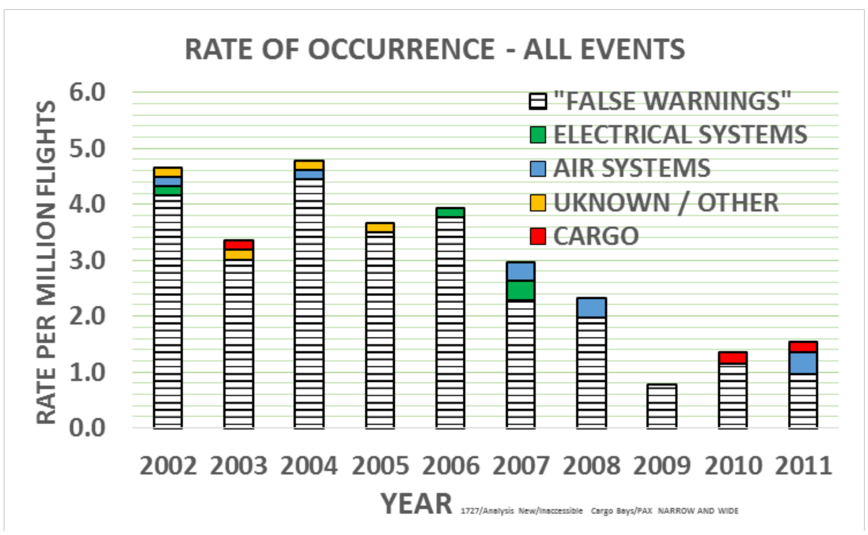

Figure 33. Inaccessible Cargo Bay - Rate of Occurrence of All Detector Events for Wide and Narrow Body Passenger Airplanes

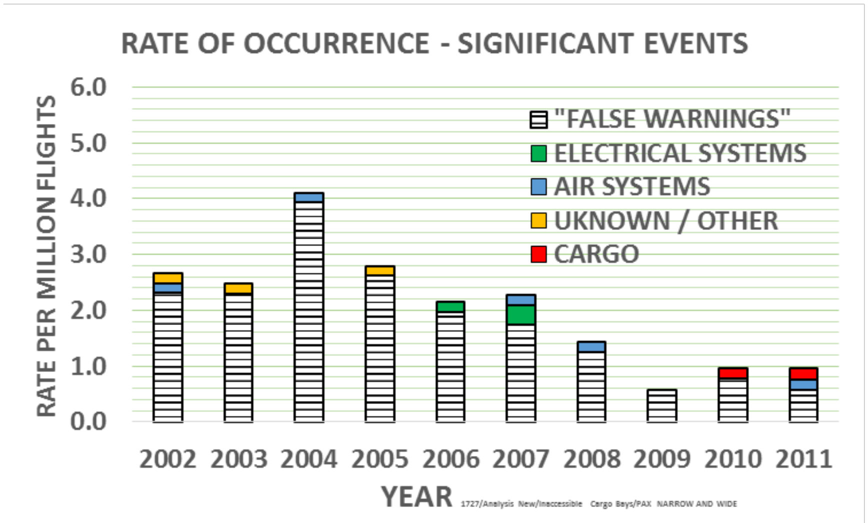

Figure 34. Inaccessible Cargo Bay - Rate of Occurrence of Significant Detector Events for Wide and Narrow Body Passenger Airplanes

<u>12.3 RATE OF OCCURRENCE OF DETECTOR EVENTS – FREIGHTER AIRPLANES</u>

The rate of occurrence of all detector events for inaccessible cargo bays on freighter airplanes is shown in figure 35 and for significant events in figure 36. The average rate over the study period was in the region of 4 per million flights for both all events and significant events. However, this has reduced over the latter period of the study and is now likely to be compatible with passenger airplanes.

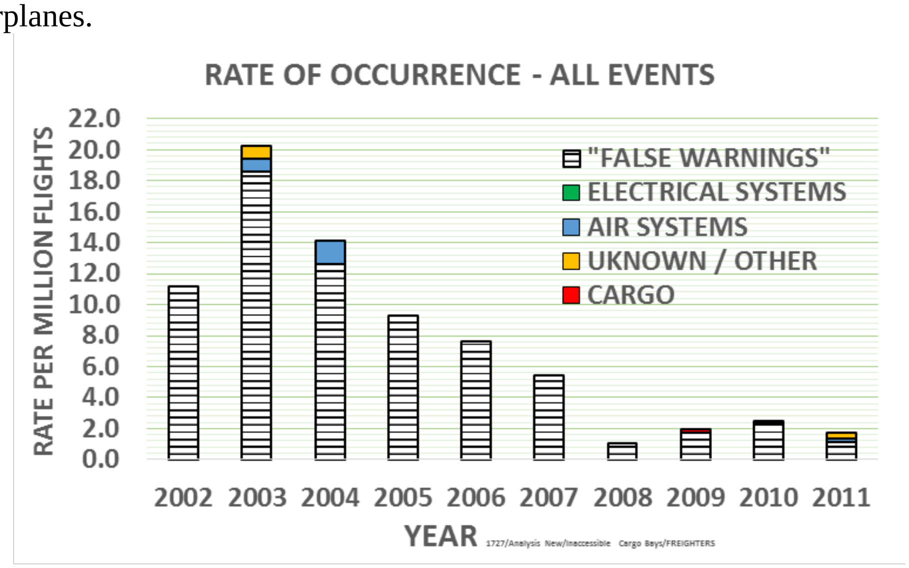

Figure 35. Inaccessible Cargo Bay - Rate of Occurrence of All Detector Events per Year for Freighter Airplanes

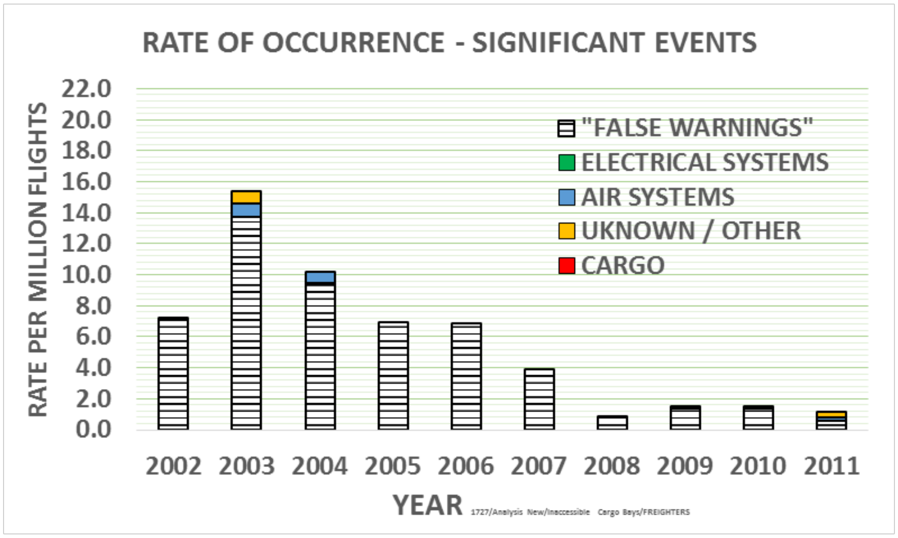

Figure 36. Inaccessible Cargo Bay - Rate of Occurrence of Significant Detector Events per Year for Freighter Airplanes

Observation 43 – INACCESSIBLE CARGO BAY – Passenger and Freighter Airplanes - Over the study period, the rate of occurrence per flight of detector events for inaccessible cargo bays appears to have diminished markedly for both passenger and freighter airplanes. For passenger airplanes the average rate was found to be in the region of 3 per million flights for all events and 2 per million flights for significant events in comparison with freighter airplanes where the rates were in the region of 4 per million flights for both all events and significant events.

12.4 DECTECTOR EVENTS BY FIRE, SMOKE OR FUME SOURCE

The breakdown of causes of all detector events for inaccessible cargo bays installed on passenger and freighter airplanes is shown in figure 37. Perhaps of most significance is the small proportion of events that are caused by fire, smoke or fumes from cargo. Three, and possibly four, occurrences were identified that were attributed to the cargo. These occurrences are shown in Appendix C.

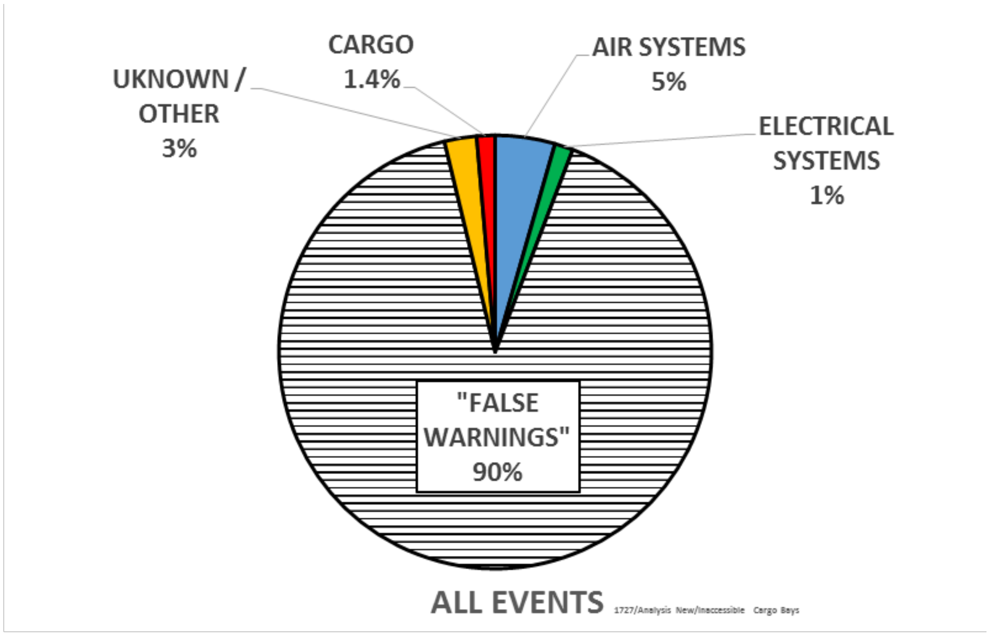

Figure 37. Inaccessible Cargo Bay Detector Events – by FSF Source

There is not a marked change in the breakdown of detector events by FSF source if only the significant events are considered. The breakdown is also similar for both passenger and freighter airplanes.

Observation 44 – INACCESSIBLE CARGO BAY – Passenger and Freighter Airplanes - It appears that approximately 1% of flight deck warnings of fire or smoke in inaccessible cargo bays result from actual fires.

<u>12.5 TRENDS IN FALSE WARNINGS</u>

Figure 38 illustrates the cumulative rate of occurrence per flight of false warning detector events. The data used to generate the curves is for all inaccessible cargo bay detector events - similar trends are experienced for significant events. The cumulative rates are derived by dividing the total number of events experienced from 2002 by the cumulative number of flights over the period. Since the rates shown in figure 38 are cumulative it is likely that freighter airplanes are currently experiencing actual rates that are similar to passenger airplanes.

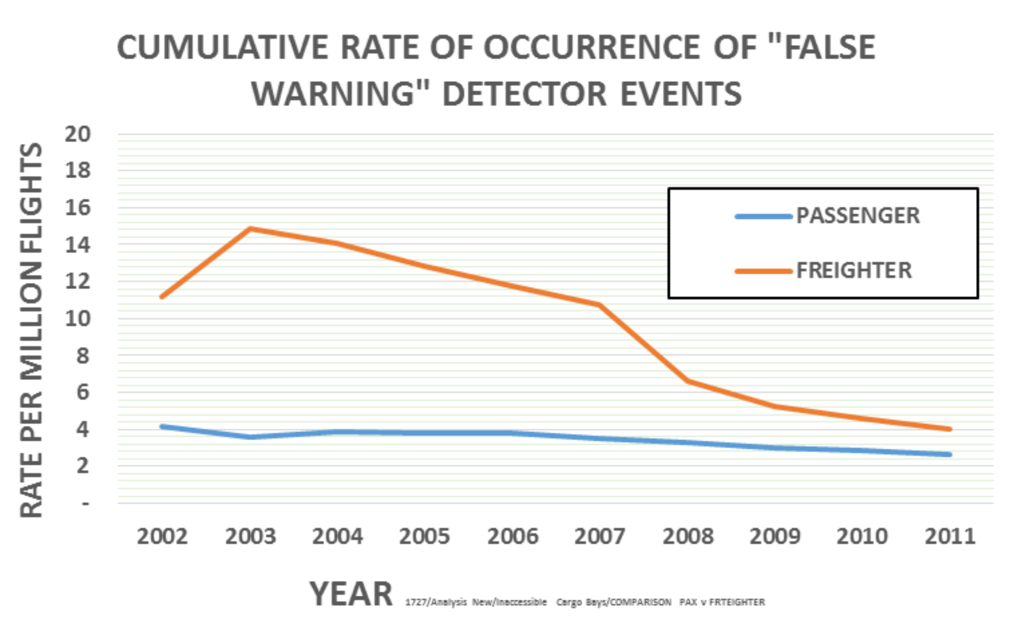

Figure 38. Inaccessible Cargo Bay - Rate of Occurrence of All False Warning Detector Events per Year for Freighter and Passenger Airplanes

Observation 45 – INACCESSIBLE CARGO BAY – Passenger and Freighter Airplanes - The rate of occurrence per flight of false warning detector events for inaccessible cargo bays on freighter airplanes appears to have improved markedly over the study period and is now likely to be compatible with passenger airplanes. While not as marked, it is likely that there has also been some improvement on passenger airplanes.

12.6 PROPORTION OF FALSE WARNINGS CAUSING FLIGHT DISRUPTIONS

Table 22 shows the proportion of inaccessible cargo bay false warning detector events that resulted in an unscheduled landing or a rejected take-off.

Table 22. Inaccessible Cargo Bay - Proportion of False Warnings resulting in Unscheduled Landings or Rejected Take-offs

	All False Warning Events	Unscheduled Landing	Unscheduled Landing Proportion	Rejected Take-off	Rejected Take-off Proportion
Narrow Passenger	123	71	58%	1	1%
Wide Passenger	25	17	68%	0	0%
All Passengers	148	88	59%	1	1%
All Freighters	115	66	57%	2	2%

1727/Analysis New/Inaccessible Cargo Bay

Observation 46 – INACCESSIBLE CARGO BAY – Passenger Airplanes - The data analysis suggests that approximately 60% of false warning detector events resulted in an unscheduled landing of which it is assessed that approximately 53% of these were diversions and 47% were returns to the departure airport. A further 1% of false warning inaccessible cargo bay detector events resulted in a rejected take-off.

Observation 47 – INACCESSIBLE CARGO BAY – Freighter Airplanes - The data analysis suggests that freighter airplanes have a similar proportion of false warning detector events that result in an unscheduled landing to passenger airplanes. It is assessed that approximately one third of these unscheduled landings were diversions and two thirds were return to the departure airport. A further 2% of false warning inaccessible cargo bay detector events resulted in a rejected take-off.

13. ACCESSIBLE CARGO BAYS

13.1 ANNUAL NUMBER OF DETECTOR EVENTS

The annual number of detector events for accessible cargo bays shows no significant discernible trend over the period 2002 to 2011 as illustrated in figure 39. This chart relates to all detector events irrespective of the cause or its consequences.

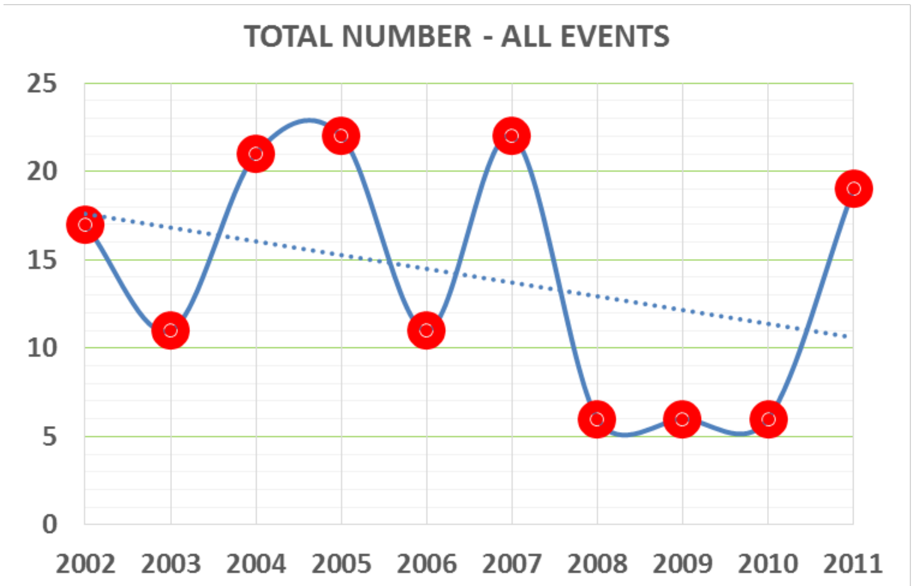

Figure 39. Accessible Cargo Bay - Number of Detector Events per Year

Observation 48 – ACCESSIBLE CARGO BAYS – No significant discernible change in the annual number of detector events for accessible cargo bays was identified over the study period with the average being in the region of 14 per year.

13.2 RATE OF OCCURRENCE OF DETECTOR EVENTS – PASSENGER AIRPLANES

Accessible cargo bays were only found on regional passenger airplanes. Hence, the flights and landings data for this category of airplanes were utilized. No significant trend in the rate of occurrence of detector events for accessible cargo bays on regional airplanes can be determined from the data analyzed as illustrated in figure 40. The average rate over the study period was in the region of 3 per million flights.

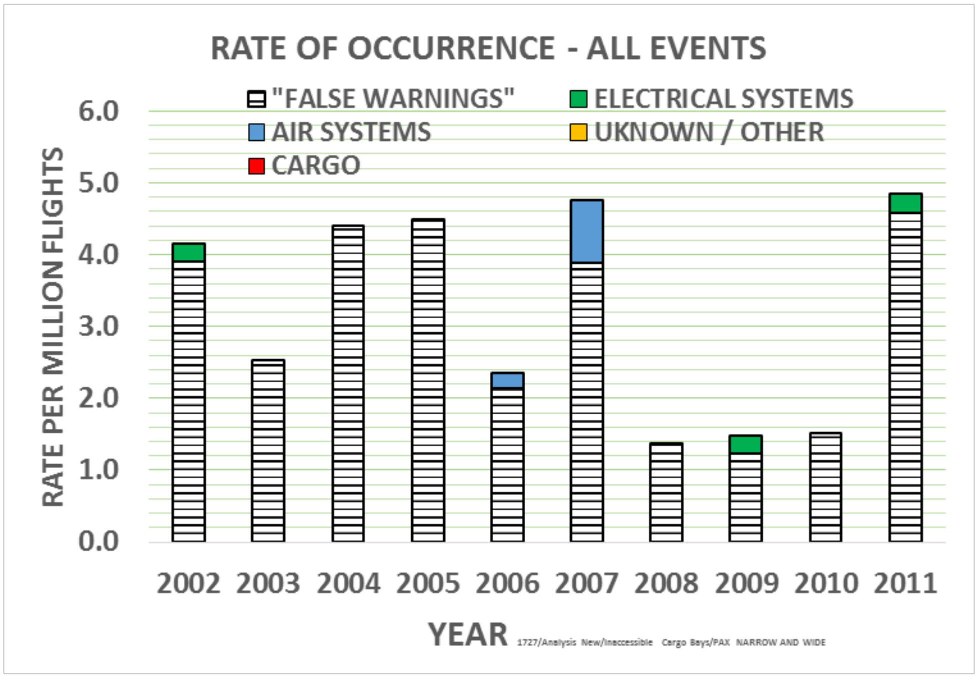

Figure 40. Accessible Cargo Bay - Rate of Occurrence of Detector Events per Year for Regional Passenger Airplanes

Observation 49 – ACCESSIBLE CARGO BAYS – Passenger Airplanes (Regional) - No discernible change in the rate of occurrence per flight of detector events for accessible cargo bays was identified over the study period with the average rate being in the region of 3 per million flights.

13.3 DETECTOR EVENTS BY FIRE, SMOKE OR FUME SOURCE

Figure 41 shows the cause of detector events for accessible cargo bays based on all events. The proportion of events that are considered to be false warning is approximately 94% with no occurrences found that were caused by the cargo. The proportion of false warnings is similar when consideration is given to only significant events.

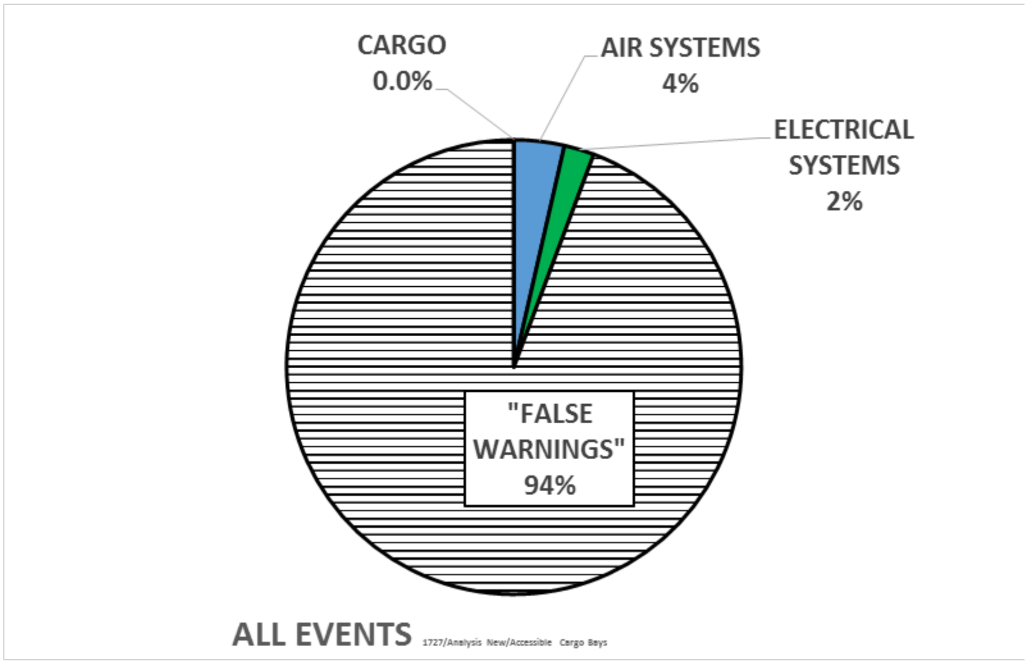

Figure 41. Accessible Cargo Bay - Detector Events – by FSF Source

Observation 50 – ACCESSIBLE CARGO BAYS – Passenger Airplanes (Regional) - No actual fires in accessible cargo bays were identified in the study with approximately 94% of detector events being classified as false warnings – the remaining detector events were attributed to the aircraft systems.

13.4 TRENDS IN FALSE WARNINGS

Observation 51 – ACCESSIBLE CARGO BAYS – Passenger Airplanes (Regional) - Since approximately 94% of detector events are considered to be false warnings the rate of occurrence of false warnings is similar to all detector events i.e.; approximately 3 per million flights.

13.5 PROPORTION OF FALSE WARNINGS CAUSING FLIGHT DISRUPTIONS

Table 23 shows the proportion of cccessible cargo bay false warning detector events that resulted in an unscheduled landing or a rejected take-off to regional passenger airplanes.

Table 23. Accessible Cargo Bay - Proportion of False Warnings resulting in Unscheduled Landings or Rejected Take-offs

	All False Warning Detector Events	Number of Unscheduled Landings	Unscheduled Landing Proportion	Number of Rejected Take-offs	Rejected Take-off Proportion
Regional Airplanes	141	37	26%	4	3%

1727/Analysis New/Accessible Cargo Bays

Observation 52 – ACCESSIBLE CARGO BAYS – Passenger Airplanes (Regional) - The data analysis suggests that approximately one quarter of accessible cargo bay false warnings detector events resulted in an unscheduled landing of which it is assessed that approximately 20 percent of these were diversions and approximately 80 percent were returns to the departure airport. A further 3% of accessible cargo bay false warnings detector events resulted in a rejected take-off.

14. MAIN DECK CARGO BAYS – FREIGHTER AIRPLANES

14.1 ANNUAL NUMBER OF DETECTOR EVENTS

The annual number of detector events for main deck cargo bays is illustrated in figure 42.

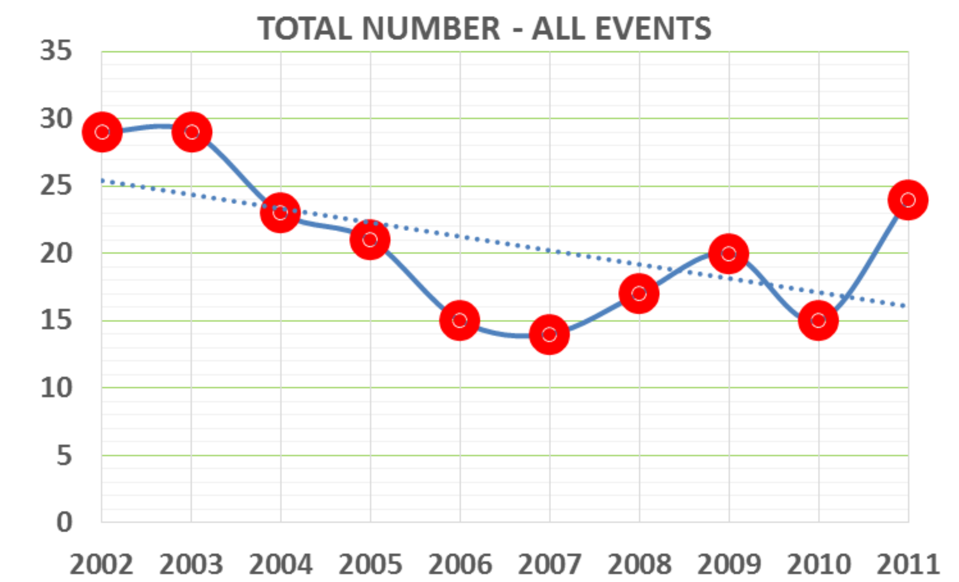

Figure 42. Main Deck Cargo Bay - Number of Detector Events per Year

Observation 53 – MAIN DECK CARGO BAYS – Freighter Airplanes – While inconclusive, it appears that there may be a reduction in the annual number of detector events for main deck cargo bays over the study period with the average being approximately 20 per year.

14.2 RATE OF OCCURRENCE OF DETECTOR EVENTS – FREIGHTER AIRPLANES

The rate of occurrence of all detector events for freighter airplanes is shown in figure 43 and for significant events in figure 44. The average rate over the study period was in the region of 17 per million flights for all detector events and 10 per million flights for significant detector events.

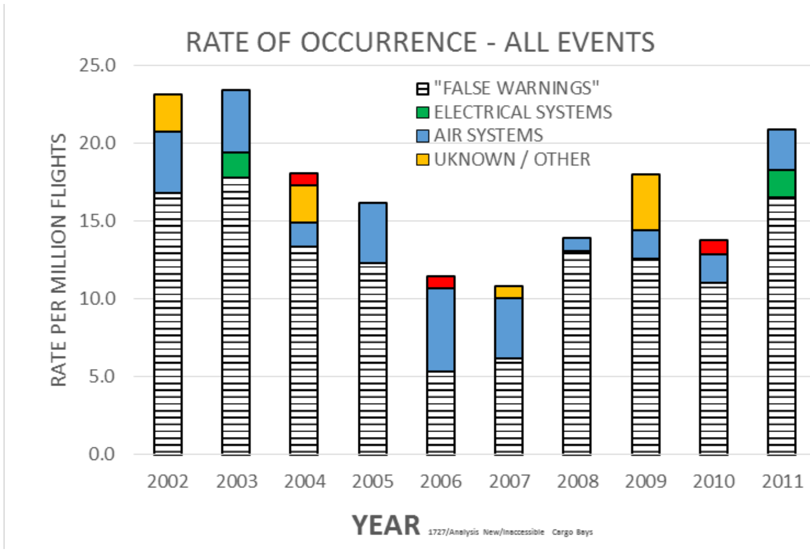

Figure 43. Main Deck Cargo Bay - Rate of Occurrence of All Detector Events per Year for Freighter Airplanes

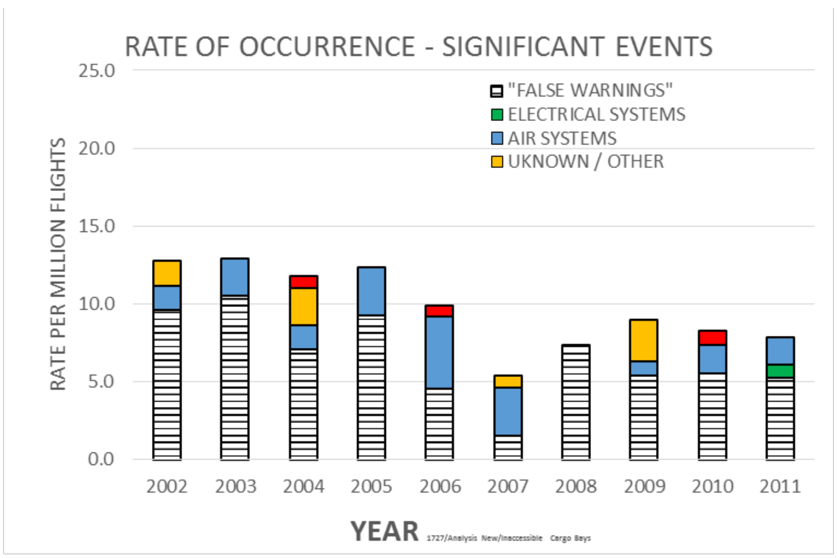

Figure 44. Main Deck Cargo Bay - Rate of Occurrence of Significant Detector Events per Year for Freighter Airplanes

Observation 54 – MAIN DECK CARGO BAYS – Freighter Airplanes - The rate of occurrence per flight of significant detector events for main deck cargo bays appears to have made some modest improvement over the study period.

14.3 DECTECTOR EVENTS BY FIRE, SMOKE OR FUME SOURCE

The breakdown of causes of detector events is shown in figure 45 for main deck cargo bays. All events are considered in the data used to derive figure 45. As was seen with the smaller inaccessible and accessible cargo bays the proportion of events that are caused by fire, smoke or fumes from cargo is small – being approximately 1.4%. It is therefore likely that for main deck cargo bays approximately 98.6% of flight deck fire annunciations are not caused by fire, smoke or fumes originating from the cargo.

Only three occurrences were identified that were attributed to the cargo and all of them resulted in the aircraft being destroyed with the accident in 2010 resulting in the death of both flight crew members. These occurrences are shown in Appendix D. A further 2 events were identified where there were in-flight reports of fumes from the cargo but they were not reported as detector events.

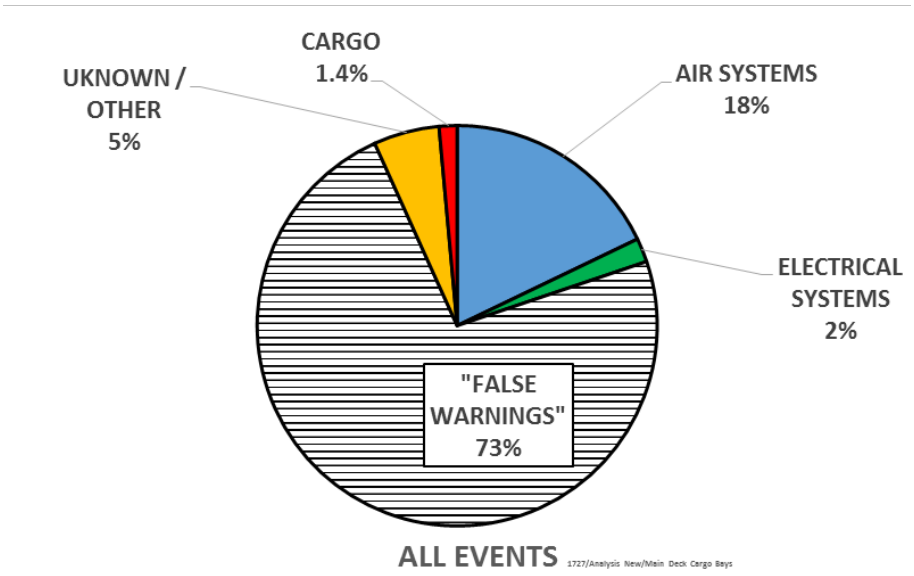

Figure 45. Main Deck Cargo Bay - Detector Events by FSF Source

Observation 55 – MAIN DECK CARGO BAYS – Freighter Airplanes - It is likely that for main deck cargo bays approximately 98.6% of flight deck fire annunciations are not caused by fire, smoke or fumes originating from the cargo.

Observation 56 – MAIN DECK CARGO BAYS – Freighter Airplanes - Three cargo bay fires were identified over the study period and all resulted in the aircraft being destroyed with the accident in 2010 resulting in the death of the two crew members. These three events constitute 1.4% of main deck cargo bay detector events. A further two events were identified where there were in-flight reports of fumes from the cargo but they were not reported as detector events.

14.4 TRENDS IN FALSE WARNINGS

Figure 46 illustrates the cumulative rate of occurrence per flight of false warning detector events. The data used to generate the curve is for all inaccessible cargo bay detector events. The cumulative rate of occurrence per flight of significant false warning events is shown in figure 47. The cumulative rates are derived by dividing the total number of events experienced from 2002 and dividing by the cumulative number of flights over the period.

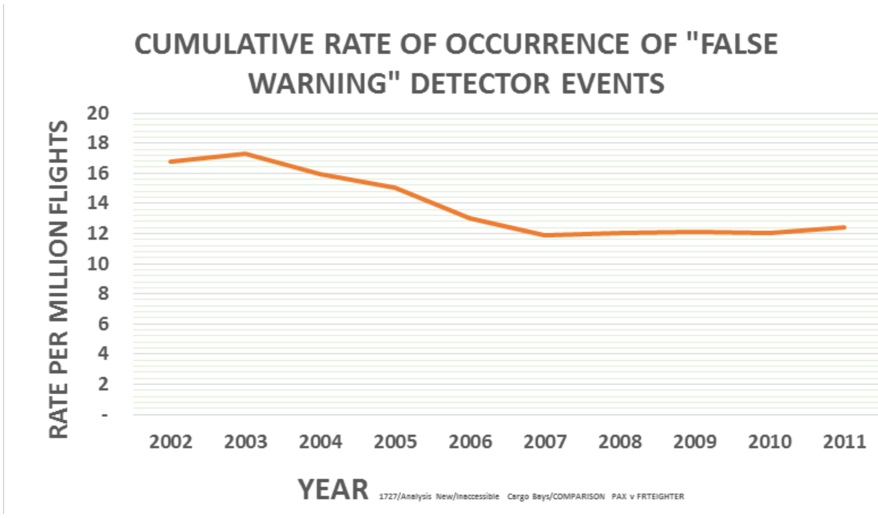

Figure 46. Main Deck Cargo Bay - Rate of Occurrence of All False Warning Detector Events per Year

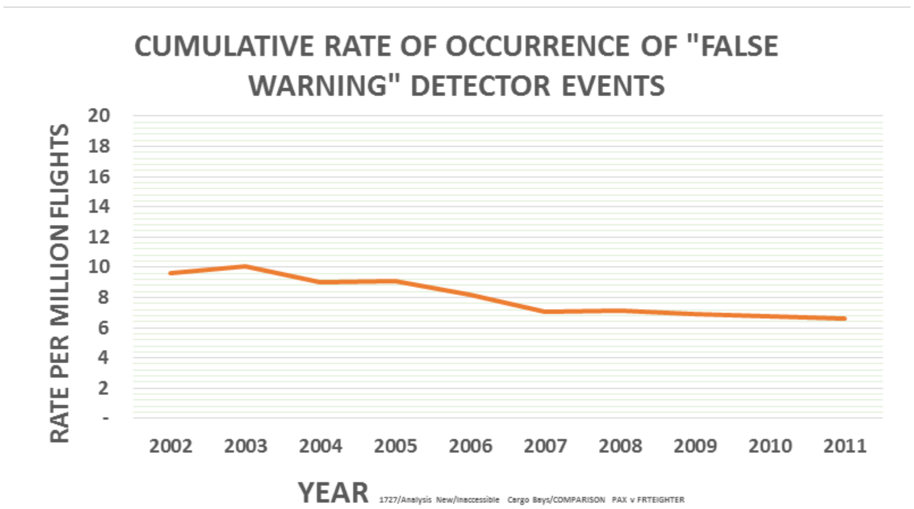

Figure 47. Main Deck Cargo Bay - Rate of Occurrence of Significant False Warning Detector Events per Year

Observation 57 – MAIN DECK CARGO BAYS – Freighter Airplanes – false warning detector events for main deck cargo bays appear to have made some modest improvement over the study period.

14.5 PROPORTION OF FALSE WARNINGS CAUSING FLIGHT DISRUPTIONS

Table 24 shows the proportion of false warning detector events that resulted in an unscheduled landing or a rejected take-off to freighter airplanes.

Table 24. Main Deck Cargo Bay - Proportion of False Warnings Resulting in Unscheduled Landings or Rejected Take-offs

	All False Warning Events	Unscheduled Landing	Unscheduled Landing Proportion	Rejected Take-off	Rejected Take-off Proportion
All Freighters	151	61	40%	10	7%

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Observation 58 – MAIN DECK CARGO BAYS – Freighter Airplanes - The data analysis suggests that approximately 40% of false warning detector events resulted in an unscheduled landing of which it is assessed that approximately one third were diversions and two thirds were returns to the departure airport. A further 7% of false warning detector events resulted in a rejected take-off.

15. LAVATORIES

15.1 ANNUAL NUMBER OF DETECTOR EVENTS

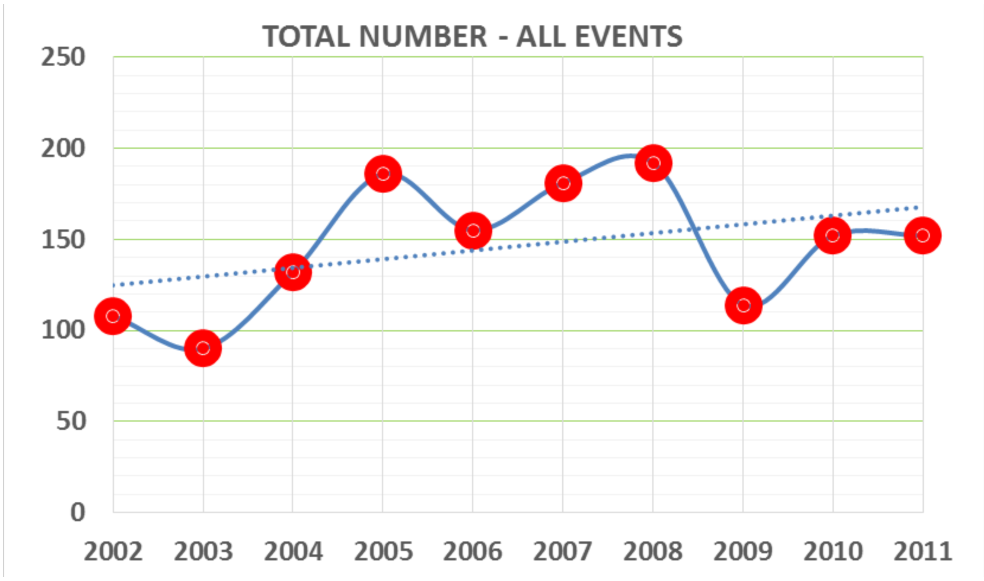

Figure 48. Lavatory - All Detector Events per Year for Passenger Airplanes

Observation 59 – LAVATORY – Passenger Airplanes - The data analysis suggests that the annual number of all lavatory detector events is approximately 150 per year.

15.2 RATE OF OCCURRENCE OF DETECTOR EVENTS

Figure 49 and figure 50 show the rate of occurrence of all lavatory detector events and significant detector events for passenger airplanes respectively. No conclusive trends are illustrated from these data. The variation in annual rates is likely to be caused by various factors including recurrent airplane faults.

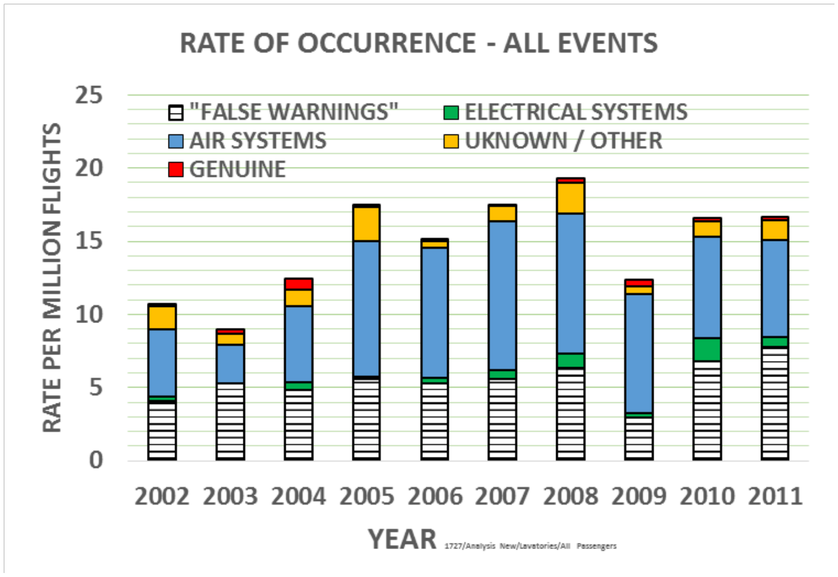

Figure 49. Lavatory - Rate of Occurrence of All Detector Events per Year for Passenger Airplanes

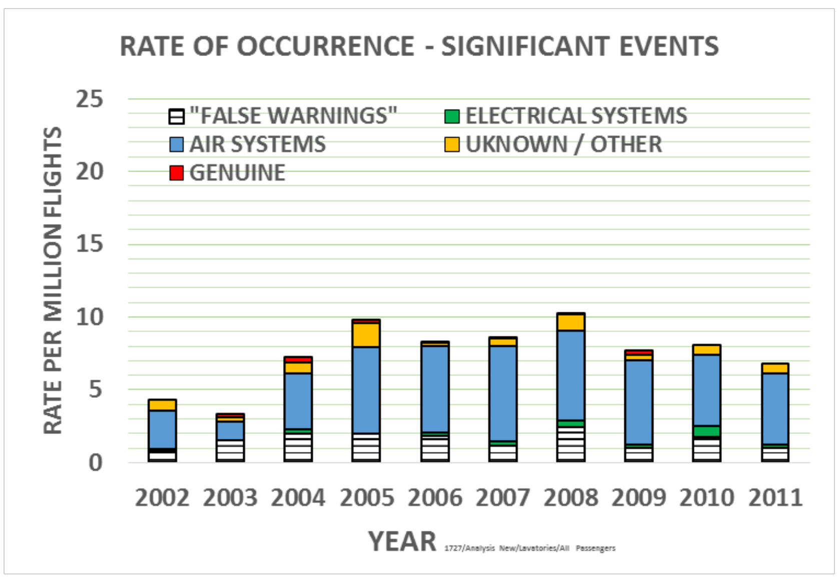

Figure 50. Lavatory - Rate of Occurrence of Significant Detector Events per Year for Passenger Airplanes

Observation 60 – LAVATORY – Passenger Airplanes - The analysis of data did not reveal any discernible trends in the rate of occurrence of lavatory detector events with an average rate over the study period of approximately 15 per million flights for all events and 8 per million flights for significant events.

15.3 DETECTOR EVENTS BY FIRE, SMOKE OR FUME SOURCE

Figure 51 and figure 52 show all and significant detector events for lavatories in all passenger airplanes.

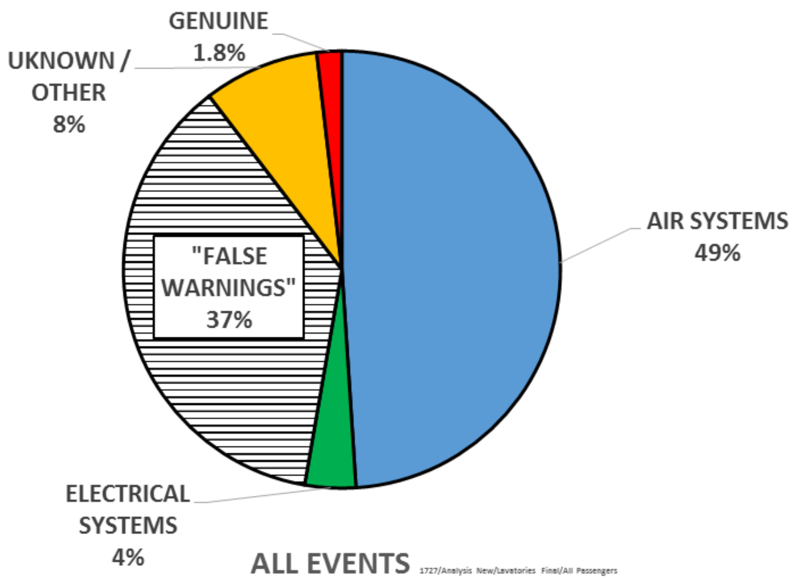

Figure 51. Lavatory - Passenger Airplane All Detector Events – by FSF Source

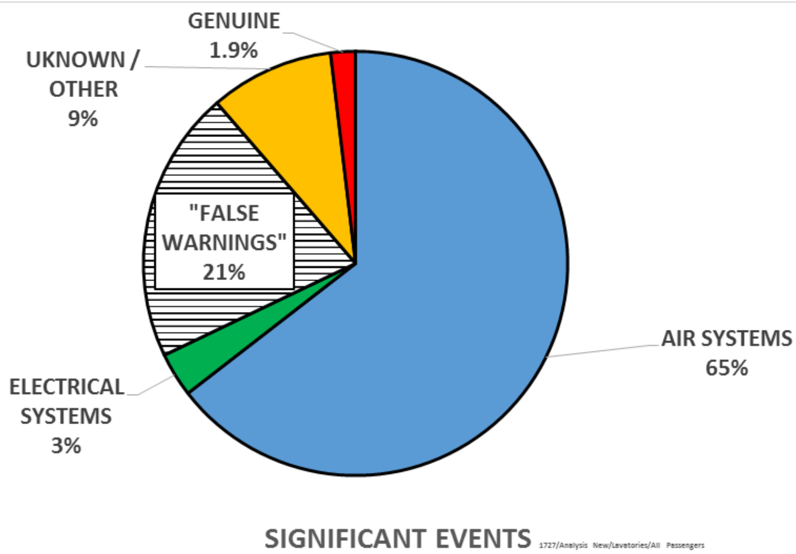

Figure 52. Lavatory - Passenger Airplane Significant Detector Events – by FSF Source

The genuine events relate to any fire, smoke or fume event originating in the lavatory. They will include fire, smoke or fumes associated with electrical systems within the lavatory – lights, fans, water heaters, etc., as well as combustible materials. However, smoke or fumes generated outside of the lavatory e.g.; from cabin lighting, but entering into the lavatory were allocated to the group of events – Electrical Systems. This allocation is quite arbitrary and dependent on what is considered to be a genuine or false warning. The remainder are attributable to airplane systems – predominately the air system (engines, APU, bleed system and air conditioning systems).

Observation 61 – LAVATORY – Passenger Airplanes - Approximately 2% of lavatory detector events result from fire, smoke or fumes originating in the lavatory. The proportion of the detector events that are associated with faults in the detection system (false warnings) is approximately 37% for all events and 21% for significant events. The remainder are attributable to airplane systems – predominately the air system (engines, APU, bleed system and air conditioning systems).

15.4 TRENDS IN FALSE WARNINGS

Figure 53 illustrates the cumulative rate of occurrence per flight of false warning detector events. The data used to generate the curve is for all lavatory false warning detector events. The cumulative rate is derived by dividing the total number of events experienced from 2002 by the cumulative number of flights over the period.

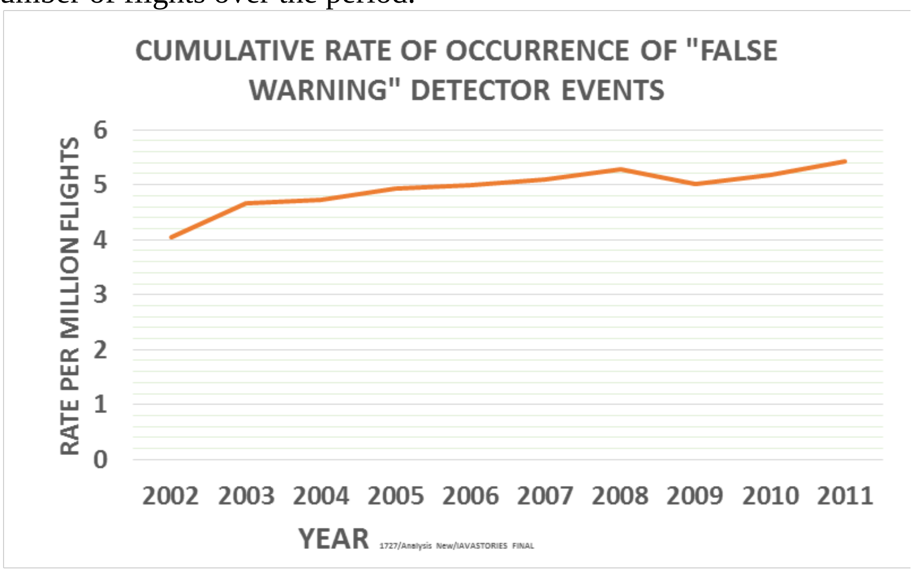

Figure 53. Lavatories - Cumulative Rate of Occurrence of All False Warning Detector Events per Year for Passenger Airplanes

Observation 62 – LAVATORY – Passenger Airplanes - The analysis of data suggests some increase in the rate of occurrence of false warning detector events in lavatories over the study period. The average rate of occurrence is in the region of 5.5 per million flights.

15.5 PROPORTION OF FALSE WARNINGS CAUSING FLIGHT DISRUPTIONS

Table 25 shows the proportion of false warning lavatory detector events that result in an unscheduled landing or a rejected take-off. The breakdown of events is presented for regional, narrow and wide body airplanes and for freighter airplanes.

Table 25. Lavatory - Proportion of False Warnings resulting in Unscheduled Landings or Rejected Take-offs

	All False Warning Detector Events	Number of Unscheduled Landings	Unscheduled Landing Proportion	Number of Rejected Take-offs	Rejected Take-off Proportion
Regional Passenger Airplanes	440	112	25%	19	4%
Narrow Passenger Airplanes	59	8	14%	0	0%
Wide Passenger Airplanes	40	1	3%	0	0%
All Passenger Airplanes	539	121	22%	0	0%
All Freighter Airplanes	4	0	0%	0	0%

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Observation 63 – LAVATORY – Passenger Airplanes - Typically 22% of false warning lavatory detector events result in an unscheduled landing. However, for regional passenger airplanes this proportion is approximately 25%, for narrow body passenger airplanes 14%, and for wide body passenger airplanes 3%, suggesting that the larger, longer flight time airplanes are less likely to return to the departure airfield or divert due to false warnings. Approximately 8% of these unscheduled landings are diversions. The remainder are returns to the departure airport. There were no freighter airplane flight disruptions resulting from lavatory false warnings identified in the study.

Observation 64 – LAVATORY – Passenger Airplanes - The study identified only 19 rejected take-offs resulting from false warning lavatory detector events and they were all on regional passenger airplanes.

16. E & E BAYS

16.1 ANNUAL NUMBER OF DETECTOR EVENTS

Figure 54 shows the total number of E & E bay detector events per year for all airplanes (passenger and freighter). The average is approximately 20 per year.

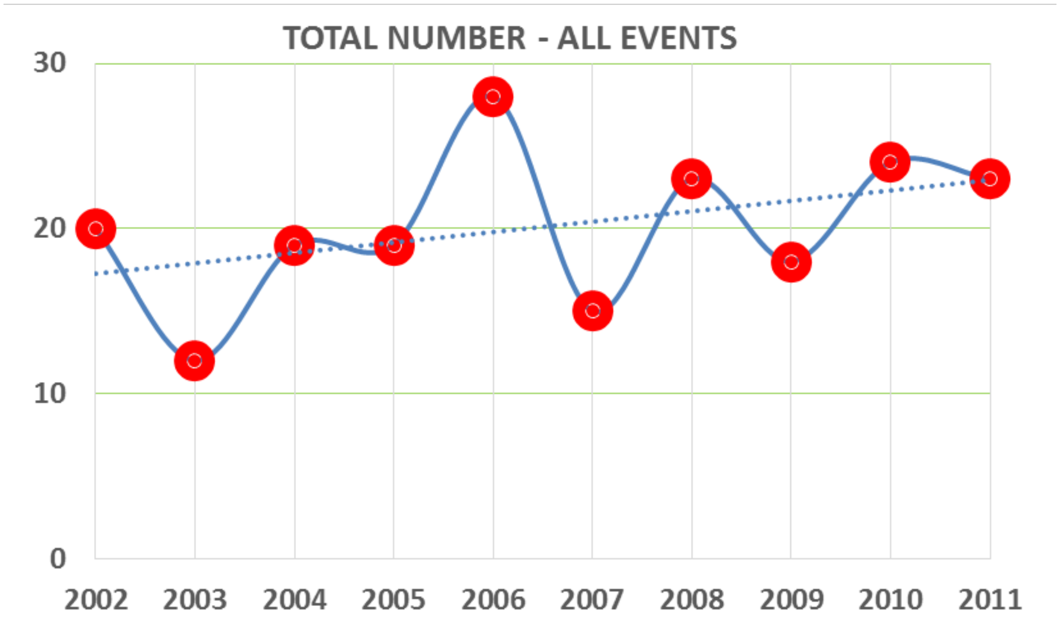

Figure 54. E & E Bay - Detector Events per Year

16.2 RATE OF OCCURRENCE IN DETECTOR EVENTS

Figure 55 and Figure 56 show the rate of occurrence of all E & E bay detector events and significant E & E bay detector events. The data relates to all airplanes – passenger and freighter. No conclusive trends are illustrated from these data. The variation in annual rates is likely to be caused by various factors including recurrent airplane faults.

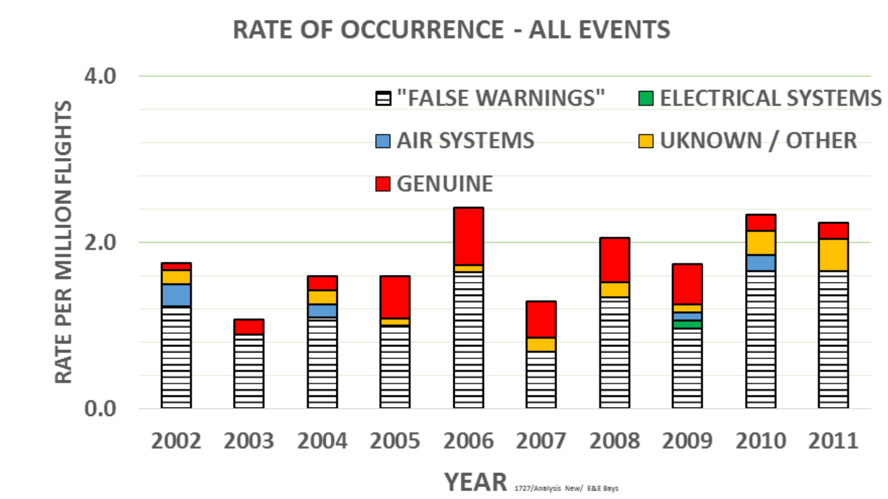

Figure 55. E & E Bay - Rate of Occurrence of All Detector Events per Year for All Airplanes

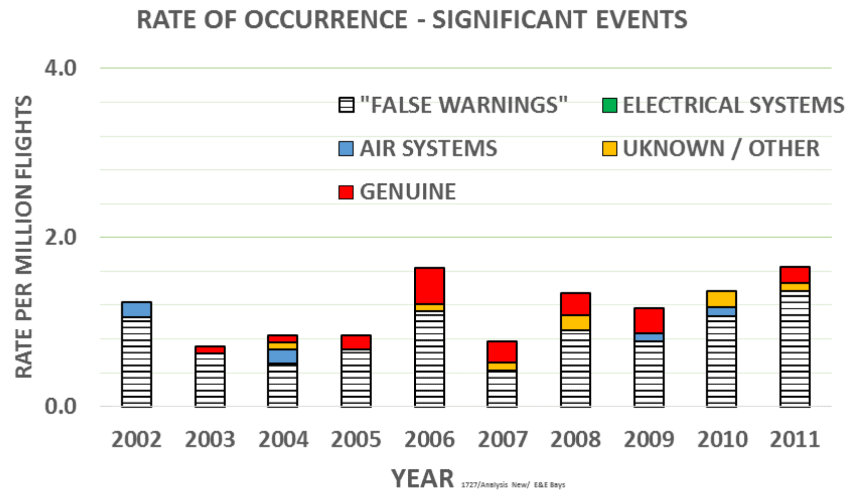

Figure 56. E & E Bay - Rate of Occurrence of Significant Detector Events per Year for All Airplanes

Observation 65 – E & E BAY – Passenger and Freighter Airplanes - There appears to be no significant trend in the annual number of detector events with an annual average of approximately 20 per year, nor in the rate of occurrence of detector events with an average of 1.8 per million flights for all events and 1.1 per million flights for significant events.

16.3 DETECTOR EVENTS BY FIRE, SMOKE OR FUME SOURCE

Figure 57 and figure 58 show all and significant detector events for E & E bays in all airplanes.

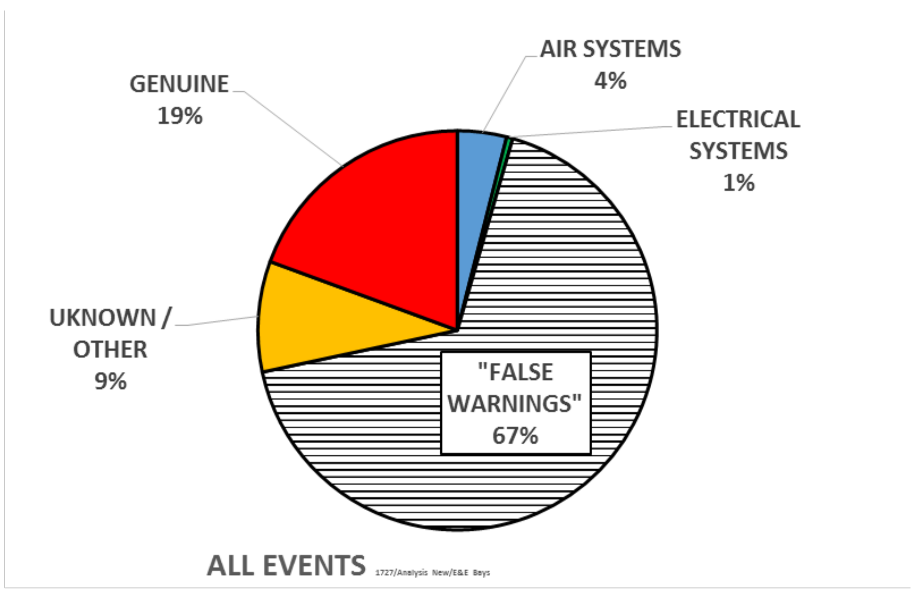

Figure 57. E & E Bay - All Detector Events – by FSF Source

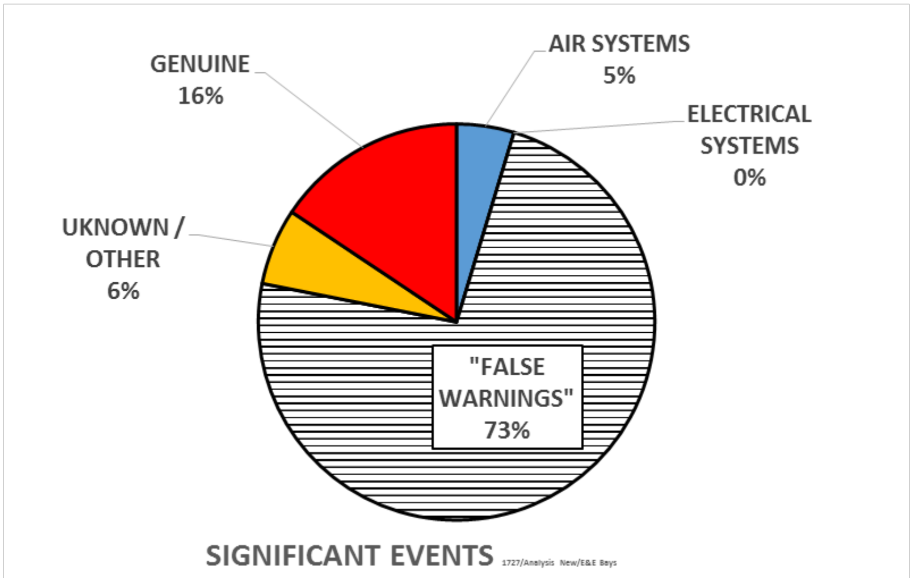

Figure 58. E & E Bay - Significant Detector Events – by FSF Source

The genuine events relate to any fire, smoke or fume event considered to have originated in the E & E bay. The category of events categorized as false warnings relate to faults considered to originate within the detection system.

Observation 66 – E & E bAY – Passenger and Freighter Airplanes - In the region of 15% to 20% of E & E bay detector events are likely to be caused by smoke or fumes originating in the bay. The proportion of the detector events that are false warnings is approximately 70%.

16.4 TRENDS IN FALSE WARNINGS

Observation 67 – E & E BAY – Passenger and Freighter Airplanes - The analysis of data did not reveal any discernible trends in the rate of occurrence of false warnings detector events suggesting no significant improvement in the false warning rate over the study period. The average rate of occurrence is approximately 1.2 per million flights for all false warnings and 0.8 per million flights for significant false warnings.

16.5 PROPORTION OF FALSE WARNINGS CAUSING FLIGHT DISRUPTIONS

Table 26 shows the proportion of false warning E & E bay detector events that result in an unscheduled landing or a rejected take-off. The breakdown of events is presented for regional, narrow, and wide body passenger airplanes and for freighter airplanes.

Table 26. E & E Bay - Proportion of False Warnings Resulting in Unscheduled Landings or Rejected Take-offs

	All False Warning Detector Events	Number of Unscheduled Landings	Unscheduled Landing Proportion	Number of Rejected Take-offs	Rejected Take-off Proportion
Regional Passenger Airplanes	63	21	33%	5	8%
Narrow Passenger Airplanes	32	25	78%	1	3%
Wide Passenger Airplanes	4	4	100%	0	0%
All Passenger Airplanes	99	50	51%	6	6%
All Freighter Airplanes	36	22	61%	3	8%

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Observation 68 – E&E BAY – Passenger and Freighter Airplanes - Approximately 51% of false warnings in E&E bay for passenger airplanes result in an unscheduled landing and 61% on freighter airplanes. However, there is significant variation among airplane categories suggesting that the smaller, shorter flight time airplanes are less likely to return to the departure airport or divert due to false warnings perhaps due to the closer proximity of destination airfields. Less than 25% of unscheduled landings are diversions. The remainder are returns to the departure airport.

Observation 69 – E&E BAY – Passenger and Freighter Airplanes - The study identified only 9 rejected take-offs resulting from false warning E & E bay detector events. This sample size is too small to make any observations regarding variations among airplane categories.

17. CREW REST AREAS

17.1 ANNUAL NUMBER OF DETECTOR EVENTS

Crew rest areas were found only on wide body airplanes. The analysis was carried out on passenger and freighter airplanes combined. The annual number of crew rest area detector events for passenger and freighter wide body airplanes is shown in figure 59. The average is approximately 2.5 per year.

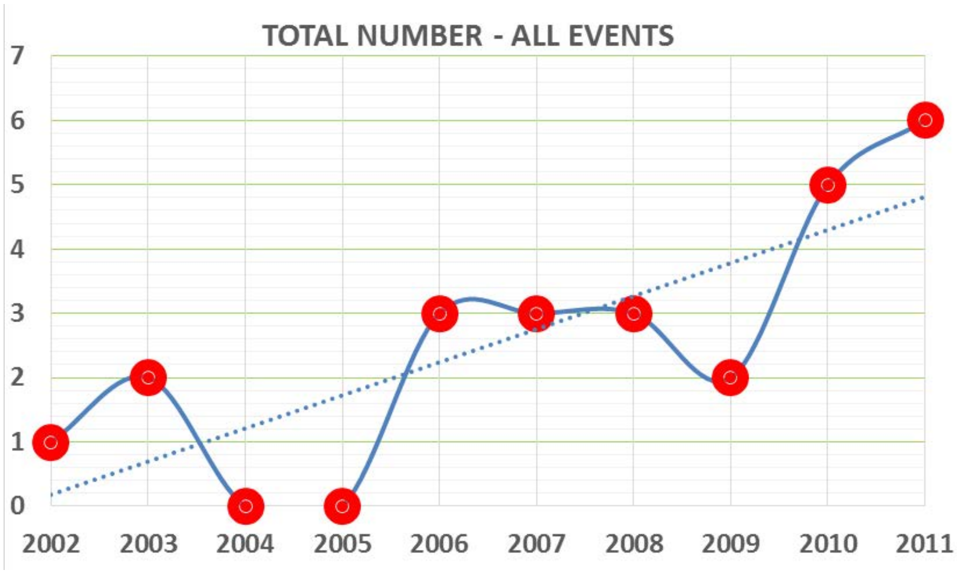

Figure 59. Crew Rest Areas - Wide Body Airplane Detector Events per Year

Observation 70 – CREW REST AREAS – Passenger and Freighter Airplanes – While the number of occurrences per year of Detector events for crew rest areas seems to be increasing, the data set is small and no firm conclusions can be made in this respect regarding trends. The average number over the study period was 2.5 per year.

17.2 RATE OF OCCURRENCE OF DETECTOR EVENTS

Observation 71 – CREW REST AREAS – Passenger and Freighter Airplanes - While the rate of occurrence of detector events for crew rest areas seems to be increasing, the data set is small and no firm conclusions can be made in this respect regarding trends. The average rate over the study period was 3.6 per million flights.

17.3 DETECTOR EVENTS BY FIRE, SMOKE OR FUME SOURCE

Figure 60 shows the causes of all detector events for crew rest areas in wide body passenger airplanes.

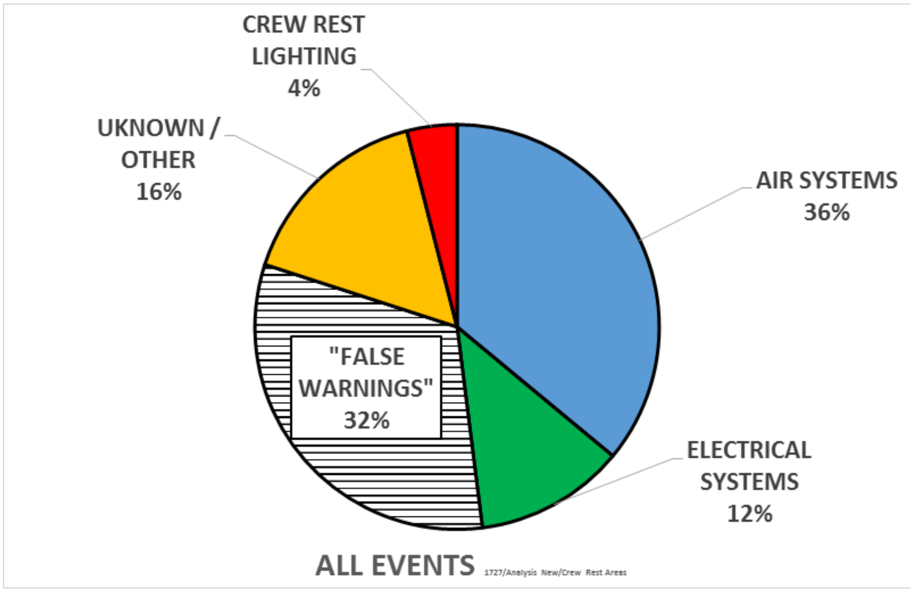

Figure 60. Crew Rest Areas - Causes of All Detector Events

Since the sample size was small, the detector events with the unknowns were removed from the analysis so that a more representative division of the causes could be established. These proportions are shown in figure 61. The most frequent cause of a detector event was found to be the airplane air systems (engines, APU, bleed system and air conditioning systems). Only one of the events (approx. 4%) was directly associated with the crew rest area and was attributable to the lights. In the region of one third of the events were associated with faults in the detection system - false warnings.

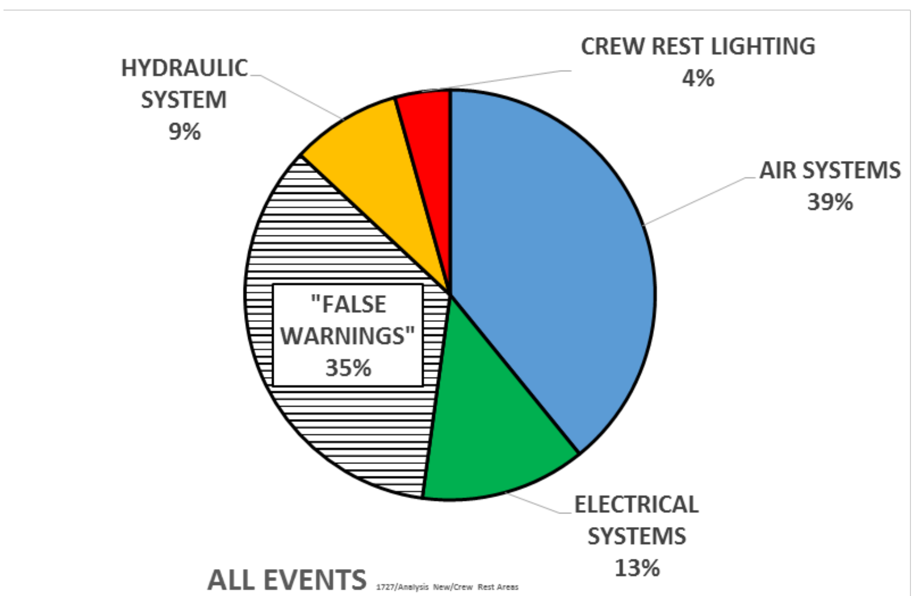

Figure 61. Crew Rest Areas - Identified Causes of All Detector Events

There were only five significant detector events associated with cabin crew rest areas. Three resulted in a return to the departure airport, one a diversion and one a rejected take-off.

Observation 72 – CREW REST AREAS – Passenger and Freighter Airplanes - Only one detector event (approx. 4%) was directly associated with FSF originating in the crew rest area and was attributable to the lights. In the region of one third of the events were associated with faults in the detection system - false warnings. The remainder of the detector events were attributable to the aircraft systems predominantly air systems (engines, APU, bleed system and air conditioning systems).

17.4 TRENDS IN FALSE WARNINGS

Observation 73 – CREW REST AREAS – Passenger and Freighter Airplanes - The average rate of occurrence of false warning detector events over the study period was in the region of 1 per million flights. While this seems to be increasing, the data set is small and no firm conclusions can be made in this respect.

17.5 PROPORTION OF FALSE WARNINGS CAUSING FLIGHT DISRUPTIONS

Observation 74 – CREW REST AREAS – Passenger and Freighter Airplanes - There were only five significant detector events found for crew rest areas. Two of these were attributed to fumes from the air systems originating from the engine. The remaining three were false warning detector events. These three events resulted in one rejected take-off, a diversion and a return to the departure airport.

18. WHEEL WELLS

18.1 ANNUAL NUMBER OF DETECTOR EVENTS

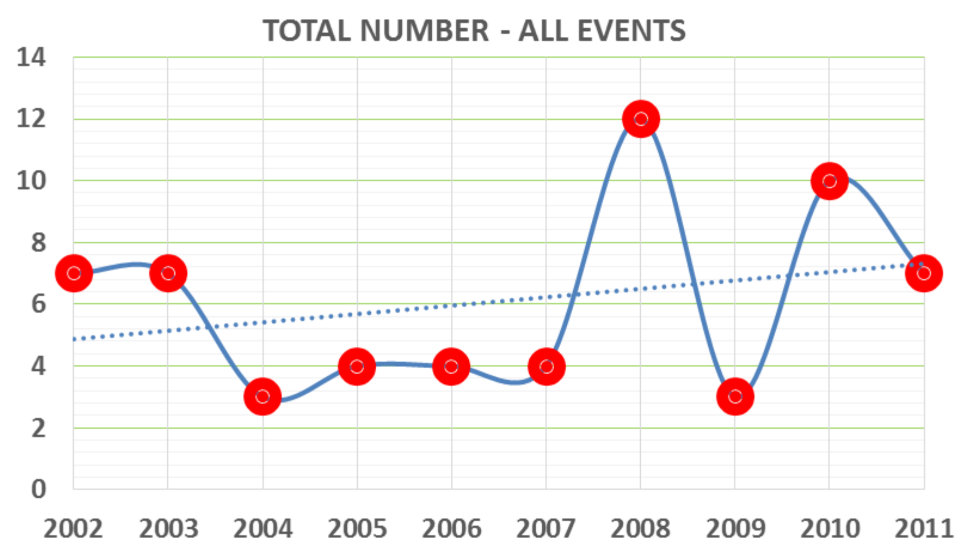

Figure 62. Wheel Wells - All Airplane Detector Events per Year

Observation 75 – WHEEL WELL – Passenger and Freighter Airplanes - A total of 61 wheel well detector events were found. The annual number of all wheel well detector events found in the analysis was approximately 6 per year. Of these approximately 75% resulted in significant events.

18.2 RATE OF OCCURRENCE OF DETECTOR EVENTS

Observation 76 – WHEEL WELL – Passenger and Freighter Airplanes - No discernible trend was identified for detector events in wheel wells. Rates of occurrence could not be determined since the number of airplanes fitted with wheel well detection systems is unknown.

18.3 DETECTOR EVENTS BY FIRE, SMOKE OR FUME SOURCE

The breakdown of causes of detector events for all wheel well events is shown in figure 63 and for significant events in figure 64.

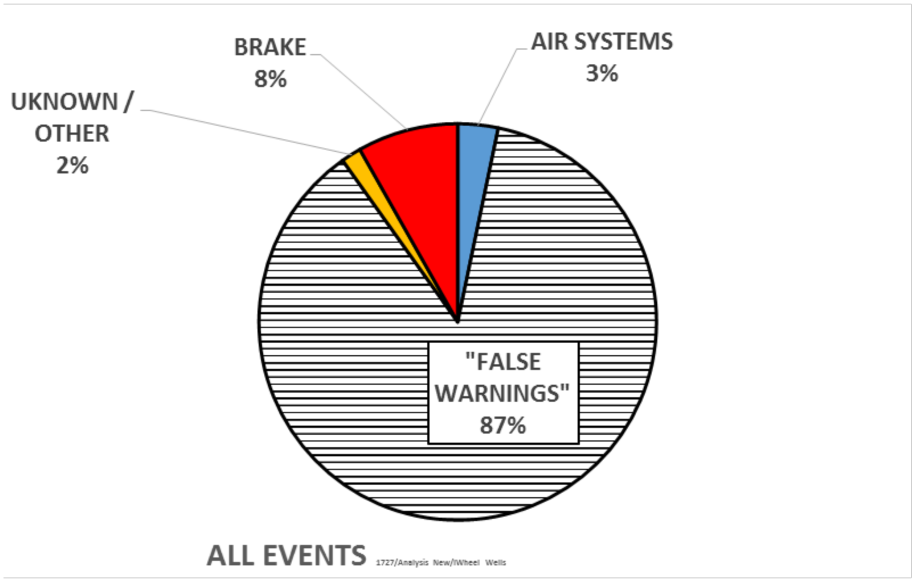

Figure 63. Wheel Wells - Causes of All Detector Events

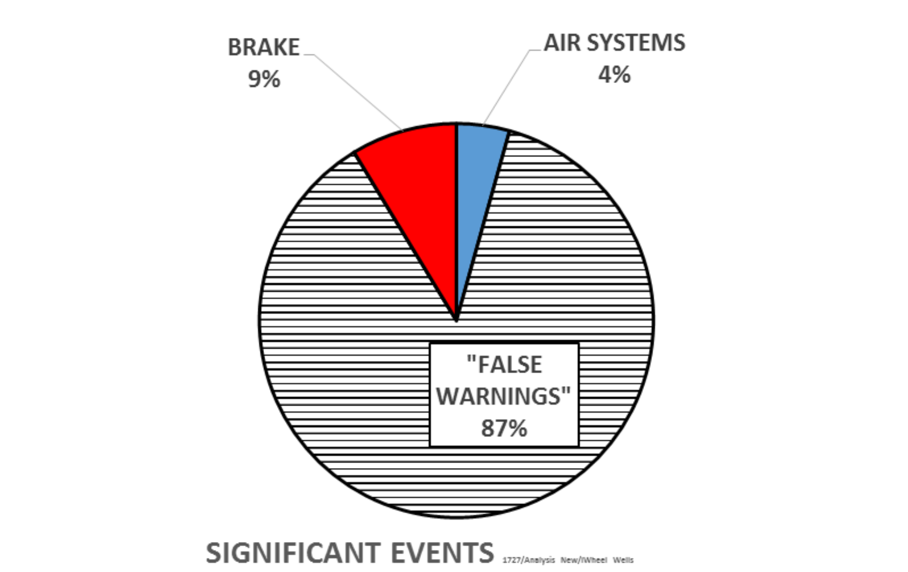

Figure 64.   Wheel Wells - Causes of Significant Detector Events

Observation 77 – WHEEL WELL – Passenger and Freighter Airplanes - Approximately 87% of flight deck annunciations of wheel well fires are false warnings. Less than 9% are caused by fire, smoke or fumes associated with the brakes. The remainder are caused by the airplane's air systems (engines, bleed system).

18.4 TRENDS IN FALSE WARNINGS

Observation 78 – WHEEL WELL – Passenger and Freighter Airplanes - Trends in the rate of occurrence of false warnings could not be determined due to the number of airplanes fitted with wheel well detection systems being unknown.

18.5 PROPORTION OF FALSE WARNINGS CAUSING FLIGHT DISRUPTIONS

Observation 79 – WHEEL WELL – Passenger and Freighter Airplanes - Fifty-two wheel well false warnings were identified with approximately 65% resulting in unscheduled landings and of these approximately three-quarters were returns to departure airport. The remainder resulting in diversions. No wheel well detector events were found that resulted in rejected take-offs.

19. REFERENCES

1. U.S. Department of Transportation, *Treatment of the Values of Life and Injury in Economic Analysis*, United States, Author. *https://www.faa.gov/regulations_policies/policy_guidance/benefit_cost/media/econ-value-section-2-tx-values.pdf*

2. Eurocontrol, (2015). *Standard Inputs for EUROCONTROL Cost-Benefit Analyses*, Edition No. 7, Eurocontrol, EUROCONTROL Headquarters, 96 Rue de la Fusée, B-1130 Brussels, Belgium. https://www.eurocontrol.int/sites/default/files/publication/files/standard-input-for-eurocontrol-cost-benefit-analyses-2015.pdf(last visited April 2016).

3. European Aviation Safety Agency, (2008), *Boeing Commercial Airplanes Additional data on operating costs*, European Aviation Safety Agency. Germany,

4. International Air Transport Association, (2014), *Diversion Management*, http://www.iata.org/whatwedo/workgroups/Documents/ACC-2014-GVA/occ-5-diversion.pdf(last visited April 2016).

5. Flight Safety Foundation, (2011), *Financial SMS*, AeroSafety World, United States, Author.

6. U.S. Department of Transportation, *Memorandum To: Secretarial Officers Modal Administrators, Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses*, United States, Author.

7. U.S. Department of Transportation, (2015). *Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in U.S. Department of Transportation Analyses- 2015 Adjustment*, United States, Author.

https://www.transportation.gov/sites/dot.gov/files/docs/VSL2015_0.pdf

8. University of Westminster (2011), *European Airline Delay Cost Reference Values*, United Kingdom, Author. https://www.eurocontrol.int/sites/default/files/content/documents/sesar/business-case/european_airline_delay_cost_reference_values_2011.pdf (last visited June 2016).

9. Hynes and Associates, Inc. (1999). *Frequency and Costs of Transport Airplane Precautionary Emergency Evacuations*, DOT/FAA/AM-99/30. US Department of Transportation, Office of Aviation Medicine, Washington DC, United States of America. https://www.faa.gov/data_research/research/med_humanfacs/oamtechreports/1990s/media/AM99-30.pdf

APPENDIX A -OBSERVATIONS SUMMARY

APPENDIX B - GLOSSARY

Term	Explanation
False Warning	The term false warning relates to any indication to the crew that is erroneous and caused by faults in the detection system.
All Events	All occurrences resulting from fire, smoke or fumes and detector events (i.e. those that involved the operation of an onboard fire or smoke warning system) irrespective of their consequences.
Detector Event	The term detector event is used in this study to indicate any annunciation from a fire or smoke detector - false or genuine.
Fire, Smoke or Fumes (FSF)	Fire, smoke or fumes will also relate to odors, haze etc., as might be experienced in any occupied area or an equipment bay, engine, cargo bay, etc.
Flight Interruption	A diversion, return to departure airport or a rejected take-off.
Genuine Warning	Indication to the crew that fire, smoke or fumes are actually present in the associated area. However, it includes only FSF that is generated by a source for which the detection system was designed to detect. For example, it will exclude smoke generated in a cargo bay originating from the air conditioning system.
Occupied Area	Occupied area relates to areas of the aircraft that are accessible to the flight or cabin crew. They include the passenger cabin, flight deck, galleys, lavatories and crew rest areas. On freighter airplanes, they will also include the main deck cargo bays. These areas are not subdivided further since the data is often not sufficiently detailed to enable the extent of the fire, smoke or fume event to be located precisely, and it may be that while smoke was reported in the cabin, in many instances, it is likely that it would have also been present in other areas.

Term	Explanation
Significant Event	While data has been entered into the fire, smoke or fumes occurrence database for all FSF and detector events meeting the selection criteria, in many instances, the occurrences were not of great consequence, and in some instances, it was not feasible to ascertain whether the occurrences were while crew or passengers were on board the airplane or whether the data was describing an event that occurred during maintenance. It was, therefore, decided that as well as analyzing all events on the database, analysis would also be carried out on the more significant occurrences which had a greater impact on the safety or operational aspects of the airplane. These significant events include both those that relate to fire, smoke or fume occurrences and detector events (i.e.; those that involved the operation of an onboard fire or smoke warning system). These more significant occurrences were classified as significant events if they resulted in, or it was likely that they resulted in, any of the following: • Diversion • Return to the Departure Airport • Rejected Take-off • Emergency Evacuation • Depressurization • Fuel Dump • In-Flight Thrust Engine Shutdown (includes shutdown during take-off or landing) • Emergency Descent • Emergency Declared • Emergency Services Deployed • Ground Damage (other than Minor Damage) • Airplane Damage (Minor, Substantial or Destroyed) • Overweight Landing

APPENDIX C-INACCESSIBLE CARGO BAY FIRES

The following table lists the inaccessible cargo bay detector events that are thought to be caused by the cargo. Event Number 4 may or may not have been caused by the cargo. All text is verbatim.

Event Number	Date	Aircraft Type	Aircraft Category	SDR/ASIAS Text
1	25th October 2003	Airbus 321	Passenger	(-23) AFTER PUSHBACK FROM GATE 1 AN INDICATION SMOKE IN THE AFT CARGO AREA WAS REPORTED BY THE CREW. THE AIRCRAFT WAS TOWED BACK TO THE GATE AND ALL PASSENGERS WERE DEPLANED NORMALLY. IT WAS DETERMINED THE CAUSE OF THE SMOKE WAS DUE TO AN ACTUATED TOGGLE SWITCH ON A UNIT BEING SHIPPED BY ULTRA LIFT CORP. OF SAN JOSE, CA, AND THE BATTERY WAS NOT DISCONNECTED. SEVEN OF THESE UNITS WERE LOADED INTO THE AFT CARGO AREA, AND WERE STACKED IN TWO ROWS ALLOWING THE TOGGLE SWITCH TO BE ACTUATED BY AN EXPOSED METAL PLATE THAT PENETRATED THE CARD BOARD BOX THUS GENERATING AN EXTREME AMOUNT OF HEAT. THE OVERHEATING WAS EVIDENCED BY MELTED WIRES AND VISIBLE BURN MARKS LEFT BEHIND. ULTRA LIFT, THE MANUFACTURER/SHIPPER OF THE UNIT DID NOT PROVIDE INFORMATION TO AERONET WORLDWIDE, THE FREIGHT FORWARDER, ABOUT THE POWER SONIC GEL LEAD-ACID 12 VOLT, 35 AMP BATTERY INSTALLED AND CONNECTED TO THE UNIT. THE PACKAGING OF THE UNIT DID NOT DISTINGUISH A CLASS 8 CORROSIVE/DANGEROUS GOODS SHIPMENT, NOR DID THE AIR WAYBILL INDICATE SUCH.
2	14th August 2009	McDonnell Douglas MD-11	Freighter	LEVEL 3 LOWER FWD CARGO FIRE INDICATION DURING LANDING ROLLOUT. FIRE BOTTLE DISCHARGED. BOTTLES WERE BLOWN DUE TO CARGO FIRE IN ONE LD3 CAN. THE CAN WAS REMOVED FROM ACFT AND FIRE WAS EXTIGUISHED BY FIRE DEPARTMENT. INSPECTED FWD CARGO COMPARTMENT AND NO DAMAGE FOUND.
3	12th November	Boeing 737	Passenger	IAD - INFLIGHT DCW-DFW. CREW REPORTED AFT CARGO COMPARTMENT FIRE DETECTION LIGHT ILLUMINATED AND BELL WENT OFF. FIRE EXTINGUISHERS

Event Number	Date	Aircraft Type	Aircraft Category	SDR/ASIAS Text
	2010			WERE DISCHARGED. EMERGENCY DECLARED FLIGHT DIVERTED IAD LANDED WITHOUT INCIDENT.AIRCRAFT REMOVED FROM SERVICE. PASSENGER BAGS WERE INSPECTED AND A BAG THAT CONTAINED A FLASHLIGHT HAD BEEN LEFT ON AND OVERHEATED.IT CREATED HEAT AND SMOKE THAT ACTIVATED THE FIRE DETECTORS.DAMAGE WAS CONTAINED IN THE BAG. REPLACED FIRE EXTINGUISHERS THAT HAD BEEN DISCHARGED. SYSTEM GROUND CHECK NORMAL OPERATION. AMERICAN AIRLINES FLIGHT 548, B737-800, WAS ENROUTE FROM DCA TO DFW AND DIVERTED TO IAD AFTER THE CREW RECEIVED AN INDICATION OF A FIRE IN THE AFT CARGO HOLD. THE AIRCRAFT LANDED ON RUNWAY 12 AND WAS MET BY THE ARFF. THE CREW WAS INTERVIEWED AND REPORTED THAT THEY WERE APPROXIMATELY 30 MILES WEST OF IAD WHEN THEY RECEIVED THE AURAL AND VISUAL INDICATION THAT THERE WAS A FIRE IN THE AFT CARGO HOLD. THEY DECLARED AN EMERGENCY, FOLLOWED THEIR CHECKLISTS AND UTILIZED THE ONBOARD FIRE SUPPRESSION SYSTEM. THE CARGO FIRE LIGHT EXTINGUISHED WITHIN 30 SECONDS, HOWEVER THE LIGHT RETURNED WHILE THE AIRCRAFT WAS ON SHORT FINAL. AFTER LANDING THERE WAS NO EMERGENCY EVACUATION AND THE ARFF DETERMINED THAT THERE WAS NO HEAT COMING FROM THE AFT CARGO COMPARTMENT, AND DEPLANING OF PASSENGERS AND CREW WAS ACCOMPLISHED VIA PEOPLE MOVERS. SUBSEQUENT OFFLOADING AND SEARCHING OF AFT CARGO BAGS DETERMINED THAT A FLASHLIGHT HAD BEEN INADVERTENTLY SWITCHED ON INSIDE A PASSENGERS BAG. THE FINDINGS FROM THE FAA SECURITY AND HAZARDOUS MATERIALS OFFICE AND THE NTSB INDICATE THAT THE CAUSE OF THE FIRE AND SMOKE WAS DUE TO A SPORTSMAN'S WAREHOUSE BRAND (ITEM # 1139424) 12 VOLT HIGH INTENSITY XENON FLASHLIGHT THAT WAS ON INSIDE A PASSENGERS PACKED BAG. THE HALOGEN LIGHT BULB HEATED UP ENOUGH TO IGNITE A MAP THAT WAS STOWED IN THE SAME POCKET AS THE FLASHLIGHT AND BURN A HOLE IN THE BAG CAUSING THE AFT CARGO HOLD SMOKE DETECTOR LIGHT TO ILLUMINATE. THE AALA CMO WAS NOIFIED OF THIS INCIDENT ON 11/12/2010

Event Number	Date	Aircraft Type	Aircraft Category	SDR/ASIAS Text
				AND A SERVICE DIFFICULTY REPORT (SDR) WAS SUMITTED ON 11/15/2010. FAA SECURITY AND HAZARDOUS MATERIALS FIELD OFFICE HAS COMPLETED THEIR REPORT AND SUBMITTED IT TO WASHINGTON HEADQUARERS FOR REVIEW AND CORRECTIVE ACTION. THERE WERE NO OPERATIONAL OR AIRWORTHINESS ISSUES INVOLVED IN THIS INCIDENT. SEE NTSB REPORT NO. DCA11SA005.THIS REPORT IS CLOSED.
4	14th October 2011	Boeing 737	Passenger	THEN GOT FULL FIRE WARNING LIGHT& BELLS RAN QRH DISCHARGED BOTTLES. FLT ATTENTANT CALLED UP, REPORTED SMELLED SMOKE, CALLED FOR FIREMEN AND WHEN THEY OPENED CARGO DOOR THEY SMELLED SMOKE. PERFORMED CONDITIONAL INSPECTION FOR SMOKE/ODOR IN CABIN/FLIGHT DECK IAW AMM 05-51-95-200-801C1, NO DEFECTS NOTED. ALSO SEE NON-ROUTINES 4482386, 4482383, 4482385 FOR CORRECTIVE ACTION.

APPENDIX D – FREIGHTER MAIN DECK CARGO FIRES

The following Table lists the main deck cargo bay detector events that were caused by the cargo.

Event Number	Date	Aircraft Type	Description
1	27th April 2004	Fokker F.27	DURING FLIGHT FDX7145 EZE-POA THE CARGO SMOKE WARNING LIGHT ILLUMINATED. THE THIRD CREW MEMBER OCCUPYING THE JUMP SEAT CHECKED THE CARGO COMPARTMENT AND OBSERVED FLAMES IN THE REAR OF THE AIRCRAFT. THE CREW DECLARED AN EMERGENCY AND THE JUMPSEAT CREW MEMBER USED 2 HAND HELD EXTINGUISHERS ON THE CARGO TO SUPPRESS THE FLAMES. THE AIRCRAFT MADE A SUCCESSFUL LANDING IN MELO, URUGUAY. AFTER LANDING FIRE CREWS ARRIVED AND FINISHED EXTINGUISHING THE FIRE WHICH WAS STILL SMOLDERING.
2	7th February 2006	McDonnell Douglas DC-8	ON FEBRUARY 7, 2006, ABOUT 2359 EASTERN STANDARD TIME, UNITED PARCEL SERVICE COMPANY FLIGHT 1307, A MCDONNELL DOUGLAS DC-8-71F, N748UP, LANDED AT ITS DESTINATION AIRPORT, PHILADELPHIA INTERNATIONAL AIRPORT, PHILADELPHIA, PENNSYLVANIA, AFTER A CARGO SMOKE INDICATION IN THE COCKPIT. THE CAPTAIN, FIRST OFFICER, AND FLIGHT ENGINEER EVACUATED THE AIRPLANE AFTER LANDING. THE FLIGHT CREWMEMBERS SUSTAINED MINOR INJURIES, AND THE AIRPLANE AND MOST OF THE CARGO WERE DESTROYED BY FIRE AFTER LANDING. THE SCHEDULED CARGO FLIGHT WAS OPERATING UNDER THE PROVISIONS OF 14 CODE OF FEDERAL REGULATIONS PART 121 ON AN INSTRUMENT FLIGHT RULES FLIGHT PLAN. NIGHT VISUAL CONDITIONS PREVAILED AT THE TIME OF THE ACCIDENT. THE NATIONAL TRANSPORTATION SAFETY BOARD DETERMINES THE PROBABLE CAUSE(S) OF THIS ACCIDENT TO BE: AN IN-FLIGHT CARGO FIRE THAT INITIATED FROM AN UNKNOWN SOURCE, WHICH WAS MOST LIKELY LOCATED WITHIN CARGO CONTAINER 12, 13, OR 14. CONTRIBUTING TO THE LOSS OF THE AIRCRAFT WERE THE INADEQUATE CERTIFICATION TEST REQUIREMENTS FOR SMOKE AND FIRE DETECTION SYSTEMS AND THE LACK OF AN ON-BOARD FIRE SUPPRESSION SYSTEM.
3	3rd September	Boeing 747	ON SEPTEMBER 3RD 2010, A BOEING 747-44AF, REGISTRATION N571UP, DEPARTED DUBAI

Event Number	Date	Aircraft Type	Description
	2010		INTERNATIONAL AIRPORT [DXB] ON A SCHEDULED INTERNATIONAL CARGO FLIGHT TO COLOGNE, GERMANY [WITH TWO FLIGHT CREW MEMBERS ON BOARD]. TWENTY TWO MINUTES INTO THE FLIGHT, AT APPROXIMATELY 32,000 FEET, THE CREW ADVISED AIR TRAFFIC CONTROL THAT THERE WAS AN INDICATION OF AN ON-BOARD FIRE ON THE FORWARD MAIN DECK AND DECLARED AN EMERGENCY. THE SMOKE DETECTORS HAD DETECTED SMOKE IN THE FORWARD MAIN DECK CARGO COMPARTMENT. THE CAPTAIN ELECTED TO RETURN TO DXB. THE SMOKE DID NOT ABATE DURING THE EMERGENCY, IMPAIRING THE ABILITY OF THE CREW TO SAFELY OPERATE THE AIRCRAFT FOR THE DURATION OF THE FLIGHT BACK TO DXB. THE AIRCRAFT APPROACHED DXB RUNWAY 12 LEFT, THEN OVERFLEW THE NORTHERN PERIMETER OF THE AIRPORT AT 4500 FT AT AROUND 340 KTS. THE PILOT FLYING COULD NOT VIEW THE PRIMARY FLIGHT DISPLAYS OR THE VIEW OUTSIDE THE COCKPIT. [THE AIRCRAFT MADE] AN UNCONTROLLED DESCENT INTO TERRAIN, NINE NAUTICAL MILES SOUTH WEST OF DUBAI INTERNATIONAL AIRPORT ONTO A MILITARY INSTALLATION, NARROWLY AVOIDING A LARGE URBAN CONURBATION. THERE WAS AN EXTENSIVE POST-CRASH FIRE WHICH CONSUMED THE BULK OF THE AIRCRAFT AND REMAINING CARGO. THERE WERE NO SURVIVORS. PRIOR TO THE FLIGHT TO DUBAI, CARGO WAS LOADED INTO ALL POSITIONS IN HONG KONG. A CONSIGNMENT OF MIXED CARGO INCLUDING A SIGNIFICANT NUMBER OF BATTERIES, INCLUDING LITHIUM TYPES, WAS LOADED ONTO THE PALLETS LOCATED AT MD POSITIONS 4, 5, AND 6, AMONG OTHER POSITIONS. UPON ARRIVING IN DUBAI, THE UNIT LOAD DEVICES (ULD) IN POSITIONS 13L, 14L, 14R, 18L, 19L, AND 20 WERE REMOVED FROM THE AIRCRAFT. SOME OF THESE ULD’S WERE REPLACED WITH OTHER OUT-BOUND ULD’S. NO CARGO WAS UNLOADED FROM THE FORWARD SECTION OF THE MAIN DECK. THE CARGO GROUP EXAMINED SHIPPING INVOICES FOR THE CARGO ON BOARD THE AIRCRAFT, AND AT LEAST THREE SHIPMENTS OF LITHIUM BATTERIES WHICH SHOULD HAVE BEEN DECLARED AS HAZARDOUS MATERIALS WERE IDENTIFIED IN THE PALLETS AT POSITIONS 4 AND 5. THERE WERE NO DECLARED SHIPMENTS OF HAZARDOUS MATERIALS ON BOARD THE ACCIDENT FLIGHT.