

SMOKE, FIRE AND FUMES IN TRANSPORT AIRCRAFT

PAST HISTORY, CURRENT RISKS AND RECOMMENDED MITIGATIONS

Part 2: Training



Second Edition 2018

A Specialist Paper by the **Royal Aeronautical Society**

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About this Paper

This paper represents the views of the Flight Operations Group of the Royal Aeronautical Society. It has not been discussed outside the Learned Society Board and, as such, it does not necessarily represent the views of the Society as a whole, or any other Specialist Group or Committee.

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Front cover:

Cabin Fire Training Facility. (Dallas Fort Worth Fire Training Research Center)



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2 October 2018

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PREFACE

This document is Part 2 of the Royal Aeronautical Society's specialist document 'Smoke, Fire and Fumes in Transport Aircraft' (SAFITA), first published in February 2007. Sadly, since the initial publication there have been additional accidents and fatalities due to in-flight fires; therefore, the Flight Operations Group of the Royal Aeronautical Society decided to update the document and re-issued it as 'SAFITA Part 1: Reference' in March 2013. Part 1 has been updated to highlight remaining safety issues; in addition, new sections concerning lithium batteries, composite materials and predictive technologies have been added, together with recommendations to reflect the current risks.

Several recent accidents and incidents have identified issues with crew training as a contributory factor. In addition, studies have shown that there is a need for further guidance on acceptable means of compliance for current aircraft crew fire training requirements. Therefore, the Flight Operations Group identified a significant need to provide additional information and recommendations for flight crew and cabin crew training to handle in-flight fires. The Group has published this document as 'SAFITA Part 2: Training' to address this need. SAFITA Part 2: Training was first published in February 2014 and updated in October 2018.

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1. Introduction

A study by the UK Civil Aviation Authority (UK CAA, 2002) found that the average time for a hidden fire on-board an aircraft to become catastrophically uncontrollable was less than 20 minutes. Fire tests conducted by various regulatory authorities have shown that fires allowed to spread into the aircraft's overhead area may become uncontrollable in as few as 8-10 minutes (FAA, 2014).

According to the Federal Aviation Administration (FAA), in the event of an in-flight fire: *"...delaying the aircraft's descent by only two minutes is likely to make the difference between a successful landing and evacuation, and a complete loss of the aircraft and its occupants."* (FAA, 2014)

The need for urgent and appropriate action by the aircraft crew is therefore essential, but they will only be able respond effectively if they have been adequately trained. While SAFITA Part 1 addressed the current risks and proposed mitigations for smoke and fire events in commercial transport aircraft, the purpose of SAFITA Part 2 is to serve as a reference document for regulators, operators and training organisations, on training best practices and compliance with mandatory requirements.

The mandatory requirements, or minimum standards, issued by some National Aviation Authorities (NAAs) are not very specific as to how operators may comply with the requirements or how compliance will be verified. Most operators and training organisations already provide aircraft crew fire training in full compliance with the applicable requirements and many provide more than is required. However, in 2009 the UK CAA identified that there was non-compliance with the then requirements of EU OPS by some operators.

Hidden fires have been identified as a significant hazard for commercial aircraft operations (UK CAA, 2002; FAA, 2014). However, in many NAA training requirements there is still no specific requirement for appropriate aircraft crew training to mitigate the risks of this hazard. The NTSB found: *"...that current training programs still do not adequately prepare crewmembers to fight the type of hidden in-flight fires likely to occur on airplanes"* (2002). The resulting NTSB recommendation A-01-85 (2002) for amendments to aircraft crew fire training requirements has not been fully actioned by all interested parties.

The proliferation of personal electronic devices (PEDs) and increased dependence of aircraft on electrical systems, as cited in the SAFITA Part 1 has not resulted in changes to aircraft crew fire training requirements by some NAAs (RAeS, 2018).

SAFITA Part 2 provides operators and training organisations with guidance on how, as a minimum, to comply with regulatory requirements and provides references to relevant advisory material which might assist in the provision of aircraft crew fire and smoke training. Recommendations regarding aircraft crew fire and smoke training made by NAAs and other safety related organisations are included in this document.

Both fatal and non-fatal case studies of in-flight fires are included in Appendix 4. They provide a useful study in the training of in-flight fires and should be incorporated into aircraft crew training, whenever relevant. Alternative case studies involving a specific aircraft type to be operated should also be considered.

Where appropriate, relevant extracts are included from the EASA requirements and UK CAA publications, including UK CAA Flight Operations Department Communications (FODCOM) and Safety Notices, as well as documents produced by other aviation safety agencies, such as the UK Air Accident Investigation Branch (AAIB), the FAA and the NTSB.

2. Abbreviations

AAIB	UK Air Accident Investigation Branch
AC	FAA Advisory Circular
AD	Airworthiness Directive
AOC	Air Operators Certificate
APU	Auxiliary Power Unit
ATC	Air Traffic Control
CAA	Civil Aviation Authority
CVR	Cockpit Voice Recorder
CRM	Crew Resource Management
DGP	ICAO Dangerous Goods Panel
EASA	European Aviation Safety Agency
ELT	Emergency Locator Transmitter
EU OPS	European Union Regulations for Commercial Transportation by Aeroplane
FAA	Federal Aviation Administration
FODCOM	UK CAA Flight Operations Department
FSF	Flight Safety Foundation
GCAA	General Civil Aviation Authority of the United Arab Emirates
HMSO	Her Majesty's Stationary Office
ICAO	International Civil Aviation Organization
JAA	Joint Aviation Authorities
IFE	In-flight Entertainment
NAA	National Aviation Authority
NPA	Notice of Proposed Amendment
NTSB	US National Transportation Safety Board
OM	Operations Manual
PBE	Protective Breathing Equipment
PED	Portable Electronic Device
RAeS	Royal Aeronautical Society
RFFS	Rescue and Fire Fighting Services
SCCM	Senior Cabin Crew Member
TCCA	Transport Canada Civil Aviation
TSB	Canadian Transportation Safety Board
UPS	United Parcel Service

3. Background

In May 1985 a fire totally destroyed one large spectator seating area at a football stadium in Bradford, England. The fire, although quite small to start with, spread rapidly along the length of the seating area. It took less than four minutes for the entire spectator stand to be engulfed in flames.

There were 56 fatalities. The cause of the fire was probably a match or cigarette being dropped on debris, which then ignited (HMSO, 1986).



Bradford City Football Stadium fire – May 1985

If a fire on the ground with the potential for several different means of escape can be so devastating and result in so many fatalities, how challenging would it be for an aircraft crew to manage a serious in-flight fire, potentially one of the most significant and catastrophic in-flight emergency scenarios that they will encounter? Prompt assessments and actions by flight crew and cabin crew will determine the outcome of the emergency. The FAA and UK CAA studies demonstrated that failure to act immediately to a fire or smoke threat may lead to fatal consequences. (FAA, 2004; UK CAA 2002)

If a fire occurs in any area of the aircraft accessible to the aircraft crew during flight, a crew member will have to fight the fire while keeping the flight crew fully informed of what is happening. The flight crew will have to make rapid assessments of the situation and a decision regarding diversion to the nearest suitable aerodrome, or if flying over water, may, as an absolute last option, have to decide whether to ditch the aircraft.

According to the FAA (2014), delaying the aircraft's descent by only two minutes may make the difference between a successful landing and evacuation and a loss of the aircraft and its occupants.

Aircraft crew should locate the source of the smoke and/or fire as quickly as possible and deal with it urgently in order to ensure that the fire situation does not become uncontrollable. They should initiate fire-fighting action immediately.

Cabin crew should be trained to communicate the essential information to the flight crew regarding an in-flight fire, so that the flight crew can make well-informed decisions. This should be reflected in specific procedures that are covered in both classroom and practical training. These procedures should be included in the AOC holder's Operations Manual. Operators should ensure that there is consistency between flight crew and cabin crew procedures. Training should ensure that each group is familiar with the each other's procedures, preferably by accomplishing joint training.

In recent years initiatives have been undertaken by several NAAs and other aviation safety organisations. These include:

- NTSB Review and Recommendations on In-flight Fires (NTSB, 2002);
- FAA Advisory Circular 20-42D - Hand Fire Extinguishers for use in Aircraft
- FAA Advisory Circular 120-80A – In-flight Fires (FAA, 2014);
- UK CAA Safety Plan of 2011/2013 (UK CAA, 2011);
- UK CAA Cabin Crew Fire Training Needs Analysis (UK CAA, 2009).

In Advisory Circular (AC) 120-80A – In-flight Fires (FAA, 2014), the FAA identified that the time for the situation to become non-survivable was as little as seven minutes, and that only in one third of hidden fire events would the aircraft reach an aerodrome before the fire became uncontrollable. An example of this is the accident involving an Air Canada DC-9 which diverted to Cincinnati in June 1983 when a lavatory compartment fire became uncontrollable (NTSB, 1986).



DC-9 accident – Cincinnati June 1983

The FAA AC addresses the problems of hidden fires, but this issue is not addressed or mentioned in any EASA requirements or advisory material.

The speed and effectiveness of aircraft crew actions are vital to a successful outcome of an in-flight fire event. Many aircraft crew are not aware that the time available to successfully deal with an in-flight fire may be extremely limited. This issue should be stressed during initial and recurrent aircraft crew training and case studies should be included to demonstrate the importance of taking urgent action.

4. Training priorities

The priorities in aircraft crew training for smoke, fire and fumes events have come into sharp focus as a result of the tragic examples mentioned in this document. Regulators, operators and training providers should ensure that the training emphasises the priorities highlighted by the Flight Safety Foundation (FSF) in their checklist template for responding to smoke, fire and fumes events (2005). The main priorities are summarised, in order, as follows:

- 1) Protection – aircraft crew use the appropriate equipment and tools to protect themselves so that they can maintain the ability to handle the situation; any delay in the use of protective equipment can have adverse consequences (AAIB, 2005);
- 2) Conduct the appropriate immediate actions – aircraft crew must action the appropriate immediate actions as soon as possible to deal with the source of the smoke/fire/fumes; any delay in performing these actions can rapidly affect the survivability of the situation (UK CAA, 2002);
- 3) Be prepared for a rapid diversion or even an emergency landing if the incident is not resolved quickly – it is imperative that aircraft crew understand the urgency of landing as soon as possible if the source of the smoke/fire/fumes is not identified and/or extinguished and the situation is deteriorating (UK CAA, 2002).

Adoption of the training recommendations in this document should significantly improve the chances of surviving a smoke/fire/fumes event, if the priorities above are reinforced throughout the training.

5. Crew fire-fighting procedures

To ensure effective cooperation and similar levels of proficiency, flight and cabin crew should train together. For fires located in the cabin, many operators of larger aircraft types have specific procedures for a three-person team to deal with an in-flight fire. Such procedures typically specify the following responsibilities:

- The Fire Fighter: The crew member who first discovers the fire immediately fights the fire and calls for assistance of another cabin crew member;
- The Communicator: Calls for further crew assistance, alerts the flight crew and conducts other actions as specified in the Operations Manual;
- The Coordinator: Obtains back-up fire-fighting equipment and conducts other actions as specified in the Operations Manual.

There may need to be some flexibility in this approach, in that the crew member who first arrives at the location of the fire may not necessarily be best placed to continue to be the primary fire fighter. This crew member fights the fire with whatever means are immediately available. If the volume of smoke or its toxicity is such that PBE needs to be used, then the donning of PBE should be undertaken by another crew member, while the first fire-fighter continues to deal with the situation in the interim. Once PBE has been donned and additional fire-fighting equipment is made available at the location of the fire, the role of the fire-fighter may need to be transferred to the second crew member.

Operators should assess the effectiveness of their procedures in respect of the number of cabin crew required to be carried, together with the cabin configuration, systems and installations. This should include consideration of multi-deck aircraft, where applicable, as well as the minimum number of required cabin crew and also any cabin crew rest requirements.

For operations with fewer than three cabin crew members, some fire-fighting procedures might need to be combined; in such cases the effectiveness of the fire-fighting procedures should be given particular attention. This is especially important for single-cabin crew operations where one cabin crew member will be responsible for a number of tasks, including communication and coordination with the flight crew. If the flight crew workload permits, the cabin crew may require assistance from one of the flight crew to manage both fighting the fire and managing the passengers. This will only be possible where there is enough suitable smoke protection equipment for both crew members.

Operators should also consider procedures for the cabin crew to assist the flight crew in dealing with a fire in the flight crew compartment when necessary. These procedures need to include the following factors:

- Flight crew procedures for the initial request and maintaining communication with the senior cabin crew member;
- Procedures for crossing the smoke barrier;
- Crew communication procedures while cabin crew are in the flight crew compartment; these procedures should take account of workload and task allocation.

On passenger aircraft with no cabin crew, the operator should include guidance in the Operations Manual for flight crew in handling a cabin smoke/fire/fume event. The priorities remain protection, appropriate checklist, consider diversion or immediate landing. With these priorities in mind, if workload permits and suitable protective equipment is available, one of the flight crew may conduct fire-fighting in the cabin.

Flight crew may be required to assess and/or fight fires in both the passenger cabin and/or flight crew compartment. Therefore, both fire-fighting procedures and training should be standardised for flight and cabin crew. It is recommended that training is conducted jointly where possible.

6. Communication and co-ordination

As with any in-flight emergency, an in-flight smoke/fire/fume event requires effective communication and co-ordination between all aircraft crew members to achieve a safe outcome. During an in-flight fire the aircraft crew need to act as a complete team. Aircraft crew training should include specific training objectives that ensure the operator's communication procedures for various in-flight smoke/fire/fume events are practiced and crew members are proficient. Communication procedures for aircraft crew following the detection of a fire anywhere within the aircraft structure should be clearly described in the Operations Manual. Aircraft crew should be trained in following these communication procedures through the use of realistic training scenarios. Cabin crew should be trained in how to communicate the essential information to the flight crew regarding an in-flight fire in a concise, consistent and clear manner. The operator's Operations Manual should include the vital communication requirements, including essential information required during the initial alert from cabin crew to the flight crew and communication between the cabin crew locations. Communication training should include coordination between cabin crew locations, as well as coordination with

the flight crew. Emphasis should be placed on the use of the aircraft interphone in order to preserve the smoke barrier between the cabin and the flight crew compartment.

On aircraft with a single cabin crew member, the operator should ensure that the communication procedures provided in the Operations Manual match the realities of a smoke/fire/fume event in the type of aircraft. Clear priorities should be established for the use of protective equipment, alerting the flight crew, maintaining a smoke barrier as far as possible, fire-fighting and passenger handling. The use of appropriate scenarios in training should ensure that cabin crew practise and demonstrate their proficiency.

On passenger aircraft with no cabin crew, the operator should provide guidance in the Operations Manual for the flight crew in communicating with and handling the passengers in the event of a smoke/fire/fume event in the cabin. There may be no barrier between the cabin and the flight crew compartment and the passengers may be faced with flight crew in full protective equipment, where such equipment is not available to them. Training should ensure that flight crew have practice in passenger handling during such a scenario, especially if they are flying an aircraft that does not have a flight crew compartment door. The training should include initial passenger briefing, passenger control and emergency briefings for landing/ditching. Operators should use realistic scenarios in training that follow the full sequence of events to an appropriate conclusion. Combined training with cabin crew and/or the use of experienced cabin crew instructors can be very beneficial for flight crew that have never been exposed to good cabin crew training.

The FAA issued Report Number DOT/FAA/FS-88/1 (Cardosi and Huntley, 1988), titled ‘Cockpit and Cabin Crew Coordination’. The FAA Report stated: *“Cockpit and cabin crew coordination is crucial not only in emergencies, but also during normal operations.”*

Some 25 years later, this statement is still valid, and even more so with the installation of flight crew compartment security doors on larger aircraft that are locked during flight. As a result, the primary means for communication between the flight crew and the cabin crew is the interphone system, rather than face-to-face communication. In their report the FAA considered that one of the problems of co-ordination was with cabin crew not providing information to the flight crew in a timely manner.

In the intervening years, Crew Resource Management (CRM) has been expanded to include all aircraft crew members including cabin crew.

As in any emergency, CRM is an essential element of aircraft crew procedures. All aircraft crew should have access to accurate and concise information as the situation develops, this includes updates from the cabin and suitable briefings from the flight crew, so that all crew members can plan and act in a coordinated manner. Crew should be aware of the stress and workload on crew members, especially the flight crew and those fighting the fire.

Flight crew should be able to rely on accurate information received from the cabin crew regarding an in-flight fire or smoke event. The information to be communicated by the cabin crew to the flight crew and senior cabin member should include the following:

- Which cabin crew member is speaking and from what location;
- The location of the fire or smoke;
- The source of the fire and any associated smell;
- The size of the fire, the amount and colour of the smoke that is being produced;
- The cabin crew actions being undertaken and the number of fire extinguishers used;
- Passenger reaction and cabin crew actions to control the situation;

- The development of the situation, when the fire is extinguished, and the conduct of post-fire procedures.

In some in-flight fire or smoke situations, it might be necessary for the cabin crew to communicate with the flight crew while wearing PBE via the interphone; some PBE designs make such communication difficult. UK CAA CAP 789 addresses such issues in respect of practical training (2011). Such issues should be addressed in both initial and recurrent practical fire training.

Communication issues related to the locked/secured flight crew compartment door should be specifically addressed in flight crew and cabin crew procedures and training, as applicable to the aircraft type to be operated. This will need to include possible scenarios where, due to failure of the interphone system, it might be necessary for the flight crew compartment door to be opened to allow face-to face communication between flight crew and cabin crew. In these circumstances, procedures should ensure that the migration of smoke or fumes into the flight crew compartment from the cabin is minimised and that the smoke barrier is maintained.

In aircraft with no flight crew compartment door, aircraft crew training needs to emphasise the importance of flight crew protection; any delay in the use of protective equipment could have serious consequences (AAIB, 2005). Training should also address any possible mitigating actions that could be taken, such as the use of a curtain or other suitable barrier that will not adversely affect an evacuation. In addition, flight crew should be fully familiar with the smoke removal procedures for their aircraft. Flight crew training should provide guidance about how to evaluate whether smoke is the greater threat and whether flight crew actions should shift to smoke removal procedures. Operators should consider whether such procedures should be memory actions for aircraft without a smoke barrier.

7. Practical fire training

As previously mentioned, the UK CAA identified non-compliance with the existing requirements of EU OPS by some operators (2009). The Royal Aeronautical Society's Flight Operations Group identified a need for further guidance on acceptable means of compliance for current aircraft crew fire training requirements. Comprehensive guidance is provided in Appendix 1. This section addresses the challenges faced by operators trying to provide realistic practical aircraft crew fire training.

The Montreal Protocol on Substances that Deplete the Ozone Layer, last amended by the nineteenth meeting of the parties in September 2007, is currently ratified by over 190 countries (UNEP, 2007). The Protocol bans the production of Halon and prohibits its discharge during fire training. Aircraft crew cannot actually experience the discharge of Halon on a live fire during practical training. Halon extinguishers filled with water as an alternative extinguishing agent do not accurately replicate the extinguishing characteristics of Halon or the techniques of application required for the agent. Some Halon replacement extinguishing agents may provide better alternatives to water as a training medium.

Another issue is the amount of pressure required to activate a fire extinguisher. Some extinguishers used in training do not exactly replicate the extinguishers carried on board aircraft. This is especially true of the integral brass seal that needs to be broken on some types of Halon extinguishers when the operating handle is pressed. The force needed to break the seal on an 'operational' fire extinguisher is often significantly greater than the force needed to activate the discharge of the fire extinguishers used in training. This important difference should be addressed in training.

During training in the 1980s, aircraft crew usually fought fairly large fires in the open air. At that time oil tray fires were favoured and Halon could be used. These fires were usually quite large and challenging. They could be difficult to extinguish unless the correct procedure was used, such as aiming the extinguisher at the base of the flames. Re-ignition was often a major factor. While a fire of such size would be most unlikely to occur on a commercial aircraft, it did provide an awareness of the problem and also the effectiveness of Halon.



Practical fire training in the 1980s

Since such fires were not realistic to a cabin fire situation, in the late 1980s the UK CAA decided that the requirement should be changed to cabin crew fighting a fire representative of an interior aircraft fire. This has now become an EASA requirement in AMC1 ORO.CC.125(d) and ORO.CC.140.

Unfortunately, in some cases this has resulted in aircraft crew dealing with fires of such a small size that extinguishing the fire provides little or no challenge and consequently offers limited training value. The size of the fire to be extinguished in practical training and the level of difficulty in extinguishing the fire are critical to achieving verification of aircraft crew proficiency. A fire that is easily extinguished in training may well lead to a false sense of security and may not address the difficulties of dealing with an actual in-flight fire including the issue of re-ignition or the correct means of operating a fire extinguisher.

The size of the fire and the level of difficulty in extinguishing the fire in practical training should be consistent with real situations. The Operations Manual should specify the following:

- The actual size of the fire and the fire source(s) used in the training;
- The level of difficulty required to extinguish the fire;
- The different fire scenarios appropriate to the aircraft type to be operated.

Unfortunately, this is not always the case; the level of difficulty and assessment of aircraft crew proficiency are often left up to the individual instructor's subjective assessment. Clearly, effective standardisation is required.

Training in the use of Protective Breathing Equipment (PBE) during practical training also presents problems. The vast majority of aircraft crew will probably never remove PBE from its container nor remove PBE from its sealed packaging other than during an actual in-flight fire or smoke emergency. During training sessions PBE neck seals will be stretched and/or damaged due to repeated use; this means that most aircraft crew will never don a PBE that has a neck seal that fully replicates an operational unit.

The UK CAA in their Paper 2009/01 – Cabin Crew Fire Training – Training Needs Analysis (2009), stated: *“The only part of the procedure of using PBE that is practiced is the actual donning of the PBE. This is usually conducted on training units that do not replicate the tightness of the seals to be encountered on an operational unit. In one case the condition of the PBE neck seals, were in such a bad state as to be almost non-existent.”*

A damaged training unit neck seal does not offer comparable experience of donning a live PBE with an unused neck seal which will be much more restrictive. While it may be difficult to replicate the donning of a live PBE unit in this respect, operators and training organisations need to exercise quality control for PBE training unit neck seals so that the training remains as meaningful as is practical.

Some operators and training organisations achieve the EASA requirements for aircraft crew fire-fighting in separate training scenarios, with aircraft crew extinguishing a fire without the use of PBE, and the use of PBE by aircraft crew when not extinguishing a fire. This would appear to be meeting the mandatory requirements with little consideration as to the probability of a serious in-flight fire or smoke event, when both fire extinguishers and PBE will need to be used simultaneously, perhaps while using other equipment such as fire gloves.

Combining fire extinguisher training with PBE training is certainly feasible since some operators and training organisations achieve both elements in one practical fire training scenario. Therefore, regulatory requirements should reflect the likelihood of an in-flight fire in which different items of fire safety equipment need to be used simultaneously. Attempting to meet practical fire training requirements in unrealistic, separate fire training scenarios is not satisfactory.



Combining fire extinguisher training with PBE training & fire gloves

Many operators and training organisations now use gas-powered fire training rigs, where the actual fire is controlled by the instructor. In the case of some fire training rigs, it is the instructor who actually turns off the gas supply, thereby extinguishing the fire, rather than the individual aircraft crew member achieving this, which might not be in full compliance with the EASA requirements. Additionally, the EASA requirement in ORO.CC.115 paragraph (d) states: “Checks shall be performed by personnel appropriately qualified to verify that the cabin crew member has achieved and/or maintains the required level of proficiency.” Therefore, the standards applied by the instructor should be consistent with the procedures and should be specifically defined in the Operations Manual. Operators need to carefully consider the limitations of fire training rigs in respect of instructor actions and the standardisation of training provided to aircraft crew.

8. Flight crew-specific training considerations

Flight crew training for smoke/fire/fume events normally occurs in two separate training events. Flight crew procedures and diversion/emergency landing procedures are conducted during flight simulator training; while fire-fighting and communication with the cabin crew are dealt with during safety and emergency procedures training. Some operators have access to ground training simulators that include a flight crew compartment where full, realistic scenarios may be practised, but many do not. Flight crew fire training is often conducted at a fire service training facility or in an unrepresentative cabin environment. This is especially the case in business aviation, where there is a shortage of representative training facilities.

As recommended by most regulatory authorities, flight crew safety and emergency procedures training should be combined with cabin crew training, where practical. Flight crew may be required to fight a fire in the flight crew compartment, crew rest area and/or assist in the cabin, so they should have the same level of proficiency as the cabin crew. As already stated, combined training is also vital to ensure good communication and CRM proficiency between flight and cabin crew. Flight crew operating aircraft without cabin crew can also benefit from the expertise of an experienced cabin crew emergency procedures instructor, so that the flight crew are provided with suitable training in cabin fire-fighting procedures and passenger handling considerations.

Flight crew training objectives should emphasise the priorities of the Flight Safety Foundation template (FSF, June 2005), with the first priority being protection. The training should emphasise the importance of checking and maintaining good communication after donning protective equipment.

The flight crew should then prioritise the appropriate checklist. FSF and the RAeS recommend that operators use or develop an integrated smoke/fire/fumes checklist for situations where the source of the smoke/fire/fumes is unclear (FSF 2005; RAeS 2013). Flight crew training should emphasise the importance of tackling the source of the smoke/fire/fumes as quickly as possible and the reasoning behind the need for an integrated checklist, if adopted. Flight crew should be familiar with the information that the cabin crew should provide (RAeS, 2013).

If the source is not confirmed visually to be extinguished after the initial actions, the flight crew should then immediately initiate a diversion to the nearest suitable airfield. Training should emphasise the importance of keeping the senior cabin crew member briefed on the flight crew plans, particularly time constraints and the nature of any emergency landing. The flight crew should be aware that the cabin crew may have urgent information concerning the development of the situation in the cabin and they must balance the need to manage their workload with the need for up-to-date information from the cabin. An out-of-date or incorrect understanding of the cabin situation can have serious consequences (NTSB, 1986).

If subsequent action does not result in visual confirmation that the source has been extinguished, then the flight crew should consider an immediate emergency landing or ditching. Training should involve scenarios that continue to a logical conclusion and include the requirement for further communication between the flight crew and the cabin crew.

For operations with only one cabin crewmember, flight crew training should involve scenarios that include passenger handling and other situations where flight crew assistance may be required by the cabin crew.

For operations without cabin crew, the priorities of the Flight Safety Foundation template still apply (FSF, 2005). Operators should ensure that their training includes scenarios involving the decision for one flight crew member to leave the flight crew compartment for fire-fighting and/or passenger management. The training should include the procedures for transferring from flight crew compartment protection equipment to portable protection equipment and vice versa. The training should also include the communication procedures for rapid recall to the flight crew compartment and considerations for aircraft not fitted with an interphone. Operators should also include training in passenger handling for crowd control, passenger assistance for smoke inhalation, and passenger emergency briefing.

Recent air carrier incidents and accidents have highlighted a lack of understanding among some flight crews regarding the proper use of crew oxygen masks when faced with smoke or fumes in the cockpit. The fatal accident involving the crew of United Parcel Service (UPS) Flight 6 departing Dubai, UAE, for example, when faced with substantial cockpit smoke, donned their oxygen masks at the appropriate time, yet one crewmember left his mask at the NORMAL setting, allowing smoke to enter his mask along with minimal amounts of oxygen. On another cargo aircraft incident, the three flight crew, when faced with fumes in the flight crew compartment, placed their masks in the EMERGENCY setting; this setting so impeded communication that each flight crew member would pull his mask away from his face to communicate both with ATC and within the cockpit.

Flight crew oxygen mask training historically has been limited to certain simulator events. Often the masks – and smoke goggles, if installed – are allowed to be removed so as not to impede training. Additionally, the flight simulator masks often do not actually replicate the behaviour of the actual masks in the aircraft; e.g., using the mask in the simulator may allow perfect communication at EMERGENCY flow settings, but when faced with using the same setting in actual flight, communication may be very difficult.

Finally, some mask controls are not intuitive. It may be difficult for the user to identify the mask setting once it has been donned. For that reason, oxygen mask training should be sufficient and repetitive enough to ensure a high level of proficiency that flight crew can maintain even in the stressful circumstances of a real emergency.

In addition to existing flight crew oxygen mask training, each operator should include the following:

- Clear guidance regarding when it is appropriate to use each mask function (i.e., NORMAL, 100%, EMERGENCY);
- An SOP requiring masks to be stowed with 100% selected, unless this generates a constant flow of oxygen;
- Actions to take if communication difficulty is encountered in the EMERGENCY setting;
- Guidance regarding communication while wearing masks (i.e., using the flight interphone for intra-cockpit communication vs. using ATC Comm for all communication);
- Repetitive, hands-on drills with masks in a classroom or other non-simulator environment to increase familiarity with controls;
- Alternate cockpit sources of oxygen in the event of mask malfunction during use, including locating that source in extremely low visibility.

For operators of aircraft equipped with vision-assurance-technology devices for use in smoke-filled cockpits, flight crews should receive both initial and recurrent training regarding its use. Classroom or distance training should include not only a system description and a

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review of deployment procedures, but also a discussion suggesting general guidelines for intra-cockpit communications when visibility is limited by smoke. For example, a more ‘closed-loop’ communication will be necessary (e.g., the flying pilot’s ‘gear down’ command should elicit a “I have placed the gear handle down” response).

While vision-assurance-technology simulator training does not necessarily require the simulator to be filled with smoke, the training should nevertheless incorporate a means to eliminate intra-cockpit visibility – other than through the device – to replicate a realistic smoke-filled cockpit environment. The object of the training should be for the crewmembers not only to gain confidence in the effectiveness and use of the device but also to develop the communication skills outlined in the classroom training.

9. Maintaining the smoke barrier

SAFITA Part 1 deals with the importance of the smoke barrier and this issue should also be addressed in aircraft crew training (RAeS, 2013).

Minimising the migration of smoke from the cabin into the flight crew compartment is essential for the continued safe operation of the aircraft.

In most large transport aircraft the flight crew compartment door is a major part of the smoke barrier between the flight crew compartment and the passenger cabin. In the event of an in-flight fire in the cabin, it is essential that the flight crew compartment door remains closed and that the primary communication between the flight crew and the cabin crew is conducted by means of the crew interphone system.

In the event of a fire occurring in the flight crew compartment, the commander may decide that the flight crew compartment door should be opened, although this may be necessary in any case if cabin crew assistance is required to deal with the fire.

Aircraft crew procedures and associated training should address these issues during initial training and recurrent training.

10. Hidden fires

Most in-flight fires are quickly detected and are dealt with rapidly and successfully by the aircraft crew.

However, an in-flight fire that goes undetected for even a short time, has the potential to grow in size and become uncontrollable, probably resulting in a catastrophic event.

Fires that are ‘hidden’ are not readily accessible, may be difficult to locate and are more challenging to extinguish. Some examples of hidden fires would be fires behind sidewall panelling or in overhead areas. Hidden fires present significant problems for aircraft crew, in terms of identifying the exact source and location of the fire. This creates difficulties for the effective discharge of extinguishing agents at the actual source of the fire.

For many years, aviation safety agencies around the world have raised the issue of hidden fires and the problems with aircraft crew dealing with such an in-flight event.

The Transportation Safety Board of Canada (TSB) in their Aviation Investigation Report into the Swissair Flight 111 involving a MD-11 which suffered an in-flight fire leading to www.aerosociety.com

collision with water in September 1998 made the following statements:

- At the time of the accident “...the aviation industry (manufacturers, regulators, operators and associations) did not treat the issue of in-flight fire protection as a “system” of inter-related measures; that is, there was no requirement for an overall assessment of various fire-related defences.”
- “No major initiatives had been established to assess all components together, or to evaluate their inter-relationships with a view to developing improved, coordinated, and comprehensive firefighting measures. There was a lack of integration of the various potential measures to combat in-flight fires.”
- “Considerable industry efforts have been made to prepare and equip aircraft crews to handle some types of in-flight fires (e.g., readily accessible passenger cabin fires). However, these efforts have fallen short of adequately preparing aircraft crews to detect, locate, access, assess and suppress in-flight fires in a rapid, coordinated and effective manner.”
- “It was not anticipated within the aviation industry that aircraft crews could be confronted with a fire in the attic area of an aircraft. Neither were crews trained to appreciate how quickly in-flight fires can develop into uncontrollable situations.”
- “There was little emphasis on the possibility that a fire may have already started by the time smoke is detected, or that once a fire has started, it may not be isolated or eliminated by existing check-list procedures.”
- “Swissair flight crews trained together with cabin crews and met industry standards for dealing with readily accessible fires in the passenger cabin area, such as fires in galleys or lavatories. None of the firefighting training included firefighting in the cockpit, avionics compartment, or in hidden areas behind panels or above the cockpit or cabin ceiling area.”
- “In general, pilots are not expected to leave their flying duties to engage in firefighting duties outside the cockpit. This expectation is consistent with industry norms, which dictate that the cabin crew fight the fire so that the pilots continue to fly the aircraft.”
- “Cabin crews were trained to locate and extinguish in-flight fires, but their training was limited to those areas of the aircraft that are readily accessible. This training would not prepare cabin crew members for firefighting in the attic area or other hidden areas. Further, cabin crews were not specifically trained to fight fires in the cockpit or avionic compartment areas.”

The NTSB (2002) issued several recommendations to the FAA to require the enhancement of aircraft crew training for dealing with hidden fires.

In response to the NTSB recommendations, the FAA issued AC 120-80A (2014). This AC addressed a wide-range of issues relating to in-flight fire and smoke, including the problem of hidden fires. This AC includes in Appendix 2, a diagram of a typical wide body aircraft cross-section and shows various areas such as air conditioning units and ventilation airflow, attic areas, sidewall panels, tunnel areas, cargo compartments and outflow valve(s). The FAA has stated that the attic areas vary considerably between small regional jets and wide body aircraft

and that: *“Crew members must understand the volume of overhead space in a particular aircraft to effectively combat hidden fires in this area.”*

Actions taken by aviation agencies relating to in-flight fires, including hidden fires, are detailed in Section 18 and in Appendix 2 of this document.

NAAAs recognise that hidden fires are a significant in-flight threat (UK CAA, 2011). This is certainly the case for the FAA (2014), who issued AC 120-80A to identify aircraft crew training and operational issues. This is also reflected in UK CAA advisory material (2011), although not included in EASA requirements or advisory material for aircraft crew training.

In spite of this FAA advisory material, many aircraft crew may have little or no theoretical training on hidden fires. Fires occurring behind sidewall and ceiling panels can result in smoke emission some distance away from the actual location of the fire. Such panels will have to be prised open or removed in order to access the source of the fire and to discharge an extinguishing agent. Equipment for achieving interior panel removal, such as a crash axe or crowbar, is on many aircraft located only in the flight crew compartment. On all larger aircraft there will be the additional issue of a locked flight crew compartment door and the associated security procedures for access. In respect of EASA requirements, only aircraft that have more than 200 passenger seats installed are required to have a second crash axe or crowbar located in the passenger cabin adjacent to the aft galley. Many NAAs, including the FAA, have no requirement for such equipment to be located in the passenger cabin. Any practical training may be extremely limited with little information available regarding the removal of interior panels and how best to apply extinguishing agent agents. The emission of smoke, possibly some distance from the actual location of the fire, may result in the extinguishing agent having little or no effect if the identification and location of the fire and associated aircraft crew actions are remote from the actual source of the fire. This is addressed in SAFITA Part 1 (RAeS, 2018).

UK CAA Paper 2002/01 – ‘A Benefit Analysis for Enhanced Protection from Fires in Hidden Areas on Transport Aircraft’, clearly details the need for urgency in order for flight crew and cabin crew to take the necessary actions to deal with an in-flight fire event.

The UK CAA (2009) has stated: *“In-flight aircraft fires are a very rare occurrence but have the potential to be catastrophic. Of particular concern are fires that originate behind cabin walls and ceilings, where locating the fire and gaining access can be difficult.”*

In July 2013 an Ethiopian Airlines Boeing 787 was involved in an incident at London Heathrow. The aircraft had been parked for several hours on a remote stand with no personnel on board when smoke was observed to be coming from the aft section of the fuselage. The London Heathrow Airport Rescue and Fire Fighting Services (RFFS) were sent to the aircraft and discovered an internal fire which they extinguished. The initial investigation by the UK Air Accident Investigation Branch (AAIB) identified that the likely cause of the fire was related to a fixed system Emergency Locator Transmitter (ELT) installed in the area above Doors 4 (AAIB, 2013). Of particular interest is the following AAIB statement:

“... large transport aircraft do not typically carry the means of fire detection or suppression in the space above cabin ceilings and had this event occurred in flight it could pose a significant safety concern and raise challenges for the cabin crew in tackling the resulting fire.”

Despite the recognised potential threat of hidden fires, very little is included in aircraft crew mandatory training requirements by the major NAAs, although both the FAA and the UK CAA have issued advisory material. There is no mention of hidden fires in EU-OPS or in the EASA

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requirements in respect of fire training for aircraft crew. As a result many aircraft crew may receive little or no theoretical or practical training on how to deal with an in-flight hidden fire. They may have received little information as to the actual removal of interior panels and how best to apply an extinguishing agent to a hidden fire. Additionally, aircraft crew may not be aware of the problems of electrical circuits, cables and other components that may exist behind panels where incorrect actions may have an adverse effect on electrical systems and could make the situation worse.

Aircraft crew training in fire-fighting and the associated procedures should take into account, the specific types of aircraft that they operate, as well as any unique installations that might have an impact on hidden fires, such as aircraft crew rest areas.

The FAA (2014) identified that in the case of a hidden fire, in only one third of such events would the aircraft reach an aerodrome before the fire became uncontrollable. This clearly identifies the risk and the urgency of the required aircraft crew actions. However, it is questionable if this need for urgent action is effectively addressed in both theoretical and practical fire training. Such training should also include the location of suitable additional equipment, such as crash axe and/or crowbar. On aircraft that are only equipped with a crash axe and/or crowbar in the flight crew compartment, training should remind cabin crew of the availability and location of this equipment and the procedures for accessing the equipment in an emergency. Training should include the following:

- Emphasis on the danger of hidden fires and the importance of prompt action, providing accurate information to the flight crew and the need to action the appropriate checklists/procedures as quickly as possible;
- How to safely attempt to locate smoke/fire/fume sources behind panels;
- The principles of extinguishing agents and associated fire-fighting techniques, such as heavier-than-air extinguishers that should be applied from above;
- Dangers of, and procedures for, accessing behind aircraft panels, including the possible location of wiring and other components.

11. Location of crash axes and crowbars

As stated previously, on aircraft with fewer than 200 passenger seats installed, the only crash axe or crowbar mandated by the EASA requirements is located in the flight crew compartment. For aircraft with 200 or more passenger seats installed, EASA requires the provision of a second crash axe or crowbar to be stowed adjacent to the aft galley. The FAA requires only one crash axe under all circumstances and the location is not prescribed. Operators should consider the provision of an item of non-lethal equipment, to be located in the passenger compartment so as to minimise the opening of the flight crew compartment door and thereby maintain the smoke barrier. Such equipment could be of assistance in the removal of panels to gain access to a hidden fire.

12. Electrical fires

Aircraft crews are trained to deal with electrical fires in galley areas and lavatory compartments. However, the increasing complexity of electrical installations, especially on larger aircraft, such as In-flight Entertainment (IFE) Systems, charging systems for laptop computers and passenger use of an ever-increasing number of PEDs should be addressed in aircraft crew procedures and training and in particular the potential problems in dealing with a lithium battery fire.

Additionally, premium class cabins have passenger seats that are driven by electrical motors so as to position the seats in a variety of recline and sleeping positions. Such seats have high electrical loads with associated circuit breakers usually located in the cabin under the control of the cabin crew.

Each electrical system installed in an operator's aircraft under the control of flight crew or cabin crew should have a specific procedure to deal with an electrical failure that might result in an in-flight fire. For each system the use and restrictions for associated circuit breakers should be addressed and such procedures should be included in training, as applicable. The location of circuit breakers accessible to cabin crew and the responsibility for the operation of such equipment should be included in cabin crew training and specified in the Operations Manual.

13. Lithium battery fires

The hazards and associated risks of lithium battery fires are covered in SAFITA Part 1 (RAeS, 2018). In recent years there has been a significant rise in the number of PEDs that have lithium batteries as their power source. On a typical flight, an aircraft carrying 100 passengers could have more than 500 lithium batteries on board including devices such as laptop computers, tablet devices, mobile phones, cameras, electronic watches, e-readers, electronic flight bags, etc. Many such devices have a lithium battery as an integral sealed unit so the battery cannot be easily replaced from an unapproved source, thereby reducing the risk of a lithium battery fire in such devices.

However, lithium batteries present a potentially serious fire hazard, including fire, explosion, smoke and fumes. It is essential that aircraft crews are trained to deal with lithium battery fires. ICAO has issued 'Emergency Response Guidance for Aircraft Incidents Involving Dangerous Goods' and this includes incidents involving PED fires with lithium battery cells (ICAO, 2013).

Additionally, In July 2014, the UK CAA issued two Information Notices regarding in-flight dangerous goods events including lithium batteries. CAA Information Notice Number IN 2014/117 (issued 21 July 2014) 'Videos on the Hazards to Flight Safety from the Improper Carriage of Lithium Batteries' provides information regarding the availability of videos on CAA's YouTube Channel. CAA Information Notice Number IN 2014/118 (issued 21 July 2014) 'Revised Guidance on Dealing with Dangerous Goods Incidents in the Cabin' provides comprehensive guidance on dealing with in-flight incidents involving dangerous goods including lithium batteries. Risk mitigation guidance for operators has also been published by IATA and includes training recommendations. (IATA, 2014)

Advice from the UK CAA in Information Notice 2014/118, is to submerge the lithium battery device in water. In larger aircraft types with galleys, a bar box might be a suitable piece of equipment to use for this purpose. Of concern with this advice is how the device is to be submerged without exposing the crewmember/firefighter to risk of serious injury from a venting or exploding lithium battery.

Although the guidance from ICAO in Appendix 3 stresses the importance of not moving a portable electronic device which is or has been involved in a fire (possibly involving a lithium battery fire), it would be prudent to have an alternative procedure to deal with such an event if it occurs in or close to the flight crew compartment. Given that most flight crew compartments have very limited space in which to deal with a lithium battery fire, and the proximity of the device to electronic systems and to the flight crew themselves, the retention of the device in the flight crew compartment should be considered as a serious hazard. Therefore, at the

commander's discretion, if he/she considers that not moving the affected device presents a greater risk, it should be moved to an area in the passenger compartment where the cabin crew may more readily be able to deal with the situation. Extreme caution should be exercised in moving the device with adequate protection for the crewmember/firefighter. A barrier or shield along with fire gloves and possibly PBE should be used for this procedure. If PBE is not available, then smoke goggles could be used instead.

Containment devices are now available on the market that may reduce the risk associated with a PED fire. Some of these containment devices contain capturing devices that provide a shield for the flight crewmember. Protecting the crewmember tasked with moving the overheating device is paramount. Considering the proliferation of lithium battery powered devices being carried on board aircraft, the industry should consider evaluating the suitability of such devices for managing PED fires in-flight. Operators that provide aircraft crew with such devices should ensure that the procedures for their use are detailed in the Operations Manual and that the aircraft crew are trained in their use and protecting themselves from bodily harm from overheating electronic devices.

Some National Aviation Authorities recommend the use of water or non-alcoholic liquids to cool an overheating device. Consideration should be given to the potential risk of water causing damage in the flight deck, near an in-flight entertainment system or other areas. In addition, there is a significant risk to the crewmember/firefighter while pouring water onto the device. Many modern electronic devices are water resistant or water proof reducing or eliminating the effectiveness of water as a cooling agent.

There is now technology that cools the device using a dry agent thereby eliminating the consequence of water. This technology should be used where available.

It is essential that the crew be trained in the identification of lithium battery fires versus aircraft fires (electrical, pneumatic, oven or waste bin). Lithium battery fires require different fire fighting techniques and pose a different type of risk to crewmembers. Training to recognise and fight lithium battery fires should include considerations for moving the device.

Lithium battery fires are increasing in frequency (RAeS 2018), therefore, improvements in crewmember training are needed quickly.

It should be noted that the use of burn bags is not recommended by the FAA in SAFO 09013 (Supplement) (FAA 2009) and Advisory Circular 20-42D (FAA 2014) due to the risk of serious injury to crew when inserting an overheating device into a bag. Other extinguishing agents (dry) and containment devices that adequately protect crew should be used.

14. Combi aircraft operations

Combi aircraft are configured with both passengers and cargo being carried on the main deck. The cargo section of a Combi aircraft is separated from the passenger compartment and is usually located in the aft section of the main deck.

Following a fatal accident in 1987 when a South African Airways Boeing 747 Combi suffered an in-flight fire in the cargo compartment (aft of Doors 4 on the main deck), the FAA, as well as other NAAs, introduced additional requirements for Combi aircraft, including crew member procedures for normal and emergency situations. These requirements included the need for additional practical training for crew members in realistic Combi aircraft environments. (FAA, 1993; Republic of South Africa, 1990)

In the event of an in-flight fire in the cargo compartment of a Combi aircraft, intervention by the aircraft crew may be required. Some Combi operations are undertaken in wide-bodied aircraft and with a cargo compartment of considerable size. For example, there are usually six or seven containers and/or pallets on a Boeing 747 main deck.

The difficulty of fighting a fire in a Combi cargo compartment is significant since it involves a crew member:

- Donning protective clothing;
- Donning PBE;
- Entering the cargo compartment through a cargo compartment door;
- Unlatching the 'g-net';
- Locating the large Halon fire extinguisher and lance;
- Locating the source of the fire in one of the containers and/or pallets;
- Extinguishing the fire;
- Monitoring the area for re-ignition.

All this is to be achieved in a large and potentially unfamiliar environment and with limited communication with the flight crew or other cabin crew members.

Operators using Combi aircraft should assess the effectiveness of their aircraft crew fire-fighting procedures and ensure that the required practical training fully reflects what might be expected of an aircraft crew member in the event of an in-flight fire occurring in a cargo compartment on a Combi configured aircraft.

15. Fire training instructors

The qualifications and/or experience of persons conducting training and associated checking of flight and cabin crew proficiency in responding to in-flight smoke, fire, and fumes should be specified in the operator's Operations Manual.

With respect to fire training, such persons should have experience in theoretical and practical fire training, be competent in instructional techniques and have a good working knowledge of aircraft crew in-flight fire operating procedures specific to the actual aircraft type(s) and associated systems to be operated.

Suitably qualified persons should have good working knowledge of the operator's Operations Manual and Safety Notices relevant to aircraft crew fire-fighting procedures and equipment.

16. Third party training

Many operators outsource their aircraft crew fire training to third party training organisations. The provision of aircraft crew fire training by a third-party training organisation may result in issues of consistency with the AOC holders Operations Manual (UK CAA, 2009).

Third party training organisations should adhere to the same standards as if the operator were providing in-house training. The operator should audit the training to ensure full compliance with their Operations Manual and Training Manual and that the mandatory training and checking requirements are achieved. Again, standardisation of the training is essential.

The training and associated records provided by a third-party training organisation are the

responsibility of the operator and not the third party training organisation.

Further guidance on such issues is provided in CAP 789 (UK CAA, 2011).

17. EASA cabin crew initial safety training requirements

EASA Requirements for Initial Safety Training and Examination specifies significant theoretical (and practical) cabin crew fire training requirements. These include:

- Dealing promptly with in-flight fire and smoke events and identification of the fire source;
- Informing the flight crew and actions necessary for coordination;
- Frequent checking of potential fire risk areas;
- Classification of fires and use of appropriate extinguishing agents;
- Practical training in fire-fighting and in the donning of smoke protection equipment used in aviation;
- Procedures of ground-based emergency services.

Despite the essential nature of these requirements, they are only required to be addressed during initial training and examination, and are therefore sometimes considered to be ‘once only’ training requirements. The importance of these issues cannot be overstated; for cabin crew to be trained in these items only once in their careers may lead to a lack of competence in subsequent years. If this training is not repeated it is probably unrealistic to expect a cabin crew member to be able to recall items of initial training five or ten years later and could lead to incorrect actions in the event of an in-flight fire.

While some operators address some or all of these training items in recurrent training, it is recommended that all operators do so.

The EASA requirements for cabin crew Initial Safety Training listed above are required for the EASA Cabin Crew Attestation and are transferable between EASA AOC Holders. It should be noted that the elements of the EASA requirements for Initial Safety Training are not completely generic. Moreover, cabin crew Initial Safety Training might not necessarily be conducted by an AOC Holder, but by a Third-Party Training Organisation approved by the NAA to conduct such training. Therefore, it is important that operators consider the above issues in cabin crew Operator Aircraft Type Specific Training and Operator Conversion Training, in accordance with the procedures and equipment relevant to the aircraft types to be operated, as specified in the AOC Holder’s Operations Manual.

18. Actions taken by aviation safety agencies

The US National Transportation Safety Board

In 2002, the NTSB issued a review of in-flight fires. This review identified some significant shortfalls in aircraft crew training and misinformation on the use of Halon fire extinguishers. In one case, during an in-flight fire, the commander instructed the cabin crew not to discharge a Halon extinguisher because he was concerned about Halon being sprayed in the cabin. In addition, at least one operator had no emergency drill to deal with hidden fires.

The NTSB Safety Recommendations made to the FAA are in Appendix 2.

The US Federal Aviation Administration

In response to the NTSB Safety recommendations (2002), the FAA issued AC 120-80 in 2004. In 2014 this was updated with AC 120-80A.

The FAA provided guidance for the uses of hand-held fire extinguishers in AC 20-42D (FAA 2011).

A wide-range of issues are addressed by the FAA and these are included in Appendix 2.

UK Civil Aviation Authority

In the UK CAA Safety Plan of 2011/2013, a number of high-risk factors for civil aviation were identified. One of these was an in-flight fire and the UK CAA decided to conduct a Training Needs Analysis for Cabin Crew Fire Training.

Extracts from the UK CAA Safety Plan and the Cabin Crew Training Needs Analysis and other initiatives are in Appendix 2.

Additional advisory material on fire issues is available in UK CAA CAP 789 - Requirements and Guidance Material for Operators (2011), UK CAA FODCOM's and Safety Notices.

The Transportation Safety Board of Canada (TSB)

On 2 September 1998 Swissair MD-11, Flight Number 111, departed New York on a scheduled flight to Geneva. The aircraft experienced a significant fire event in the flight crew compartment and although a diversion to Halifax, Nova Scotia, was commenced the aircraft crashed into the sea. There were no survivors.

The TSB made several important statements in both their interim and final accident reports relating to aircraft crew procedures and training in the event of an in-flight fire or smoke event. The TSB statement regarding hidden fires can be found at Section 9. Additional information from the TSB regarding the Swissair MD-11 accident is given in Appendix 2.

19. Recommendations

This section describes the RAeS Flight Operations Group recommended mitigations for the issues addressed in the previous sections regarding aircraft crew training in dealing with an in-flight fire.

19.1 General

Recommendation 1

Any aircraft crew training for handling smoke/fire/fume events should emphasise the priorities of the FSF checklist template. In particular the training should emphasise the urgency required in fighting an in-flight fire.

Recommendation 2

Whenever practical, flight crew and cabin crew fire training should be combined to provide experience in effective co-ordination and communication between them.

Recommendation 3

All flight crew and cabin crew members should be trained to fight lithium battery fires. Training should include the use of protection equipment, consideration of movement of the device, means of cooling the device and containment of the device.

Recommendation 4

When the training of aircraft crew in fire-fighting techniques has been outsourced to a third-party organisation, the operator remains responsible for the content and consistency of such training and should ensure this through regular audit processes.

Recommendation 5

Operators should ensure that instructors' assessment of crew proficiency in extinguishing fires is standardised, especially when the equipment requires the instructor to decide when the fire has been extinguished.

19.2 Training Equipment

Recommendation 6

Aircraft crew fire training should be realistic in terms of fire-fighting equipment, aircraft types and operational procedures.

Recommendation 7

Extinguishing agents used in training should be chosen to replicate most closely those used on board the aircraft to be operated.

Recommendation 8

Extinguishers used in training should require the same degree of hand pressure to operate as operational units on board the aircraft.

Recommendation 9

Operators should verify that seals on Protective Breathing Equipment (PBE) used in training are effective and replicate PBE carried on board the aircraft.

Recommendation 10

The difficulties in fighting a fire while simultaneously using fire extinguishers, PBE and fire gloves in a real fire situation on board an aircraft should be reflected as accurately as possible in training.

Recommendation 11

Practical fire training should demonstrate the actual difficulties in communicating either face-to-face or by interphone with other aircraft crew members while wearing protective equipment.

Recommendation 12

Operators that provide aircraft crew with containment devices should ensure that the procedures for their use are detailed in the Operations Manual and that the aircraft crew are trained in their use.

19.3 Fire Training Scenarios

Recommendation 13

Operators should use realistic scenarios in training that follow the full sequence of events to an appropriate conclusion.

Recommendation 14

Operators should use training scenarios that require on-going communication between the cabin crew and flight crew as the scenario develops.

Recommendation 15

For operations without cabin crew, flight crew training should include the procedures for transferring from cockpit smoke protection to portable protection equipment.

Recommendation 16

For operations without cabin crew, flight crew training should include the procedures for passenger handling in a smoke/fire/fumes event.

Recommendation 17

Operators should ensure that there is regular and effective communication between the instructional team for aircraft crew safety and emergency procedures training and the flight crew instructional team for flight crew simulator training.

Recommendation 18

Flight crew training should emphasise that if the source of the fire is not confirmed visually to be extinguished after initial actions the flight crew should initiate a diversion.

Recommendation 19

Flight crew oxygen mask training should ensure complete familiarity for use in an emergency situation.

Recommendation 20

The problems and procedures for dealing with hidden fires, lithium battery fires, flight crew compartment fires, avionics compartment fires, and crew rest compartment fires should be addressed in NAA requirements for theoretical and practical fire training. Training should include protection of flight crewmembers fighting the fire and movement of overheating devices into a containment vessel if there are containment devices available on the aircraft. If vision assurance equipment is installed, then practical training should be conducted. Training according to this recommendation should be conducted during initial and recurrent training.

Recommendation 21

In Combi aircraft, the special difficulties associated with access to and unfamiliarity of crews with cargo compartments should be stressed in training.

Recommendation 22

Aircraft crew training should include an understanding of the vital requirement of maintaining a smoke barrier between the flight crew compartment and the passenger

compartment (i.e. the flight crew compartment door).

Recommendation 23

Operation of circuit breakers to isolate an electrical circuit and limit the continued ignition source of the fire should be addressed in both flight crew and cabin crew training together with the restrictions on their use.

Recommendation 24

Where a flight requires only one cabin crew member, he/she should be trained in the responsibilities and difficulties of managing a cabin fire situation; operators should develop specific procedures for dealing with an in-flight fire in such circumstances.

Recommendation 25

Where a flight is permitted to operate without any cabin crew, operators should develop specific procedures and training for flight crew to deal with an in-flight fire and any passengers on-board.

19.4 Regulatory Improvements

Recommendation 26

NAAAs should conduct a comprehensive review of aircraft crew fire training requirements in light of SAFITA Part 2: Training, as well as other industry initiatives, and determine the need for future rule-making in the long term and the issuing of advisory material in the short term.

Recommendation 27

EASA (and if applicable, other NAAAs) should review their fire training requirements and determine what changes might be appropriate to address the problems for aircraft crews in dealing with hidden in-flight fires, including fires in attic areas, avionic compartments and fires in the flight crew compartment.

Recommendation 28

The EASA requirements (and, if applicable, other NAA requirements) for cabin crew initial fire training should be repeated on a three-year cycle to ensure continued competence.

20. References

- AAIB. (2005). Cessna 550 Citation 11, G-VUEA. *AAIB Bulletin 3/2005*. 38-44. AAIB
- AAIB. (2013). Boeing 787-8, ET-AOP. *AAIB Special Bulletin S5/2013*. AAIB
- Cardosi, K M, & Huntley, M S (1988). *Cockpit and Cabin Crew Coordination*. FAA
- FAA. (1993). Airworthiness Directive 93-07-15, Amendment 39-8547. FAA
- FAA. (2004). In-flight Fires. *AC 120-80*. FAA
- FAA. (2009). Fighting Fires Caused By Lithium Type Batteries in Portable Electronic Devices. *SAFO 09013*. Washington, DC. FAA.
- FAA. (2011, January 11) Hand Fire Extinguishers for use in Aircraft, Advisory Circular 20-42D, Washington, DC. FAA
- FAA. (2014) In-Flight Fires, Advisory Circular 120-80A, Washington, DC. FAA

- FSF. (2005). Flight Crew Procedures Streamlined for Smoke/Fire/Fumes. *Flight Safety Digest*. 24 (6), 31-36.
- IATA (2014). *Lithium Batteries Risk Mitigation for Operators*. 1st Edition. Montreal: IATA.
- ICAO. (2013). Emergency Response Guidance for Aircraft Incidents Involving Dangerous Goods. *Doc 9481 – AN/928*. ICAO
- NTSB. (1986). *Aircraft Accident report Air Canada McDonnell Douglas DC-9-32*. Retrieved from <http://www.nts.gov/investigations/summary/AAR8602.html>
- NTSB. (2002). *A-01-83 through -87: Recent In-flight Fires*. Washington: NTSB
- RAeS. (2013). *Smoke, Fire and Fumes in Transport Aircraft Part 1: Reference*. London: RAeS
- RAeS. (2018). *Smoke, Fire and Fumes in Transport Aircraft Part 1: Reference. Fifth Edition* London: RAeS
- Republic of South Africa. (1990) Report of the Board of Inquiry into the Helderberg Air Disaster. Pretoria: Government Printer
- Taylor, P M Rt Hon Lord Justice. (1989). *The Hillsborough Stadium Disaster*. London: HMSO
- TSB. Aviation Investigation Report – In-Flight Fire Leading to Collision with Water
Swissair Transport Limited – McDonnell Douglas MD-11 HB-IWF
Peggy’s Cove, Nova Scotia 5nm SW – 2 September 1998
Report Number A98H0003
- UK CAA. (2001). *CAA Paper 2002/01: A Benefit Analysis for Enhanced Protection from Fires in Hidden Areas on Transport Aircraft*. Gatwick: UK CAA.
- UK CAA. (2009). *Cabin Crew Fire Training - Training Needs Analysis*. Gatwick: UK CAA.
- UK CAA. (2009). CAA Works with Airlines on Fire Training Policy. *CAA Newsroom*. Retrieved from:
<http://www.caa.co.uk/application.aspx?catid=14&pagetype=65&appid=7&newstype=n&mode=detail&nid=1727>
- UK CAA. (2013). Aviation regulators launch joint fire safety initiative. *CAA Newsroom*. Retrieved from:
<http://www.caa.co.uk/application.aspx?catid=14&pagetype=65&appid=7&newstype=n&mode=detail&nid=2265>
- UK CAA, (2011). CAP 789. *Requirements and Guidance Material for Operators*. Gatwick: UK CAA
- UK CAA. (2011). *Safety Plan 2011 to 2013*. Gatwick: UK CAA.
- UK CAA. (2014). Information Notice Number IN 2014/117. *Videos on the Hazards to Flight Safety from the Improper Carriage of Lithium Batteries*. Gatwick: UK CAA.
- UK CAA. (2014.) Information Notice Number IN 2014/118. *Revised Guidance on Dealing with Dangerous Goods Incidents in the Cabin*. Gatwick: UK CAA.
- UNEP. (2007). *The Montreal Protocol on Substances that Deplete the Ozone Layer*. UNEP

Appendix 1

The EASA Requirements for Cabin Crew Fire Training and Suggested Guidance Material

Appendix 1 to Part-CC – Initial training course and examination

The EASA Requirements	Guidance on Meeting the EASA Requirements
8. Fire and smoke training:	
8.1. emphasis on the responsibility of cabin crew to deal promptly with emergencies involving fire and smoke and, in particular, emphasis on the importance of identifying the actual source of the fire;	<ul style="list-style-type: none"> ➤ Importance of in-flight fires and the need to identify the exact fire source wherever it might be located, i.e. all areas of the aircraft accessible to the crew during flight. ➤ Identification of the location of the fire and its intensity, the amount of smoke being produced, and associated smells that might provide indications as to fire source; ➤ All such information to be communicated to the SCCM and to the flight crew by the cabin crew. ➤ The need for immediate and urgent action in dealing with an in-flight fire. ➤ The limited amount of time available for achieving a successful outcome using case studies where appropriate. ➤ Passenger management and crowd control. ➤ Specific procedures for dealing with fires involving aircraft systems.

The EASA Requirements	Guidance on Meeting the EASA Requirements
<p>8.2. the importance of informing the flight crew immediately, as well as the specific actions necessary for coordination and assistance, when fire or smoke is discovered;</p>	<ul style="list-style-type: none"> ➤ Specific procedures for communication and coordination with the flight crew and other cabin crew members and the specific actions required to deal with an-flight fire. ➤ For operations with only one cabin crew member, particular importance on fire-fighting and communication procedures, including criteria for requesting assistance from dead-heading crew members and if necessary passengers. ➤ Actual communications between cabin crew and flight crew, taking into account the lack of face-to-face communication imposed on many aircraft by the locked/secured flight crew compartment door and reliance on communication via interphone. ➤ Communication of the essential information to the flight crew regarding an in-flight fire, so that the flight crew can make well-informed decisions as to an emergency descent and/or diversion. ➤ Essential information to be communicated by the cabin crew to the flight crew, including the following: <ul style="list-style-type: none"> a. Which crew member is speaking and from what location; b. The location of the fire and source of the fire and any associated smell. c. The size of the fire and the amount and colour of the smoke being produced; d. The cabin crew actions being undertaken and the number of fire extinguishers used; e. Passenger reaction, and cabin crew actions to control the situation; and f. The development of the event, when the fire is extinguished, and the conduct of post-fire procedures. ➤ That the high level of work-load on the flight crew will be extremely demanding during an in-flight fire event and that information passed to the flight crew by the cabin crew needs to be clear and concise, and relevant to the situation. ➤ The occurrence of multiple fires in different areas of the passenger cabin or areas accessible to passengers and crew during flight including multi-deck aircraft. ➤ The options for cabin crew to deviate from specific emergency procedures to deal with differing fire situations.
<p>8.3. the necessity for frequent checking of potential fire-risk areas including toilets, and the associated smoke detectors;</p>	<ul style="list-style-type: none"> ➤ The location of potential fire-risk areas and the required frequency of the checking of such areas including the visual checking of associated smoke detectors. ➤ Best practice for fire-prevention to include all galley and other electrical systems as well as restrictions on the use and re-setting of circuit breakers under the control of cabin crew.
The EASA Requirements	Guidance on Meeting the EASA Requirements

8.4 the classification of fires and the appropriate type of extinguishing agents and procedures for particular fire situations;	<ul style="list-style-type: none"> ➤ Basic fire chemistry (The Fire Triangle) – oxygen; heat; fuel. ➤ Classes of fires and associated types of extinguishers. Alternative methods of fire-fighting using equipment/resources other than fire extinguishers.
8.5. the techniques of application of extinguishing agents, the consequences of misapplication, and of use in a confined space including practical training in fire-fighting and in the donning and use of smoke protection equipment used in aviation; and	<ul style="list-style-type: none"> ➤ Optimum use of each type of extinguisher carried on the aircraft, to include the limited amount of extinguishment carried, especially in the case of smaller aircraft. ➤ The training in fire-fighting and donning of smoke protection equipment (i.e. PBE) will need to be covered in detail during Aircraft type specific training, and Operator conversion training. ➤ Third-party training organisations will need to take this into consideration, although the use of any fire extinguishers and PBE will not necessarily be consistent with the equipment carried on board by the operator.
8.6. the general procedures of ground-based emergency services at aerodromes.	<ul style="list-style-type: none"> ➤ Training to be undertaken in association with, or advice from, local airport Rescue and Fire Fighting Services (RFFS), to the general procedures of ground-based emergency services at aerodromes, including the use of standard emergency hand signals by rescue and fire-fighting service personnel;

ORO.CC.125 – Aircraft type specific training and operator conversion training

The EASA Requirements	Guidance on Meeting the EASA Requirements
(c). the aircraft type specific training programme shall:	
<p>(c) (2). cover at least the following aircraft type specific training elements:</p> <p>(i) aircraft description as relevant to cabin crew duties;</p> <p>(ii) all safety equipment and systems installed relevant to cabin crew duties;</p> <p>(v) fire and smoke protection equipment where installed.</p>	<p>➤ All equipment that might be used in fire-fighting and the exact location of such equipment to include, fire extinguishers, PBE, torches, protective clothing such as fire gloves, crash axes and/or crowbars, etc.</p>
<p>(d). (3) cover at least the following operator specific training elements as relevant to the aircraft type to be operated:</p> <p>(i) description of the cabin configuration;</p> <p>(ii) location, removal and use of all portable safety and emergency equipment carried on board;</p> <p>(v) fire and smoke training including the use of all related fire-fighting and protective equipment representative of that carried on board;</p>	<p>➤ A detailed description of the cabin configuration to include the location of fire risk areas such as lavatory compartments, galleys, crew rest areas, etc., as well as the location of circuit breakers in cabin areas and the restrictions on the re-setting of circuit breakers.</p> <p>➤ See AMC1 ORO.OPS.CC.125(d).</p>

AMC1 ORO.CC.125(c) – Aircraft type specific training and Operator conversion training – Training Programme – Aircraft Type Specific Training

The EASA Requirement	Guidance on Meeting the EASA Requirements
(d) Fire and smoke protection equipment. Each cabin crew member should be trained in using fire and/or smoke protection equipment where fitted.	➤ See AMC1 ORO.OPS.CC.125(d).

AMC1 ORO.OPS.CC.125(d) – Aircraft type specific training and Operator conversion training

The EASA Requirements	Guidance on Meeting the EASA Requirements
<p>(b) Safety and emergency equipment. Each cabin crew member should receive realistic training on and demonstration of the location and use of all safety and emergency equipment carried including:</p> <p>(3) fire extinguishers and protective breathing equipment (PBE);</p> <p>(4) crash axe or crowbar;</p> <p>(5) emergency lights including torches;</p> <p>(6) communication equipment, including megaphones;</p> <p>(10). other portable safety and emergency equipment where applicable</p>	<ul style="list-style-type: none"> ➤ Training to include the type(s) of fire-fighting equipment carried on each aircraft type(s) and variant(s) to be operated and include specific cabin configurations such as crew rest areas, lavatory compartments, galleys, cargo areas accessible to the cabin crew during flight, etc. ➤ Each cabin crew member to demonstrate their knowledge on the location and use of all fire-fighting equipment and demonstrate their ability to remove such equipment from the different stowage areas found on the aircraft type(s) and variant(s) to be operated. ➤ The fire-fighting equipment to be representative of that carried on the aircraft type(s) and variant(s) to be operated. ➤ Fire extinguishers that are not representative in terms of weight, size or operation, to those carried on the aircraft type(s) or variant(s), are not to be used in any part of training. ➤ Differences in fire extinguishers used in training may be necessary in order to overcome the restrictions on Halon discharge in order to meet the requirements of the Montreal Protocol. Any differences in equipment are to be specified in the Operations Manual (OM) and stressed during training. ➤ The use of fire axes and crowbars to access hidden fires is to be addressed in practical training. ➤ Alternative means of accessing hidden fires is to be specified. ➤ Galley and other electrical systems in the cabin and areas accessible to cabin crew during flight, to be included in training as well as restrictions on the use and re-setting of circuit breakers. ➤ The location of circuit breakers accessible to cabin crew and responsibility for such equipment to be included in training and specified in the OM procedures.

The EASA Requirements	Guidance on Meeting the EASA Requirements
<p>(c) Normal and emergency procedures.</p> <p>Each cabin crew member should be trained on the operator's normal and emergency procedures as applicable with emphasis on the following:</p> <p>(4) Other in-flight emergencies.</p>	<ul style="list-style-type: none"> ➤ Training to include an in-flight fire, with particular emphasis on identifying the actual source of the fire taking into account the systems and installations relevant to the aircraft type(s) and variant(s) to be operated. ➤ Training to include all relevant fire scenarios and address flight crew compartment fires and fires in cargo areas as well as other areas which are accessible to the cabin crew during flight. ➤ Training to identify not only the nature of the fire, and its source and location, but also its intensity, and the amount of smoke that is being produced, as well as the effective use of all fire-fighting equipment. ➤ The occurrence of multiple fires in different areas of the passenger cabin or areas accessible to crew during flight. ➤ Cabin crew fire training to include communications and coordination with the flight crew and other cabin crew by use of the interphone and also the difficulties of communication while wearing PBE. ➤ When combined flight crew and cabin crew is not conducted, there needs be an effective liaison between both training departments so as to ensure consistent in-flight procedures as specified in the OM and in related flight crew procedures and documentation.
(e) Fire and smoke training:	
<p>(1) Each cabin crew member should receive realistic and practical training in the use of all fire-fighting equipment including protective clothing representative of that carried in the aircraft;</p>	<ul style="list-style-type: none"> ➤ The fire-fighting equipment to be representative of that carried on the aircraft type(s) and variant(s) to be operated.

The EASA Requirements	Guidance on Meeting the EASA Requirements
<p>(2) Each cabin crew member should:</p> <p>(i) extinguish an actual fire characteristic of an aircraft interior fire except that, in the case of halon extinguishers, an alternative extinguishing agent may be used;</p>	<ul style="list-style-type: none"> ➤ Each cabin crew member demonstrates their ability to extinguish an actual fire. ➤ If more than one type of fire extinguisher is carried on the aircraft type(s) or variant(s), each type of extinguisher will need to be used in practical training by each cabin crew member. ➤ Fire extinguishers that are not representative in terms of weight, size or operation, to those carried on the aircraft type(s) or variant(s), not to be used in any part of training. ➤ Differences in fire extinguishers used in training may be necessary in order to overcome the restrictions on Halon discharge in accordance with the requirements of the Montreal Protocol. Any differences in equipment are to be specified in the OM and stressed during training. ➤ Some fire extinguishers require additional pressure to break the fire extinguisher seal, to the amount of pressure that is experienced with a training unit. When practicable, such pressure will need to be replicated on training units. When not practicable, the differences will need to be stressed in training. ➤ The size of the fire will need to present the cabin crew with an actual challenge in terms of extinguishing the fire. Fires that are easily extinguished might result in a false sense of security. ➤ Fires scenarios will need to be consistent with installations on the aircraft type(s) and variants(s) to be operated. ➤ Where 'gas-powered' fire training rigs are utilised, the specific use of them will need to be specified in the OM especially in cases where the instructor actually terminates the supply of the gas. Specific criteria is to be specified in the OM as to when the gas supply is terminated in order to ensure that the cabin crew member has clearly demonstrated proficiency. ➤ Hidden fires and access to hidden fires will need to be addressed in practical training. ➤ Combination of practical fire extinguisher training with practical PBE training and the use of protective clothing such as fire gloves. ➤ Cabin crew fire training will include communication and coordination with the flight crew and other cabin crew by use of the interphone system and the difficulties of communication while wearing PBE. ➤ Fire re-ignition will be dealt with on practical level.

The EASA Requirements	Guidance on Meeting the EASA Requirements
<p>(ii) exercise the donning and use of PBE in an enclosed, simulated smoke-filled environment with particular emphasis on identifying the actual source of fire and smoke.</p>	<ul style="list-style-type: none"> ➤ Each cabin crew member will need to demonstrate their ability to don PBE, and to use it in an enclosed simulated smoke-filled environment. ➤ If more than one type of PBE is carried on the aircraft type(s) or variant(s) to be operated, each type of PBE will need to be used in practical training by each cabin crew member. ➤ The removal of PBE from its container and packaging will need to be addressed in training. This may need to be achieved by a suitable training video or other media facility. ➤ Special attention will need to be paid to PBE neck seals and their integrity so as to ensure a level of difficulty of donning that would be encountered with an operational unit. ➤ The density of the smoke-filled environment will need to be a standard specified in the OM – suggested criteria might be a specified number of visible seat rows. ➤ The time spent in a smoke-filled environment by each cabin crew member will need to be a standard specified in the OM. ➤ Practical PBE training will need to be conducted in conjunction with practical fire extinguisher training, as well as communication and coordination by use of the interphone. ➤ All aspects of cabin crew fire training will need to include communications and communication with the flight crew and other cabin crew by use of the interphone, and include communication of only essential information.

ORO.CC.140 – Recurrent Training

The EASA Requirements	Guidance on Meeting the EASA Requirements
(a) Each cabin crew member shall complete annually recurrent training and checking.	
(b) Recurrent training shall cover the actions assigned to each member of the cabin crew in normal and emergency procedures and drills relevant to each aircraft type and/or variant to be operated.	➤ Emergency procedures should include in-flight fires and different fires scenarios depending on the aircraft type as well as the facilities and the installations on-board including electrical systems in the passenger cabin.
(d) Operator specific training elements:	
(1) Recurrent training shall include annually:	
(i) by each cabin crew member	
(A) Location and handling of all safety and emergency equipment installed or carried on board; and	➤ Such training might necessitate a visit(s) to the actual aircraft type(s) and variants(s) to be operated. Aircraft visit(s) will need to be specified in the CCTM.
(B) the donning of life-jackets, portable oxygen and protective breathing equipment (PBE).	➤ If more than one type of PBE is carried, each cabin crew member will need to don each type of PBE.
(iv) emergency procedures;	
(2) Recurrent training shall also include at intervals not exceeding three years:	
(iii) realistic and practical training in the use of all fire-fighting equipment, including protective clothing, representative of that carried in the aircraft;	
(iv) by each cabin crew member:	
(A) extinguishing a fire characteristic of an aircraft interior fire;	➤ See the detail in AMC1 ORO.CC.140 – Recurrent Training.
(B) donning of PBE in an enclosed simulated smoke-filled environment.	➤ See the detail in AMC1 ORO.CC.140 – Recurrent Training.

AMC1 ORO.CC.140 – Recurrent Training – Training Programmes

The EASA Requirements	Guidance on Meeting the EASA Requirements
(a) Elements of annual recurrent training programme	
(1) Training on the location and handling of safety and emergency equipment should include all relevant oxygen systems, and any equipment such as defibrillators if carried on board.	<ul style="list-style-type: none"> ➤ Such training may necessitate a visit(s) to the actual aircraft type(s) and variant(s) to be operated. Aircraft visits will need to be specified in the OM. ➤ If more than one type of PBE is carried, each cabin crew member will need to don each type of PBE.
(2) Training on emergency procedures should cover pilot incapacitation procedures and crowd control techniques.	<ul style="list-style-type: none"> ➤ Review of the fire related items required for Initial training course and examination.

The EASA Requirements	Guidance on Meeting the EASA Requirements
(b) Additional triennial elements of training	
<p>(2) Training in the use of all fire-fighting equipment, including protective clothing, representative of that carried in the aircraft should include individual practice by each cabin crew member to extinguish a fire characteristic of an aircraft interior fire except that, in the case of halon extinguishers, an alternative extinguishing agent may be used. Training should place particular emphasis on identifying the actual source of fire or smoke.</p>	<ul style="list-style-type: none"> ➤ Each cabin crew member will need to demonstrate their ability to extinguish an actual fire. ➤ If more than one type of fire extinguisher is carried, each type of extinguisher will need to be used in practical training by each cabin crew member. ➤ Differences in fire extinguishers used in training may be necessary in order to overcome the restrictions on Halon discharge in accordance with the requirements of the Montreal Protocol. Any differences in equipment will need to be specified in the OM and stressed in training. ➤ Some fire extinguishers require additional pressure to break the fire extinguisher seal to that experienced with a training unit. When practicable such pressure will need to be replicated on training units. When not practicable, the differences will be stressed in training. ➤ The size of the fire will need to present the cabin crew with an actual challenge in terms of extinguishing the fire. Fires that are easily extinguished might result in a false sense of security. ➤ The actual size of the fire and the fire source used in the training will need to be described in the OM together with level of difficulty to extinguish the fire, together with different fire scenarios. ➤ Fires scenarios will need to be consistent with installations on the aircraft type(s) and variant(s) to be operated. ➤ Fire re-ignition will need to be dealt with on a practical level. ➤ Where ‘gas-powered’ fire training rigs are utilised, the specific use of them will need to be specified in the OM especially in cases where the instructor actually terminates the supply of the gas. Specific criteria will need to be specified in the OM as to when the gas supply is terminated in order to ensure that the cabin crew member has clearly demonstrated proficiency. ➤ Hidden fires to be addressed in practical training. ➤ Practical fire extinguisher training to be combined with practical PBE training and the use of protective clothing such as fire gloves. ➤ Cabin crew fire training to include communications and coordination with the flight crew and other cabin crew by use of the interphone.

The EASA Requirements	Guidance on Meeting the EASA Requirements
	<ul style="list-style-type: none"> ➤ Each cabin crew member to demonstrate their ability to don and use PBE in an enclosed simulated smoke-filled environment. ➤ If more than one type of PBE is carried on the aircraft or variant, each type of PBE to be used in practical training by each cabin crew member. ➤ The removal of PBE from its container and packaging to be addressed in training. This may need to be achieved by a suitable training video or other media facility. ➤ Special attention to be paid to PBE neck seals and their integrity to be such so as to ensure a level of difficulty of donning that would be encountered with an operational unit. ➤ The density of the smoke-filled environment to be a standard specified in the OM – suggested criteria might be a specified number of seat rows. ➤ The time spent in a smoke-filled environment by each cabin crew member to be a standard specified in the OM. ➤ Practical PBE training to be conducted in conjunction with practical fire extinguisher training, as well as communication and coordination by use of the interphone. ➤ All aspects of cabin crew fire training to include communications and coordination with the flight crew and other cabin crew by use of the interphone, including communication of essential information. ➤ When combined flight crew and cabin crew training is not conducted there will need to be an effective liaison between both training departments so as to ensure consistent in-flight procedures as specified in the OM.

ORO.CC.115 – Conduct of training courses and associated checking

The EASA Requirements	Guidance on Meeting the EASA Requirements
<p>(a) A detailed programme and syllabus shall be established by the operator for each training course in accordance with the applicable requirements of this Subpart, and of Annex V (Part-CC) to Regulation (EU) No 290/2012 where applicable, to cover the duties and responsibilities to be discharged by the cabin crew members.</p> <p>(b) Each training course shall include theoretical and practical instruction together with individual or collective practice, as relevant to each training subject, in order that the cabin crew member achieves and maintains the adequate level of proficiency in accordance with this Subpart.</p> <p>(c) Each training course shall be:</p> <ol style="list-style-type: none"> (1) conducted in a structured and realistic manner; and (2) performed by personnel appropriately qualified for the subject to be covered. <p>(d) During or following completion of all training required by this Subpart, each cabin crew member shall undergo a check covering all training elements of the relevant training programme, except for crew resource management (CRM) training. Checks shall be performed by personnel appropriately qualified to verify that the cabin crew member has achieved and/or maintains the required level of proficiency.</p>	<ul style="list-style-type: none"> ➤ The check of fire-training proficiency will need to address each element of required theoretical and practical training. ➤ Where it is not possible to conduct certain practical proficiency checks, these items will need to be specific reference in the OM and be addressed by alternative means of training and checking, e.g. removal of PBE from its packaging. ➤ In the case of Third Party Training, a clear understanding between the operator and the Third Party Training organisation will need to be established as to the level of required proficiency. ➤ Operators should ensure that the EASA requirements are clearly stated in cabin crew training record forms, or by specific reference to the syllabi in the OM. ➤ Simply stating in training records that ‘fire and smoke training’ has been completed does not necessarily comply with the EASA practical training requirements. ➤ Third Party Training organisations will need to ensure that the training records that they produce are fully in accordance with the individual operator’s requirements and documentation. ➤ Fire training records produced by Third Party Training Organisations are the responsibility of the operator.

Appendix 2

Actions taken by aviation safety agencies in respect of in-flight fire

The US National Transportation Safety Board

In a review of in-flight fires in 2002, the NTSB made the following Safety Recommendations to the FAA:

- “Issue an AC that describes the need for crewmembers to take immediate and aggressive action in response to signs of an in-flight fire. The AC should stress that fires are often hidden behind interior panels and therefore may require a crew member to remove or otherwise gain access to the area behind interior panels in order to effectively apply extinguishing agents to the source of the fire. (A-01-83)”
- “Require Principle Operations Inspectors to ensure that the contents of the advisory circular (recommended in A-01-83) are incorporated into crewmember training programmes. (A-01-84)”
- “Amend 14 Code of Federal Regulations 121.417 to require participation in fire fighting drills that involve actual or simulated fires during crewmember recurrent training and to require that those drills include realistic scenarios on recognizing potential signs of locating, and fighting hidden fires. (A-01-85)”
- “Develop and require implementation of procedures or airplane modifications that will provide the most effective means for crewmembers to gain access to areas behind interior panels for the purpose of applying extinguishing agent to hidden fires. As part of this effort, the FAA should evaluate the feasibility of equipping interior panels of new and existing airplanes with ports, access panels, or some other means of applying extinguishing agent behind interior panels. (A-01-86)”
- “Issue a flight standards handbook bulletin to principle operations inspectors to ensure that air carrier training programs explain the properties of Halon and emphasize that the potential harmful effects on passengers and crew are negligible compared to the safety benefits achieved by fighting in-flight fires aggressively. (A-01-87)”

The Federal Aviation Administration

In response to the NTSB safety recommendations, the FAA issued AC 120-80 in 2004.

In this AC the FAA addressed:

- The dangers of in-flight fires and in particular hidden fires;
- The need for rapid assessment of the situation and the taking of immediate and aggressive action;
- The gaining of access behind panels;
- The effectiveness of Halon as an extinguishing agent;
- Definitions associated with fire;
- Cause and indications of in-flight fires;
- Alternative resources available for fighting a fire;
- Types of hand-held fire extinguishers and their operation;
- Possible harm to passengers of exposure to Halon discharge;
- Flight crew and cabin crew actions;
- Restrictions on the use/resetting of circuit breakers.

This clearly demonstrates the need for urgency in order for aircraft crew to take the necessary actions to deal with an in-flight fire event and that in only one third of such instances will the aircraft reach a suitable alternate aerodrome before the fire becomes uncontrollable.

The table below, taken from Appendix 3 in the FAA AC 120-80, shows the time that various aircraft crew had in actual incidents between the first indication of fire, to the point when the fire became catastrophically uncontrollable. Also, that for aircraft with hidden fires, an approximate assessment is that only one third will reach a suitable aerodrome before the fire becomes uncontrollable.

Date:	Location:	Aircraft Type:	Time to become non-survivable:
July 1969	Biskra, Algeria	Caravelle	26 minutes
July 1973	Paris, France	Boeing 707	7 minutes
November 1973	Boston, USA	Boeing 707 (Cargo)	35 minutes
November 1979	Jeddah, Saudi Arabia	Boeing 707	17 minutes
June 1983	Cincinnati, USA	Douglas DC-9	19 minutes
November 1987	Mauritius, Indian Ocean	Boeing 747 (Combi)	19 minutes
September 1998	Nova Scotia, Canada	Douglas MD-11	16 minutes

The average 'Time to become 'non-survivable' in the above accidents is just 20 minutes. In spite of this worrying statistic there is no reference in the EASA requirements for aircraft crew training to address the issue of hidden fires, either as a requirement for theoretical training or practical training, nor has any guidance material been issued by EASA.

Three additional fire-related accidents are worthy of note as follows:

- UPS, DC-8 in-flight and post ground fire accident in Philadelphia, 8 February 2006;
- UPS, Boeing 747-400F in-flight fire accident, 3 September 2010, departing Dubai for Cologne;
- Asiana, Boeing 747-440F in-flight fire accident, 28 July 2011, departing Incheon, South Korea, for Shanghai in China.

The UK Civil Aviation Authority

UK CAA - Safety Plan of 2006/2007

The UK CAA Safety Plan stated: *“The CAA believes that the current training practices and standards may no longer [be] totally appropriate; recent accident experience indicates that consideration should be given to the implications of more substantial cabin fire than currently trained. In addition the introduction of locked flight crew compartment security doors could have an implication for training procedures. The possibility of multiple, simultaneous fires should also be considered in training.”*

UK CAA – Cabin Crew Training Needs Analysis

The Training Needs Analysis was conducted by an independent organisation and the results of the work were published in UK CAA Paper 2009/01 – Cabin Crew Fire Training – Training Needs Analysis, conducted by Ray Cherry and Associates – Aeronautical and Safety Engineers (UK CAA, 2009).

The purpose of the Analysis was: *“To evaluate current and possible future issues, and identify potential improvements to existing fire training in order to ensure that cabin crew members have the most appropriate training and procedures to match current and likely fire threats.”*

In March 2009, the UK CAA made the following statements in respect of the Cabin Crew Fire Training Analysis:

“One of the most serious threats in air transportation today is an in-flight fire. Cabin crew and flight crew actions are the primary line of defence in such an occurrence and it is therefore essential that they have the most appropriate training to deal with the threat.”

“In-flight aircraft fires are a very rare occurrence but have the potential to be catastrophic. Of particular concern are fires that originate behind cabin walls and ceilings, where locating the fire and gaining access can be difficult.”

“As the cabin environment is always changing, with new aircraft – such as the A380 – being introduced, the UK CAA considered it timely to review overall cabin crew training needs to ensure cabin crew have the necessary skills to deal with current and future fire threats.”

“The UK CAA will work with the European Aviation Safety Agency (EASA) to develop European-wide safety rules, and with UK operators to ensure that best fire training advice is available.”

“As the safety regulator for UK operators, we must ensure that cabin crew receive fire fighting training that is both adequate and appropriate. As the aviation industry continues to evolve, new fire threats emerge that must be considered. The study indicates that there are a number of issues to consider for the future and we will be working with the UK industry and our European partners to provide guidance.”

A cross-section of operators was visited during the Training Needs Analysis; most were UK operators, but some non-UK operators were also involved.

The UK CAA determined that the main findings of the analysis were:

- In-flight fires were a serious threat;
- Cabin crew were the first line of defence and that flight crew had little control over an in-flight fire situation;
- Training should be appropriate and effective;
- Fire extinguishers and PBE used in training were not always representative to those carried on board the aircraft to be operated;
- Some operators had more than one type of fire extinguisher and more than one type of PBE;
- The removal of PBE from packaging was not practised;
- Discharge of Halon was not easily replicated because of restrictions imposed by the Montreal Protocol;
- The severity of fire encountered in training, differed between operators and training organisations;
- There was a need for training to deal with fire re-ignition – otherwise training might encourage a false sense of security;
- PBE used in training was often damaged – especially in the case of PBE neck seals;
- Practical PBE training was not usually combined with practical fire-fighting training;
- The time spent by aircraft crew in smoke while wearing PBE differed between 20 seconds and seven minutes, the density of smoke differed significantly, and smoke scenarios were not always appropriate or realistic;
- Where joint training was not conducted there was a need for close and effective liaison between flight crew and cabin crew training departments;
- Fire training needs to be in compliance with the requirements of the operator and appropriate to the operation;
- Some important aspects of theoretical fire training were only required by the EASA requirements to be carried out once, i.e., during initial training;
- Hidden fires were not always addressed in training.

The analysis also identified further questions as follows:

- Was the type of fire appropriate to the operation of the aircraft and its installations?
- If gas rigs are used, what criteria were there for the instructor to terminate the gas supply?
- Were multiple fires addressed in training?
- Were communications issued addressed in PBE training, i.e., use of the interphone and PA while actually wearing PBE?
- Should cabin crew wear their uniform when conducting fire training?
- In the case of single cabin crew operations, was the effectiveness of operational procedures and training for fighting an in-flight fire actually addressed by operators?
- Was removal of fire-fighting equipment from stowage(s) practised by individual cabin crew?
- Was the management and control of passengers included in fire scenarios?
- Was Third Party Training controlled and regularly audited by the operator?
- Was Third Party Training reviewed on a regular basis by the operator in order to ensure that changes to procedures and equipment were addressed?

- Did Third Party training organisations have access to the relevant parts of the Operations Manual?

The main conclusions of the analysis were:

- There was lack of definition of some of the EASA requirements and there was lack of advisory material issued by EASA;
- Many operators did more than the EASA requirements;
- There were few criteria for the checking of proficiency;
- Combined flight crew and cabin crew training to deal with in-flight fires should be increased;
- There was a need to incorporate CRM issues into fire training;
- Health and Safety issues needed to be addressed in fire training.

In May 2009, the UK CAA organised an industry working group to look at the above findings and conclusions in order to develop advisory material (UK CAA, 2009). The working group presented their material to the CAA in the late summer of 2009. Resulting from this the UK CAA issued FODCOM 19/2010 ‘Cabin Crew Fire and Smoke Training’.

Note: Although the UK CAA Training Needs Analysis was conducted primarily in respect of cabin crew, many of the findings and conclusions are equally appropriate to flight crew procedures and training.

In August 2013 the CAA announced the launch of a joint fire safety initiative with the FAA (UK CAA, 2013). Although the film that has been produced by both agencies is related to the importance of compliance with maintenance procedures, the UK CAA made the following important statements:

“Indeed, the CAA has previously identified fire as one of the ‘significant seven’ safety risks to commercial aviation, along with such threats as ‘loss of control’ and ‘runway excursions’. Of particular concern is the threat of fires breaking out in hidden areas of the aircraft, which cabin crew are unable to access and bring under control in-flight. The importance of reducing fire risks was highlighted with the recent significant fire on the Ethiopian Airlines Boeing 787 on the ground at London Heathrow. As the film points out, an in-flight fire that is out of control will on average lead to the flight crew losing control of the aircraft within 15 minutes.”

The Transportation Safety Board of Canada (TSB)

The Swissair MD-11 Accident

The TSB in their 2000 interim aviation safety recommendations – In-flight fire-fighting – Swissair Flight 111 (MD-11), stated:

“The TSB review of SR 111 and other in-flight fire occurrences has shown that where an in-flight fire continues to develop, there is little time between detection of the fire and the loss of aircraft control. It must be anticipated that aircraft systems will be affected, either as a direct result of the fire, or as a result of emergency procedures such as the de-powering of electrical busses. It is imperative that fire fighting procedures be well defined and that aircraft crews be well trained in handling all in-flight fires.”

“Although aircraft crews are trained to fight in-flight fires, there are no requirements that cabin and flight crews train together, or that they be trained to follow an integrated fire-fighting plan and checklist procedure. For example, neither flight crews nor cabin crews are trained to fight in-flight fires in the cockpit. Several operators contacted by the TSB indicate that flight crews and cabin crews do not receive training specific to fighting fire in the cockpit. The division of roles and responsibilities between flight and cabin crews with respect to who will be combating an in-flight fire in the cockpit is not clearly defined in manuals and company procedures.”

Additionally, the TSB in their final accident investigation report A98H0003 (TSB, 2003), made the following statements:

“Conclusions - Findings as to Causes and Contributing Factors”

“There was a reliance on sight and smell to detect and differentiate between odour or smoke from different potential sources. This reliance resulted in the misidentification of the initial odour and smoke as originating from an air conditioning source.”

“There was no integrated in-flight fire-fighting plan in place for the accident aircraft, nor was such a plan required by regulation. Therefore, the aircraft crew did not have procedures or training directing them to aggressively attempt to locate and eliminate the source of the smoke, and expedite their preparations for a possible emergency landing. In the absence of such a fire-fighting plan, they concentrated on preparing the aircraft for the diversion and landing.”

“Conclusions – Other Findings”

“Coordination between the pilots and the cabin crew was consistent with company procedures and training. Crew communications reflected that the situation was not being categorized as an emergency until about six minutes prior to the crash; however, soon after the descent to Halifax had started, rapid cabin preparations for an imminent landing were underway.”

“Safety Action – In-flight fire-fighting”

“Along with initiating the other elements of a comprehensive fire-fighting plan, it is essential that flight crews give attention, without delay, to preparing the aircraft for a possible landing at the nearest suitable airport. Therefore, the TSB made the following recommendation: Appropriate regulatory authorities take action to ensure that industry standards reflect a philosophy that when odour/smoke from an unknown source appears in an aircraft, the most appropriate course of action is to prepare to land the aircraft expeditiously. A00-18 (issued 4 December 2000)”

“An uncontrollable in-flight fire constitutes a serious and complicated emergency. A fire may originate from a variety of sources, and can propagate rapidly. Time is critical. Aircraft crews must be knowledgeable about the aircraft and its systems, and be trained to combat any fire quickly and effectively in all areas, including those that may not be readily accessible. The TSB believes that the lack of comprehensive in-flight fire fighting procedures, and coordinated aircraft crew training to use those procedures, constitutes a safety deficiency. Therefore the TSB made the following recommendation: Appropriate regulatory authorities review current in-flight fire-fighting standards including procedures, training, equipment, and accessibility to spaces such as attic areas to ensure that aircraft crews are prepared to respond immediately, effectively and in a coordinated manner to any in-flight fire. A00-20 (issued 4 December 2000)”

Appendix 3

ICAO - Dangerous Goods

The ICAO recommended procedures for responding to lithium battery fires can be found in Appendix 3. (ICAO DOC 9481 – AN/928 – Emergency Response Guidance for Aircraft Incidents Involving Dangerous Goods.)

Recommended Procedures in Case of Fire Involving a Portable Electronic Device

Use standard procedures – obtain and use a fire extinguisher

Standard emergency procedures must be used to deal with any fire. Although Halon has been shown not to be effective against lithium metal fires, Halon will be effective in fighting the subsequent fire of surrounding materials, or in fighting a lithium-ion battery fire.

Remove external electrical power from the device if applicable

A battery has a higher likelihood of catching fire through thermal runaway during or immediately following a charging cycle, although the effects of thermal runaway* may be delayed for some period of time. By removing external power from the device, it will be assured that additional energy is not being fed to the battery to promote a fire.

***Note:** Thermal runaway is a situation where an increase in temperature changes the condition in such a way that causes a further increase in temperature, often leading to a destructive result.

Douse the device with water or other non-flammable liquid to cool cells and prevent ignition of adjacent cells

If available, a water fire extinguisher should be used to cool the cells in the battery that have ignited, preventing the spread of heat to adjacent cells. If a water fire extinguisher is not available, any non-flammable liquid may be used to cool the cells and the device.

Do not move the device

A battery pack involved in a fire has been shown to reignite and emit flames multiple times as heat is transferred to other cells in the pack. It is preferable to cool the device using water or other non-flammable liquid. Injuries may occur if the device reignites while the device is being moved.

Remove power to remaining electrical outlets until the aircraft's system can be determined to be free of faults, if the device was previously plugged in

By removing power to the remaining electrical outlets, it can be assured that a malfunctioning aircraft system does not contribute to additional failures of the passengers PEDs.

In case of spillage – collect emergency response kit or other useful items

Collect emergency response kit, if provided, or collect for use in dealing with spillage or leakage:

- A supply of paper towels, newspapers or other absorbent paper or fabric such as seat cushion covers, head rest covers, etc;
- Oven gloves or fire resistant gloves, if available.

Appendix 4

Case Studies

Catastrophic In-flight Fires

Boeing 707 - Paris, France – 11 July 1973

(Reference: Journal Officiel de la Republique Francaise – 1976 No: 17 – 6 April 1976 and Cabin Safety Research Technical Group Accident Database, Version 4.3, Issue 16 Accident Reference 19730711A.)

The Boeing 707 was en route from Rio de Janeiro to Paris.

There were 134 passengers and crew on board. There were only 11 survivors.

The problem started with a fire in one of the aft lavatory compartments. Crew members were unable to contain the fire and smoke and were unable to identify the source of the fire. The captain reported a malfunction to the engines and requested ATC for an emergency landing at Orly. The captain also reported “fire on board”.

Smoke migrated into the passenger cabin and into the flight crew compartment. Flight crew donned oxygen masks and smoke goggles but the amount of black smoke in the flight crew compartment meant that the flight crew could not see the instruments and therefore the flight crew compartment were opened and an emergency landing was made with the flight crew using the open windows to make a crash landing in a field.

It is thought that many passengers died from smoke inhalation while the aircraft was in flight.

The Accident Report stated: *“Although the hypothesis of a fire which originated in the left toilet cannot be excluded, it is more likely that the fire started and developed in the aft right toilet probably in the washbin unit.”*

Since that time many requirements have been introduced to address potential problems with lavatory compartment fire issues. However, with smoking prohibitions on aircraft now in place in most countries, and potential non-compliance by passengers with the restrictions, the possibilities of a lavatory compartment fire continues to be threat to flight safety. Cabin crew still need to be vigilant and to continue their routine inspections of lavatory compartments and associated smoke detectors.

Douglas DC-9 - Cincinnati, USA - 2 June 1983

(Reference: National Transportation Safety Board Report – NTSB/AAR – 86/02 and Cabin Safety Research Technical Group Accident Database – Accident Reference 19830602A.)

The DC-9 was en route from Dallas to Toronto, and onwards to Montreal.

There were 46 passengers and crew on board. There were 23 fatalities.

The flight crew heard the circuit breakers ‘popping’ and associated this with the aft lavatory compartment flush motor. The flight crew did not consider this to be a serious problem. They attempted to reset the circuit breakers. The cabin crew identified a strong smell and this was traced to the aft lavatory. A fire extinguisher was discharged into the lavatory compartment and it was thought that the fire had been extinguished. The first officer donned breathing equipment and went aft to investigate/fight the fire. The passengers began to smell smoke in the cabin and the ‘Master Breaker’ alarm went off on the flight deck.

A diversion was made to Cincinnati and soon after touch down the interior of the aircraft ignited. When the aeroplane stopped, visibility in the cabin was almost non-existent at a distance of two to three feet above the cabin floor.

The NTSB Accident Report determined that the probable causes of the accident were a fire of undetermined origin, underestimated severity and misleading information provided to the captain on the progress of the fire. The NTSB concluded that the air conditioning packs were turned off some four minutes before the landing at Cincinnati and therefore there was virtually no fresh air supply into the flight crew compartment and the passenger cabin. The Accident Report stated: *“Propagation – regardless of the ignition source, the physical evidence showed that there was an area of intense burning in the lower aft outboard corner of the lowest section of the amenities section, and it also showed that the fire propagated forward from that point. As the fire moved forward from the amenities section, it also burned through the lavatory walls allowing smoke, hot gases, and fumes to rise to the air space between the lavatory shell and the airplane’s outer skin and between the aft pressure bulkhead and the lavatory’s line walls.”*

The time taken to initiate an emergency descent and diversion contributed to the accident. Had a decision been made by the captain earlier, the aircraft could have landed at Louisville, and between three to five minutes would have been saved.

The source of the smoke was never identified by the cabin crew or the first officer. The captain was not advised of the exact location of the fire, nor did he ask for precise location or extent of the fire. Crew members reporting that the fire was abating misled the captain about the fire severity and he delayed his decision to declare an emergency and to land.

CAA Paper 2002/01 stated: *“The precise source of the fire was never established. However it propagated between the trim panels and the fuselage. As the aircraft successfully landed, even a slowing of the propagation of the fire would have allowed all passengers to successfully evacuate. It is therefore assessed that enhancements to fires in hidden areas would have resulted in all lives being saved”.*

Boeing 747-200 (Combi) - Indian Ocean (off Mauritius) – 28 November 1987

(Reference: Report of the Board of Inquiry into the Loss of South African Airways Boeing 747-244B Combi Aircraft “Helderberg” in the Indian Ocean on 28 November 1987.)

The Boeing 747-200 (Combi) was en-route from Taiwan to Johannesburg via Mauritius.

There were 229 passengers and crew on board. There were no survivors.

The captain contacted Mauritius ATC to report a smoke problem and requested permission to descend. Two minutes later a full emergency was declared and when asked for a position the captain was uncertain and advised ATC they had lost a lot of electrics. Another two minutes later the position was reported to be 65 miles from Mauritius. Communication with the aircraft was lost 20 minutes after initial contact.

The position given by the Captain was not correct and it was 12 hours before floating wreckage from the aircraft was spotted and in that time had drifted some way from the point of impact.

Time for the in-flight fire becoming non-survivable was 19 minutes.

The location of the aircraft on the seabed took some time and was eventually found at a depth of 16,000 feet (5,000 metres). There were 3 separate debris fields. These were 1.5, 2.3 and 2.5 km apart which suggest that the fuselage broke up before impact with the water.

The investigation identified that the seat of the fire was in the forward right hand pallet which would have been located just behind the bulkhead and ‘G’ net for cargo restraint aft of door 4R. The cargo manifest for that pallet showed that it contained mostly computers in polystyrene packaging. It is possible that the fire produced gases that accumulated in the ceiling area of the cargo compartment and that a ‘flash’ fire occurred. Nothing was ever proven regarding the carriage of undeclared dangerous goods apart from the fact that a major and catastrophic fire in the main deck cargo compartment caused the loss of the aircraft.

Since the FAA was responsible for the original certification of the Boeing 747 ‘Combi’ it was their responsibility to review the airworthiness considerations and effectiveness of fire safety for the aircraft. At that time there were many ‘Combi’ 747’s operating worldwide.

The FAA came to the conclusion that new requirements were needed to address the possibility of an in-flight fire on ‘Combi’ aircraft. During their review the FAA consulted widely with manufacturers and operators as well as with the JAA and Transport Canada Civil Aviation (TCCA). This resulted in the issue of an FAA Airworthiness Directive that would affect not just the Boeing 747 ‘Combi’ but other large ‘Combi’ aircraft.

The FAA Airworthiness Directive introduced significant new requirements for ‘Combis’ and some operators found that complying with these new standards was not economically viable.

Note: A ‘Combi’ is an aircraft configured for the carriage of passengers and cargo on the same deck. On this Boeing 747 the cargo was carried in pallets between Doors 4 and 5 on the

main deck. The cargo compartment on this aircraft was categorised as Class ‘B’ and relied on crew intervention to fight an in-flight fire.

McDonnell Douglas MD-11 - Nova Scotia, Canada – 2 September 1988

(Reference: Transportation Safety Board of Canada Aviation Investigation Report Number A98H0003 and Cabin Safety Research Technical Group Accident Database – Reference 19980902A.)

Additional information on this accident is at Section 10 - Hidden fires.

The MD-11 was en-route from New York to Geneva.

There were 231 passengers and crew on board. There were no survivors.

About 53 minutes after take-off the flight crew detected a smell in the flight deck and their attention was drawn to an unspecified area above and behind them. Whatever they saw initially was no longer visible and they agreed that the origin was something to do with the air conditioning system.

When they had assessed what they had seen was definitely smoke they decided to divert and were advised by ATC that Halifax would be their nearest aerodrome.

While the flight crew were preparing for the landing in Halifax they were unaware that a fire was spreading above the ceiling area at the front of the aircraft.

About 13 minutes after the abnormal odour was first detected the FDR began to record a rapid succession of aircraft systems-related failures. The flight crew then declared an emergency.

About one minute later the radio communications were lost with the aircraft and the flight recorders stopped functioning.

Some five minutes later the aircraft crashed into the sea at Peggy's Cove, Nova Scotia.

The investigation into this accident by the Transportation Safety Board (TSB) of Canada took more than four years. The probable cause of the accident was a combination of faulty wiring and flammable materials. The TSB report concluded that the aircraft certification standards for material flammability were inadequate. They also concluded that arcing from electrical wiring associated with the in-flight entertainment system was the likely cause of fire ignition and that the circuit breakers on the MD-11 were not capable of protection against all types of arcing events.

The TSB report included the following statements:

- In the operating environment at the time, operators did not have policies in place to ensure that flight crews would be expected to treat all odours and smells as potential fire threats until proven otherwise.
- An effective fire fighting plan shall include procedures that address the optimum involvement of flight crew and cabin crew to detect, locate, access, assess, and suppress an in-flight fire in a coherent and coordinated manner.
- The cabin crew were trained to locate and extinguish in-flight fires, but their training was limited to those areas of the aircraft that were accessible. This training would not

prepare cabin crew members for fire fighting in the attic area or other hidden areas. Cabin crew were not specifically trained to fight fires in the cockpit or avionics compartment areas.

- There was no integrated in-flight fire fighting plan in place for the accident aircraft, nor was such a plan required by regulation.
- Coordination between the flight crew and the cabin crew was consistent with company procedures and training.
- Crew communications reflected that the situation was not being categorised as an emergency until six minutes before impact.
- No smoke was reported in the cabin by the cabin crew at any time before the CVR stopped recording.
- As a minimum aircraft crews need to be provided with a comprehensive fire fighting plan that is based on the philosophy that the presence of any unusual odour or smoke in an aircraft should be considered to be a potential fire threat until proven otherwise.

Boeing 747-44AF - Dubai, United Arab Emirates – 3 September 2010

(Reference: General Civil Aviation Authority of the United Arab Emirates (GCAA) – Air Accident Investigation Report – AAIS Case Reference 13/2010 – Uncontained Cargo Fire Leading to Loss of Control Inflight and Uncontrolled Descent into Terrain)

On 3 September 2010 Boeing 747-44AF departed Dubai International Airport (DXB) on a scheduled cargo flight to Cologne in Germany.

Earlier in the day the aircraft had arrived at DBX from Hong Kong with a mixed cargo including significant consignments of lithium batteries. These lithium battery consignments remained on board for the sector from DBX to Cologne.

Two flight crew were on board the aircraft.

Twenty minutes into the flight, at approximately 32,000ft, the flight crew contacted Bahrain ATC to advise that there was an indication of a fire in the forward main deck cargo compartment.

The flight crew declared an emergency and a return to DXB was requested.

Additionally, the flight crew advised that the flight crew compartment was full of smoke and that they could not see the radios.

The CVR detailed a pitch control problem that was discussed by flight crew during the first five minutes of the emergency.

The amount of smoke in the flight crew compartment impaired the ability of the flight crew to safely operate the aircraft for the duration of the flight back to DBX.

During the descent to DBX, the captain's oxygen supply ceased to function and resulted in him leaving his seat and not returning for the remainder of the flight due to incapacitation involving inhalation of toxic gases. It was confirmed during pathological examination that the captain lost consciousness due to toxic poisoning.

The first officer became the pilot flying but could not see outside the flight crew compartment, the primary flight crew displays or the audio control panel in order to return to the United Arab Emirates (UAE) radio frequencies.

The GCAA Accident Investigation Report states:

“The penetration by smoke and fumes into the cockpit area occurred early into the emergency. The cockpit environment was overwhelmed by the volume of smoke. There are several mentions of the cockpit either filling with or being continuously ‘full of smoke’, to the extent that the inability of the crew to safely operate the aircraft was impaired by the inability to view their surroundings.” “.....the crew could neither view the primary flight displays, essential communications panels or the view from the cockpit windows.”

As the aircraft approached DBX the flight crew were advised that they were too high and too fast and that a 360° turn was required. After the aircraft overflew DBX the flight crew were

advised that an alternative aerodrome at Sharjah International Airport (SHJ) approximately ten nautical miles away was available.

The flight crew confirmed a heading change and the aircraft reduced speed and entered a descending right turn south of DBX before radar contact was lost. Loss of control of the aircraft resulted in an uncontrolled descent into terrain, nine nautical miles south west of DBX.

There were no survivors.

The final GCAA report included 95 findings and 36 recommendations. The report concluded that a large fire developed in palletised cargo on the main deck consisting of consignments of mixed cargo including a significant number of lithium battery types and other combustible materials. The fire escalated rapidly into a catastrophic uncontained fire.

This accident reinforces the importance of urgent action by the flight crew in making an emergency descent and diversion to the nearest available aerodrome, and the importance of maintaining the smoke barrier although the penetration of smoke into the flight crew compartment on this occasion was not under the control of the flight crew.

Non-Catastrophic In-flight Fires and Smoke Incidents

Lockheed L-1011 TriStar – 170 miles east of Goose Bay, Canada – 17 March 1992

(Reference: Lois Kyle-Issenman – Transportation Safety Board of Canada – SCSI International Aircraft Cabin Safety Symposium - Costa Mesa – 1993)

The Lockheed L-1011 TriStar was en route from Frankfurt to Atlanta.

The aircraft was 170 nautical miles east of Goose Bay when the cabin crew reported a fire towards the rear left side of the cabin. At the same time a pneumatic duct overheat warning light illuminated in the flight deck. Shortly after this the cabin crew reported that the fire had been extinguished. The aircraft diverted to Goose Bay where it landed safely.

The fire started under the rear passenger floor between the side wall of the mid cargo compartment and the exterior wall of the aircraft. This is known as the ‘cheek’ area and on the L-1011 extends from the wheel well to the aft pressure bulkhead. Flames suddenly entered the cabin through the return air vent and were reported to be two feet in height above the cabin floor.

When the fire was detected the cabin crew rapidly established communication with the flight crew. The cabin crew carried out their procedures quickly and efficiently. The 1st cabin crew member on the scene determined that the fire was electrical and used a Halon extinguisher. A 2nd cabin crew member used a water extinguisher on burning clothing. A third cabin crew member contacted the flight crew and communication with the flight crew was maintained throughout the incident. Back-up fire extinguishers were relocated from the flight deck just in case they were required.

It took three minutes to extinguish the fire using three Halon and one water fire extinguishers.

Passengers from the area of the fire were relocated to other seats in the passenger compartment.

One of the flight crew came into the cabin to assess the damage and to confirm that the fire had been extinguished, and a PA was made by the flight crew to reassure passengers.

Although there was considerable burn damage it was localised due to the fact that the fire was extinguished before it could spread.

The most probable cause of the fire was electrical arcing and an accumulation of dust and lint in the area.

The cabin crew fought the fire rapidly and effectively and the Halon extinguished the fire very effectively.

The cabin crew displayed excellent decision making, crew coordination, communication and leadership.

One of the main messages from this potentially catastrophic occurrence confirms that the importance of effective procedures and that the importance of effective training should never be underestimated.

Airbus A340 – 120 miles north of Lusaka, Zambia – 5 December 1998**(Reference: AAIB Bulletin No: 8/99 Ref: EW/C98/12/1)**

The A340 was en-route from London to Johannesburg. There were 273 passengers and crew on board.

Nine hours into the flight, with some of the cabin crew taking rest in the lower lobe crew rest area, a passenger notified the cabin crew in the aft galley that there was a fire in the cabin. The cabin crew identified that there was a fire in a central overhead bin towards the back of the cabin. On reaching the location the cabin crew member attempted to discharge the Halon extinguisher but was unable to exert enough pressure on the extinguisher handle to break the seal in order to initiate operation. A passenger took the extinguisher and discharged its content into the overhead bin and also discharged the contents of a second extinguisher which had been handed to him. The fire was extinguished but there was a considerable amount of smoke and passengers in the area were advised to keep their heads down.

The captain was advised of the situation and the relief pilot was sent to the cabin to assist and evaluate the situation. It was determined that since the fire was extinguished the flight would continue to its destination.

All cabin crew received initial practical training in the use of fire extinguishers and additional practical training every three years, so why was the cabin crew member unable to initiate discharge of the fire extinguisher?

The actual use of 'live' fire extinguishers during crew training is prohibited under the terms of the Montreal Protocol, so most crew fire training is achieved with Halon extinguishers filled with water. As a result the fire extinguishers used in training did not fully replicate the extinguishers carried on board the aircraft. This was especially true of the integral brass seal that needed to be broken on this type of extinguisher when the operating handle is pressed. The force of breaking this seal on an 'operational' fire extinguisher was considerably greater than the force needed to activate discharge on fire extinguishers used in training.

Cessna 550 Citation – Manchester, England – 21 April 2003**(Reference: AAIB Bulletin No: 3/2005 Ref: EW/G2003/04/19)**

The Cessna 550 Citation was operating a positioning sector from Edinburgh to Manchester Airport with two flight crew on board and no passengers.

On the approach and descent into Manchester the flight crew became aware of a smell of burning electrical insulation and although there was no smoke in the flight crew compartment at this stage, the cabin was observed to be full of smoke.

The captain instructed the co-pilot to don his oxygen mask and at the same time initiated a MAYDAY call to air traffic control. At this time smoke began to enter the flight crew compartment causing the captain breathing difficulties. Having made the MAYDAY transmission the captain donned oxygen and as he did so smoke was beginning to obscure the instrument panel and forward vision from the flight crew compartment.

With no evident malfunction in the flight crew compartment the captain initiated the SMOKE REMOVAL emergency drill from memory. The captain decided not to carry out any subsequent emergency drills as he considered that the preparation for the approach and landing at Manchester was the priority.

During the visual final approach the concentration of smoke in the flight crew compartment increased again, although forward vision was not restricted further. The flight crew landed the aircraft normally and stopped it on the runway before shutting down the engines, removing all electrical power and evacuating via the forward main exit.

The captain sustained a sore throat and chest due to inhalation of smoke while making the MAYDAY transmission.

Subsequent examination of the aircraft and aircraft parts by the operator and by the AAIB established that the internal condition of the ‘cockpit’ defog fan was responsible for considerable smoke being drawn from the fan into the cabin air-flow.

The operator’s emergency procedure for a smoke event was contained in the Operations Manual issued to each captain and included in the flight crew compartment emergency checklist. The flight crew would normally be required to conduct either the ELECTRICAL FIRE OR SMOKE drill or the ENVIRONMENTAL SMOKE OR ODOUR, drill depending on the perceived source of the smoke.

The procedure also directs the flight crew to declare a MAYDAY and to “LAND AS SOON AS POSSIBLE”. It then advises the flight crew to carry out SMOKE REMOVAL if this is warranted. The Operations Manual also states: “The pilot-in-command shall, in an emergency situation that requires immediate decision and action, take any action he considers necessary under the circumstances. In such cases he may deviate from rules, operational procedures, and methods in the interest of safety.

The AAIB report also stated that the captain’s decision not to complete relevant emergency procedures was influenced by the time available and the need to concentrate on the approach and landing at Manchester.

In effect, the captain chose to action what he considered to be the most important part of the procedure, i.e. “Land as soon as possible”

Note: The flight crew compartment is separated from the passenger cabin by a curtain and not by a flight crew compartment door.

Bombardier DHC-8 - Leeds, England – 4 August 2005**(Reference: AAIB Bulletin No: 4/2007 Ref: EW/C2005/08/10)**

The DHC-8 was en-route from Birmingham to Edinburgh.

There were 60 passengers and crew on board.

During the flight an oily smell was noticed in the flight deck followed by a build-up of smoke in the flight deck and the cabin. The flight crew declared an emergency and ATC suggested Leeds as the most suitable aerodrome for a diversion.

The cabin crew donned PBE and prepared the cabin for an emergency landing. The cabin crew found that the smoke level in the cabin was getting thicker and that they could no longer see the length of the cabin. After landing at Leeds an emergency evacuation was conducted without any injury.

The cause of the smoke was later identified as a crack in the compressor support member of the No. 2 engine.

Due to the high flight crew work-load during the emergency, the flight crew were prevented in communicating with the cabin crew for some time. This caused concern to the cabin crew as to the state of the flight crew. Additionally, the cabin crew reported that the PBE severely hindered communication with passengers. Because of this one of the cabin crew decided to remove their PBE before landing.

Checks made during the investigation confirmed that verbal communication while wearing PBE was difficult even when in close proximity to another person. The operator's training criteria required cabin crew to practice donning PBE once a year and wearing PBE in a smoke-filled environment once every three years. The accident investigators concluded that this training had not fully prepared the cabin crew for the extent of the associated difficulties, raising questions as to effectiveness of their training.

The AAIB made the following safety recommendations:

“It is recommended that for all large aircraft operating for the purpose of public transport, the UK CAA and the EASA should take such steps, procedural or technical, as are necessary to improve the reliability and availability of communication between flight and cabin crews, including the reliability of communications equipment and associated power supplies in both normal and emergency configurations.”

“It is recommended that the UK CAA and EASA review the current training requirements for cabin crew in the use of smoke hoods to mitigate the communications difficulties which may be encountered and to improve the ability of all crew members to communicate while wearing smoke hoods.”