EASA REGULATORY IMPACT ASSESSMENT

OCCUPANT PROTECTION FROM POST CRASH FIRE AND SMOKE

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Issue 2

AMENDMENT RECORD

ISSUE NUMBER	DATE	REMARKS
1	September 2009	Initial Issue
2	December 2009	Minor Amendment - Section 1.2 paragraphs 3 and 4

CONTENTS

ABBREVIATIONS

AC	Advisory Circular
AMC	Acceptable Means of Compliance
CAA	Civil Aviation Authority (U.K.)
CS	Certification Specification
CSRTG	Cabin Safety Research Technical Group
CWM	Cabin Water Mist
EASA	European Aviation Safety Agency
EPA	Environmental Protection Agency
ETSC	European Transport Safety Council
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
JAA	Joint Aviation Authorities
MPS	Minimum Performance Standards
NPA	Notice of Proposed Amendment
NTSB	National Transportation Safety Board (United States of America)
PPBE	Passenger Protective Breathing Equipment (Smoke Hoods)
RIA	Regulatory Impact Assessment

DEFINITION OF TERMS

Occupant Protection Time *is the time in the accident sequence, from the aircraft coming to rest, to the point at which occupants within the cabin cease to be protected from the fire penetrating into the fuselage.*

1 PURPOSE AND INTENDED EFFECT

1.1 ISSUE WHICH THE NPA IS INTENDED TO ADDRESS

A study carried out for the EASA (Reference 1) involved a review of the current cabin safety threats and the degree to which they were addressed by CS-25 requirements. This study identified "Occupant protection from Post Crash Fire and Smoke" as a significant threat to occupant survival.

The issue of occupant protection in post crash fires has been addressed in part by the regulatory action taken by the EASA in amending CS-25 at Amendment 6, by the addition of 25.856(b). This new regulation requires that Thermal Acoustic Insulation fitted to the lower half of the fuselage provides a fire barrier to protect the cabin from fire entry following a post impact pool fire.

Whilst this regulatory action reflects that taken by the FAA in their Final Rule (Reference 2), the EASA considered that an updated review of the potential risks posed to occupant survival from ground pool fires was required. To this end they commissioned a study (Reference 3) to carry out this review and to identify potential regulatory means for mitigating these risks. The study proposed that CS 25.856(b) be replaced by a more objective rule that had the potential to provide a more cost beneficial means of providing Enhanced Fuselage Burnthrough Protection from post impact pool fires. However, the study also concluded that:

> *"Fire entry into the cabin through fuselage breaks, ruptures, and opened doors constitutes a major threat to occupants in approximately three-quarters of pool fire accidents and this cannot be mitigated by enhanced fuselage burnthrough protection."*

Therefore if this residual threat to occupants from ground pool fires is to be mitigated a means other than Enhanced Fuselage Burnthrough Protection must be found.

The EASA study (Reference 1) suggested three potential means of mitigating the post crash fire threat:

1. Cabin Water Mist Systems[1]
2. Enhanced Fuselage Burnthrough Protection
3. Passenger Smoke Hoods

Enhanced Fuselage Burnthrough Protection has been subjected to a Regulatory Impact Assessment as part of the EASA study (Reference 3), and as such is not considered in detail in this RIA. However, the protection afforded by Enhanced Fuselage Burnthrough Protection is considered in the assessment of the residual ground pool fire threat when considering the safety impact of Cabin Water Mist Systems.

[1] The term Cabin Water Mist should be considered as being synonymous with Cabin Water Spray within this RIA. Water Mist is now used in preference to Water Spray in order to reflect more precisely the characteristics of the system.

1.2 SCALE OF THE ISSUE

Various estimates have been made of the lives lost from ground pool fires.

A review of the in-service threats experienced in recent accidents carried out as part of the EASA study (Reference 1) suggested that:

> *"Based on the accident review, smoke/toxic gas inhalation during post-crash fires has caused many injuries and fatalities. It was assessed that over the review period 1998 to 2007, smoke/toxic gas inhalation has resulted in at least 135 and possibly 147 fatalities in three fatal accidents."*

Of the estimated number of 135 deaths, 124 were attributed to one accident - the accident to the A310 in Irkutsk in July 2006. The 135 ground pool fire fatalities approximates to an average of 13.5 deaths per year over the period 1998 to 2007 for the western world fleet.

A study carried out by the NTSB (Reference 4) found that 306 (66 percent) of the 465 fatalities in partially survivable U.S. aviation accidents from 1983 through to 2000 died from impact forces, 131 (28 percent) died from fire and smoke, and 28 (6 percent) died from other causes. The 131 fire and smoke fatalities approximates to 7 deaths per year in the United States. The US fleet accumulates approximately 36% of the number of flights worldwide. If the US accident rate was assumed to be typical of the world fleet then the 7 deaths would equate to approximately 19 on a worldwide basis – which is not too dissimilar from the experience suggested by the EASA study.

A Benefit Analysis carried out for the FAA relating to Enhanced Burnthrough Protection and Cabin Water Spray (Reference 5), was based on accidents occurring over the period 1967 to 1996. This analysis suggested that 46 lives might be saved per year worldwide by the introduction both of these improvements. For aircraft with Enhanced Fuselage Burnthrough Protection it was assessed that Cabin Water Spray systems could save a further 34 lives per year. The apparent anomaly between this prediction and the assessed number of lives lost per year to ground pool fires suggested by the EASA and NTSB studies is likely to be attributable to the following factors:

1. Variations in the fatal accident rate due to improvements in the safety levels exhibited by the world fleet of aircraft over recent years.
2. The variation that might be expected from estimating from small sample sizes [the assessment carried out in the EASA study (Reference 1) was limited to a small study period and the majority of the fatalities resulted from one accident].
3. Variations in the number of flights per year accumulated by the world fleet.
4. Changes in the average number of occupants on-board aircraft (due to increases in the capacity of aircraft and economic drivers that change the passenger load factor)
5. Progressive changes in occupant survivability

However, perhaps the biggest of these factors is the change in the number of fatal accidents per year, and in particular those involving ground pool fires, since the FAA study (Reference 5) was completed. A study carried out for Transport Canada (Reference 6) assessed the likely trend in the number of fatal accidents from all causes to the world fleet of aircraft. These predicted trends and the data generated for the EASA study on Enhanced Fuselage Burnthrough Protection (Reference 3) may be used to assess the likely number of pool fire accidents per year. Data from the EASA study suggested that the ratio of pool fire accidents to all fatal accidents was approximately 0.13. If it is assumed that this proportion remains largely constant then the trend in pool fire accidents may be derived as shown in Figure 1. The actual number of pool fire accidents per year is also shown in Figure 1 for comparison.

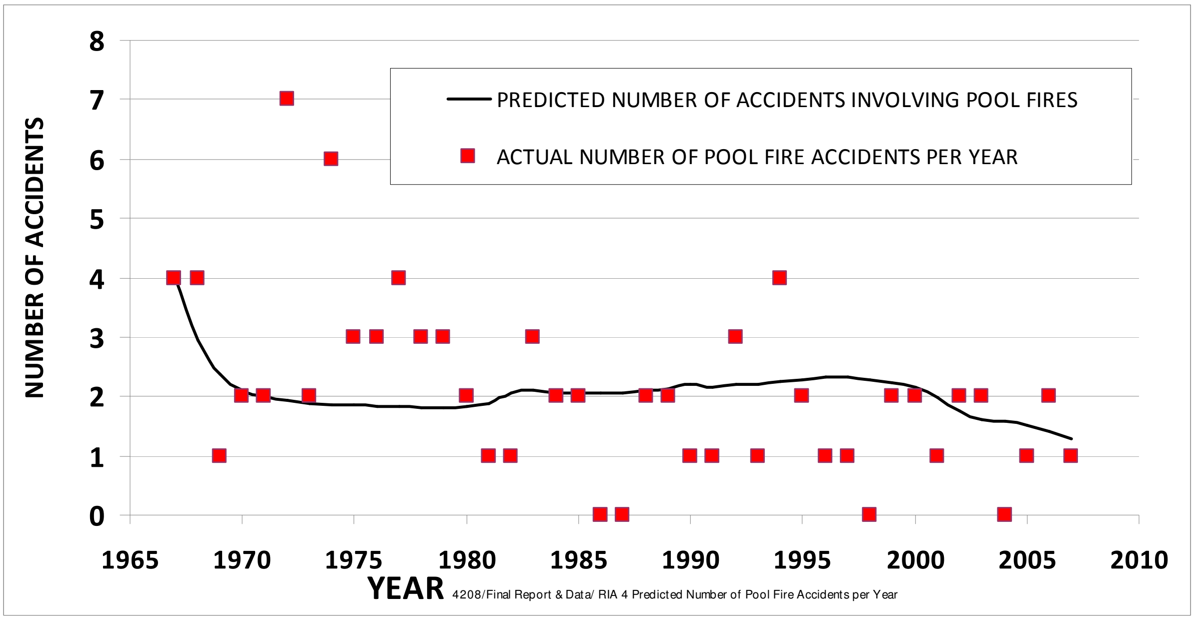

Figure 1 Actual and Predicted number of Pool Fire Accidents

It may be seen that from the period 1967 to 1996, the period of the FAA Benefit Analysis (Reference 5), there were on average approximately 2 accidents per year involving ground pool fires. A review of the pool fire accidents over this period suggests that the average number of fire fatalities in this type of accident is in the region of 20. Therefore it might be expected that over the period 1967 to 2000 the average number of fire fatalities resulting from ground pool fires might be in the region of around 40 per year.

However, the Transport Canada study suggests that the accident rate for the world fleet has diminished markedly since 2000. This is also reflected in Figure 1, where the predicted number of pool fire accidents appears to be reducing to one per year. This may be symptomatic of the improved accident rate being experienced by current production aircraft. The Transport Canada study (Reference 6) suggested that current production aircraft were exhibiting an accident rate that is in the order of four times better than the current world fleet.

A reduction from two pool fire accidents per year to one would result in the assessed number of fire fatalities reducing to approximately 20 per year, which is comparable with what might be concluded from the EASA and NTSB studies (Reference 1 and Reference 4 respectively).

Furthermore, a reduction in the number of pool fire accidents from two, over the period studied for the FAA Benefit Analysis, to one, would suggest that the prediction of benefit for Cabin Water Mist systems might reduce from 34 to 17.

Due to the uncertainties associated with the in-service record regarding this issue, the FAA and Transport Canada are currently commissioning a study to evaluate the proportion of fire fatalities in aircraft accidents over the period 1967 to 2006.

1.3 BRIEF STATEMENT OF THE OBJECTIVES OF THE NPA

The objectives of the proposed NPA are to ensure that the requirements contained in CS-25 afford an adequate level of protection for occupants in post-impact pool fire accidents commensurate with the costs incurred.

2 OPTIONS

2.1 SCOPE OF OPTIONS

Three means are considered for occupant protection from post crash fire and smoke - Enhanced Fuselage Burnthrough Protection, Cabin Water Mist Systems, and Passenger Smoke Hoods. It is proposed in all three options that any regulatory action that is taken is limited to aeroplanes with seating configurations of 20 seats or more. This will exclude the smaller transport category and cargo aeroplanes. The primary reason for this is that aeroplanes with small passenger capacities are less likely to realise a significant benefit from any of the protection means proposed due to their high exit-to passenger ratio. Since the protection means considered will impose additional cost, there must be a commensurate benefit to justify the regulatory change. It is considered that such benefits are unlikely to be sufficient to justify regulatory action for aeroplanes with low passenger capacities. Furthermore the 20-passenger threshold is consistent with other occupant safety regulations, such as those for interior materials and cabin aisle width. The protection means considered will increase the evacuation capability of airplanes, with 20 or more passengers, regardless of the exit arrangement.

2.1.1 Enhanced Fuselage Burnthrough Protection

A previous study carried out for the EASA (Reference 3) resulted in the generation of a Regulatory Impact Assessment. This RIA proposed that the current CS 25.856(b) relating to the provision of burnthrough protection from Thermal Acoustic Insulation materials be deleted and replaced by a more objective rule:

> ***CS 25.xxx Fuselage burnthrough fire protection***
> *"For aeroplanes with a passenger seating configuration of 20 seats or more, means must be provided to minimise the risk to occupants from the effects of fire penetration into the cabin following a post-impact ground pool fire. All practicable measures must be taken to protect the occupants from fire and smoke for a minimum of five minutes. (See AMC 25.xxx)"*

The EASA study (Reference 3) also concluded:

> *"Fire entry into the cabin through fuselage breaks, ruptures, and opened doors constitutes a major threat to occupants in approximately three-quarters of pool fire accidents and this cannot be mitigated by enhanced fuselage burnthrough protection."*

Hence, if the fire fatalities resulting from pool fire accidents that are not prevented by Enhanced Fuselage Burnthrough Protection are to be addressed, an alternate means must be found.

The proposed regulatory change regarding Enhanced Fuselage Burnthrough Protection is currently under review by the EASA. If the Agency decide not to proceed with implementing *CS 25.xxx Fuselage burnthrough fire protection* into the requirements, then the life saving potential of the means, proposed in this RIA for providing occupant protection from post crash fire and smoke, are likely to increase.

2.1.2 Cabin Water Mist Systems

Much of the previous research, and proposed regulatory action considered by the Airworthiness Authorities, has related to a Cabin Water Mist system for use in post-crash fire scenarios only. More recently it has been suggested that they might also be beneficial in combating intentional and unintentional in-flight fires in the cabin. Therefore, this Regulatory Impact Assessment considers their use for providing improved protection for occupants from both in-flight fires and post impact pool fires.

2.1.3 Passenger Smoke Hoods

In 1987 the major Airworthiness Authorities of North America and Europe concluded that a mandatory requirement for the carriage of Passenger Smoke Hoods “could not be justified at that time”. However, following an accident to an A310 aircraft in July 2006 the accident investigating authority recommended that further consideration be given to the use of Passenger Smoke Hoods on large transport aeroplanes. Therefore, this Regulatory Impact Assessment considers their use for providing improved protection for occupants from the effects of smoke.

2.2 THE OPTIONS IDENTIFIED

1. Do Nothing

- The “Do Nothing” option means to make no improvements to CS-25 in relation to Occupant protection from Post Crash Fire and Smoke beyond those proposed by the deletion of CS 25.856(b) and the addition of *CS.25.xxx Fuselage burnthrough fire protection*

2. Amend CS-25 to provide Improved Occupant Protection from Post Crash Fire and Smoke by means of Cabin Water Mist Systems

- As with the proposed regulatory change to CS-25, regarding Enhanced Fuselage Burnthrough Protection, five minutes of *Occupant Protection Time* is required. This will entail:
  - The addition of a new CS-25 requirement:

    CS 25.yyy Occupant Protection from Post Crash Fire and Smoke
    “For aeroplanes with a passenger seating configuration of 20 seats or more, means must be provided to protect occupants from the effects of fire penetration into the cabin following a post-impact ground pool fire. These means must include the provision of a Cabin Water Mist system which must be operable both in-flight and following ground impact that could result in fuselage breaks or ruptures. All practicable measures must be

taken to protect the occupants from fire and smoke for a minimum of five minutes. (See AMC 25.yyy)"

- Provision of guidance material to define the Minimum Performance Standard for a Cabin Water Mist system and an Acceptable Means of Compliance relating to issues such as the crash impact conditions and levels of reliability required of a system.

3. Amend CS-25 to provide Improved Occupant Protection from Post Crash Smoke by means of Passenger Smoke Hoods

- This proposed option will entail:

  - The introduction of a new CS-25 requirement:

    CS 25.zzz Passenger Smoke Hoods

    "For aeroplanes with a passenger seating configuration of 20 seats or more, smoke hoods must be provided at each passenger seat meeting the standards specified in ETSO-xxx, (See AMC 25.zzz)"

  - Provision of guidance material to define the location and accessibility required of Passenger Smoke Hoods

  - The introduction of a new ETSO-xxx defining the standards to which a passenger smoke hood should be designed and manufactured.

4. Carry out further research into feasible, cost beneficial options that might provide Improved Occupant Protection from Post Crash Fire and Smoke

2.3 THE PREFERRED OPTION SELECTED

After due consideration the Agency believes that **Option 4 - Carry out further research into feasible, cost beneficial options that might provide Improved Occupant Protection from Post Crash Fire and Smoke** is to be preferred.

3 SECTORS CONCERNED

The proposed regulatory changes are to CS-25 and hence the aircraft affected will be those for which the application for a type certificate is made after the regulatory changes considered in this RIA. All newly designed CS-25 aircraft, with twenty or more seats, will need to comply. The primary cost of the regulatory change will be borne by the aircraft manufacturer. These costs will result from increases associated with the design, testing and manufacture of the required occupant protection means. Aircraft operators will also be affected since the design solutions will result in weight increases and additional maintenance. There will be a marginal cost to the EASA in their oversight of the manufacturer in showing compliance with the regulatory change and costs may also be incurred by the Agency if further research is carried out.

4 IMPACTS

Each option is considered separately in relation to regulatory change against the following impacts:

- Safety
- Economic
- Environmental
- Social
- Other aviation requirements outside of EASA scope
- Foreign comparable regulatory requirements

Equity and fairness issues are also addressed for each of the regulatory options.

4.1 OPTION 1 - DO NOTHING

4.1.1 Safety

The number of lives lost to post impact fires is likely to reduce due to the apparent reduction in the number of fatal accidents per year and the corresponding reduction in the number of fire related accidents. The precise number of fire fatalities likely to be incurred worldwide is therefore difficult to assess. However, the continual increase in air traffic and the number of passengers carried by the larger aircraft being introduced into service will tend to compensate to some extent for the reduction in the annual number of accidents. The Do Nothing option will therefore mean that there will be no further reduction in the number of fire fatalities due to improvements in occupant survival beyond those that are afforded by the current airworthiness requirements.

4.1.2 Economic

The Do Nothing option will result in the Manufacturers and Aircraft Operators not bearing the costs associated with Options 2 and 3 and the EASA not bearing the costs that might be associated with Option 4.

4.1.3 Environmental

There are no environmental issues associated with the Do Nothing option.

4.1.4 Social

There are no social impacts associated with the Do Nothing option.

4.1.5 Other aviation requirements outside EASA scope

There are no aviation requirements outside the EASA scope associated with this option.

4.1.6 Foreign comparable regulatory requirements

There are no current foreign regulatory activities associated with occupant survival in post crash fires.

4.1.7 Conclusions

Based on the rationales contained in Sections 4.2, 4.3 and 4.4 regarding the alternative options, and the continuation of a significant number of fatalities resulting from post crash fires of adopting Option 1 it is concluded that this is not the preferred option.

4.2 OPTION 2 - IMPROVED OCCUPANT PROTECTION FROM FIRE & SMOKE BY MEANS OF CABIN WATER MIST SYSTEMS

4.2.1 Safety

Research on Cabin Water Mist or Cabin Water Spray systems was initiated from a Recommendation issued by the UK AAIB following the accident at Manchester Airport on 22 August 1985 (Reference 7):

> *4.27 A research program should be undertaken to establish the effect of water mist-spray extinguishing systems on the toxic/irritant constituents of fire atmospheres.*

Tests carried out by the FAA and UK CAA showed that in a post-crash cabin fire event, water mist is effective in cooling the cabin, wetting the materials, and slowing the progress of fire (Reference 8). The system was shown to result in significant delays in the onset of cabin flashover, providing a more survivable cabin atmosphere and additional escape time.

The JAA issued a Draft Notice of Proposed Amendment (NPA) for Cabin Water Spray Systems in May 1992 (Reference 9). Due to the adverse assessment of benefit no further regulatory work has been carried out since this date. However, Transport Canada, supported by the US FAA and UK CAA, has been funding a research project to investigate the feasibility of a Cabin Water Mist system as part of an aircraft integrated fire protection system (Reference 10). One of the outcomes of this research project is a technical specification for a Cabin Water Mist system (Reference 11).

4.2.1.1 Disbenefits

A Disbenefit analysis was commissioned by the FAA in 1993 (Reference 12) which raised several concerns regarding Cabin Water Mist systems. Perhaps the most significant concerns from this study and from other sources were:

1. The effects of **inadvertent operation** on electrical and electronic systems

2. **Reduced visibility** due to water mist and/or smoke dispersion in the cabin during evacuation and possible interference from **noise** generated by the CWM system with evacuation commands.

3. **Physiological hazards**

Each of these potential disbenefits is considered in turn:

1. Inadvertent operation

A study carried out by the State Key Laboratory of Fire Science, University of Science and Technology of China (Reference 13) into Water Mist Systems

> *"Recently, extensive full-scale fire tests have been conducted to evaluate the feasibility of using water mist systems for the protection of electrical and electronic equipment. Studies showed that fine water mist was effective in extinguishing in-cabinet electronic fires, as well as fires in a computer room, without causing short circuits or other damages to electrical and electronic components. Water mist has also demonstrated some advantages in*

suppressing fires in electrical and electronic equipment, in comparison to gaseous agents. For example, water mist appears to be the most effective extinguishant for a hot cable fire due to its efficient cooling. In addition, evacuation of the compartment may not be necessary and the electronic equipment can be continuously operated during discharge of the water mist system, especially if a zoned water mist system is used. On the contrary, when halocarbon gaseous agents are used, the compartment has to be evacuated completely due to high concentrations of corrosive gases generated by the agent in fire suppression, which disables the operation of the room."

Whilst further research may be required to assess whether this benign effect on electrical and electronic equipment is reflected in an aircraft environment the Chinese study does suggest that the use of the system in flight in the presence of a cabin fire may not present a greater hazard to the aircraft than the fire itself.

Although inadvertent operation of the system in the absence of a threat may not constitute a hazard to the aircraft, the primary concern is the inconvenience caused to passengers and aircraft operators by nuisance operation. In order to ensure that inadvertent operation of the system occurs at an acceptably low frequency it may need to be designed and manufactured to a level of reliability commensurate with the Extremely Remote[2] classification - equivalent to a numerical target of 10^{-7} per aircraft hour or less.

2. Reduced visibility and noise

Results of evacuation trials carried out at Cranfield University suggested that, for the specific scenarios investigated (in the test programme), the use of "cabin water spray" systems would not be likely to cause any significant adverse consequences for emergency evacuation of the aircraft (Reference 14). The test programme however, did not address the effect on evacuation of wetting of the cabin interior and escape slides or the effect of water on floor proximity lighting.

The effects of wetting of escape routes and floor proximity lightning may require further research.

3. Physiological hazards

A number of potential physiological hazards were identified and examined by the International Cabin Water Spray Research Management Group (Reference 8), as follows:

- Inhalation of Hot Moist Air

  "Measurements taken during the wide body optimisation tests showed that the increase in water vapour content with time was similar for sprayed and unsprayed tests and was well below saturation at the higher temperatures. There is, consequently, no increase in hazard from this source."

- Inhalation of Particulate and Water Droplets

  "The use of water spray was found to decrease greatly the amount of solid particles and liquid droplets capable of penetrating into the lungs, and also the

[2] as defined in the Advisory Material to 25.1309

irritants attached to them, thereby reducing the risk of lung damage. "Although a small amount of larger, non-respirable droplets in the smoke may have been due to the water spray, these had a low dissolved acid gas content and were considered unlikely to present any additional hazard."

- Hypothermia in Evacuees

"… medical advice is that the water spray will not increase the risk of hypothermia unless the victim is wet through to the skin, and the likelihood of this is considerably reduced in the case of a zoned system…"

The Eurofeu Position Paper on Water Mist for Fire Fighting Application (Reference 15) states the following:

"Human safety relating to the deployment of water mist in manned areas has been addressed by the US Environmental Protection Agency (E.P.A). A Medical Health Panel evaluated the water mist under the Significant New Alternatives Policy (SNAP) and the results were published in August 1995[3].

The overall conclusion was that water mist using potable water is benign to nature and does not present a toxicological or physiological hazard to human beings and is thus safe for use in occupied areas."

4.2.1.2 Life Saving Potential

In the conclusions of the research programme on cabin water spray (Reference 8), the International Cabin Water Spray Research Management Group stated that the system was likely to be effective and presented no insurmountable problem areas. It was estimated that cabin water spray systems would save an average of 14 lives per year world-wide, or 6 lives in the US, Canada and European countries of the JAA (at the time) combined. However the cost per life saved was assessed to be in the order of $22m to $32m. The European Transport Safety Council review (Reference 16) stated that "the figures underestimated the number of lives that could be saved, and with costs minimised if features are introduced at the design stage, future aircraft should be equipped accordingly."

A more recent study (Reference 5) carried out for the FAA based on improved accident data suggested that the life saving potential of Cabin Water Mist systems in post crash fires was likely to be in the region of 34 lives per year world-wide. However, as discussed in Section 1.2 of this RIA this assessment was based on typically 2 pool fire accidents per year occurring over the study period from 1967 to 1996 compared with one accident per year which is what appears to be the current rate of occurrence.

Therefore the prediction of the number of lives saved per year from Cabin Water Mist systems of 34 per year for the world fleet would reduce to approximately 17.

Whilst it would seem evident that fatalities resulting from pool fire accidents are likely to continue, the life saving potential of Cabin Water Mist systems cannot be predicted

[3] Protection of Stratospheric Ozone; Acceptable Substitutes for the Significant New Alternatives Policy (SNAP) Program - [Federal Register: July 28, 1995 (Volume 60, Number 145)][Rules and Regulations]

accurately due to the significant improvements in accident rates that appear to have been achieved over recent years.

4.2.1.3 Recommendations from Accident Investigating Authorities

Other than the recommendation made by the UK AAIB following the accident at Manchester Airport on 22 August 1985 (Reference 7) no further Accident Investigating Authority recommendations have been found that are directly pertinent to Cabin Water Mist systems.

4.2.2 Economic

A study conducted by AIM Aviation under contract to the UK CAA (Reference 17) was directed toward analysing the *"... possible costs of a reduced weight Cabin Water Spray System Installation"*. This study carried out a detailed analysis of costs, including those for newly designed aircraft. The costs included Direct Operating Costs, the costs of procurement and installation, etc. The derived costs on an aircraft per year basis are dependent on many factors including system weight, cost of fuel, aircraft fleet size, etc. These factors have changed since the time of the AIM Aviation study as has the technology associated with Cabin Water Mist systems.

However, by way of comparison, the AIM Aviation system weight assessment for a narrow bodied aircraft was in the region of 530 lb. If the life saving potential of a Cabin Water Mist system were 34 lives per year, as suggested by the FAA study (Reference 5), then based on a fuel cost of US$ 2 per gallon, an average flight time of 1.5 hours and an incremental cost per flight hour per pound weight of US$ 0.0049 then the cost per life saved would be in the region of US$ 7.5m. However, if the life saving potential of a Cabin Water Mist system reduced to 17 per annum then the cost per life saved would increase to US$ 15m[4].

These cost estimates would, at first, seem to be prohibitively high, especially since they do not take into account the costs associated with the design and manufacture of a Cabin Water Mist system or the operating costs of such a system that would be borne by the aircraft operator. However, there are several factors that need to be taken into account when making a more precise estimate of the cost per life saved of a Cabin Water Mist system, including the following:

The life saving potential derived in the FAA study for Cabin Water Mist systems was based on their being used solely for occupant protection in post crash fires. Their use for in-flight occupant protection would increase the assessment of benefit. Furthermore, Water Mist systems have been considered for combating fires in inaccessible areas. If this application of a Water Mist system was found to be practicable it would further increase the assessment of benefit.

The weight estimates made in the AIM study (Reference 17) are likely to be pessimistic since advances in technology are likely to have resulted in more efficient Water Mist systems of lower weight and perhaps cost.

Water Mist systems are being considered as a fire extinguishant for Class C cargo compartments. For aircraft so configured it may be feasible that the stored water used for

[4] This cost may be compared with the FAA's current value of life, used in cost benefit analyses of US$ 5.8m.

this application could be shared with the Cabin Water Mist system with a resultant reduction in system weight.

4.2.3 Environmental

It is likely that there are limited environmental impacts associated with the introduction of Cabin Water Mist systems proposed by this regulatory action. However, it will be necessary for the manufacturer to give consideration to the materials used in a Cabin Water Mist system, their manufacturing process, and their performance in post impact pool fires to ascertain that there are no unacceptable environmental impacts. The additional fuel burn associated with the increase in aircraft weight is expected to be small.

Additionally it may be feasible that a Cabin Water Mist system could reduce the quantity of toxic gases and particles released into the atmosphere following a post impact pool fire. This may be of particular significance in the case of accidents to carbon composite aircraft where the release of fibres from the disintegration and burning of the aircraft structure might have a detrimental effect on the environment.

4.2.4 Social

There are no social impacts associated with the introduction of Cabin Water Mist systems proposed by this regulatory action other than those associated with the safety, economic and environmental impacts discussed in Sections 4.2.1, 4.2.2 and 4.2.3 of this RIA.

4.2.5 Other aviation requirements outside EASA scope

There are no aviation requirements outside the EASA scope associated with the introduction of Cabin Water Mist systems proposed by this regulatory action.

4.2.6 Foreign comparable regulatory requirements

There are no current foreign regulatory activities associated with this option.

4.2.7 Conclusions

It is evident that there are safety improvements that could result from the introduction of Cabin Water Mist systems. It is also likely that the potential disbenefits might not be as prohibitive as was thought in the 1990s. The rough order of magnitude assessment of the potential life saving and costs incurred do not account for the safety potential that might exist for the in-flight use of CWM systems. Furthermore, research has been carried out in the United States regarding the use of water mist systems in aircraft hidden areas and electrical/avionic equipment bays. Although the results of this research are not currently available it would seem that there is potential for the use of Water Mist systems in hidden areas. Whilst, for the most part, the threat from hidden area fires has been mitigated by the requirements for improved flammability standards of Thermal Acoustic Insulation (TAI) materials, there is still concern regarding the flammability of contaminated or aged TAI materials and other materials in hidden areas. If the use of the system in flight could result in positive enhancements to safety these might be achieved with minimal cost and weight increases beyond those incurred by accommodating the post-impact fire threat. The extended application of Water Mist systems requires further research in order to establish the protection that they might afford in combating in-flight fires.

4.3 OPTION 3 - IMPROVED OCCUPANT FIRE & SMOKE PROTECTION BY MEANS OF PASSENGER SMOKE HOODS

4.3.1 Safety

4.3.1.1 Past Research and Assessments of Life Saving Potential

Following the accident at Manchester Airport, on 22 August 1985, the AAIB recommended to the UK CAA the formulation of a requirement for the provision of Passenger Smoke Hoods to afford passengers an effective level of protection during fires which produce a toxic environment within the aircraft cabin (Reference 7).

As stated in CAP 593 (Reference 18), the UK CAA accepted this Recommendation and gave urgent consideration to the formulation of requirements for the design and provision of Passenger Smoke Hoods for passengers.

However, subsequent considerations by the FAA and CAA raised concerns that the use of Passenger Smoke Hoods might result in a delay in the evacuation due, primarily, to the time taken to don the mask. In a report published by the UK CAA (Reference 19)[5] it was concluded that:

> *"In the past, the CAA and the FAA have emphasised the probable loss of life resulting from the likely delay in an emergency evacuation due to the extra time needed to don smoke hoods. Tests by Linacre College and the FAA's Civil Aeromedical Institute (CAMI) have suggested donning time delay is small and evacuation rate is little reduced so long as floor level exits of sufficient size are provided. However, no laboratory test can get anywhere near to simulating the real ground fire accident."*
>
> *"The Authority is concerned that in a crash situation, with passengers experiencing shock and perhaps panicking, any delay in putting on a smoke hood, particularly by parents of young children or partners helping each other, would reduce the benefit (of smoke hoods). It would only require one or two people to get into difficulty with their smoke hoods, for the whole evacuation to be in jeopardy. This, the Authority feels, is an unacceptable safety risk and it is for this reason that it has decided not to require the provision of passenger smoke hoods in British-registered aircraft."*

However, a CAA paper (Reference 20) suggested that there were a potential 9[6] lives to be saved per year worldwide from the use of "...effective passenger smoke hoods". The final CAA position was formulated in collaboration with other Airworthiness Authorities. In December 1987 in the light of major collaborative research carried out in the UK, USA, Canada and France a decision was made by these countries that a mandatory requirement for the carriage of Passenger Smoke Hoods could not be justified at that time.

[5] Salient parts of CAP 586 pertinent to the disadvantages of Smoke Hoods are reproduced in Appendix 1 for reference.

[6] It should be noted that this assessment of the lives to be saved from Smoke Hoods was made in 1987. Since that time many factors have changed that would affect the benefit likely to be achieved. Many of these factors are discussed in Sections 1.2 and 4.2.1.2 in relation to Cabin Water Mist systems.

Nevertheless, the UK CAA continued with completion of its specification for a smoke hood defining both the equipment performance and installation requirements (Reference 21).

In a report produced by the European Transport Safety Council in 1996 (Reference 16) it was stated that the delay in evacuation time due to the use of Passenger Smoke Hoods may only have detrimental effects in the event of flashover and that flashover was considered *"a relatively rare event".* The review recommended the use of Passenger Smoke Hoods to increase fire survivability.

4.3.1.2 Recommendations from Accident Investigating Authorities

The Irkutsk A310 accident in July 2006 resulted in the Accident Investigating Authority making a recommendation regarding Passenger Smoke Hoods. The reported injuries to occupants resulting from the accident were as follows:

> *"Thirteen individuals suffered carbon monoxide poisoning and eight received heat burns. 23 individuals [of the 60 who were hospitalized] who had suffered mechanical traumas were subjected to the effect of high temperatures and carbon monoxide poisoning. Of the 120 passengers who died, 119 died as a result of acute carbon monoxide poisoning in conjunction with oxygen insufficiency in the inhaled air (in one case, the poisoning was accompanied by trauma to the skull and brain) and one female passenger died from severe trauma combined with burns to the body. Forensic medical experts concluded that one [flight attendant] died from acute carbon monoxide poisoning. The concentration of carboxyhemoglobin in her blood was 85%. The three unidentified flight attendants, died as a result of acute carbon monoxide poisoning… Another flight attendant, while helping passengers inside the cabin, died from acute carbon monoxide poisoning".*

The safety recommendations, pertinent to Passenger Smoke Hoods, issued by the Accident Investigating Authority were as follows:

> *5.4. To EASA and other Certifying Authorities together with the Manufacturers of Large Transport Aircraft:*
> *5.4.3. To evaluate the usefulness of cabin crew smoke hood devices in assisting the evacuation of airplanes; to evaluate the possibility of equipping large transport airplanes with devices for passengers and/or flight attendants to be used in case of an emergency evacuation without suffering from the effects of smoke and toxic fumes.*

4.3.2 Economic

In a study carried out by the United States General Accounting Office in 2003 (Reference 22) the following statements were made regarding the costs of Passenger Smoke Hoods for aircraft passengers.

> *"Smoke hoods are currently available and produced by several manufacturers; however, not all smoke hoods filter carbon monoxide. They are in use on many military and private aircraft, as well as in buildings. An individually-purchased filter smoke hood costs about $70 or more, but according to one manufacturer bulk order costs have declined to about $40 per hood. In addition, they estimated that hoods cost about $2 a year to install and $5 a year to maintain. They weigh about a pound or less and have to be replaced about every 5*

> *years. Furthermore, airlines could incur additional replacement costs due to theft if smoke hoods were placed near passenger seats in commercial aircraft."*

It must be stressed that the costs of the smoke hoods referred to above are unlikely to comply with the UK CAA Specification for Passenger Smoke Hoods (Reference 21). Costs related to smoke hoods meeting this standard are not currently available. However, it is evident that the costs of the Smoke Hoods referred to in the report from the United States General Accounting Office are exceptionally low.

4.3.3 Environmental

It is likely that there are limited environmental impacts associated with the introduction of Passenger Smoke Hoods proposed by this regulatory action. However, it will be necessary for the manufacturer to give consideration to the materials used in the manufacturing process to ascertain that there are no unacceptable environmental impacts.

4.3.4 Social

There are no social impacts associated with the introduction of Passenger Smoke Hoods proposed by this regulatory action other than those associated with the safety, economic and environmental impacts discussed in Sections 4.3.1, 4.3.2 and 4.3.3 of this RIA.

4.3.5 Other aviation requirements outside EASA scope

There are no aviation requirements outside the EASA scope associated with the introduction of Passenger Smoke Hoods proposed by this regulatory action.

4.3.6 Foreign comparable regulatory requirements

There are no current foreign regulatory activities associated with this option.

4.3.7 Conclusions

It is evident that there may be safety improvements that could result from the introduction of Passenger Smoke Hoods. However, there are also many unknowns associated with their use and potential disbenefits. Perhaps the most controversial issue is the question as to whether Passenger Smoke Hoods are likely to present an impediment to evacuation, and if so to what degree, and how often, do the conditions resulting in an evacuation impediment, occur. The cost of Passenger Smoke Hoods meeting the CAA Specification is unknown. However, the costs of smoke hoods that are currently commercially available are extremely low. Whether commercially available smoke hoods could be shown to be cost beneficial is also unknown and cannot be determined unless there is a greater understanding of the potential disbenefits that might be associated with them, regarding their potential adverse effects on evacuation.

4.4 Option 4 - Carry out further research into feasible, cost beneficial options that might provide Improved Occupant Protection from Post Crash Fire and Smoke

4.4.1 Safety

The adoption of Option 4 will delay any benefits to safety that might accrue from implementing the regulatory action proposed by Options 2 and 3.

4.4.2 Economic

Since, it is unlikely that research will be undertaken by organisations other than the world's primary Airworthiness Authorities – EASA, FAA and Transport Canada - there will be an economic burden on these Authorities associated with the adoption of this Option.

The research topics suggested in Sections 4.4.2.1 and 4.4.2.2 are those considered necessary to undertake prior to regulatory action being undertaken in relation to Cabin Water Mist systems and Passenger Smoke Hoods.

4.4.2.1 Cabin Water Mist Systems

A study carried out for Transport Canada (Reference 23) identified issues requiring further research before Cabin Water Mist systems can be considered as feasible:

1. A Minimum Performance Standard needs to be established in order to qualify a Cabin Water Mist system against on-ground and in-flight fire threats.

2. Further consideration needs to be given to the required duration that a Cabin Water Mist System needs to operate to provide adequate protection for both on-ground and in-flight fire threats.

3. The target performance that may be required for a Cabin Water Mist System intended for in-flight use needs to be defined. This should take into account the influence of varying cabin configurations and the effects of extreme temperature conditions affecting the activation and operation of the system.

4. An evaluation needs to be carried out to determine whether the volume of water required for the Cargo Compartment Water Mist/Inerting System is likely to be sufficient for the effective operation of a Cabin Water Mist System.

5. Further consideration needs to be given to the integrity of the power supplies needed for the Cabin Water Mist System.

6. The weight of a complete Cabin Water Mist System needs to be assessed.

7. Consideration needs to be given to the crashworthiness standards appropriate to the Cabin Water Mist System since it is required to operate in a post-crash scenario.

8. Further consideration needs to be given as to the effects of both intentional and inadvertent operation of the Cabin Water Mist System in flight and the consequential levels of integrity required of the system.

9. The implications of meeting the proposed reliability levels for the Cabin Water Mist System need to be investigated.

10. Further consideration needs to be given to the fire standards of the component parts of the Cabin Water Mist System and their effects on cost and weight.

11. A more detailed system architecture, meeting the target reliability levels for a Cabin Water Mist activation system, needs to be developed and investigated.

12. Further consideration needs to be given to combining the use of the onboard potable water system and dedicated water tanks for enhancing the protection afforded by the Cabin Water Mist System.

As a result of this Regulatory Impact Assessment it would also appear that

13. The effects of wetting of escape routes and floor proximity lightning need to be assessed.

14. The safety benefits and disbenefits likely to accrue from Cabin Water Mist systems need to be reassessed in particular in relation to their potential for combating in-flight fires in inaccessible areas

4.4.2.2 Passenger Smoke Hoods

The research that is required prior to Passenger Smoke Hoods being considered as a cost beneficial solution to post impact fires (and in-flight fires) includes the following:

1. Further consideration of the effects of Passenger Smoke Hoods on evacuation in relation to various accident scenarios that might occur.

2. A determination of the benefits that might be afforded by commercially available Smoke Hoods

4.4.3 Environmental

Any research carried out into Cabin Water Mist systems must take into account the environmental issues that might be associated with the introduction of these systems and equipment into future aircraft designs. There are no environmental issues associated with the research other than those that might relate to any testing that might be carried out (e.g. fire testing). It is expected that these will be accommodated by the procedures that will be put in place by the test facilities.

4.4.4 Social

There are no social issues associated with the research other than those that might relate to any testing that might be carried out (e.g. evacuation testing). It is expected that these will be accommodated by the procedures that will be put in place by the test facilities.

4.4.5 Other aviation requirements outside EASA scope

This is not applicable to this research activity.

4.4.6 Foreign comparable regulatory requirements

There are no current foreign regulatory activities associated with this option. However, FAA and Transport Canada have been carrying out research into Cabin Water Mist Systems as part of an Integrated Fire Protection system concept (see References 10 and 11).

4.4.7 Conclusions

It is evident that there are potential benefits likely to accrue from the introduction of Cabin Water Mist systems. Their use in combating the adverse effects of post impact pool fires has been the subject of much research and it has been shown that positive benefit is likely to be realised by their introduction. However, due to the improvements that have been realised over recent years in the fatal accident rate to the world fleet, the precise magnitude of the life saving potential that they are likely to afford is uncertain. Furthermore, the use of Cabin Water Mist systems for protection to occupants from in-flight fires both within the cabin and in inaccessible areas has not been the subject of research on civil aircraft and the potential life saving that might accrue from their use in this role has not been determined.

The use of "...effective Passenger Smoke Hoods" was assessed in a study carried out by the CAA and FAA (Reference 20) to have the potential to save 9 lives per year worldwide. However, the magnitude of the life saving potential of Passenger Smoke Hoods today may be somewhat different due to the improvements that have been made in both fatal accident rates and occupant survivability. Furthermore, the issue regarding the disbenefits that may be associated with Passenger Smoke Hoods, in terms of adverse effects on evacuation, have still to be resolved. Additionally, the potential benefit that might accrue from Passenger Smoke Hoods, of the type that are currently commercially available, has not been evaluated.

Resolution of the issues that require further research into Water Mist systems could result in their being required by regulation. If this were the case, there may no longer be a need for further consideration of Passenger Smoke Hoods since CWM might afford the level of protection to occupants that is sought.

5 SUMMARY AND FINAL ASSESSMENT

5.1 COMPARISON OF THE POSITIVE AND NEGATIVE IMPACTS FOR EACH OPTION EVALUATED

5.1.1 Option 1 - Do Nothing

This option will result in there being no change to CS-25 and hence there will be no economic impact on the manufacturers, aircraft operators or the EASA. However there will be no further improvement in occupant protection from post-crash fires beyond that afforded by the CS-25 amendments associated with Enhanced Fuselage Burnthrough Protection. Whilst this change to the regulations is likely to result in an improvement in safety it will not address the fire fatalities resulting from the majority of pool fire accidents. Furthermore it will not capitalise on the opportunities that might exist for combating in-flight fires from Water Mist systems.

5.1.2 Option 2 – Improved Occupant Protection from Fire & Smoke by means of Cabin Water Mist systems

It is evident that there are safety improvements that could result from the introduction of Cabin Water Mist systems. It is also likely that the potential disbenefits might not be as prohibitive as was thought in the 1990s. The rough order of magnitude assessment of the potential life saving and costs incurred do not account for the safety potential that might exist for the in-flight use of CWM systems. Research has been carried out in the United States regarding the use of water mist systems in aircraft hidden areas and electrical/avionic equipment bays. Although the results of this research are not currently available it would seem that there is potential for the use of water mist systems in hidden areas. Furthermore, research carried out in China suggests that water mist systems used in ground applications may be more effective in extinguishing electrical fires than gaseous extinguishants and that they have a benign effect on the functioning of electrical and electronic equipment without adverse effects on humans.

For the most part the threat from hidden area fires has been mitigated by the requirements for improved flammability standards of Thermal Acoustic Insulation (TAI) materials. However, there is still concern regarding the flammability of contaminated or aged TAI materials and other materials in hidden areas. If the use of the system in flight could result in positive enhancements to safety these might be achieved with minimal cost and weight increases beyond those incurred by accommodating the post-impact fire threat. The extended application of Water Mist systems requires further research in order to establish the protection that they might afford in combating in-flight fires.

5.1.3 Option 3 - Improved Occupant Protection from Fire & Smoke by means of Passenger Smoke Hoods

It is evident that there may be safety improvements that could result from the introduction of Passenger Smoke Hoods. However, there are also many unknowns associated with their use and potential disbenefits. Perhaps the most controversial issue is the question as to whether Passenger Smoke Hoods are likely to present an impediment to evacuation, and if so to what degree, and how often, do the conditions resulting in an evacuation impediment occur. The cost of Passenger Smoke Hoods meeting the CAA Specification is unknown. However, the costs of Smoke Hoods that are currently commercially available are extremely low. Whether commercially available Smoke Hoods could be shown to be cost beneficial is also unknown and cannot be determined unless there is a greater understanding of the potential disbenefits that might be associated with them regarding their potential adverse effects on evacuation.

5.1.4 Option 4 - Carry out further research into feasible, cost beneficial options that might provide Improved Occupant Protection from Post Crash Fire and Smoke

It is evident that there are potential benefits likely to accrue from the introduction of Cabin Water Mist systems. Their use in combating the adverse effects of post impact pool fires has been the subject of much research and it has been shown that positive benefit is likely to be realised by their introduction. However, due to the improvements that have been achieved over recent years in the fatal accident rate to the world fleet the precise magnitude of the life saving potential that they are likely to afford is uncertain. Furthermore, the use of Cabin Water Mist systems for protection to occupants from in-flight fires both within the cabin and in inaccessible areas has not been the subject of research on civil aircraft and the potential life saving that might accrue from their use in this role has not been determined.

Resolution of the issues that require further research into Water Mist systems could result in their being required by regulation. This could result in there no longer being a need for further consideration of Passenger Smoke Hoods since CWM might afford the level of protection to occupants that is sought. For this reason the preferred option is Option 4 with the initial research being directed toward Water Mist systems.

5.2 A SUMMARY DESCRIBING WHO WOULD BE AFFECTED BY THESE IMPACTS AND ANALYSING ISSUES OF EQUITY AND FAIRNESS

5.2.1 The aircraft manufacturers

Option 1 Do Nothing
This option will have no impact on aircraft manufacturers.

Option 2 Improved Occupant Protection from Fire & Smoke by means of Cabin Water Mist Systems
This option will result in a significant economic impact on aircraft manufacturers due to the design development and installation of Cabin Water Mist systems for future aircraft designs. It is therefore imperative that solutions are developed that are cost beneficial.

Option 3 Improved Occupant Protection from Fire & Smoke by means of Passenger Smoke Hoods
This option will result in a small economic impact on aircraft manufacturers.

Option 4 Carry out further research into feasible, cost beneficial options that might provide Improved Occupant Protection from Post Crash Fire and Smoke
This option will have no impact on aircraft manufacturers.

5.2.2 The operators

Option 1 Do Nothing
This option will have no impact on aircraft operators.

Option 2 Improved Occupant Protection from Fire & Smoke by means of Cabin Water Mist Systems
This option will result in a moderate economic impact on aircraft operators due to the additional fuel burn associated with the system weight and the maintenance required of the system.

Option 3 Improved Occupant Protection from Fire & Smoke by means of Passenger Smoke Hoods
This option will result in a small economic impact on aircraft operators resulting from any additional maintenance and weight increases that might be associated with Passenger Smoke Hoods.

Option 4 Carry out further research into feasible, cost beneficial options that might provide Improved Occupant Protection from Post Crash Fire and Smoke
This option will have no impact on aircraft operators.

5.2.3 EASA

Option 1 Do Nothing
This option will have no impact on the EASA.

Option 2 Improved Occupant Protection from Fire & Smoke by means of Cabin Water Mist Systems
This option will result in a moderate economic impact on the EASA due to the rulemaking activity required and the subsequent oversight of the industry to ensure compliance with the proposed regulatory change.

Option 3 Improved Occupant Protection from Fire & Smoke by means of Passenger Smoke Hoods
This option will result in a moderate economic impact on the EASA due to the rulemaking activity required and the subsequent oversight of the industry to ensure compliance with the proposed regulatory change.

Option 4 Carry out further research into feasible, cost beneficial options that might provide Improved Occupant Protection from Post Crash Fire and Smoke
This option could have a small economic impact on the EASA in contributing to the funding required for research. However, the level of commitment from the EASA may be reduced by combining the research with any that may be undertaken by the FAA and Transport Canada.

5.2.4 Issues of equity and fairness

There are no issues of equity and fairness associated with any of the regulatory options considered in this Regulatory Impact Assessment.

5.3 FINAL ASSESSMENT AND RECOMMENDATION OF A PREFERRED OPTION

Based on the assessments made in this Regulatory Impact Assessment the preferred Option is **Option 4 - Carry out further research into feasible, cost beneficial options that might provide Improved Occupant Protection from Post Crash Fire and Smoke**

It is further considered that the focus of the initial research should be on Water Mist systems since it is feasible that a successful outcome of the research into these systems might afford the level of protection required by occupants from the fire threat without the need to regulate for Passenger Smoke Hoods.

Co-ordination of the research activity by means of the Cabin Safety Research Technical Group (CSRTG) may result in the FAA and Transport Canada sharing the economic burden of the research activity with the EASA.

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Appendix 1 – The Disadvantages of Passenger Smoke Hoods as cited in the UK CAA Document CAP 586 - Improving Passenger Survivability In Aircraft Fires: A Review

Opposition to the mandatory provision of passenger smoke hoods has been expressed by fire safety specialists in other aviation authorities, fire services, research organisations, the airline industry and various representative bodies.

The major concern of these specialists is not with the technical design of passenger smoke hoods so long as they comply with the recognised aviation specification. It is mainly the unpredictable response of untrained passengers to a strange piece of equipment in rapidly changing conditions that causes professionals to argue against the value of smoke hoods on transport aircraft. It is unlikely that smoke hoods will be less complicated to don than the flotation life jackets required for over-water flights. Although data is difficult to come by, it is not thought that high levels of life jacket use have been attained in unpremeditated ditchings. In this respect it should be noted that in a recent fire accident, one of the few fatalities is attributed to the inability of the passenger, even though uninjured, to do something as simple as undoing his seat belt.

In the past, the CAA and the FAA have emphasised the probable loss of life resulting from the likely delay in an emergency evacuation due to the extra time needed to don smoke hoods. Tests by Linacre College and the FAA's Civil Aeromedical Institute (CAMI) have suggested donning time delay is small and evacuation rate is little reduced so long as floor level exits of sufficient size are provided. However, no laboratory test can get anywhere near to simulating the real ground fire accident. Even the Cranfield Applied Psychology Unit's competitive behaviour evacuation tests in smoke are far removed from simulating actual human response to the rapidly changing conditions of some post crash ground fires with the associated shock, disorientation and possible injury.

For smoke hoods to have any potential to save life, they must be readily available to passengers in their seats, easy to don by the old, the infirm and the very young, capable of providing adequate means to see and hear, and reliable in respect of fire and toxic gas protection. The deaths by suffocation of four Israelis reported earlier this year, due to their inexperience in donning gas masks, illustrates the hazard of using unfamiliar equipment.

Furthermore, it is important to understand how smoke hoods might affect the ground fire evacuation. Where passengers have survived a crash, are mobile but shocked, and threatened by a developing fuel-fed fire, they will immediately evaluate and respond to:

- The need to get out of their seat and evacuate the aircraft quickly;

- The safety of others, particularly children and partners;

- The instinct to take personal belongings;

and were smoke hoods available,

- The need to protect themselves by donning the smoke hood.

Each passenger has to develop a strategy for his own survival. This strategy must not be unduly complicated, otherwise precious seconds will be lost. When threatened by fire passengers would be faced with the dilemma - “Do I put on a smoke hood or do I just get out as quickly as possible?” It would only take a few passengers to hesitate over the question before a disciplined and orderly evacuation becomes disorganised and chaotic. Worse still, if some passengers had donned their hoods and others not, some of the latter may try to get back to their seats to fetch theirs, effectively blocking the aisle and stopping evacuation.

Other issues cited by professional safety specialists are:

(a) Passengers could easily be lulled into a false sense of security once smoke hoods are donned. Generally, once protected, people will tend to stand up rather than get down as low as possible. This usually means they are more exposed to the effects of high temperatures and more likely to be within the fire/smoke layer.

(b) Smoke hoods could increase the evacuation time due to impaired vision and communication.

(c) Some passengers, such as parents or spouses, may delay evacuating in order to ensure that their children or their partners have correctly donned their hoods. This might cause blocking of aisles.

(d) The importance of training in the use of smoke hoods should not be underestimated. Trials have shown that untrained people do the most improbable things.

(e) It is probable that passengers will, due to trauma in an emergency, forget about smoke hoods. In cases where aircraft have ditched only 50% of life-jackets have been used.