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Cabin Water Fire Suppression Systems

When, and how effective?

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Many organisations have carried out tests. The ability of a known density of correctly sized water droplets to suppress the effects of a fire, is proven. The amount of water required has, in tests, been reduced to as little as 8 US gallons for many aircraft types. A convincing case can be made to demonstrate that a Cabin Water Fire Suppression System (CWFS) could save many more lives in the next 40 years than some other presently installed systems have saved in the past 40 years. Why therefore are not the Rule Makers - making Rules?

The answer is superficially simple, Cost Benefit. Even with dramatically reduced weight of water, the installed system weight and price will impose an excessive cost penalty on the operators. Add to this the very fine safety record of the airlines, the precarious commercial status of that industry worldwide, the apparent fact that safety features do not yet seem to sell seats, the insurers unwillingness to reward an airline that instals such systems, and it is clear that the prospects for introducing Cabin Water Fire Suppression Systems are quite bleak - unless.

Unless but unpalatable: Another major accident occurs where a large loss of life would clearly have been considerably reduced by an installed CWFS.

Unless but unlikely: Safety sells seats in much the same way as it is now beginning to sell cars, and or an insurance premium benefit would result.

Unless and just possible: The benefit analysis calculations can be influenced by sharing some of the services, and in consequence the weight and cost with other fire suppression/extinguisher systems and perhaps the potable water system.

Unless and worthy of debate: Other systems with a lower life saving probability can be removed to, in effect, mitigate the operating penalty of a Cabin Water Fire Suppression system.

Unless but very difficult to quantify: The cost of injury and the resultant short and long term medical treatment can be worked into the benefit analysis.

BACKGROUND

What has lead GEC-Marconi Avionics to the above conclusions and what has attracted the attention of an avionics company to this subject?. The latter can be answered in two words: The Disbenefits. To understand the answer requires a brief review of the company's activity on Cabin Water Fire Suppression.

Some three years ago we were encouraged to take an interest in the subject by strong hints that a high integrity control system might be required. Such systems are of course our bread and butter and our curiosity was aroused.

Early work lead to contact with the British Petroleum (B.P) Innovation Centre and eventually the purchase of the rights for the B.P. dual fluid nozzle for use on aircraft. Extensive collaboration with B.P. and exposure to the overall scene soon made it clear that the disbenefits then being discussed were governed by the amount of water needed. Although testing by a number of companies and the authorities was refining nozzle design, the amount of water that seemed necessary to provide approximately 3 minutes additional passenger protection was high. High even in the case of a non failure survival system, in other words a Simplex System with a single source of water.

Examination of the massive amount of test data available from the extensive B.P. fire and nozzle development tests indicated that if the volume of the cabin in which fire ingress occurs is filled with a known density of water droplets, or in the case of the B.P. tests, that volume is effectively isolated by two curtains of water droplets, then the rest of the cabin would probably remain habitable. This realisation resulted in the concept of: Put the water only where there is a threat.

Theoretical calculations on the basis of the BP test results indicated that a non failure survival simplex system capable of a combating a single fire ingress would require a water weight of approximately 36 KGs for a narrow body aircraft, and approximately 54 kgs for a widebodied aircraft. That is approximately 10 US gallons and 15 US gallons respectively.

Federal Aviation Administration (FAA) testing[1] to develop an optimised zone system has now indicated a requirement for 8 US gallons for a narrow body aircraft and preliminary tests on a widebodied test article achieved success with 21 US gallons of water with a strong probability that this latter figure could be reduced.

A single failure surviving duplex system would consequently require approximately 16 - 40 US gallons, a two failure surviving triplex system 24 - 60 US gallons. Even the triplex system water weight is below the water weight requirements of early non failure surviving systems.

THE DISBENEFITS

Disbenefit studies carried out for the Civil Aviation Authority (CAA)[2] and FAA indicate the consequences of the carriage of large quantities of water for a system capable of deploying water droplets throughout the entire cabin. The disbenefit of perhaps greatest concern is the impact of inadvertent operation in the air. While no draft Notice of Proposed Rule Making/Notice of Proposed Amendment/ Performance Specification data has been issued by the authorities, it is logical to assume that the system would have to meet a figure of $1x10^{-9}$ per aircraft operating hour of an inadvertent operation hazarding flight safety. To minimise return to service activity a figure approaching $1x10^{-9}$ for any inadvertent operation is advisable, and system features to minimise the amount of water discharged in any inadvertent operation highly desirable.

A zone, or threatened area system clearly reduces the total amount of water to be carried and in consequence the operating penalty of the water weight and the amount of water available for inadvertent discharge. These systems also reduce other disbenefits such as effect on visibility, survivability of wet passengers etc.

SYSTEMS CONSIDERATIONS

The most efficient system conceived to date seems to be a zone or threatened area system with very low probability of inadvertent operation, some level of failure survival capability, and one assumes a sensible level of availability. This demands a control system capable of detecting the threat, overcoming failures, operating the correct nozzles only when required and never (well hardly ever) when not . In other words at least a duplex high integrity sensor, interface, and control system, utilising the design techniques and including the monitoring facilities which are now almost second nature to the designer of safety critical avionic systems. Such systems bring with them the benefits to maintenance of Built in Test and automatic fault isolation.

Fundamental to system architecture are the unknown requirements for failure survival, and the uncertain requirement for availability. Guidance on the latter appears in CAA Paper 93011 which states that the probability of the system being inoperable when required should be no worse the 10^{-3} per flight hour. Unfortunately the time to availability of maintenance is not stated, and as broad hints have been dropped that it might be permissable for an aircraft to depart on a limited number of sorties with an unserviceable system it is clearly difficult to consider the influence on system architecture of the possible requirement.

RECENT ACTIVITIES

The recent spate of reports issued by the CAA[3] lead to the conclusions previously stated. The Authority have obviously made a determined effort to arrive at cost and weight for a range of system configurations and aircraft types, and while it is possible to criticise some aspects of the technical solution, weight, and cost etc; the results of the activities provide much more realistic guidance to the consequences of the installation of CWFS than have been published to date. These consequences include an estimated cost to the US/Canada/Europe fleet which has probably dissuaded the Authorities from immediately proceeding down the Rule making path until and unless the cost penalty can be reduced. One method might be to combine the services of a CWFS with other Fire Suppression or extinguisher systems on aircraft.

THE HALON SITUATION

The imminent cessation of Halon production is resulting in a rapidly gathering momentum to find replacements. In the aviation industry, an initiative is being taken by the FAA[4] who with other Civil Aviation Authorities are mounting an extensive test programme to seek alternatives. In addition military organisations on both sides of the Atlantic are actively involved in test programmes or requirements definition.

The CAA have carried out limited testing of water mist nozzles in a simulated cargo bay environment[5] which indicate that there is some potential for water droplet techniques. The B.P. Innovation Centre tests conclusively proved the effectiveness of water droplets on hydro carbon fuel fed fires.

These two test programmes alone give some encouragement to those seeking an environmentally friendly replacement for Halon. There are however, significant hurdles to be overcome, not the least of which are: How to get sufficient density of water droplets into all the nooks and crannies of the threatened areas and the, theoretical at least, high quantity of water that may be required to defeat the threat. These infer other disbenefits which might be overcome, or reduced to acceptable proportions if the water quantity can be minimised. The parallel with the CWFS disbenefits is obvious.

CWFS EFFECTIVENESS

In the event that the cost benefit of a CWFS can be made acceptable by various means, how effective would it be in real accident conditions? The fire tests carried out by various authorities and interested companies prove the ability of the fundamental technique to extend the habitable environment time. It does work! - at least under the test conditions imposed.

While studying the possible system requirements, the effect on system architecture, and implementation details, GEC-Marconi Avionics Systems engineers have raised a number of queries. When discussing CWFS with airlines and potential installers worldwide, it seems that many of these queries are also in the minds of their staffs. In the absence of draft regulations informal guidance from the authorities has not surprisingly been conditioned by the fact that the technical situation was and is still evolving. When seeking guidance, the general impression has however been gained that anything is better than nothing. How true, how very true particularly when considered in the light of the lives saved by other installed systems.

It is suggested that maybe the situation is now somewhat different. It seems that there will at least be some delay in CWFS rule making; perhaps some of that time should be spent considering and where practical taking action which could improve the efficiency of CWFS. Almost certainly some of these probable actions would read across directly to the use of water droplets as a practical replacement for halon.

The most regularly expressed comments concern the environment of the fire tests, these are basically associated with the threat, and the cabin arrangements. Some doubts have been expressed about the validity of the 200 litre kerosene fire threat and on this subject the Authorities are very positive in their opinion that in the first few minutes after a fire threatening accident, the test threat is realistic. Certainly the FAA fire test arrangements for drawing the fire into the cabin are very convincing. Cabin arrangements are a different matter.

Anyone travelling regularly by air will be aware of the wide variations in cabin layout, furnishings and fittings from airline to airline, let alone from aircraft type to aircraft type. Fire tests have in general been carried out with representations of, but seldom, complete cabin furnishings and certainly not with a selection of the wide range of different layouts and types of furnishing. So what is the effect of: Class dividers that can and are moved regularly, different seat back heights, different luggage bin shapes, galleys, toilets, entertainment system projectors, lumps, bumps, etc, etc?. Also what is the effect on cabin furnishings of the accident, and the consequence on CWFS performance? Quite simply no one knows, and quite realistically it is just not sensible to even contemplate conducting fire tests for a reasonable sample of such conditions. While it can be confidently stated that almost any volume of water droplets, making its way into a threatened area will provide some level of protection, is that really good enough? If it were possible to asses the effect of different cabin furniture environments would it not be possible to design for maximum effectiveness, and should not the Authorities be considering at least minimum requirements which accommodate such circumstances. Yes, yes - and yes it is probably practical to use modern computing power and modelling techniques to predict performance under many circumstances, and to also utilise modelling as part of a certification process.

Queries having greater technical impact result from considerable discussion on Failure Survivability and the need to trade off, for example fire proofing, and crash proofing against multiplexing of components. Finally, the very fundamental factor of cabin attitude. As airlines tend to comment:.

"We don't ever expect the system to have to work but if it is needed it will be after a crash or major accident".

Testing has only been carried out with level fuselages, the consequences of various attitudes are not therefore known. But how important is this factor?. As a general rule the greater the attitude resulting from the crash, the less survivable whether there is a fire threat or not. If the benefit analysis would be affected by a system capable of efficient operation at attitudes of, for example, 30 or 40 degrees, computer modelling could probably provide guidance on the design features required to achieve maximum efficiency..

Yes, any CWFS is better than nothing but ....

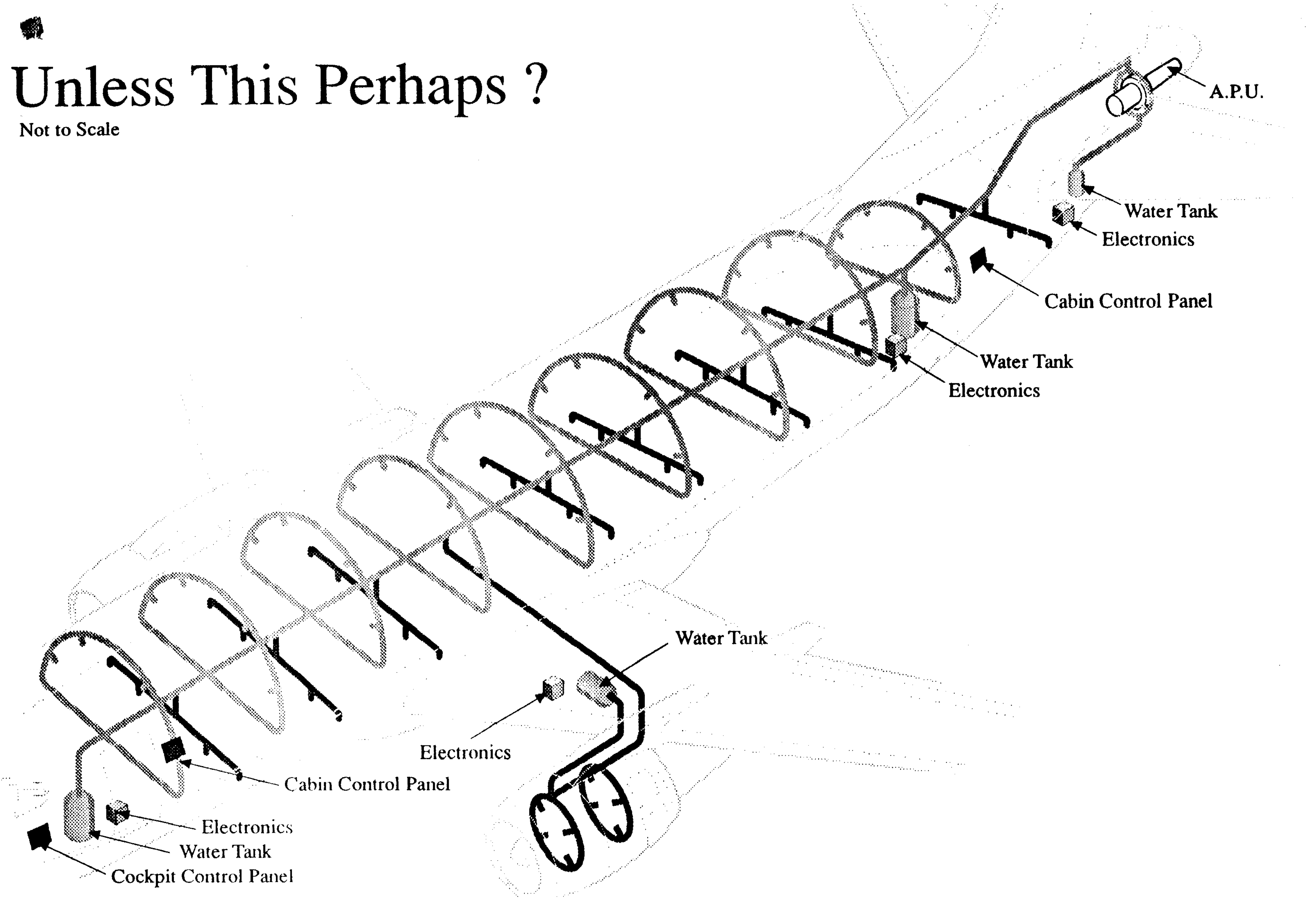
CONCLUSIONS

CWFS works, it has greater potential for life saving than some systems already installed, but it is the only multi unit Civil Avionics system specifically required to perform adequately after a major incident or accident. In consequence there are many questions to be answered on the practical requirements for the system. Tools and techniques are available to enhance the system effectiveness, however industry is unlikely to pursue the subject wholeheartedly as despite the prospect of 800 seat airliners and the evacuation consequences they present, CWFS Rule Making is unlikely to occur in the short to medium term - Unless!

2462 words.

Unless This Perhaps ?

Not to Scale



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