Risk Management Choices — Where to Invest?

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The aviation community is clearly committed to flight safety. However, although safety performance is already good in many regions of the world, underlying growth and financial pressure are persistent challenges to continuous safety improvement. Given the complex interdependencies of our global aviation environment, it is not always obvious where to invest our finite resources to achieve the best safety benefit. There may be no single "right" answer, but this paper outlines the process used by U.K. CAA to exercise a measure of systematic control over the development of its safety program.

The paper will present new analysis of worldwide fatal accident data and describe how it is used by the U.K. CAA in deciding where to target safety initiatives. The priority areas are then analyzed using a new technique designed for the purpose, generating actions that form the basis of the CAA Safety Plan. This is a systematic way of identifying priorities, monitoring safety performance and deciding on actions. It differs in concept from methods being developed by other leading organizations. For context, there will be brief mention of the complementary "bottom up" risk identification by front line regulators, and point to the current work to produce new assessment tools whereby we may better focus our regulatory inspection resources according to the risks associated with the activities of approved organizations.

The main content of the paper will discuss the top down process that is used to provide systematic analysis of overall risk areas. The risks to be addressed are initially identified through the analysis of all fatal accidents to large public transport airplanes worldwide. The analysis results 1980–96 were published previously but the CAA can now present accidents up to the end of 2006 for a 10-year update, including causal factors, circumstantial factors and outcomes. The priorities identified through this data are "customized" for the U.K. by detailed analysis of high-risk (nonfatal) events to U.K. operations, from which additional priorities and observations are generated.

Using these priorities as the major risk areas, lower level occurrence data is interrogated to quantify the incidence of precursor events, providing a systematic rationale for what is prioritized and how data is used. This is "work in progress" to develop a more useful data source and the paper will describe what has been achieved, what we hope to achieve in the future and underutilized sources, such as Flight Data Monitoring. The difficulties of assessing "future risks" will be discussed.

Once the major risk areas are identified, multi-disciplinary groups are formed to work through a structured process known as the "fishbone analysis" developed within CAA to identify potential vulnerabilities and candidates for improvement. This model has created some interest internationally and many of the questions received about the CAA Safety Plan have been requests for information about this method. The paper will provide sufficient detail for anyone who might wish to consider implementing the technique. Finally, there will be some reference to costs and the comparison of general industry operating costs with the costs of undertaking safety initiatives.

1. Introduction

Improving aviation safety is getting harder. The easy changes have been made and the obvious lessons have been learned, the accidents are rare and involve multiple unique circumstances. Finances are in ever-shorter supply and the public toleration for risk continues to fall. How, then, should we decide where to invest? Of course, there is no perfect right or wrong answer to that question.

However, it is an issue that has exercised us considerably at U.K. CAA. We have an obligation to maintain safety but we do not have infinite resources. We are funded through fees and charges to industry and we must demonstrate that what we are doing is good value for industry money. We believe that we have made some headway in finding a method that is both systematic and proportionate, and embeds a new analysis technique that others might find useful.

This paper will briefly review the background to devising this method and then offer a step-by-step "user guide" for anyone who might like to try something similar in their own organizations.

2. Background

Safety initiatives are of interest at the national level, but also exist in the context of international safety initiatives such as those conducted by the Flight Safety Foundation and the FAA's Commercial Aviation Safety Team (CAST) and the European activity under ECAST.

However, there are still national responsibilities and interests that endeavor to monitor and improve safety. National aviation authorities should remain vigilant in effectively monitoring safety in their own fleets and exploring further where risks are indicated. This enables them to identify safety issues and raise them internationally, initiate new actions or, where appropriate, to encourage their own Operators to use some of the excellent tools developed by FSF and CAST.

During the growth of the aviation industry there have been various philosophies of safety improvement, with increasing levels of maturity as time progressed. This has generally evolved through the stages outlined below.

2.1 Reactive — Bottom Up

In the past, the traditional approach was to react to individual accidents or incidents. This approach worked well in the early days of aviation when accidents were more frequent and there were still relatively common problems to solve. However, with more reliable aircraft and well-tried procedures, it soon became evident that "chasing the last accident" was not necessarily the best way to prevent the next one.

2.2 Proactive — Bottom Up

As time moved on, it was recognized that a more proactive stance was needed. Specialists and experts were asked for their views, individually or in teams, about what actions should be taken. This taps into high levels of expert knowledge and proposals were often insightful and well targeted. Divisional Risk Teams were formed to collate and discuss risk issues and propose solutions.

This was useful but incomplete. The actions that are proposed tend to be those that are of interest to certain energetic individuals. There is no check to determine whether or not the most important problems across the aviation system are being addressed, or whether effort was proportionate. Some areas received more attention because those areas were more blessed with people who had the inclination and imagination to initiate activities. The busiest regulatory areas were often under-represented as people already fully committed to their day-job tasks elected not to spend more time proposing initiatives that they would then have to work on. When particular individuals left or moved on, the energy for certain actions left with them. Actions proposed inevitably remained within specific disciplines or "silos" and did not necessarily mesh with those from other areas. Finally, after the initial 2–3 years during which experienced people put forward their "pet problem" that had bothered them for years, the fountain of ideas dried up. The infrastructure for this process still exists within but very few proposals for action arrive through this route. More common are direct requests for action from local managers to undertake a specific initiative, either by a research project or internal action. These direct proposals make up some 30 percent of actions undertaken.

2.3 Proactive — Top Down

It seemed that a fresh approach was needed to provide a plan of action that was balanced with risks, would shake out unrecognized vulnerabilities, and integrate the perspectives of a wide range of aviation disciplines. This method consists of three main stages — identifying the major risks through accident and incident analysis, structured team analysis of the issues arising and moderation with common sense.

The remainder of this paper will offer a "user guide" for anyone wishing to undertake the process and a basic account for the interested observer.

3. Identification of Major Risks from Accident and Incident Analysis

3.1 What Are the Risks of a Catastrophe?

The first step in this process is to ascertain what are the main risks that cause fatal accidents to large airplanes. We have ample data on the more frequent occurrences that do not end in fatality, but the risks we are really interested in are: what might lead us into the next catastrophe? This is not necessarily easy to extrapolate from less serious events.

Reportable accident statistics tend to be dominated by ramp damage, minor ground collisions, broken ankles in turbulence and other events that are not really precursors of a catastrophic loss. This can skew and dilute the safety statistics until we believe that the greatest risk area in aviation is overhead lockers dropping duty free bottles on passengers. Serious incidents are a better indicator, although it is sometimes hard to define what is "serious" and even harder to collect data internationally.

The causal factors and surrounding circumstances are more similar to the accidents that end in fatality but still not entirely representative of catastrophic events. For example, CAA analyses suggest that in nonfatal high-risk events, technical failure is more prevalent than in fatal accidents. If the aircraft develops a fault or the weather is severe and the pilot successfully copes, as he has been trained to do, it may end in a reported event rather than fatality. If the pilot mishandles the flight, it seems that the technology is less likely to rescue the situation and fatality is more likely. For example, a recent analysis of Runway Excursions & Overruns showed that the majority of recorded events occur during landing, often in bad weather, and often result in an excursion that is nonfatal. The fatal excursions, as a group, were more likely to occur on takeoff and involve mishandling, albeit often involving a technical failure (although not always a failure that would necessarily hazard the aircraft).

Fortunately there are very few fatal accidents, but this good fortune for the traveling public is less desirable for the statistician. Fatal accidents worldwide are analyzed to provide sufficient numbers of events to yield a reasonable overview of prevailing risks. The amount of information available on accidents varies. The U.K. CAA Accident Analysis Group

(AAG) uses Airclaims summaries, which are often relatively brief, plus whatever additional information is available, ranging from a comprehensive accident investigation report to press reports or sometimes nothing. In these cases the amount of inference that is reasonable may be quite sparse, but it is normally possible to determine the "Consequence" or accident type (e.g. Loss of Control, Controlled Flight Into Terrain (CFIT)) and infer some causal factors. If the event is a CFIT, it can be reasonable to suggest that there was a "Loss of Position Awareness" although it may be impossible to determine why this may have occurred. In addition to Causal Factors, the AAG also records circumstantial factors. These are factors that could not really be designated as causal but are of interest in the data. The most common is "Lack of Fitment of Currently Available Safety Equipment" where, for example, TAWS or TCAS were not required, but could have been voluntarily fitted and weren't.

The U.K. CAA publishes the AAG analysis of worldwide fatal accidents in CAP 776 on the CAA website. The most prevalent risk areas to emerge from this analysis are:

Loss of Control (following a technical failure)

Loss of Control (for non-technical reasons)

Loss of Control (due to ice)

Controlled Flight into Terrain (CFIT)

Post-Crash Fire (may be assigned in addition to other consequences)

Runway Excursions and Overruns

Crew related issues dominate accident causal factors, featuring in three quarters of fatal accidents. It is important to note that this does not imply that the pilot was "at fault" or "to blame" because it is now well established that "pilot error" cannot continue to be the scapegoat for the many and various factors that can lead to the error occurring.

With the limited information available, those predisposing factors are not always apparent for AAG. However, it is important to include crew factors in this data because it highlights the crucial importance of pilot performance in safety and therefore reminds us to invest resources in anything that might support that (e.g., training and simulation facilities) and to minimize influences that might adversely contribute (e.g., time pressure, fatigue, distraction).

The most prevalent crew related factors are Flight Handling and Omission of Action/Inappropriate Action. This generally relates to flight crew continuing their descent below decision height or minimum descent/safety heights without visual reference, failing to fly a missed approach (i.e., continuing the approach when this was not appropriate) or omitting to set the correct aircraft configuration for takeoff. The details of this analysis can be found in CAP 776 on the CAA website.

Aircraft related causal factors arise in 42 percent of fatal accidents, often (but not always) combined with crew related issues. Other important but less frequent causal factors include Fire, Maintenance/Ground Handling, Environmental (weather), Infrastructure and Air Traffic Control.

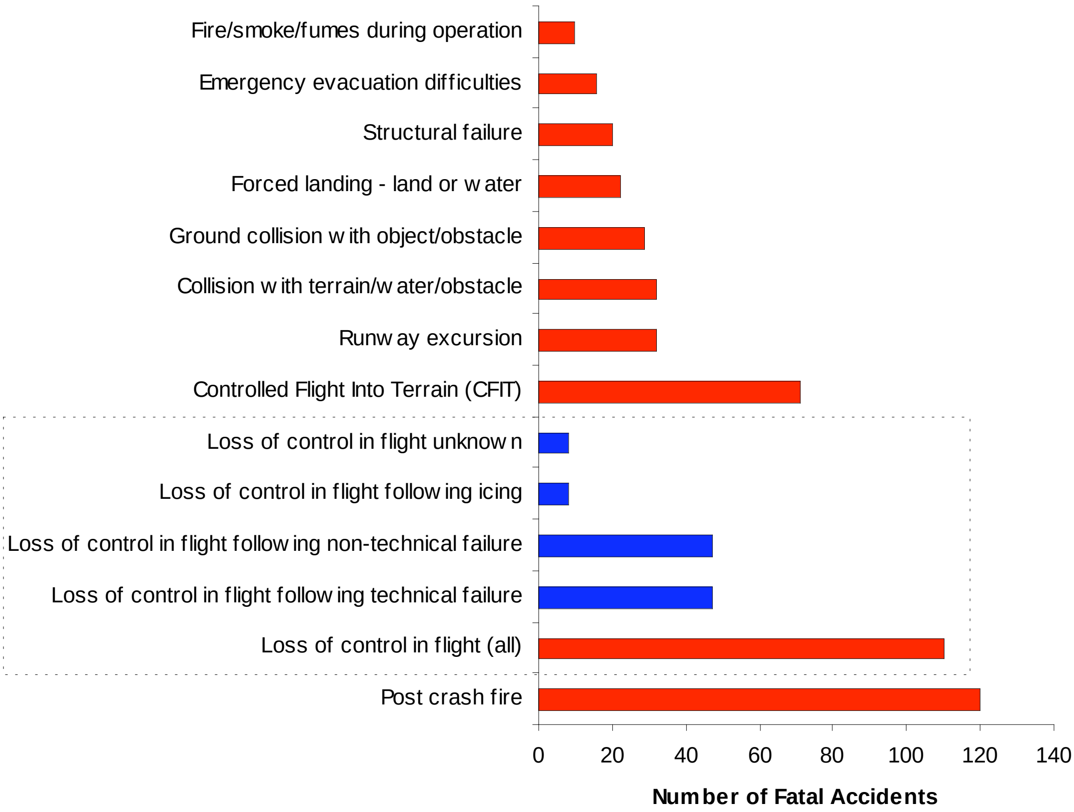

Figure 1 Top 10 consequences for all fatal accidents for the 10-year period 1997 to 2006, reproduced from CAP 776

NOTE: These consequences are not mutually exclusive (apart from the "Loss of control in flight" subcategories)

3.2 National Customization of Risks

Operational circumstances vary. It is important to examine whether the risks from worldwide fatal accidents apply in the country in which you are operating. There are two steps to this process.

3.2.1 Do Worldwide Risks Apply Nationally?

The first step is to determine whether there are local examples of fatal accidents or serious incidents in the major risk categories. Taking the U.K. as an example, it is possible to find fatal or serious occurrences in each of the major risk categories identified through the fatal accident analysis. The events listed below are all either U.K. registered aircraft or U.K. locations, or both. Arguably this suggests that the U.K. should consider all of the major risks identified to be relevant at a national level.

Loss of Control (following Technical Failure)

U.K. Registered Learjet 35 during final approach into Lyon on 2 May 2000 lost control following an engine problem. Two fatalities.

Boeing 737 inbound to East Midlands Airport on 8 January 1989 lost control following an engine problem. (Some debate over whether this should be considered "loss of control" in the traditional sense but due to the crew actions following the technical problem the aircraft became unable to maintain height.) 47 fatalities.

Loss of Control (Non-Technical)

Fokker F27 during final approach to Guernsey on 12 January 1999 lost control due to incorrect loading. Two fatalities.

Boeing 737 during approach into Bournemouth on 23 September 2007 experienced a fully developed stall following an autothrottle disconnect that was not noticed by the crew. The situation was successfully recovered and landed safely but it was classified as a Serious Incident by the Air Accidents Investigation Branch (AAIB SI).

Loss of Control (involving Icing)

U.S. registered Challenger 604 during takeoff at Birmingham on 4 January 2002 due to frost on wing surface. Five fatalities.

B777 at Heathrow on 17 January 2008 undershot the runway, probably due to icing in the aircraft fuel. AAIB SI

Controlled Flight Into Terrain

Boeing 727 during descent into Tenerife on 25 April 1980 following a loss of situation awareness by crew. 146 fatalities.

Airbus A321 at Khartoum, Sudan, on 11 March 2005, approached in challenging environmental conditions. There was a discrepancy between the pilot's approach chart and the FMGC database; consequent crew actions took the aircraft to 125ft agl 1.5nm short of the runway. (AAIB SI)

Airbus A320 on approach into Addis Abeba, Ethiopia on 31 March 2003 in IMC came within 56ft of terrain, 5nm to the northeast of the airport. A faulty ADS VOR antenna fed erroneous information to the flight deck VOR display, the Flight Management System (FMS), the navigation displays and the EGPWS computer with its associated Terrain Awareness Display (TAD). A single common position source error adversely affected all these apparently independent systems. (AAIB SI)

Aircraft Fire: Post-Crash

Korean Air Boeing 747 during climb near Bishops Stortford on 22 December 1999 suffered a loss of control with post crash fire. Four fatalities.

Cessna Citation at Farnborough, Kent on 30 March 2008 crashed following engine problems and was engulfed by fire. Five fatalities.

Aircraft Fire: During Operation

Boeing 737 during takeoff at Manchester Airport on 22 August 1985.

Engine suffered an uncontained failure during takeoff run which punctured a wing fuel tank access panel and fire developed. 55 fatalities.

Runway Excursions and Overruns

Boeing 757 during landing at Gerona on 14 September 1999. Following a destabilized approach the aircraft left the runway. One fatality.

3.2.2 Are There Additional National Risks?

The second step in customizing risks for one country (or geographic region) is to determine whether there are any additional national risks that are not reflected in the worldwide statistics. In the U.K., The High Risk Events Analysis Team (THREAT) analyzes high risk events[1] to large public transport airplanes that are either U.K. registered aircraft or events that occurred in the U.K. The THREAT group is a multi-disciplinary group with members from each major discipline (flight crew, flight test, maintenance, design, air traffic, human factors) with a Chair and Secretary from the Safety Investigations & Data Department. THREAT meets on a monthly basis to allocate causal, circumstantial and specific human factors, determine proximity to the main risk outcomes in worldwide fatal accidents (CFIT, loss of control, etc.) and identify positive factors that helped avoid catastrophic outcomes. Annually, they analyze an average of some 50 events and make general observations and proposed mitigating actions on safety issues of ongoing concern. They have completed analysis of the high-risk events from 2005 and 2006.

[1] High-risk events include accidents, serious incidents (as classified by AAIB) or events submitted as U.K. CAA Mandatory Occurrence Reports (MORs) classified by CAA as grade A or B.

The output from this team provides the "customization" of worldwide risks to adjust to the U.K. situation specifically. Their data suggests that in the U.K., airborne conflict represents a greater proportion of risk than would be suggested from worldwide data, and this is attributed to the more complex, busy airspace compared to a worldwide average. Their data also highlights the number of events related to technical failures and ground operations events. It is possible that this suggests a U.K. issue but is much more likely to be a feature of incident rather than catastrophic fatal accident events.

Airprox was the most common event type, accounting for 22 percent of all occurrences and mid-air collision was the most prevalent *potential* catastrophic outcome.[2] TCAS was the single most successful positive factor in the prevention of a mid-air collision. Half of the Airprox events occurred abroad.

The top individual causal and circumstantial factors were, respectively, "Caused by other aircraft or vehicle" and "Incorrect or inadequate procedures." The former reflected Airprox and ground collision occurrences where other aircraft or vehicles came into conflict with a large U.K. public transport aircraft, which were the subject of the study. However, when broad causal factor groups were considered, then flight crew error and aircraft-related factors contributed a similar total to the "other aircraft/vehicle" category.

A preliminary analysis of THREAT events from 2007 and 2008 assessed a total of 43 events in 2007 and 36 in 2008 (to the end of July). 47 percent occurred abroad (including seven in the U.S., six in Germany, five in Spain and four in France). 29 percent occurred during the approach or landing and 22 percent took place whilst the aircraft was on the ground (other than during the takeoff/landing roll). Airprox and other airborne "conflicts" continued to be

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[2] No mid-air collisions occurred but THREAT judged that there was the *potential* for this to happen in 20 occurrences, given slightly different but plausible circumstances. The risk of collision was deemed to be exceptionally high in four cases.

the most frequent type of occurrence (16 occurrences or 20 percent of the total) and 10 (63 percent) of these occurred abroad (four in the U.S., three in Spain and one each in Germany, Latvia and Madeira).

There were 14 occurrences involving an aircraft component malfunction or failure, which included a wide range of systems; eight ground collisions, of which five involved collisions with another aircraft (three during pushback and two during taxi), two with air-bridges and one where the aircraft was struck by a loading vehicle, and six cases of abnormal runway contact on landing (four hard landings, a tail-strike and an engine pod-strike). Examples of the main risk areas from THREAT include:

Mid-Air Collision

Embraer 145 and F15 during cruise on 27 January 2005. An F15 climbed above its cleared level and passed within 0.53 nm of the EMB145 on the airway. AAIB SI.

Boeing 737 and PA-46 during approach into Liverpool on 15 August 2005.

B-737 had to go around due to conflict with PA-46 who was unable to make visual contact with 737.

Ground Operations

Airbus A340 at Heathrow on 23 April 2005. Following a loading error the aircraft crew was contacted and some passengers moved to bring the CG back to within limits. AAIB SI.

DHC-8 at Aberdeen on 7 October 2005. A Ground Power Unit (GPU) moved forward and struck the rotating propeller; all the occupants exited the aircraft. AAIB SI.

Technical Failure

Airbus A319 during climb near Clacton on 22 October 2005 suffered a major electrical failure during climb at night. Temporarily the commander's and co-pilot's Primary Flight Displays (PFD), Navigation Displays (ND) and upper ECAM display went blank. The autopilot and autothrust systems disconnected, the VHF radio and intercom became inoperative and most of the cockpit lighting went off. AAIB SI.

In an Airbus A321 during cruise on 12 July 2006 both air conditioning packs stopped operating and the cabin altitude went above 10,000 ft. Crew and passenger oxygen masks were used and a normal landing was accomplished. AAIB SI.

3.3 Overview of the Risk List

Now we have a list of major risk areas. The initial list was gathered first from fatal accidents worldwide. It was then customized to our national profile. First, by checking our accident and incident records to confirm the worldwide risks are relevant to our national operations. Second, by adding specific national risks: high-risk events from our national records were analyzed to identify any further risks that are not apparent in the worldwide data. These were added to the major risk areas. Now the list of major risks is complete, each item is subjected to two important processes: i) data monitoring and ii) a top down "fishbone" analysis of vulnerable aspects.

4. Data Monitoring of Major Risks

This area is a "work in progress" for CAA. In the U.K. the Mandatory Occurrence Reporting Scheme (MORS) provides accounts of safety related events to aircraft and receives some 14,000 reports in a year, and ECCAIRS is developing into a Europe-wide reporting system. Such occurrence reports provide a rich source of data. For each major risk area, precursor events have been identified and there is now work ongoing to measure these precursors regularly. This is much more easily achievable for some risks than others. For example, for the risk of mid-air collision there is usually good radar data and ATC reports, and these events are often well reported by pilots. It is therefore possible to identify precursors to collision risks and collate Level Busts, Airspace Infringements, Loss of Separation in the Air, TCAS RAs and even Runway Incursions (possible collision risk) with a reasonable degree of confidence. In other cases, there are potential precursor measures that are easily identifiable, but reliably collecting them is more problematic.

Precursors to a CFIT event, for example, could usefully include excursions below Minimum Safe Altitude (MSA), navigation database (NDB) errors and hard warnings from the Terrain Avoidance Warning System (TAWS). However, TAWS warnings are known to be under-reported as MORS because known datasets have been compared with the database. This is likely to be partly because there are some airport approaches that routinely trigger TAWS events, but there is work to do to identify the proportion that relate to actual risk. Descent below MSA may or may not be reported. One reason for such an event is that the crew have lost position awareness (if the crew subsequently discover they had lost position awareness that becomes a reportable event). It could be argued that when CFIT events occur the crew would be unlikely to have been at the height they were, if they had been aware of their location. Descent below MSA per se is not reportable but unintended deviation from intended altitude of 300ft or more is reportable as is descent below Decision Height/Minimum Decision Altitude. In addition, the requirements to send an MOR relate to NDB errors but this can also be subject to interpretation; it may be reportable as “incorrect programming of, or erroneous entries into, equipment used for navigation or performance calculations, or use of incorrect data” or under Aircraft systems “malfunction or defect, … that may result in misleading indications to the crew” or Navigation systems with “significant misleading indications" or "significant navigation error attributed to incorrect data or a database coding error." However, any event that is hazardous or potentially hazardous is reportable whether or not it is specifically cited in the list of example events (CAP 382). The events should be reportable, but where interpretation is involved it may benefit from further investigation to determine the reporting rates and real risks.

Loss of control as a risk can be assessed to some degree by reports of loading errors, de-icing events, wake turbulence and approaches to the stall, but some events such as high angles of bank may simply be a necessary maneuver flown under full control.

The aim in this process is to monitor the "safety health" of the national fleet with respect to each of the major risk areas, and work is ongoing to improve the measures available.

5. Top Down "Fishbone" Analysis Teams

5.1 Method to Identify Safety Actions

A "fishbone" team consists of representatives from each major aviation discipline (flight crew, flight test, maintenance, airports, ATC, design) and some industry representatives where possible. The team works through a systematic process that has been specifically developed to shake out vulnerability to the risk under analysis. The process is standard for every issue. In turn, the team considers the relevant data available and then the possible contribution to the risk from the aircraft design, aircraft maintenance, airport features, air traffic control and pilot performance/flight operations (see Figure 2). They work through each of these possible contributors by considering a series of "guidewords," which prompt them to think of issues that may not previously have been identified. The guidewords are shown in Figure 3 and are the same for each contributor.

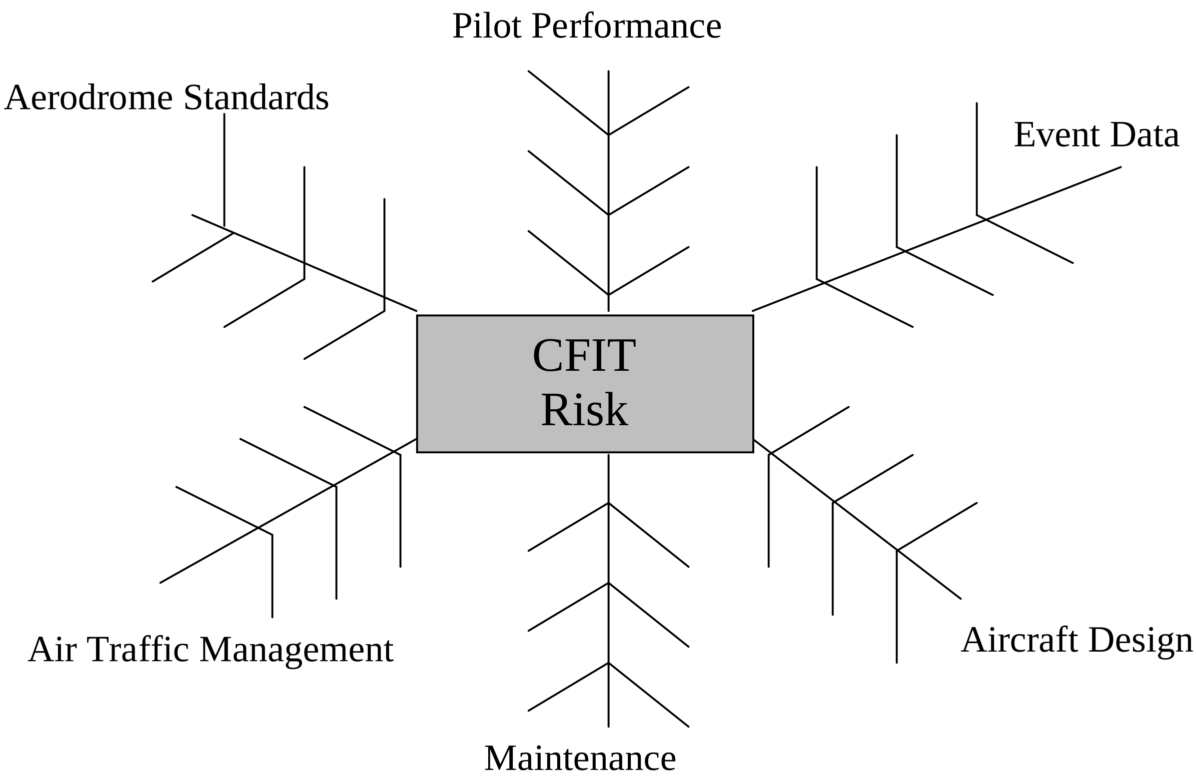


Figure 2. Areas Contributing to the Risk (in this example, CFIT)

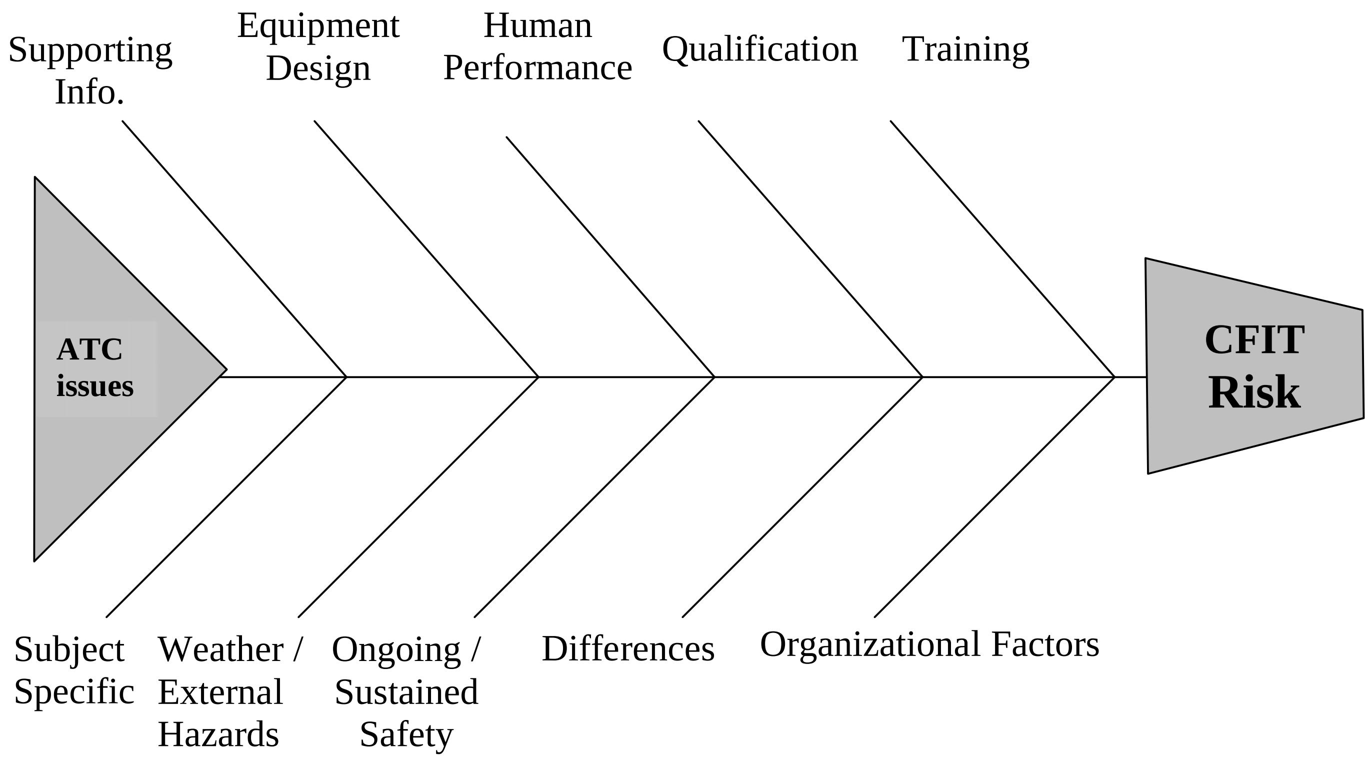


Figure 3: Guidewords to Prompt Analysis for Each Contributing Area

As each guideword is considered, any vulnerabilities identified are noted on the appropriate "fish bone" creating multiple additional spines emanating from each bone. Experience in conducting this process shows that the initial response will be stunned silence, as none of the group members has any particular issue about the subject that they are waiting to input. Letting the silence run for a while normally starts to generate discussion and it is surprising how many issues may begin to surface.

5.2 Method to Prioritize Safety Actions

The fishbone process generates many suggested actions and so prioritization is normally necessary. At this point, the causal factor analyses from AAG and THREAT can be used to decide which potential interventions are most likely to have the greatest effect — normally those that address crew performance issues (e.g., flight handling) are favored because that is the single most common causal factor. There is also consideration of the priorities identified by initiatives such as the Future Aviation Safety Team (FAST).

The next step is to set the actions against the international initiatives such as FSF, CAST and ECAST activities and to ensure that activities do not duplicate the actions that they are already undertaking. Finally the selection is tempered with a common sense filter to identify which actions are most likely to succeed in reducing accident risk in a reasonable timescale and which represent the best value for money.

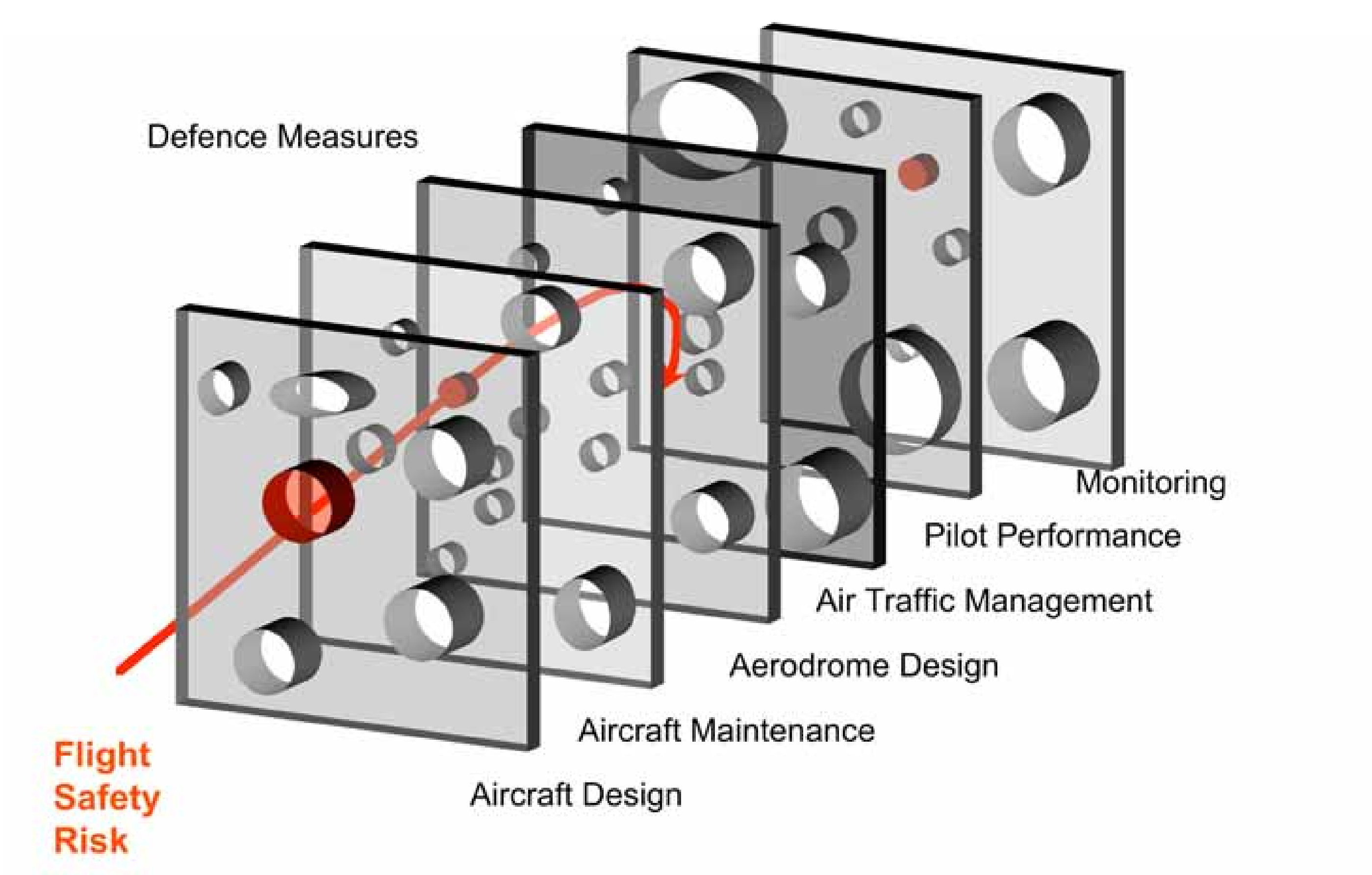
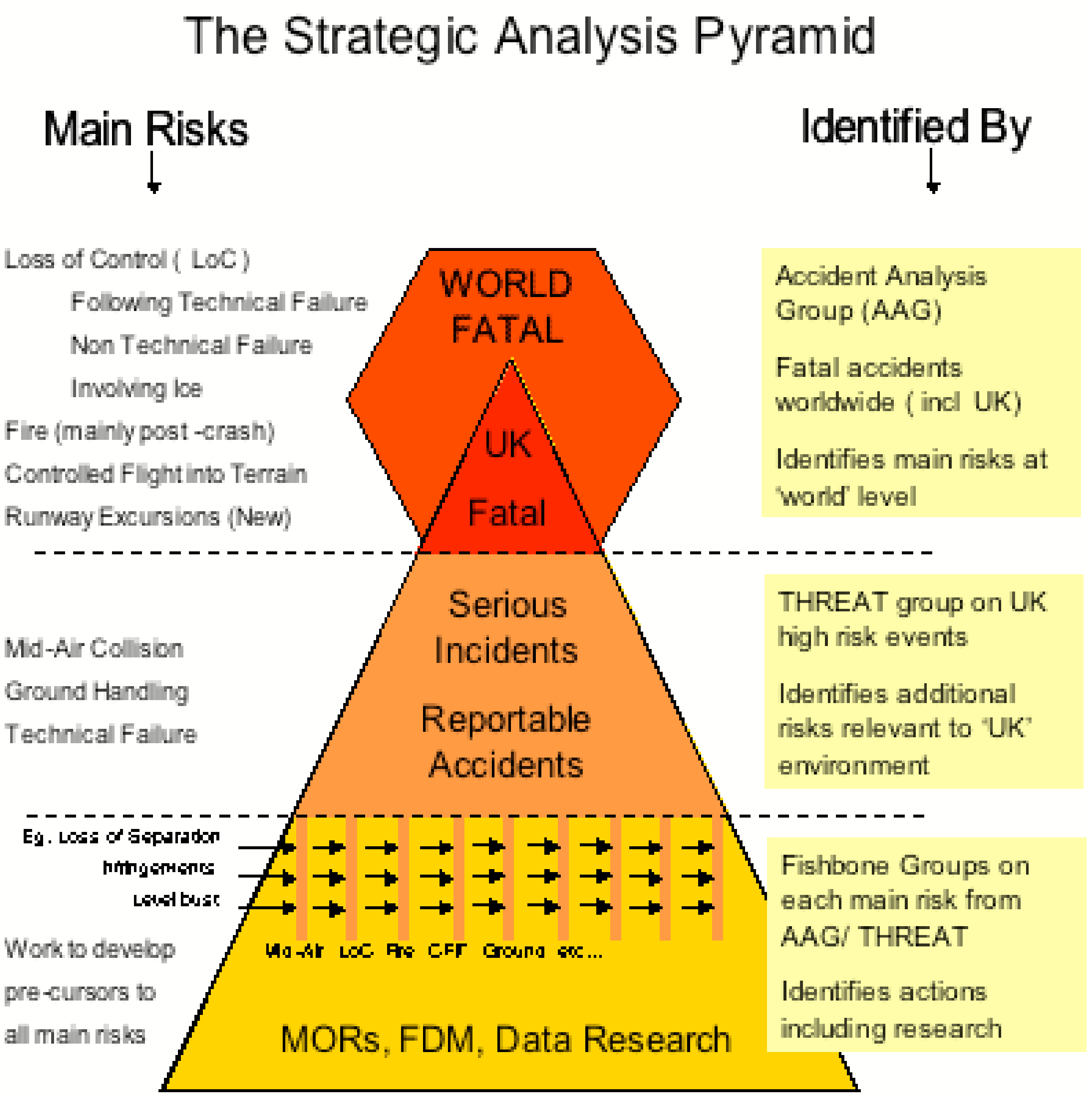


Figure 4: The "Swiss Cheese" Format Symbolizes Layers of Safety Defenses

The process of doing this is interesting. Due to the prompting, issues emerge that had not been previously considered and the questions and inputs from other disciplines help each other to draw out their thoughts. Sometimes, representatives from different areas believed that a particular risk in their area was addressed elsewhere in the system, only to find that their colleagues had been relying on their area to give that assurance. It is important that the participants are open, lateral thinkers and don't take a defensive posture to justify the "rightness" of the current situation in their discipline. If possible, it can be useful to request team members by name instead of asking departments to send a representative of their choice. This allows some control over the personalities involved which makes a significant difference to the likely success of the exercise.

From an organizational point of view, there is a spin-off benefit of improving liaison and understanding between departments. As ideas are put forward, any vulnerabilities identified are recorded on the appropriate "fishbone" spikes. Once the jumble of thoughts has been captured, it can be summarized by arranging it in the format that has come to be called the "Swiss Cheese" depiction of safety barriers (Figure 4), made famous by Professor James Reason. Important vulnerabilities are represented by the "holes" in the cheese. There are various ways to do this and groups differ in their choices. Some identify each barrier as one of the contributor areas, "aircraft," "airport," etc.; others identify the chronological development of the risk, such as "ignition," "propagation," "in-flight actions" and "ground actions" related to a fire risk. It is not essential to be too fussy about the formats used, and in some ways better to allow groups to develop a format that they feel represents their thinking in the best way. Once the risks have been crystallized and presented in terms of breaching safety defenses, it becomes clearer what actions might be taken to address the risks. These are recommended by the group and then progressed through the management infrastructure to determine which of the recommendations will be accepted to become part of the next CAA Safety Plan.



6. Thinking About Safety: Cultural Battles Past, Present and Future

There is considerable variation in the way that different people think about safety, some more scientifically defensible than others. The majority of commentators from mature areas of the industry have moved forward from the reactive "blame" culture of the early years of aviation. It is now more commonly believed that "fixing the last accident" is not a comprehensive safety policy and that simply blaming pilots who make errors is neither fair nor effective. This is good progress and it has been achieved through a long cultural battle fought inside organizations, on conference platforms and late into the evening in many a hotel bar. Today, there are some cultural battles that are still being fought and some that have yet to emerge in the battleground.

6.1 "More Safety Reports = More Risk"

One cultural battle that is under way but still ongoing is the interpretation of Occurrence Reports. At a basic level, there is a belief in some countries, such as the U.S. and U.K., that reporting safety occurrences should not imply that the organization or country reporting them is less safe than others. If airline A reports more safety occurrences than airline B, then that does not necessarily imply that airline B is safer. It may just not be reporting its occurrences and if that is the case, it probably has a less open reporting culture within the airline and problems are less likely to be recognized and addressed.

The same is true of national comparisons. In countries without a mature reporting scheme, there are still those who think that countries that record thousands of safety reports per year (such as the U.S. and U.K.) must be terribly unsafe places to fly. Accident rates, however, demonstrate that nothing could be further from the truth and the countries with high levels of reporting typically have very low accident rates.

One possible indicator of reporting culture is the ratio of serious events to more minor events reported. Fatal — or any — accidents or serious incidents are likely to be reported but the lesser events are more variable in reporting rates. If two organizations have similar numbers of serious events but one has many more "lower order" events, then it is likely that the company with less events is simply less willing to report. Differences can be seen between companies, countries and sectors of aviation.

For example in the U.K., large public transport airplanes have a reporting ratio of 91:1 while small public transport airplanes have a ratio of 21:1; business jets overall show 44:1 and public transport business jets, 18:1. The view that safety reports = safety risk is a perspective that is inaccurate and destructive to safety. It clearly discourages reporting (and resolving) safety issues if the submission of event reports is likely to be seen as evidence of unsafe operations.

6.2 "We Don't Need Safety Improvement Initiatives"

A cultural battle that is fought on a cyclical basis concerns the need for safety initiatives and interventions. In the period following a high profile accident, especially involving passengers or ground fatalities, sensitivities are high and it is easy to "sell" safety projects. Once there has been a high level of safety improvement activity, and aviation is enjoying the benefits with very low accident rates, the appetite for more safety activity tends to dry up.

It is all too easy to forget that the safe operations of the present are the fruits of the safety activities of yesterday and that, in these times of enormous change and development, it is the safety activities of today will assure the same safety is maintained tomorrow. Long periods of safe operation can induce a certain degree of complacency. As resources grow tighter we look for savings. We observe that *"the roof has not collapsed recently"* so we ask, *"why is it that these walls are necessary? Surely we could do without them?"*

6.3 "Safety Initiatives Are Dead Money"

A cultural battle that has started to surface is the money battle. This may be the "next big thing" in cultural terms.

Employees of airlines may often be quite divorced from real costs and this can cause commercial decisions to be made out of context. Even management pilots may assume that the cost of a diversion is the cost of the fuel without considering the subleased replacement airplane, additional landing fees and ground handling, the passengers' hotel bill or the payment and transportation of a substitute crew. This may be because these other (much larger) costs come from a different department's budget line or are recorded indirectly.

Where this becomes important for safety is when the airline management see safety improvements as an unreturned cost without considering that safety related occurrences have their own impact on cost as well. At the very least, there is the time spent by highly paid staff to investigate and interview crews each time an unresolved event type occurs. The less direct costs may be far greater: after an event that gets media attention, the passenger loss of confidence that reduces ticket sales (and fares may have to be reduced to regain sales volume). Even a 1 percent reduction in ticket revenue may be an amount of money that dwarfs the cost of the safety intervention. The impact of good safety practices on company insurance premiums can be immense and there are even more subtle costs like recruiting and training new crews when disillusioned pilots leave the company for jobs elsewhere.

Yet the individuals making the decisions about spending on safety initiatives may have little exposure to those cost implications and the accountants may never make the connection of "cause and effect." They may simply see that revenue has dropped and operating costs are up, and so hope to balance the books by reducing "optional" spending on safety projects. Ultimately the cost of a catastrophic loss is enormous and the airline may have to undertake an expensive re-branding to recover public confidence. The costs of an accident are theoretically well known but may seem too remote to affect routine daily decisions. The more mundane paybacks for safety actions are frequently unrecognized as the finance department see only a one-way hole in the accounts for funding safety work.

In the future, we will look back at and remember when we were naive enough to consider safety costs in isolation. It will be seen in much the same way that we now remember the days when we simply blamed pilots who made mistakes reading three point altimeters.

7. Summary and Conclusions

The U.K. CAA has developed a strategic analysis process to identify risk areas and safety action priorities. This consists of finding the main types of fatal accidents worldwide, reviewing U.K. data to determine whether a) those risks are relevant in the U.K. and b) there are additional risks in the U.K. to add to the list. Once this list of major risks has been completed, each risk is monitored for safety health using precursor data (work in progress) and subjected to a multi-disciplinary, top down analysis to find any vulnerability that needs to be addressed. The actions identified by this process are prioritized considering causal factors that arise in the accident analysis, the actions already under way by the international community and a “common sense” filter on the likelihood of success, cost and timescales involved. Projects selected for action are recorded and set in motion through the CAA Safety Plan (Figure 6).

Some people believe that this kind of systematic effort is not worthwhile because when it comes to these very rare catastrophic events in aviation, it may ultimately be impossible to predict the next event. No doubt it is true that it is hard to predict the next event: if it were an event that we could have predicted, we would have taken the appropriate action and prevented it. What is missing from this mindset is that by working through the risks that can be foreseen, and acting on them, we may have prevented several accidents that might have happened before that event. When the next accident occurs, and it will, we should not say that our safety efforts are useless because we didn’t predict it. We should be grateful that there weren't several more accidents before it, accidents that were predictable and didn't occur because we took the actions to prevent them.

About the Author

Dr. Hazel Courteney has been with U.K. CAA for 15 years and is currently Head of Research & Strategic Analysis. In addition to managing the CAA Research Program across all disciplines and the Strategic Analysis function of data analysis, she is Chairman of the Accident Analysis Group, a member of their Safety Risk Team secretariat and architect of the current safety risk management method described in this paper. Previously she was engaged in the introduction of crew related requirements for flight deck certification, including drafting regulatory material and implementation on aircraft type certification teams. She has been Chairman of a number of international groups including the JAA Human Factors Steering Group and the European contingent in the Harmonization Working Group.

Before joining CAA, she worked in aircraft cockpit design for 10 years, including the Eurofighter Typhoon and Merlin helicopter, spending time flying offshore and on military exercises.

Hazel has a Ph.D. in Aircraft Design Studies from London University, an M.Sc. in Engineering Production and a B.Sc. Hons. in Psychology with Computing. She is a Fellow of the Royal Aeronautical Society and flies as a private pilot.

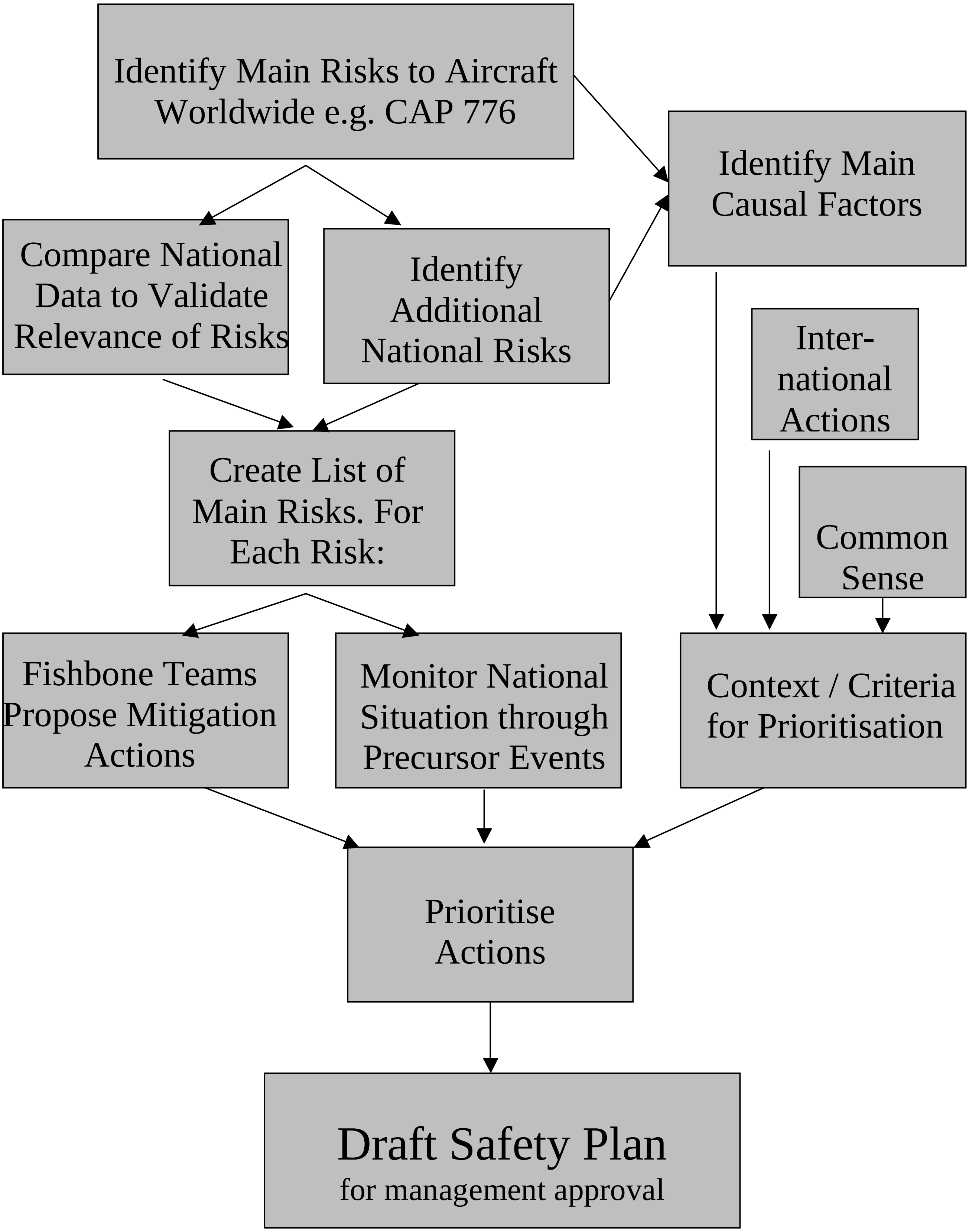


Figure 6: Summary of Steps in CAA Risk Management Process