RISK ASSESSMENT APPROACHES

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There are four risk assessment models or approaches of interest.

1. The FAA empirical data and the approach described in the FAA document FAA-APO-90-7
2. The CAA ARM
3. The Airservices ARM
4. The Threat Barrier Model

The FAA empirical data.

The US approach is based on the US empirical data. This is actual hard data on accident rates at US airfields available to the US because the size of their operation and the time over which it has been collected provide statistically significant actual accident frequency data.

This actual data is clearly more reliable than any data determined by any model.

This data takes the form of a simple relationship between movements at an airfield and the expected accident frequency (See FAA-APO-90-7)

For an untowered airfield we have:

$C_1 = 2.635 \times (Ops/10^6)^2$	Air to Air	(36%)
$C_2 = 1.257 \times (Ops/10^6)^2$	Air to ground	(17%)
$C_3 = 3.325 \times (Ops/10^6)^2$	Ground to ground	(46%)
$C_t = 7.217 \times (Ops/10^6)^2$	**Total**	**100%**

(Equation from the CAA document “Analysis of Aircraft safety in Australian Airspace” 1994)
Note: Air to air is obvious. Air to ground is a collision with one aircraft on the ground – all as serious as air to air. Ground to ground is both aircraft on the ground – many of these would be trivial – but many are not, and to date more passengers have been killed by a ground to ground collision than air-air.

The constants for towered airfields are:

	Factor – Relative Improvement with Tower
C_1 – 0.843	3.1
C_2 – 0.019	66
C_3 – 0.550	6.0
and **C_t – 1.403**	**5.1**

The differences between these numbers quantify the actual change in accident rates achieved by the introduction of a tower at US airfields. Factor shown above

There is no need for a resort to expert opinion on this matter.

Application in the US

The problems with the application of this approach in the US is that it does not take account of individual differences at individual airfields – such a conflicting overflying traffic not associated with the airfield under study and traffic mix etc. But these effects are effectively averaged.

The outcome is that this approach is therefore reliable but not accurate.

As the decision at an airfield does not depend on accurate accident frequencies but rather reliable accident frequencies this is not a serious defect.

Detailed examination of special factors during stakeholder interviews gives ample opportunity for such factors to be determined and taken into account. (See also the approach detailed in FAA-APO-90-7)

Application in Australia.

The application of these data in Australia depends on the assumption that this data also applies under Australian conditions.

The Towers Review carried out in the early 1990s depended on this data. The trigger criterion determined in the analysis used a three fold safety factor to take account of the doubt as to whether the data would apply, unadjusted in Australia.

This led to the trigger values – which have since been tightened up (made more safe) – but which are effectively in use to day. These trigger values show – for example that Albury does not require a tower.

These criteria, developed in this simple original study, are therefore reliable and very conservative. Copies of this review are available. (I have a copy)

CAA ARM

During the early to mid 1990s it was proposed that we should simply import the US approach. This was rejected by the airline industry until the, then CAA, could show that these data applied in Australia.

The CAA took on this challenge and this lead to the CAA ARM

Both ARM (The CAA and Airservices ARM) consist of two components.

The first is a **traffic modelling component** which takes traffic data and determines the frequency of ‘conflict pairs’ (Aircraft which come within a specified distance of each other – normally 1 NM horizontally and 500’ vertically.) The raw or untreated risk.

This component depends on no empirically determined constants and is as good (reliable) as the traffic data. IFR traffic data is electronic and actual. VFR data is more difficult to obtain but Airservices have achieved this by the combination of a number of approaches and nobody claims this is now sufficiently poor as to be confounding.

The outcomes of this segment of the ARM are then appropriately considered reliable.

The second component is the one that causes all the problems. This is **a fault tree analysis** which sets out to determine the likelihood as to whether each the of conflict pairs identified will lead to an accident or whether the conflict will be resolved. leading to an absolute risk level after application of the chosen ATM system.

This depends on failure rates which cannot be determined empirically but must be estimated by expert panel.

This expert panel process is very difficult to make adequate and under the very best circumstances yields little better than what many of us have referred to as a SWAG – Scientific Wild Arsed Guess.

Unfortunately, there is no alternate means of estimating these constants.

These failure rates were determined in this case (the CAA ARM) with as much care as was possible.

It is accepted scientific practice in such cases that, independent of how careful the initial estimation of such constants, at least three actions are needed in order to confirm the outcomes predicted.

Firstly, a sensitivity analysis must be carried out – the purpose of which is to identify the constants important to any significant outcome and then to challenge these constants with as much data and/or independent expert opinion as is available.

Secondly, the outcomes must be compared with all available empirical evidence.

And, finally, the overall work must then be subject to peer review and, preferably, independent confirmation.

Over time, the CAA ARM has been exposed to much of this confirmatory testing – if not as systematically as might be desirable.

The failure rates responsible for significant outcomes are understood and have been re-examined.

Most importantly, the outcomes of this model were compared to the US empirical data and this confirmed acceptable accuracy.

The model was then subject to peer review at ICAO.

Use of the ARM

The ARM delivers two different outcomes.

The first is a very reliable estimation of the raw or untreated risk and a detailed pattern of that risk – in the form of number of conflict pairs which must be handled by the ATM system. This is as reliable as the traffic data used.

The second is a less reliable, but still potentially useful, estimate of the overall residual hazard after the ATM system has attempted to resolve these conflicts. The outcomes are as good (or as bad) as the estimates of the failure rates in the fault tree model.

Further this model is capable of 'cloning' flights so that any set increase in traffic density with the same overall pattern can be simulated and the effect on both the raw risk (frequency of conflict pairs) and absolute risk levels calculated.

Much can be done to clarify the needs of the airfield from the more reliable conflict pairs data and, frequently, not as much is made of this data as should be. (The only exception is the approach taken by the AERU towards the end of its existence.)

Application of US Experience to Australia

However one of the primary reasons for this work was to test the assumption that the US data can be applied in Australia.

This large body of work failed to find a single confirmed difference between the US and Australian experience and the outcomes of (the CAA ARM) modelling of Australian airports gave the same result as the US empirical data.

Given that this leads to a proven system – why is this simple, low cost, proven approach not used in Australia?

The Airservices ARM

During the NAS 2b roll-back Airservices further complicated the CAA ARM and re-evaluated the fault tree analysis failure rates.

It was this process which was criticised by Professor O' Neil. The expert panels were not run with the appropriate level of care. The panels were populated by 'experts' with an agenda – namely to have the NAS 2b changes rolled back. Further, even the group running these panels also needed that outcome. The constants have been criticised by many and no attempt made to answer those criticisms.

There are many scientists who will not accept the outcome of this approach under any circumstances and none who will accept the outcomes unless it is carried out with the very best procedures and an honest attempt at rigour and then only after experimental confirmation.

None of these conditions applied to the Airservices ARM.

The failure rate constants in the Airservices ARM are very different from those in the CAA ARM and calculate outcomes very different from the CAA ARM. The results of the CAA ARM agree with and are confirmed by the US empirical data and accordingly the results of the Airservices ARM (being significantly different) are NOT confirmed by the available empirical data.

This model has not been subject to a sensitivity analysis and has not been subject to peer review.

Airservices continued to use this model but their risk engineers made clear (if pressed) that they understood the limitations of this model and really only took notice of the pattern of risk (outcome of the traffic modelling) and relative values, not actual levels, of risk.

This recognition of the limitations of this model by the authors of this ARM clearly indicate the inadequacy of this ARM.

Use of traffic modelling and the US empirical data

Nevertheless, the approach taken by the AERU (Airservices) which relied largely on the traffic modelling rather than the final overall levels of risk from the combined model is a very good approach. This approach allows analysis to take detailed account of the problems or inadequacies of the simple use of the US empirical data. Detailed traffic modelling can yield hard quantification of any unusual traffic patterns or mix of traffic allowing detailed and rational correction of the overall outcomes for these idiosyncratic effects at any given airfield.

There is no doubt that this is the practical approach to this risk assessment need.

Use the US data to give overall hazard levels – and use the traffic modelling in the ARM to deal with any special effects from the details of the actual traffic patters at that airfield.

If desired, the results of the empirically confirmed CAA ARM could be used instead of the US data or, preferably, to add further confirmation.

The Airservices ARM should not be used.

Threat Barrier Model

This model is simply a means of codifying expert opinion and the outcomes are not more than that – a quantification of expert opinion. This modelling approach can only be justified where no hard data or scientifically based model exists.

The same criticisms apply to this risk modelling approach as apply to the evaluation of failure rates in the ARM. The model is even more vulnerable to 'experts' with an agenda as the failure rates in this model have a clear and predictable effect on the outcome. Experts would need to be chosen who have no vested interest in the outcomes.

Experts with no vested interest are very unlikely to have the special knowledge necessary to make the judgements – so this approach is essentially self defeating.

A little consideration will show that this model is conceptually the same as the fault tree analysis component of the ARM but without any real attempt at a mechanistic approach to failure rates.

The criticisms by Professor O' Neil would need to be answered before this approach would be acceptable

The approach shouldn't be considered where an alternative exists.

As applied by R2A, this model is capable of determining relative risk values only and cannot be used as a basis for risk management or cost benefit justification.

CONCLUSION

The US empirical data is the most reliable estimate of risk at an airfield – but this data is averaged and does not take account of idiosyncratic variations in traffic patters and traffic mix at airfields with unusual traffic patters. Accordingly, this approach is not the most accurate .

The traffic modelling component of either ARM reliably determined the 'raw' risk – as number or frequency of conflicts which need to be handled by the ATM system. This is a reliable means of quantifying unusual traffic pattern or mix – for confirmation of stakeholder interviews and/or in combination with the US empirical data.

The CAA ARM is capable of calculating conservative absolute risk values with adequate reliability.

The Threat barrier model should not be used except in simple cases where a full analysis cannot be justified. The results of a threat barrier model cannot be used as the basis for a risk management or cost benefit justification as it does not reliably calculate absolute risk levels.

The Airservices ARM must not be used to calculate absolute risk levels because the failure rates in the fault tree analysis component are not reliable.

As Accurate risk assessments are not needed, the most reliable approach is to use the US FAA approach (FAA-APO-90-7) backed with traffic analysis via the CAA ARM. This approach has proven reliability and involves NO expert panel determined constants.

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