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THE EUROPEAN SINGLE SKY NEEDS HIGH QUALITY, SIMPLE INCIDENT REPORTING

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1. INTRODUCTION

Should politicians keep their promises? Should Europe's airspace be safe? Some questions obviously need the answer 'Yes'. But are turning promises into reality and ensuring that systems are demonstrably safe feasible tasks? The focus here is on the problems of European Air Traffic Management (ATM) incident reporting. This is certainly not a new concern: European ATM incident reporting is known to be patchy (SRC [Eurocontrol Safety Regulation Commission], 2005a). How are the problems to be solved: Institutional changes? More clarity about SRC documents such as ESARR 2 and ESARR 4? Better understanding of accident/incident causation? Simpler approaches? Increased vigour by ATM safety managers and regulators?

The European Union (EU) legislation setting up the Single European Sky (EC, 2002) states:

> "Smooth operation of the air transport system requires a consistent, high level of safety in air navigation services allowing optimum use of Europe's airspace and a consistent, high level of safety in air travel…"

A Eurocontrol initiative, the European Safety Plan (ESP) (Eurocontrol, 2006), aims:

> "to improve European Air Traffic Management (EATM) safety maturity across the (42) European Civil Aviation Conference (ECAC) States to a common minimum level by December 2008."

The focus here is on mid-air collisions for aircraft under air traffic control (ATC), but recognising that (eg) accidents on runways and taxiways can be equally catastrophic. How can Europe know if safety levels are consistently high in all its States? Levels of safety are very high, so there are very few accidents, certainly not on a State basis, to make such an assessment. Hence, data from ATM safety incidents have to be used. What is an incident – or a severe incident? Traditionally, severity is defined in terms of the degree of risk associated with an observed event – but this just replaces one abstraction by another; or through assessments by an expert group – so how is consistency assured between States and over time?

2. ATM INCIDENT AND COLLISION MODEL

Figure 1 shows a basic ATM Incident and Collision Model equation. The Figure also lists some of the problems encountered in trying to use it practically. If the parameters in the equation are known, then it is possible to compare the estimated collision risk, and hence safety, across States. The equation is necessarily true, simply because the definitions interlock, but every term in the equation has definitional/computational problems, as shown by the examples in the Figure. How could a different formulation of this equation eliminate such problems – they are intrinsic to trying to do the calculation of C_E.

Safety targets place a maximum value on C_E across all States (eg see SRC 2000, 2001, 2005a). C_E is not directly measurable – ATM is extremely safe. $_{FES,}$ the scaling Factor of Collisions to {Severity ~ S} incidents for State E, is extremely difficult to estimate for general ATC situations, as distinct from special subsystems. The temptation is to assume that it is about the same value across States, but this would be no more than an *ansatz*.

Some specific value of the severity S is needed. Without a bottom limit, then, in theory, all incidents could be reported, even those with minuscule safety impact, which would probably tend to lead to massive under-reporting. Eurocontrol material recognises problems with severity assessment, even when examined by genuinely expert groups, eg SRC (2005c). Thus, de Jong and van Es (2006) comment.

> "…it is obvious that a uniformly applied severity classification for air traffic occurrences in Europe appears unfeasible. There are too many different views, ideas and desires to make this possible…Although the ODA working group will propose classifications, it is concluded that it is questionable whether these are going to work…Hence, it appears there are serious problems with classifying the severity of incidents:
>
> - Incidents are not always reliably reported, let alone sufficiently investigated. Severity is therefore often not classified; and
> - There is no consistency in using one severity classification scheme."

A critical problem is with the parameter $_{RES.}$ European ATM Incident reporting is already the subject of high-level remedial action (Eurocontrol, 2006). PRC (2006) notes:

> "Based on limited information available …, reporting of incidents on "airspace events" can be considered as mature in 15 States (representing 71 % of traffic), low in 6 States, while 13 States report irregularly or have never reported since 2001. …Communication of information… is currently restricted by the Publication and Confidentiality Policy
>
> The PRC is presently not able to access safety information from individual States. While there is a need to protect an individual's identity in reporting safety events, there is *a priori* no reason why States' compliance with safety regulations and incident reporting requirements should remain confidential.
>
> Achieved levels of safety and their trends remain opaque."

Madsen (2002), GAIN Working Group E (2004) and Eurocontrol SAFREP (2005) are important background documents in understanding the legal and safety culture issues that underlie these problems. In particular, SRC's document on incident reporting, ESARR 2 (SRC, 2000), has turned out to be largely unworkable. To quote Eurocontrol SAFREP (2005), the issues include:

- "As the scope of ESARR 2 is applicable to the State, it therefore implies co-ordination between all Stakeholders involved in order to clarify the national implementation of ESARR 2;
- The new terminology implied by ESARR 2;
- The level of detail, in terms of reporting of precursors to accidents/incidents and the identification of causes;
- The severity and risk schemes which require further guidance to support a harmonised implementation across States;
- The existence of two EU Directives in the same area as ESARR 2;
- The lack of safety regulatory expert resources (human and financial) at national level; and
- The implementation of a 'non-punitive environment', with potential changes to legislation other than aviation-related."

It is in fact possible to use published Eurocontrol data to reveal how serious the reporting problems are. Dean and Baldwin (2005) analyses ACAS (Airborne Collision Avoidance System) related events on a European basis. Table 1 combines its data with activity data from another Eurocontrol source, to produce a ratio R of incidents reported to hours flown. The final column compares the R-value with that of Belgium, which had the highest R-value.

Table 1 is not perfect: some incidents are of low severity (eg where ACAS is merely alerting the pilot to keep to the present flightpath); some incidents occur outside controlled airspace; the State or ATC service provider may filter out non-significant incidents. But some crude messages are there: about half the States [NB: some States joined Eurocontrol recently] did not participate in this important work; of those that participated, about half had reporting rates at least a factor 10 down on the highest reporting state – are some of these States are a factor ten safer?

Eurocontrol's data in Table 1 is consistent with the PRC's figures. Eurocontrol has been monitoring ACAS ATC reports since 1991. 2003 was the year after the Überlingen mid-air collision. Would the average air traveller be surprised by these reporting statistics? Later paragraphs explore the potential vale of ACAS data.

3. SKETCH OF THE ATC SYSTEM DEFENCES

Incident Reporting needs to tell us about the ATC system's functioning, so the starting point must be how the system delivers safety. Figure 2 is a simplified version of the highly structured control processes and defences ensuring safety, in reality there is a very complex set of probabilistic feedbacks and interactions [compare the sequence of errors and failures in the Überlingen accident (Nunes and Laursen, 2004)]. Explanations of separation minimum, STCA (Short Term Conflict Alert) and ACAS can be found in Brooker (2005a) and its references; the symbols and are covered later.]

The existence of STCA – plus help from colleagues – means that the controller is warned about potential separation breaches, even if he or she does not notice them. Note that a separation breach can occur because the pilot deviates from the safe plan; or when the safe plan was not in fact safe, in terms of the required minimum separation between aircraft.

ATC system defences allow for error detection and corrections to be carried out before any separation is breached, ie such errors would not be detected just from records of separation breaches alone. Remedial action in the ATM system is therefore diverse and in depth (eg Brooker (2005b).

4. INCIDENT REPORTING METHODS

Incident reports can be classified into three types:

> *Individual reporting* means an operational person detects something that is unsatisfactory in safety terms and reports this to a central monitoring body. The likelihood of someone reporting an incident very much reflects the ATC provider's organisational safety culture (eg Fassert, 2001).
>
> *Event-related* reporting is triggered by automatic system warnings or alerts. The main examples are STCA and ACAS, with other systems being used in different phases of flight, eg GPWS.
>
> In *Post-processed reporting,* radar and related data is examined some time after actual operations, to determine if (eg) separation minima have been significantly breached (eg Separation Monitoring Function (SMF) in the UK).

A reasonable ATM indicator must indicate something about ATM safety or of the performance of the ATM system's safety defences. For a collision to occur:

> Must have had separation breach – the aircraft was not flying to a safe plan or the plan was not in fact safe.
>
> Must have had failed or non-existent intervention(s) to remedy, even with assistance from colleagues and warning systems.
>
> Must have had the 'right' (post any intervention) flightpaths – traffic density, route/airspace construction are factors.

There are two obvious places for safety defence indicators in Figure 2, indicated by the symbols and . The first counts initiating events that produce a separation breach, and the second covers situations where the ground-based part of the system, ie ATC, has not resolved an incident. The first indicator, at about in Figure 2, counts 'Actual Separation Breaches' – ASB. The second indicator, at about in Figure 2 counts 'Incident Not Resolved by ATC' (INRA). Remembering an earlier issue, a key point in favour of INRA is that it represents a definite 'severity' benchmark, because focuses on incidents in which the ground ATC defences have been 'used up'.

These two indicators represent decisive points in the safety defences, are very simple to understand, and can be measured reasonably consistently. This is because they correspond to measurable events or system states, rather than complex judgemental assessments of what might have taken place, ie judgements about severity. To find another simple indicator of specific severity in the flow chart between and is extremely difficult, given the variability and complexity of what can happen when ATC's defensive mechanisms restore full system control. PRC (2006) generally supports the use of using indicators such as ASB and INRA:

> "Automated incident detection and analysis provides a wealth of complementary information, as shown by positive experience in some States. This should be introduced in every State as soon as possible."

ASB and INRA need definitions that cover both typical and 'pathological' cases', eg:

> ASB This counts post-processed incidents that breached the appropriate separation minimum. It excludes incidents for which the breach was 'small', eg a 2.5 Nm horizontal closest approach when the minimum is 3 Nm. It might also exclude situations which ATC management declare 'acceptable safe', eg an operating procedure that breaches a minimum slightly, to cope with tight airspace constraints in the terminal area. But these exceptions must have been documented in the ATC unit safety case or similar document.
>
> INRA A count of Individual and/or Event-related reports in which the ground-based part of the system, ie ATC, has not resolved an incident. Was an ACAS Resolution Advisory (RA) then necessary to resolve safely? The simplest incidents to count in this category are those in which an ACAS RA is deemed by ATC to be 'justified'. [If the incident were so very short-term that an RA was not generated, eg a rapid descent to a small closest point of approach, then that obviously would have to be included under this heading.]

Thus, the second indicator does require an assessment to be made by expert controllers. But it is an assessment that is restricted to the kinds of things that controllers actually experience, rather than an extrapolation beyond that. To resolve the issues about safety culture in States, a specialist European body could be set up – based on successful State-based 'peer review' models for incident assessment.

ASBs provide an indication if the rate of 'initiating events' is changing. ASBs are used by the SRC (2005b) (although it is not obvious from the text if some 'acceptable' varieties of separation infringement are filtered from the counting).

The ratio of the counts INRA to ASB is a measure of the effectiveness of the ground ATC system in resolving initiating events. An improvement in this ratio would therefore demonstrate an improvement in ground-based ATC.

There are good grounds for believing that INRA would be a good indicator of the underlying collision rate, because the INRA would be scaled down by the proportion of ACAS RAs that did not successfully resolve the situation. In other words, that scaling-down would not be strongly dependent on the nature of the State's ground ATC operation and airspace structures. Hence, the value of F_{ES} in Figure 1 would not be strongly dependent on which State E was under consideration.

Brooker (2007) examines ATM incident reporting in more depth.

5. CONCLUSION

There has been failure over several years to produce an effective European ATM reporting system or to define what 'serious' incidents are. It is therefore important not to be too sophisticated and ambitious. Many of the current ESP tasks (under 'High Priority Activity Field 2: Incident Reporting and Data Sharing' – Eurocontrol (2006), pages 16-19) do appear ambitious, given the lack of significant past progress in implementing SRC documents such as ESARR 2 and ESARR 4 – "This activity field will carry over the area of the SSAP that has made least progress so far".

As a start – rather than trying to resolve all the complex safety culture and severity classification issues across States – incidents should be collected Europe-wide using mainly automated means; and hence use SMF/STCA/ACAS data about tangible events and/or recognisable system changes, rather than judgements about 'degree of risk'. This will generate usable benchmarks, good – not perfect – descriptions of ATM safety. Thus, the implication is that Europe should consider funding projects to enable SMF-type systems and Mode S downlinking of data.

Voltaire said "Le mieux est l'ennemi du bien" – "The best is the enemy of the good", implying that a good or very good plan is actually better than a perfect plan. Hence, identify good, simple indicators, based on significant kinds of events or states of system control, and work to ensure that automatic systems are in place and reporting rates are high.

References

Eurocontrol/SRC/PRC/EEC documents can generaly be downloaded from the http://www.eurocontrol.int/corporate/public/subsite_homepage/index.html website.

Brooker, P. (2005a). Reducing Mid-Air Collision Risk in Controlled Airspace: Lessons from Hazardous Incidents. Safety Science. 43(9), 71 5-738.

Brooker, P. (2005b). STCA, TCAS, Airproxes and Collision Risk. Journal of Navigation. 58(3), 389-404.

Brooker, P. (2007). Are there Good Air Traffic Management Safety Indicators for Very Safe Systems? To appear in the Journal of Navigation.

Dean, G. and Baldwin, T. (2005). European ACAS Operational Monitoring 2003 Report. EEC report 401.

EC (2002). A Single European Sky: Broadening horizons for air travel. http://www.bit.ac.at/Aerospace/Puplikationen/SingleEuropeanSky.pdf

Eurocontrol (2006). The European Safety Programme (ESP) for ATM. DAP/SAF 2006-26.

Eurocontrol SAFREP [Safety Data Reporting and Data Flow Task Force] (2005). Report on ATM Incident Reporting Culture: Impediments and Practices. Edition 1.0, Ref: DAP/SAF/1 26. *[dated 13 October 2005, but does not appear to be in public domain @ 1 Jul 2006].*

Fassert, C. (2001). La transparence en questions: Les incidents dans le contrôle de la navigation aérienne. *'Transparency in questions: The visibility of incidents in ATM'* EEC Report 378.

GAIN Working Group E (2004). A Roadmap to a Just Culture: Enhancing the Safety Environment.
http://204. 1 08.6.79/products/documents/roadmap%20to%20a%20just%20culture.pdf

Jong, H. H. de and Es, G. W. H. van (2006). A framework of indicators for the potential influence of ANS on air traffic safety in Europe. NLR Report for Eurocontrol Performance Review Unit. NLR-CR-2006-1 11.

Madsen, M. D. (2002). A Study of Incident Reporting in Air Traffic Control - Moral Dilemmas and the Prospects of a Reporting Culture Based on Professional Ethics. [In I RIA 2002 http://www.dcs.gla.ac. uk/~joh nson/iria2002/IRIA_2002.pdf]

Nunes, A. & Laursen, T. (2004). Identifying the factors that led to the Ueberlingen mid-air collision: implications for overall system safety. Proceedings of the 48th Annual Chapter Meeting of the Human Factors and Ergonomics Society, New Orleans, LA, USA.
http://www.aviation.uiuc.edu/UnitsHFD/conference/humfac04/nuneslau r.pdf

PRC (2005). ATM Cost-Effectiveness (ACE) 2003 Benchmarking Report: ACE 2003 Final Report.

PRC (2006). An Assessment of Air Traffic Management in Europe during the Calendar Year 2005. Performance Review Report. PRR 2005.

SRC (2000). Eurocontrol Safety Regulatory Requirement: Reporting and Assessment of Safety Occurrences in ATM. ESARR 2. Edition 2.0.

SRC (2001). Risk Assessment and Mitigation in ATM, Eurocontrol Safety Regulatory Requirement ESARR 4, Edition 1.0.

SRC (2005a). ATM Contribution To Aircraft Accidents/Incidents: Review and Analysis of Historical Data. SRC Document 2. Edition 4.0.

SRC (2005b). SRC Annual Safety Report 2005.

SRC (2005c). EAM 2 / GUI 5 Harmonisation of Safety Occurrence Severity and Risk Assessment.

State	FH - controlled flight Hours (000)	A - ACAS ATC Reports	Ratio R = A / FH	Ratio to Belgium
Belgium	108	42	0.3889	1.000
UK	1225	342	0.2792	0.718
Switzerland	303	61	0.2013	0.518
Germany	1181	177	0.1499	0.385
Sweden	383	37	0.0966	0.248
Netherlands	146	9	0.0616	0.159
Hungary	149	6	0.0403	0.104
Estonia	32	1	0.0313	0.080
France	1999	21	0.0105	0.027
Ireland	197	2	0.0102	0.026
Czech Republic	152	1	0.0066	0.017
Ukraine	182	1	0.0055	0.014
Denmark	193	1	0.0052	0.013
Austria	220	1	0.0045	0.012
Norway	271	1	0.0037	0.009
Spain	1131	-	-	-
Italy	1033	-	-	-
Greece	408	-	-	-
Turkey	389	-	-	-
Portugal	222	-	-	-
Romania	206	-	-	-
Bulgaria	114	-	-	-
Finland	109	-	-	-
Croatia	99	-	-	-
Cyprus	91	-	-	-
Slovakia	54	-	-	-
Latvia	35	-	-	-
Malta	32	-	-	-
Slovenia	24	-	-	-
Lithuania	23	-	-	-
Albania	21	-	-	-
FYR Macedonia	18	-	-	-
Moldavia	5	-	-	-

Table 1. ACAS ATC Reports and Hours Flown, by State (2003 figures)
Notes:

Hours data from PRC (2005) [page 92]
ACAS ATC Reports data from Dean and Baldwin (2005) [page 10]
Italic font means State joined on or after 1/1/2001 – from Eurocontrol website

Armenia, Bosnia & Herzegovina, Poland, Serbia & Montenegro did not supply Hours data
The ACAS ATC Report for Czechoslovakia is arbitrarily assigned to the Czech Republic
The final column is the ratio of row R-values to that of Belgium

$$C_E = \frac{N_{ES} \times F_{ES}}{H_E \times R_{ES}}$$

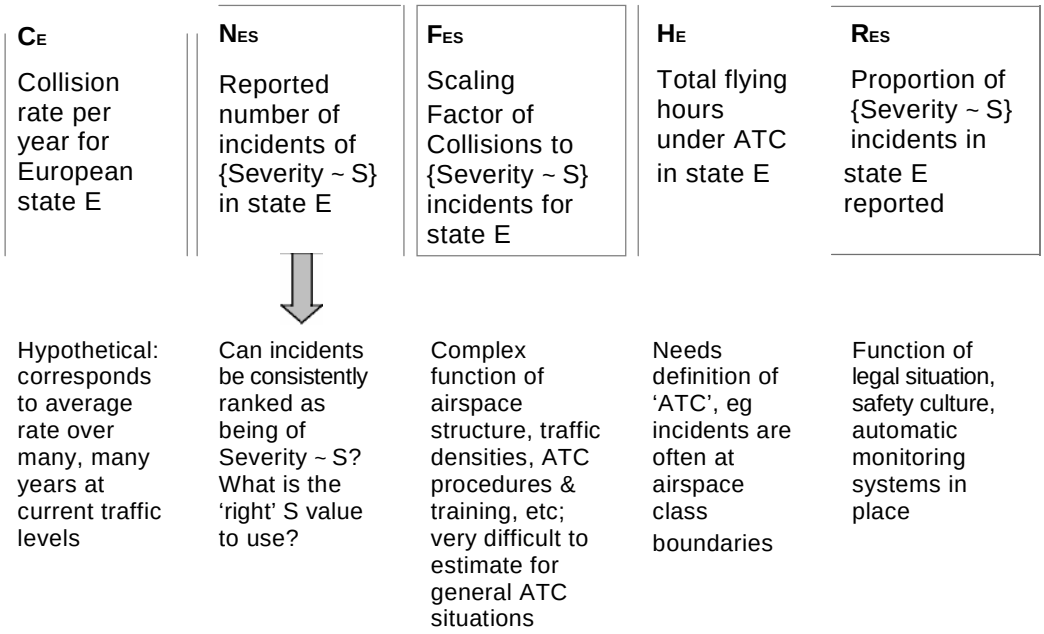

Figure 1. ATM Incident and Collision Model, plus a selection of issues

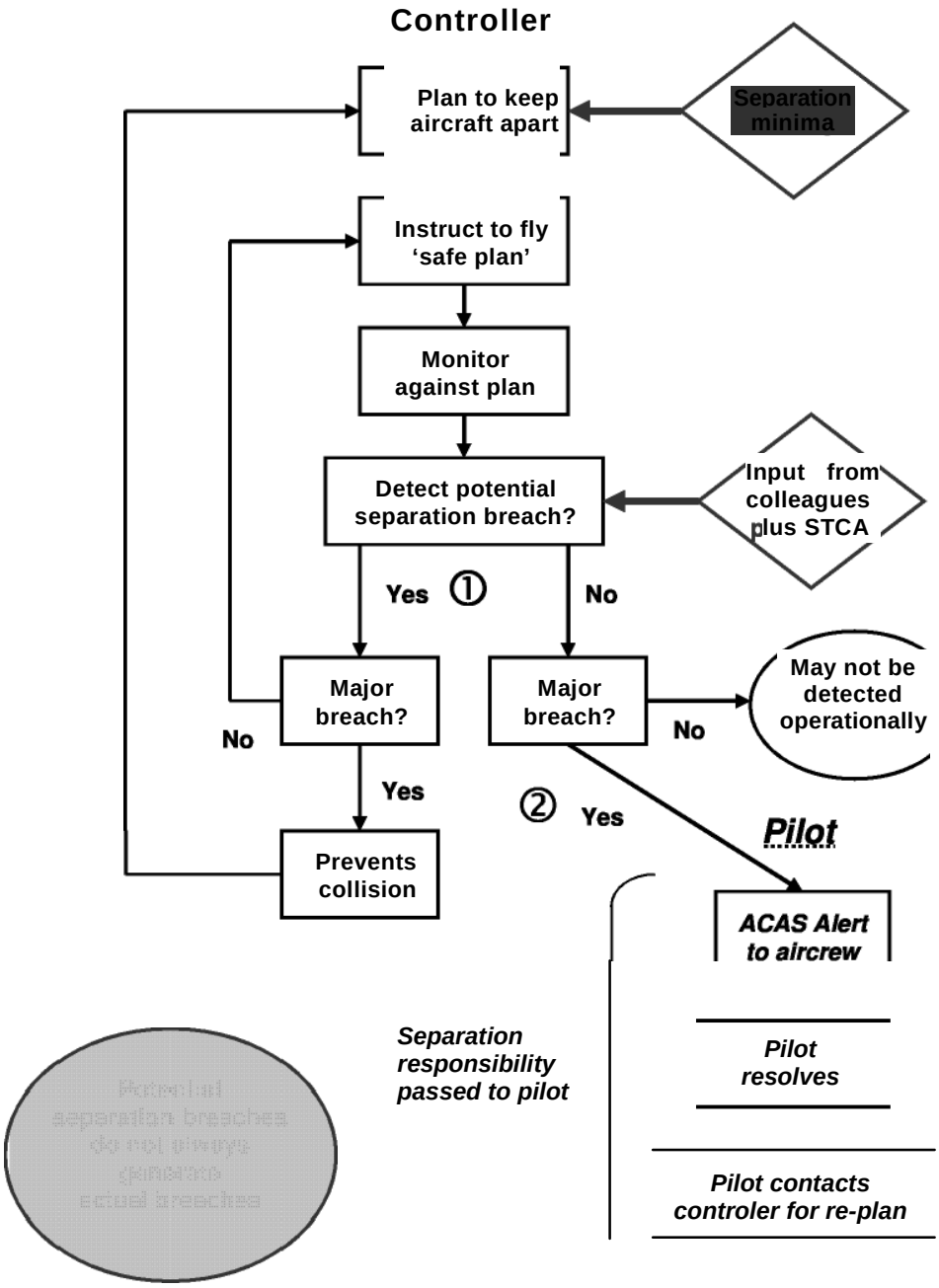

Figure 2. Simplified controller and pilot processes to prevent mid-air collisions

The European single sky needs high quality, simple incident reporting.

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