Have We Learned Enough from Überlingen:
The Challenges of Safety Improvement in European Air Traffic Management

C.W. Johnson,

Department of Computing Science, University of Glasgow, Glasgow, G12 8RZ.
http://www.dcs.gla.ac.uk/~johnson, johnson@dcs.gla.ac.uk

Abstract: This paper identifies the complex ways in which technical, organisational and political constraints shape the decisions and actions taken by national and international safety organisations. In particular, we assess the interventions made by Swiss Federal agencies and by the Air Navigation Service provider (ANSP) following the Überlingen mid-air collision in July 1st 2002. Later sections show that there are strong similarities between the influences that informed their decisions and the factors that directed the work of the European Organisation for the Safety of Air Navigation (EUROCONTROL). We address claims that 'more should have been done' in the aftermath of an accident. Often these assertions are made with the benefit of hindsight and neglect the organisational, technical and political constraints that act on national and international bodies. In order to improve our response to major accidents we should, therefore, spend correspondingly less time on blaming regulatory organisations than on working to shape the legislative and political context in which those organisations work.

1. INTRODUCTION

There has been a move away from the 'perfective' approach that focuses on inadequate operator training or indiscipline as the starting point for most incidents and accidents [Johnson, 2003]. The work of Hollnagel [2004], Rasmussen [1997], Reason [1997], and others have inspired a new perspective in which organisations must look for the longer term, 'systemic' *causes* of failure. Perrow [1984] and Vaughan [2005] have investigated the *consequences* that accidents have for organisations including the US Air Force and NASA. Similarly, Maidment [1998] and Evans [2007] consider the effects that the Southall (1997), Ladbroke Grove (1999), Hatfield (2000) and Potters Bar (2002) accidents had upon the UK rail industry. Just as a host of contextual factors influence the decisions of organisations involved in accidents, many of the same issues influence the scope for intervention by regulatory and investigatory agencies in the aftermath of an accident. There is a pressure to act as soon as possible to prevent any recurrence of an adverse event. Often public and political influences act on organisations to make decisions before all of the information about the causes of an accident can be determined. Rather than focus on the consequences of accidents for particular organisations or particular national regulatory systems, this paper looks at the constraints that scope intervention by European regulatory and safety organisations. In particular, we identify the ways in which Swiss and European Air Traffic Management organisations responded to the Überlingen mid-air collision.

The Überlingen accident occurred on the 1st July 2002 when a Boeing 757-200 was involved in a mid-air collision with a Tupolov TU154M [SAAIB, 2002, BFU, 2004]. A total of 71 crew and passengers were killed on both aircraft. The immediate causes of the accident centred on the Air Traffic Control Officer's (ATCO) instruction to the Tupolov crew, which contradicted the Traffic Alert/Collision Avoidance System (TCAS) on-board warning system. He ordered them to descend towards the Boeing 757 which was (unknown to the controller at the time) also responding to a TCAS warning to avoid the other aircraft. This accident prompted international initiatives in Europe and the US to re-examine the causes of mid-air collisions. The following pages form part of these continuing initiatives. The BFU and SAAIB reports provide a relatively thorough analysis of the causes that led to the confusion over the warning from the TCAS software. In addition, subsequent reports have focused on the decisions that led to infrastructure changes at the Air Traffic Control Centre (ACC) in Zurich [Johnson and Shea, 2007]. Scheduled maintenance procedures created some of the preconditions where the ATCO was likely to make a mistake. Other investigations have focussed on higher-level issues of governance [Weyer, 2006].

Immediately following the incident, it was argued that pilots should have known the importance of following TCAS irrespective of what the controller said. This argument is based on the premise that TCAS is reliable and should be attended to, above the advice of the human Air Traffic Controller (ATCO). From this perspective, it seems unlikely that the accident would recur providing that pilots recognise the importance of attending to their on-board systems. However, there have been several incidents since Überlingen in which pilots have followed the clearances given by controllers when they have (unknowingly) contradicted TCAS instructions. The argument that pilots should always follow TCAS ignores the impact that conflicting contextual factors play in shaping our actions within complex real-world settings. In particular, it ignores the fundamental observation that the TCAS "system" is fallible. There are further reasons why it is important to look beyond the role of TCAS in the Überlingen accident. It is unwise to focus narrowly on systems that influence decision making in the last thirty seconds before a collision. By adopting a systems

view of the accident and by looking more widely at organisation decision making, it is possible to consider the potential for future mid-air collisions.

2. THE NATIONAL RESPONSE TO UBERLINGEN

The Swiss recognised the urgency of taking immediate measures to prevent any recurrence of Überlingen. In the past, actions were deferred until recommendations were presented for adoption by the publication of an official investigation report from the Swiss Air Accident Investigation Bureau [SAAIB, 2002]. This practice was intended to avoid making interim changes that might have an adverse effect on safety before a more sustained analysis could be published. However, there was considerable pressure for a more immediate response. Amendments were proposed to the Swiss Federal Civil Aviation Act. These changes reflected the public and political sensitivity created by the accident. Responsibility for the implementation of interim recommendations was moved from the Federal Office for Civil Aviation and passed directly to the Federal Department of Environment, Transport, Energy and Communication (DETEC). This agency launched a 'root and branch' review leading to the Safety First (SAFIR) action plan, which was intended to reorganise all levels of safety management [Swiss Federal Administration, 2004].

Many of these changes reflected the clear recognition that the accident had 'systemic causes' and could not simply be blamed on individual ATCOs or aircrew. For example, the Federal Office for Civil Aviation (FOCA) separated responsibility for safety and policy. This followed a pattern established across a range of industries since the Cullen report into Piper Alpha [Johnson, 2003]. The focus on 'systemic' issues again illustrates a central theme in this paper; that changing views about the causes of accidents formed an important part of the context for organisational decision making. This was further underlined when FOCA passed the initial recommendations from the German Federal Bureau of Aircraft Accident Investigation to Skyguide, the ANSP responsible for the operation and management of Zurich ACC. Skyguide was urged to: "establish and improve a safety-oriented corporate culture, increase its training capacities increase staffing levels, expand its risk management, introduce a licensing procedure for its staff and a certification process for its technical facilities" [Swiss Federal Administration, 2004].

The Swiss government also invited NLR, the Dutch aviation research institute, to identify possible improvements across their aviation industry in the aftermath of Überlingen. The involvement of an external, independent agency helped Federal agencies to focus their interventions by "the strengthening of supervision at the DETEC General Secretariat, the adoption of the aviation policy report including the setting of Swiss aviation safety policy by the Federal Council and the reorganization of the FOCA together with an increase in staffing levels" [Swiss Federal Administration, 2007]. NLR [2006] were also invited to validate changes made following the mid-air collision. NLR argued that improvements had been made to Skyguide's risk assessment practices and safety management. The validation study also praised initiatives to improve incident reporting and to recruit additional safety staff. They did, however, argue that these initiatives had not received widespread approval from all levels within the ANSP. Problems persisted in the recruitment and retention of sufficient Air Traffic Controllers and further changes were recommended to the licensing of technical personnel. At a national level, safety initiatives still tended to be driven in a 'top down fashion' without the necessary underpinnings of an appropriate safety culture across all stakeholders as they "recover from the myth of perfection". Further caveats focused on delays in implementing the legislative guarantees that might support confidential incident reporting. It was observed that the safety staffing levels in FOCA remained relatively thin. These findings demonstrate that NLR adopted a 'systems approach' that, arguably, forms a strong contrast with the judicial intervention.

The judicial response to Überlingen cannot be understood without first considering the political and social context. Across Europe and North America there have been a number of recent initiatives to increase corporate responsibility for workplace accidents [Johnson, 2008]. Public pressure to increase accountability has been linked to the prosecution of four Skyguide middle managers for negligent homicide leading to the Überlingen accident. The Swiss district court of Bülach sentenced three managers to 12-month suspended terms and one was fined. All the sentences were suspended for a two-year period. Four other technicians and ATCOs were acquitted by the courts. Two of the four individuals convicted by the court have since retired from Skyguide. The two remaining in Skyguide employment assumed new responsibilities within the organisation. The four that were acquitted are free to resume their previous roles. There is, therefore, a paradox between the systems view, for example revealed by the separation in policy and safety within the FOCA, and the more 'perfective approach' revealed by the subsequent prosecutions under negligent homicide legislation. This can only be understood with reference to the wider forces acting on both the Swiss Federal agencies and on Skyguide [Johnson, Kirwan and Licu, 2008].

3. EUROCONTROL AND THE INTERNATIONAL ORGANISATIONAL RESPONSE

The impact of Überlingen extended well beyond Skyguide. In particular, the accident had direct consequences for EUROCONTROL's role as a focal point for ATM safety across Europe. The consequences of the accident can only be understood within the context of the political and organisational constraints that characterised the agencies 'opportunities for action'. The revised EUROCONTROL Convention of June 1997 established majority voting as the

basis for decision making and changes in the interaction between civil and military aspects of ATM operations. This practice of allowing conformance through consensus rather than direct regulatory intervention provides important insights into the role of the organisation before and after the Überlingen accident. Safety improvement ultimately depended on cooperation between member states. Some regulators chose to follow the provisions of EUROCONTROL guidance when establishing national requirements. Others did not. For instance, the BFU's report into the mid-air collision describes how EUROCONTROL played a key role in developing high-level guidance on the operation of Airborne Collision Avoidance Systems (ACAS). These included a January 1996 Aeronautical Information Circular and additional technical and operational guidance in WP–6-1– ACAS II Program, in 1999. The Überlingen report notes, however, that these documents were "only descriptions or recommendations" and not legal requirements [BFU, 2004]. The proponents of a more interventionist policy can point to Überlingen as an example of the limitations of the existing approach, since member states at a lower level of safety maturity may be at risk.

EUROCONTROL's legal status created a situation in which it could support and encourage the adoption of its guidance. However, it did not have the powers of audit and enforcement that might be required to ensure that states comply with every aspect of its requirements even in those situations where national regulatory bodies have adopted a subset of their provisions. For example, the Russian Regulatory Authority used EUROCONTROL's 'ACAS Implementation Guidance Document' (1 July 1997) to structure their training at State Special Centres [BFU, 2004]. However, these courses did not offer the simulator training that was strongly recommended in the EUROCONTROL guidance material as 'complementary and indivisible parts' of ACAS familiarisation. Although the TU154M pilots and navigators had received ACAS training based on EUROCONTROL guidance, they had not received the associated scenario-based interactions that are arguably best delivered using computer-based training. They had not, therefore, received the kinds of interactive simulations that test their ability to react under the complex time pressures that arise when ACAS issues traffic or resolution advisories. Similarly, Skyguide's management team recognised that they would have to develop particular expertise in the areas of safety, quality, audit, and risk management if they were to meet international regulatory guidance from organisations including the ICAO and EUROCONTROL. They, therefore, established a Centre of Competence (CoC) that was intended to revise the less formal safety management processes that had been used before corporatisation. Although quality and audit were well-supported by existing resources, the centre lacked specific expertise in safety and risk management. Rather than bring in external support, the ANSP chose to develop expertise within their organisation. This led to a delay in the provision of technical support for risk assessment. The Überlingen accident report, therefore, concluded that the Skyguide "Safety Policy clearly suggests the CoC should have been formally involved in the planned structure change of the upper airspace, which did not happen. Without knowledge of the planned sectorisation work the Risk Manager could not conduct a quantitative risk assessment and mitigation process" [BFU, 2004].

These findings illustrate the constraints that acted over EUROCONTROL in the years leading to the Überlingen accident. They relied upon the agreement of member states before the guidance could be published. Regulators often chose to limit the scope of these guidelines. Similarly, ANSPs often lacked the resources to implement all aspects of EUROCONTROL documentation. Even in those cases where the guidelines were followed, compliance was often delayed, e.g. some ANSPs decided to implement only ESARRs requirements that have been transposed into community law. Of course, in retrospect more might have been done. The accident might have been avoided if the same level of safety maturity had been in place across all member states. Equally, it is important not to use perfect hindsight to create an alternate version of events in which organisations such as EUROCONTROL could intervene without the legal and organisational constraints that guided their intervention in the years before Überlingen.

One of the first actions that EUROCONTROL took in the aftermath of this accident was to establish a High-Level European Action Group for ATM Safety (AGAS). The initial remit for AGAS was to ensure that European states learned from the Überlingen [BFU, 2004] and Linate accidents [ANSV, 2004]. The lessons from these mishaps were to inform the Strategic Safety Action Plan (SSAP) which ran from 2003-2005. EUROCONTROL coordinated work across more than one hundred work packages in eight major areas, Safety Related Human Resources in ATM, Incident Reporting & Data Sharing, Airborne Collision Avoidance Systems, Ground-Based Safety Nets, Runway Safety, Enforcement of ESARRs & Implementation Monitoring, Safety Awareness, Safety Research and Development. The SSAP acted as a focal point for a wide range of safety initiatives across EUROCONTROL as it sought to coordinate and communicate lessons learned between ECAC member states. The organisation was also involved in a number of studies that were outside the immediate scope of the SSAP but which were strongly connected to the Überlingen accident. These included the FARADS – the Feasibility study on TCAS Resolution Advisory downlinks. Work in this area started before Überlingen, however, the mid-air collision lent particular importance to FARADs. It was argued that ATCOs might have responded more appropriately to the conflict if they had been aware of the warnings that TCAS was providing to the aircrews. Again, the pattern of safety regulation through cooperation and consensus can be seen to motivate the formation of the AGAS group. The development of the SSAP strands, in turn, represents a further use of

working groups to develop and exchange best practice across a range of technical areas. Independent reviews provided feedback on the coverage of the response [Johnson, 2004].

In early 2006 the SSAP was declared closed. New challenges were being created by continued increases in traffic, by the accession of new member states to EUROCONTROL, and by changes in the balance of general and commercial aviation. A second programme called the European Safety Plan (ESP) was developed. This was intended to be more generic than the SSAP. It marks an important transition from a reactive response to previous accidents towards a more proactive approach to the safety of ATM systems. The ESP was increasingly influenced by the European Commission's Single Skies programme. The Single European Sky initiative is often justified in terms of rationalisation; technical innovations make it possible that ten area control centres could assume the work of fifty of the present ACCs, using functional airspace blocks (FABs). So far, progress has been mixed. The same combination of technical barriers and organisational issues that were noted in the causes of Überlingen has also been identified in delays to the implementation of FABs. Issues of sovereignty over national airspace have also been raised with respect to liability and military operations.

The European Commission has argued that informal agreements between stakeholders may be insufficient to cut through the national barriers to the implementation of the Single European Sky. Vice President Barrot, therefore, appointed a High Level Group (HLG) for the Future European Aviation Regulatory Framework in November 2006. Together with key representatives from EUROCONTROL, they concluded that an intergovernmental approach 'cannot produce a level playing field where the implementation of rules depends on the will of States and is not uniformly implemented. There is consequently a need for the Community to be the driving force in ATM' [CEC, 2007]. Although these comments were not directly motivated by the Überlingen accident, there are strong parallels between the comments of the HLG and the perceived need to increase the powers of intergovernmental organisations in order to ensure the prompt implementation of safety recommendations in the aftermath of major adverse events. Only time will tell if States have the political will and public support to enforce European legislative requirements on their national ANSPs, especially when these may have implications for their military organisations. It is unclear whether non-EU States, including Turkey and the Ukraine will accept the legal, regulatory and monitoring mechanisms that are being extended across member states.

The Single European Sky initiative builds on a legislative package that was adopted by the European Parliament and Council in March 2004. The package consisted of four regulatory elements: a framework for the creation of the Single European sky; rules on the provision of air navigation services; provisions for the organisation and use of airspace in the Single European sky and provisions on the interoperability of the European Air Traffic Management [CEC, 2007]. The impact of Überlingen on the ESP can be traced through this package and in particular, through the common requirements that were established in a Commission Regulation (EC No 2096/2005 of 20 December 2005 – known as "common requirements"). This document codified many of the EUROCONTROL ESARRs. In other words, requirements that might previously have been monitored in an "informal" way by EUROCONTROL now became legal requirements on EC member states under community law. Time limits were also to be established for conformance, setting upper bounds on the delays, for example that might be needed in order to develop staff expertise in areas such as risk assessment. This is important because the common requirements provided a legal basis, at least in principle, for enforcement actions to limit the delays that were implicated in the causes of the Überlingen accident [BFU, 2004].

Direct intervention was extended by the development of the European Aviation Safety Agency (EASA) under EC Regulation 1592/2002 and 216/2008 as the main vehicle for the European Community's safety strategy for aviation safety regulation. EASA is an agency of the European Community and is governed by European public law. It assists the European Commission in the drafting of rules on aviation safety that are to be imposed on member states at a European Community level. The European Commission retains ultimate responsibility for regulatory oversight. However, it may choose to use or amend opinions provided by EASA before initiating new regulatory interventions through the European Council and Parliament or through 'comitology'. This differs from EUROCONTROL, which as we have seen was established by an instrument of public international law viz. a convention between its founding members. EASA's enforcement powers will far exceed anything applied by EUROCONTROL. The Agency will be able to directly assist in the development of European legislation across the aviation industries and then monitor the application of the legislation by member states. EASA may, therefore, be better suited to a more interventionist approach to safety regulation across the European ATM industries. Presently this approach has yet to be proven.

EASA develops three different types of outputs: certification specifications; guidance material and draft regulations. It also issues some certifications and approvals, for example for aircraft. However, the mechanisms to encourage the implementation of existing regulations and guidance across member states still rely on the participation of national agencies through the issuing of individual certificates and licences, such as maintenance organisation approvals. This raises the critical question of how rules will be enforced once EASA's responsibility is extended to cover Air Traffic

Management. A recent UK Civil Aviation Authority review identified a number of alternate approaches [Allan, 2005]. The first of these was termed a 'focus on safety'. National agencies might ensure the implementation of EASA rules by the revocation of approvals and licenses. Improvement and prohibition notices might also be used to ensure that operators met the obligations that are intended to raise safety in a uniform manner across member states. The second approach to the national implementation of EASA requirements was termed 'punitive enforcement'.   This would involve criminal prosecutions or administrative penalties, following the model adopted, for example, by the US FAA. This would involve an extension of the judicial response to the Überlingen accident, described in previous sections. These different approaches may be seen to encourage different responses from the aviation industry when they may either passively attempt to comply with minimum standards enforced by the regulator or more actively participate in the identification and management of risks across their operations [SRC, 2008]. Many questions remain about the best ways for National Aviation Authorities to oversee and implement EASA requirements. Several nations have achieved derogations that permit delays in the implementation of EASA's existing requirements. This is to be expected given that it will take several years for all member states to reach a shared level of safety maturity, just as Skyguide recognised that it would take them several years to fully develop the safety functions in their Centre of Competence. The key to improving safety across European Air Traffic Management is to encourage consensus and support at a national level. This is no different for EASA than it was for EUROCONTROL in the years before and immediately after the Überlingen accident. The irony is that the more EASA has to rely upon its powers of audit and compliance, the more difficult it may be to promote consensus across a growing number of member states.

5. CONCLUSIONS AND FURTHER WORK
This paper has shown that Skyguide's response to Überlingen was shaped by Federal initiatives to address the structural causes of the accident and that this, in turn, was influenced by a public desire for both corrective and punitive legal sanctions.   Corrective actions were strongly influenced by prevailing 'systems views' of accidents. Legal sanctions may owe more to a wider concern across many countries to ensure corporate and managerial accountability for major accidents. We have also shown how EUROCONTROL's scope for intervention was influenced by a tradition or pattern of ensuring consensus between stakeholders. This led to the development of the SSAP which addressed the immediate causes of Überlingen and also, itself, established a pattern embodied within the ESP as a means of addressing many longer term concerns over aviation safety across Europe. Finally, we considered the reasons why the pattern or model established by the European Aviation Safety Agency will be extended to cover many of EUROCONTROL's responsibilities for ATM safety.   The European legislative provisions for EASA address key concerns over EUROCONTROL's ability to enforce recommendations after accidents, such as Überlingen. It remains to be seen whether these powers can be used to encourage consensus. The requirements for consultation under the process of comitology suggest that EASA will continue to rely on cooperation from member states as the primary means of ensuring implementation.

An implicit theme in this paper has been to address claims that 'more should have been done' in the aftermath of an accident. Often these assertions are made with the benefit of hindsight and neglect the organisational, technical and political constraints that act on national and international bodies.   In order to improve our response to major accidents we should, therefore, spend correspondingly less time on blaming regulatory organisations than on working to shape the legislative and political context in which those organisations work.

ACKNOWLEDGEMENTS

REFERENCES
Agenzia Nazionale per la Sicurezza del Volo (ANSV, 2004), Milano Linate, ground collision between Boeing MD-87, registration SE-DMA and Cessna 525-A, registration D-IEVX, Reference A/1/04, 20th January.

R. Allan, 2005. Aviation Safety Regulation: Aviation Safety Regulation in the UK And Options For Aviation Safety Regulation, UK Civil Aviation Authority, London, UK. Available on http://www.caa.co.uk/docs/1/Options%20Allan%20201205.pdf, last accessed 8th May 2008.

Bundesstelle für Flugunfalluntersuchung (BFU: German Federal Bureau of Aircraft Accidents Investigation), Accident on 1 July 2002, Near Überlingen/Lake Constance, Germany Involving Boeing B757-200 and Tupolev TU154M, Investigation Report AX001-1-2/02, May 2004.

Communication From The Commission (CEC): First Report on the Implementation of the Single Sky Legislation, Brussels, Belgium, 20th December 2007, COM(2007) 845 final. Available on http://eur-lex.europa.eu/LexUriServ/site/en/com/2007/com2007_0845en01.pdf, last accessed 8th May 2008.

EUROCONTROL, Working Together: Stakeholders (ANSPs), Brussels, Belgium, 2008. Available on http://www.eurocontrol.int/corporate/public/standard_page/focus_ansp.html, last accessed 8th May 2008.

A.W. Evans, Rail safety and rail privatisation in Britain, Accident Analysis and Prevention, 39 (3), pp.510-523. 2007.

C.F.L. Heimann, Different Paths to Success: A Theory of Organizational Decision Making and Administrative Reliability, Journal of Public Administration Research and Theory, 5(1)45-71, 1995.

E. Hollnagel, Barriers and Accident Prevention, Ashgate Publishing, Aldershot, UK, 2004.

C.W. Johnson, Failure in Safety-Critical Systems: A Handbook of Accident and Incident Reporting, University of Glasgow Press, Glasgow, Scotland, ISBN 0-85261-784-4, 2003.

C.W. Johnson, Ten Contentions Of Corporate Manslaughter Legislation: Public Policy And The Legal Response To Workplace Accidents, Safety Science, (46)3:349-370, 2008.

C.W. Johnson and C. Shea, The Contribution of Degraded Modes of Operation as a Cause of Incidents and Accidents in Air Traffic Management. In A.G. Boyer and N.J. Gauthier (eds.), Proc of 25th International Systems Safety Conference, Baltimore, USA, Unionville, VA, USA, 616-626, ISBN 0-9721385-7-9, 2007.

C.W. Johnson, B. Kirwan and A. Licu, The Interaction between Safety Culture and Degraded Modes: A Survey of National Infrastructures for Air Traffic Management, Reliability Engineering and System Safety Journal, in press, 2008.

D. Maidment, Privatisation and division into competing units as a challenge for safety management. In: A. Hale and M. Baram, Editors, Safety Management, The Challenge of Change, Pergamon, Kidlington (1998), pp. 207–218.

Nationaal Luchten Ruimtevaartlaboratorium, National Aerospace Laboratory NLR (U.G. Dees, P.J. van der Geest, H.H. de Jong and M.A. Piers), Post Implementation Audit Of Aviation Safety Management In Switzerland: On The Way From The Myth Of Perfection Towards Excellence, Technical Report NLR-CR-2006-536, Amsterdam, The Netherlands, 2006.

C. Perrow, Normal Accidents: Living with High Risk Technologies, Basic Books, New York, 1984.

J. Reason, Managing the Risks of Organisational Accidents. Aldershot, UK; Aghgate, 1997.

J. Rasmussen, Risk Management in a Dynamic Society: A Modelling Problem. Safety Science, 27, 183-213, 1997.

SRC, Future Of ATM Safety Regulation In EUROCONTROL, SRC32.07, 18/06/08, ITEM 10, ACTION PAPER, EUROCONTROL, Brussels, Belgium, 2008.

Swiss AAIB (Swiss Aircraft Accident Investigation Bureau), Final Report concerning the incident (Airprox) between THY1944 , BAG4608, IBE3514 and AZA467 on 13th September 2000 UIR Switzerland near TRA. N° A024. Federal Department of the Environment, Transport, Energy and Communications, Bern, Switzerland, 2002.

Swiss Federal Administration, Investigation Report On The Überlingen Aircraft Accident: Federal Council Accepts Errors Were Made And Expresses Apologies, Department Of The Environment, Transport, Energy And Communications, Press Release 15th May 2004, Bern, Switzerland.

Swiss Federal Administration, Project 'SAFIR' Taking Effect: Aviation Safety Management Has Improved, Department Of The Environment, Transport, Energy And Communications, Press Release 22nd January 2007, Bern, Switzerland.

D. Vaughan, System Effects. In William Starbuck and Moshe Farjoun (eds.), Organization at the Limit: NASA and the Columbia Accident. Blackwell, 2005.

J. Weyer, Modes of Governance of Hybrid Systems: The Mid-Air Collision at Überlingen and the Impact of Smart Technology. Science, Technology & Innovation Studies 2(2), 127-49, 2006.