The Überlingen Mid-Air Collision: A Tradegy—Revisited

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When Danish air traffic controller Peter Nielsen was murdered in 2004 by a Russian who lost his family at the Überlingen mid-air collision, this was only the last point of a big tragedy. 71 people lost their lives when a Boeing B-757 cargo aircraft and a Tupolew TU-154 commercial airliner collided in July 2002 over Germany, close to the Swiss border. Although several factors led to the disaster, it was also the inconsistent behaviour of the two pilots which contributed to the collision. One followed the instructions of the Traffic Alert and Collision Avoidance System (TCAS). The other followed the orders of the air controller. In this paper I argue that the redundancy systems which are constructed in order to increase safety in High Reliability Organisations (HRO) can conversely produce uncertainty. They can create situations in which decisions need to be made based on insufficient information. By reflecting on trust, culture and power I analyse why under these circumstances the commercial airliner might have been eventually steered according to the orders of the controller. Finally I apply aspects of Mathiassen and Sørensen's (2008) framework of Information Services to offer a theoretical explanation as to why the ultimate situation was impossible to resolve.

Introduction

Mid-air collisions are an enduringly relevant subject with regard to air transportation safety. In spite of improvements in air traffic management, they still seem to occur from time to time (Weber, 1982). If they do happen their consequences are fatal and almost inevitably connected with deaths. Sometimes passengers escape with a fright like in 2001 when a Boeing 747-400 and a DC-10 missed each other tightly over the Pacific Ocean, south of Yaizu, Japan (Staff, 2004). Sometimes passengers die as in the case of the Überlingen mid-air collision.

From the perspective of an Information Systems researcher mid-air collisions are particularly interesting as in most cases they indicate failure of interaction between man and machine. They represent a failure of systems which are decisively created with the purpose to offer an extremely reliable service. Furthermore they are special in the sense that they allow to re-construct the scenario in high detail. This is due to technical artefacts such as Flight Data Recorders (FDR) and Cockpit Voice Recorders (CVR) which document the sequence of events and can be analysed afterwards. Finally, mid-air collisions normally take place within an intercultural context. This can be critical if norms and standards of behaviour vary between different actors (Pidgeon, 1997).

The Überlingen mid-air collision is not only a tragedy which led to the death of 71 people and the murder of the air controller by a Russian who had lost his family in the disaster. It is also an example of failure where two systems generate conflicting information and finally cause a disaster – two systems which had been built to complement one another for the means of safety. Moreover, this accident stirs up a debate about whether humans trust more in humans or in machines, whether coherent culture and norms could have avoided the disaster and whether authoritative power-structures in the cockpit contributed to the fatal accident.

The Überlingen Mid-Air Collision

In the night of July 1, 2002, two airplanes collided at 34,890 feet over the German-Swiss border close to the town Überlingen – a Boeing 757, operated by DHL, flying from Bergamo to Brussels and a Tupolew 154, operated by Bashkirian Airlines, en route from Moscow to Barcelona. The aircraft which finally were on a 90° collision course both had Traffic Alert and Collision Avoidance Systems (TCAS) installed. During the final minutes before collision they were both under the supervision of the Zürich Area Control Centre (ACC) (BFU, 2004).

During that night the Zürich ACC performed maintenance measures on the radar and telephone system. As a result the radar system was operating only on fall-back mode and the main telephone system was shut down. Furthermore the Short Term Conflict Alert (STCA) which would normally warn the controller of any impending collision was not available either (Flottau, 2002). The fall-back telephone system had a software failure which nobody had noticed.

According to the routine at Zürich's ACC only one of the two controllers on duty, Peter Nielsen, worked at the time of the accident. Because he had to control two frequencies, Peter Nielsen needed to monitor two separate screens at the same time. On the one screen he observed the en route traffic and on the other screen all flights approaching the airport of Friedrichshafen (FHA). When he tried to reach the tower of Friedrichshafen airport in order to get the landing clearance for an Airbus 320 registered to Thai Airways he could not get through due to the telephone system malfunction. Several times he tried to hand over the Thai Airways flight and meanwhile kept the second screen unattended. Two minutes before the collision the STCA did not alert him as it normally would have done. Neither could another controller from Karlsruhe, whose STCA had gone off, warn Peter Nielsen as a result of the telephone failure (BFU, 2004; Nunes, 2004).

50 seconds before the collision TCAS warned the crew of the Tupolew about convergent traffic: "Traffic, Traffic". 40 seconds before collision Peter Nielsen became aware of the convergent course of both airplanes and instructed the Tupolew-crew to descend: "B-T-C 2937, descend flight level 3-5-0, expedite, I have crossing traffic." 36 seconds before collision the Pilot Flying (PF) of the Tupolew initiated the descent. At

the same time TCAS generated a Resolution Advisory (RA) for the Tupolew to “climb, climb”. In spite of the TCAS order the Tupolew continued its descent. At 21:35:32 Central European Summer Time (CEST) the passenger aircraft collided with the DHL airfreight machine which had followed the TCAS orders and thus mirrored the manoeuvres of the Tupolew (BFU, 2002).

How could it come so far?

As the overview of the Überlingen accident has demonstrated, many different factors contributed to the mid-air collision. These factors have been described in detail as well in the official report of the German Federal Bureau of Aircraft Accidents Investigation (BFU, 2004) as well as by Nunes and Laursen’s (2004). Although a list of factors never can be regarded as complete, we can assume that the circumstances which led to the collision are relatively clear. But as clear as these frame conditions are, as much room there is for interpretations and analyses.

For researchers such a variety of factors offers diverse starting points for analysis and for the application of theories. At first sight it seems to be appealing to approach the Überlingen collision with a classical disaster theory. The overall system to prohibit aircraft collisions is complexly interactive and tightly coupled. It offers the ideal environment in which “small errors can interact in unexpected ways”. And for sure “the tight coupling will mean a cascade of increasingly large failures”. The character of such a system virtually calls for Perrow’s Normal Accident Theory (NAT) (Perrow, 1994).

On the other hand, the happenings at the Zürich ACC ask for further analysis from a managerial and organisational standpoint as they indicate insufficiencies in air traffic capacity management. And there are indeed parties that accuse the Zürich ACC for the accident. Paul Duffy, a Russian Aviation consultant, for example stated that “the system responsible for the accident was the poor Skyguide management and quality control” (Cineflix, 2004).

From a system development point of view the problematic maintenance of the air traffic control systems could be of interest, raising the question how maintenance work should be carried out for High Reliability Systems (HRS). How to maintain systems which have to function with the same reliability during maintenance work because they are extremely critical for the safety of the organisation?

The situation of the controller might offer starting points for further research from a cognitive science angle. On the one hand the workload and stress which the controller suddenly faced and on the other hand the monotony and boredom during long quiet nights at the control centre psychologically provide an extraordinary setting (Baase, 2003; Hoc, 2000; Kirwan, 2001). Also related to this area is the interaction between the controller and his instruments which refers to the research area of Human Machine Interaction (HMI).

If we have a look at the research that has been conducted so far related to this specific case, one research paper seems to be noticeable in particular. Based on the Überlingen case Weyer (2006) analyses the distribution of control between humans and machines in collision avoidance systems. However, Weyer does not give an explanation of the disaster. He rather uses this case to support his argumentation that TCAS can be regarded “as a first step in a regime change”. He predicts a lower dependency of pilots on controllers and an increasingly higher dependency of pilots on technical artefacts (Weyer, 2006).

In this respect this essay can be seen as the presumably first attempt to use theoretical concepts to explain the Überlingen case. Although no paper can be regarded as purely non-interpretative, it can be argued that the official report (BFU, 2004) and Nunes and Laursen’s (2004) article have a strong descriptive and factual character. Therefore this essay is neither set out to explicitly describe existent papers nor to close gaps of their interpretations. It rather builds on the facts that they deliver.

In awareness of the different possible ways to approach the case, this essay focuses on one particular situation within the sequence of events – the crucial situation in which the pilot-crew of the Tupolew finally had to act. In this regard three questions appear to be central: Why could it happen that two different orders were available to the pilot-crew? Why was the airplane finally steered according the controller’s order? And, from an Information Services angle, in what way had the decision basis changed so that it could not be resolved anymore?

When redundancy systems lack independence

Flying is regarded as a very secure way of transportation. In 2007 the Jet Airline Crash Data Evaluation Centre (JACDEC) registered 52 accidents worldwide in which 752 people died. This is a rather low number considering that in the same period 4.65 billion people went by plane according to the Airports Council International (ACI) (Focus Online, 2008). In consequence, air transportation organisations can be described as High Reliability Organisations (HROs).

Paradoxically, air transportation is at the same time a highly risky field as human lives are at stake. Therefore it is an enduring issue to design secure and highly reliable systems (LaPorte, 1991; Parasuraman, 2004). This expedite is also challenging because one important learning technique is not available in this field. As Todd LaPorte said at the Close Calls Conference at the London School of Economics, in these organisations “your next error is your last try” (LaPorte, 2009). Whereas in other areas “trial and error” is a suitable way for improvement, in air transportation it is not. The asset – human lives – is just too valuable as to wait until an error occurs (Weick, 1987). As a consequence, organisations put a lot of effort into identifying errors before they occur. But obviously it is impossible to anticipate all potential errors. Too complex are the social and technical systems and too unforeseeable are potential combinations of events. Hence, alternative ways must be explored to increase system reliability.

One approach to achieve high reliability is to embed redundancy. Etymologically, redundancy exists whenever something exists in abundance. With regard to technical or organisational systems, the notion of redundancy has been introduced by Harry Nyquist. As mentioned by Landau (1969), he described any non-crucial part of a message as redundant. However, later it has been recognised that redundancy also provides characteristics which can be regarded as extremely useful to achieve continuous operational effectiveness (Jarman, 2001). Consequently, safety critical organisations now use redundancy in order to increase the reliability of their systems. If the main system fails, a redundancy system takes over and replaces the primary one (Rochlin, 2005). In air transportation redundancy is not only realised for technical systems but also for humans. If we take the pilots as an example: Not only the captain is able to fly the aeroplane but also the co-pilot (Grabowski, 2000; Helmreich, 1997).

This principle of redundancy is used for air collision avoidance. In the Überlingen case the Zürich ACC represents the primary system. In this capacity the controller Peter Nielsen had the responsibility to ensure that all aircraft moved in separated airspace. As fall-back systems there were the STCA, controllers of other ACCs and finally TCAS. STCA was unavailable due to maintenance work. The controller from Karlsruhe who had noted the impending collision could not contact Nielsen due to a telephone software failure. TCAS was fully operational. But by functioning it caused also the disaster. If TCAS had not generated the RA, the collision would not have happened.

This suggests that redundancy systems can only achieve reliability when they are designed in a specific way (Grabowski, 2000). If independence between the single redundancy systems is not given, they can even contribute to accidents (Landau, 1969). If failure of one redundancy system can negatively impact on the functionality of another redundancy system, then the reliability of the overall system is not increased, contrary to intention. Equally, this independence is not given if two systems generate conflicting information and thus increase uncertainty. Then "redundancy may increase complexity […]: redundant information gathering may lead to ambiguity and conflicting perceptions" (Rijpma, 1997). And exactly this occurred at the moment when the controller and TCAS acted in parallel. The pilot-crew of the Tupolew did not know which instruction to follow – the TCAS' RA to descend or the controller's order to climb. The Tupolew descended and thus mirrored the movement of the conflicting aircraft which followed the TCAS instructions. As a result both airplanes collided.

Those explanations might shed some light on the question why different information was available to the crew of the Tupolew. But how can we understand why the pilot-crew did not follow the TCAS command?

No trust in a computerised system?

Trust can be seen as a potential explanation why the pilot-crew of the Tupolew followed the instructions of the controller. Trust is a complex concept which is strongly connected to sociology and psychology. It basically expresses the expectation of a trusting party to receive something positive from another party. These parties do not necessarily have to be human. Often machines are regarded as trust-worthy owing to their reliability and security. Most people for example have a certain trust in the reliability of airplanes (Jøsang, 1996).

Another characteristic of trust is that it is usually associated with an external threat. If we look at the airplane-example once more: Trust would not be necessary without the potential danger of the passengers' deaths.

Trust can also help to understand the behaviour of individuals and organisations in situations where rational theories fail to provide an answer. Trust might be the last way out in situations of high uncertainty, when decision makers have to take risks because they are only provided with incomplete information. Trust can be seen as the last resort when the outcome lies no longer in your own hands but in independent actions of another party (Cahill, 2003). And, as Helmreich (2000) states, "trust is a critical element in safety culture".

One might ask why the Topolew-crew or at least the Pilot In Command (PIC) had no trust in the TCAS. Overreliance of humans on technical artefacts has been well recognised (Baase, 2003). In 1987 for example the military ship USS Vincennes shot down an Iran Air passenger aircraft. The report later suggested "task-fixation" as one contributing factor which led to "scenario fulfilment" (Peltu, 1996).

One could argue that the pilot crew was fixated on fulfilling the controller's orders and thus ignored TCAS. However, from my standpoint this does not present a strong argument. Task fixation might be sufficient to explain a single incident of a crew directing the plane according to the controller's orders. But in a comparable scenario on January 31, 2001 two airliners of Japan Airlines had a near miss. TCAS and controller produced contradicting advisories and again the crew followed the human advisory (Tomita, 2005). This begs the question of additional causative factors rather than just task fixation.

Another explanation why TCAS has been ignored in both cases could be distrust in this system. Distrust can be caused by a high proportion of false alarms, especially when systems are immature (Parasuraman, 2004). And there are indeed indicators to suggest that early versions of TCAS were literally unusable. Baase (2003) for example cites an article from the Wall Street Journal mentioning that "the system directed pilots to fly toward each other rather than away, potentially causing a collision instead of avoiding one". One could argue that pilots consequently have lost their trust in this particular system.

From my standpoint additional arguments ought to be considered. Otherwise it is not explicable that pilots nowadays seem to have a rather positive attitude towards TCAS. Bruce Nordwall (2002) for example states that "pilots generally have a high regard for TCAS, and its European counterpart ACAS (Air Collision Avoidance System). From the cockpit they are perceived as a safety net."

I argue that humans are prone to follow humans, not computers, when they are in a critical situation and have to choose between the two. This is also the result of two studies conducted by Waern (1996). Both studies come to the conclusion that the "general trust in computers was, however, much less than their trust in human beings." And even if we question the results of these somewhat artificial experiments, we can follow on from Waern's thought that the human communication style is more effective than the computational. There is no doubt that the voice of controller Peter Nielsen sounded much more dramatic than the computerised voice. As Rashid Mustafin, Deputy Chief Pilot of Bashkirian Airlines, states: "The TCAS commands are spoken in such a dispassionate voice. 'Descend. Increase descent.' Such a matter of fact type of voice. And then there is the voice of the air traffic controller's urgent command. So which ever voice sounded more urgent was the one the crew obeyed" (Cineflix, 2004).

This still leaves a question unanswered. If the English pilot-crew of the other airplane, the Boeing 757, did have direct contact to the controller, would they have also preferred the controller's order to the TCAS'? We will never be able to answer this question. However, it provides the starting point for another possible explanation. Maybe it was not only a question of trust, but also a question of culture with regard to the use of TCAS.

Culture and norms

Culture can be described as the phenomenon that individuals of the same background show similar patterns of communication, thinking and way of life. Comparable to trust, culture is not consciously perceived and needs to evolve over a period of time. Nevertheless it can have a strong impact on the behaviour and actions of people as it shapes the inner sense of "right and wrong" (Jing, 2001).

Culture also plays an important role within HROs since these organisations are often based on the same implicit assumptions and norms (Grabowski, 2000; Schein, 1996). Although a unification of norms, especially the unwritten ones, is usually difficult to achieve, these organisations develop a common understanding which in turn ensures consistent action across the organisation (Grabowski, 2000; LaPorte, 1991). This applies not only to air transportation but also to other high reliability industries. At BP for example it is an official rule to hold the handrail when taking the stairs. According to John Meakin, Chief Information Security Officer (CISO) of BP, this rule is to embed an awareness of security in the culture of BP (Meakin, 2009).

Moreover, cultural understanding and unified procedures are two ways to replace central storage of information within a distributed system. Ideally, culture would then unify behaviour beyond different locations as if by magic (Weick, 1987). Referring to the air collision avoidance system in the Überlingen case, the ACC can be regarded as a central system and the pilot's interaction with the TCAS as a distributed one. When two contradictory advisories were available to the Tupolew-crew, consequently the functionality of the system was dependant on either culture or standardised operational procedures. Both, culture and procedures could have equally led to a coherent understanding which of the two orders should be prioritised.

In the highly regulated airline industry these rules and cultural norms would usually provide an effective platform to establish consistent procedures. However, at the time of the Überlingen accident different norms seemed to have existed with regard to the TCAS usage. Neither the same tacit understanding nor a consistent world-wide rule was available to the pilots. In the United States it is generally accepted that in such situations TCAS orders ought to be prioritised (Nordwall, 2002). In contrast to that Russian operating procedures leave the decision to the pilot whether to follow TCAS or ATC. As most Russian aircraft in 2002 were not equipped with TCAS one even can assume that the standard procedure was to follow ATC commands (Flottau, 2002). This view is shared by Marinus Heijl, deputy director of the Air Navigation Bureau ICAO: "Perhaps the ICAO procedures and standards, but in particular the operating procedures for airborne collision avoidance were somewhat ambiguous, were open for interpretations" (Cineflix, 2004). This argument is also supported by the fact that guidance material now, after the Überlingen accident, emphasises that pilots should follow the TCAS instructions (Brooker, 2005; Staff, 2004). Unfortunately, neither culture nor procedure are of any help in an unprecedented case of emergency (Weick, 1987).

Or a question of power and authority?

In the literature we can find the notion of the "culture free cockpit". This expression probably intends to emphasise that irrespective of their diverse cultural background crew members communicate smoothly. However, research studies have shown that differences between attitudes of crew members exist depending on their "national, organisational, and professional cultures" (Helmreich, 2000). For example the degree of openness co-pilots display towards their captains varies considerably. Whereas in western countries concerns in relation to the safety of the flight are voiced without restraint, pilots from Eastern countries seem to be dominated by the respect for their more senior colleagues. This can result in hesitation or worse, withholding of their opinion (Helmreich, 1997; Sherman, 1997).

This leads to a discussion about the distribution of power within the cockpit. Power in general has been discussed through the centuries, for example by philosophers such as Machiavelli or Foucault. The social psychologists French and Raven (French, 1959) see power as relationships between people that can influence the goal achievement of groups. This aspect of power appears to be relevant for the Überlingen mid-air collision.

So far we have made no distinction between the Pilot In Command (PIC), the Pilot Flying (PF) and the co-pilot. But the crew constellation in the Überlingen case might be important, especially when we consider that it differed from the routine. During that night an instructor had joined the crew which resulted in a change of the usual hierarchy in the cockpit. The instructor was the PIC and Pilot Non-Flying (PNF), meaning that he gave the orders but delegated the execution to the PF. The third pilot, the co-pilot, had only a passive advisory role.

Analysing the last conversation in the cockpit, the question arises as to why the co-pilot's doubts were not considered. He was the only one who uttered his concern about the contradictory orders of TCAS. However, his doubts did not influence the outcome. His words "It says climb!" were answered by the Pilot In Command (PIC) with "he [the controller] asks us to descend." The co-pilot repeatedly asked: "Descend?" After the TCAS instruction to "increase climb", the co-pilot again remarked: "Climb did it say!" (BFU, 2004).

Did the instructor ignore the co-pilot's opinion because he was the lowest ranked officer in the cockpit? Was the co-pilot's expertise not considered as valuable? Or did he not have the personal authority to make himself heard? Did he have a different training background related to TCAS which made him more sensitive for the TCAS RA? It is not possible to answer these questions in this essay. However, they represent an interesting starting point for further analysis.

Why could the situation not be resolved? – An Information Services perspective

So far two questions have been analysed: How could it happen that contradictory information was available to the Tupolew-crew? And secondly, how can we understand that the aircraft was finally steered according to the controller's orders and not to the TCAS RA? Thus, up to this point the essay has presented factors that could serve to explain how such a critical situation could occur. Now we will turn the attention to another question. An information services perspective will be taken to analyse as to why the situation could not be resolved.

During the last 15 years an increasing number of authors have applied a services perspective instead of a traditional systems perspective. One advantage of this approach is that it helps to increase understanding of "how configurations of people and

IT artefacts interact to support work, communication, and decision-making" (Mathiassen, 2008). Although the information services perspective is often used with regard to web-services – especially Web 2.0 and Cloud Computing – it has also been applied to other areas. Brittain and MacDougall (1995) for example write about the usage of information services in the National Health Service (NHS).

Mathiassen and Sørensen (2008) mention four points that are considered characteristic for information services: (1) They are used every day; (2) they support very specific tasks; (3) they are normally portfolios of different "processing capabilities" and (4) they are different from business or software services. Although the acknowledgement of point (4) appears to be difficult with regard to air collision avoidance, the first three points are easily applicable. (1) Air traffic needs to be coordinated every day. (2) Ensuring the separation of aircraft in airspace is a very specific task and (3) various computational and human elements interact in order to fulfil it.

Mathiassen and Sørensen (2008) categorise information services along the dimensions of equivocality and uncertainty (see figure 1). Simplified, situations can be described as highly equivocal when several controversial interpretations are possible. Situations of high uncertainty are classified as those where the available information is not sufficient to complete a task (Daft, 1986; Daft, 1981).

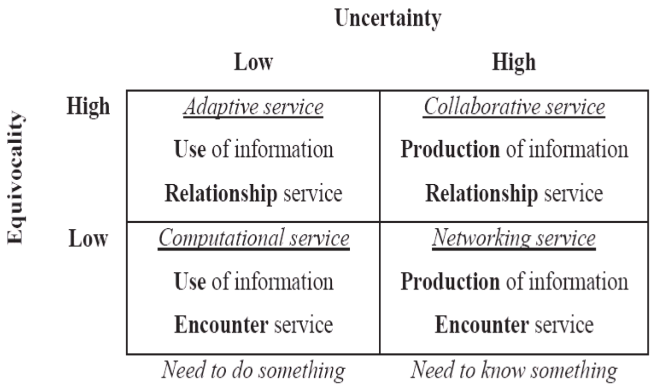

Figure 1: Diversity of organisational information services (Mathiassen, 2008)

With regard to the Überlingen case, TCAS can be regarded as an element of the information services portfolio to avoid air collisions. If we attempt to allocate it in Mathiassen and Sørensen's (2008) framework, it falls in the category of computational encounter services. "An encounter is a straightforward, standardised service that spans a short period of time and has a predefined context (Mathiassen, 2008)." These are procedures which have been designed for a specific purpose through a "process of input, computation, and subsequent output". TCAS only intervenes when the separation between aircraft is no longer guaranteed. In this case TCAS uses information of the Secondary Surveillance Radar (SSR) to produce standardised RAs. The RAs are based on computerised input (low uncertainty) and leave no room for interpretation (low equivocality). As long as the pilots follow the RAs, the separation of the airplanes is re-established. Within seconds the critical situation is resolved and TCAS switches back into passive mode (Williams, 2004).

Similarly, the instructions of controller Peter Nielsen for the Tupolew-crew can be interpreted as a service. Mapped to the above framework, his advise can be described as an adaptive service. The controller uses the information available to him in order to advise the crew. As human interaction takes place, both parties – controller and crew – are in a position to give each other feedback. They can react to the high equivocality by discussing the situation and adapting their actions. The controller for example could have adjusted his advise to descend if the crew had told him that TCAS had produced a contradictory RA. But, and this is a key point, the controller can only act on the available information. As a result, even if the crew had informed him about the contradictory orders, he could not have resolved the situation, because he had no information about the action of the DHL-crew.

Hoc (2000) mentions "incidents or breakdowns" as factors which can impact on procedures. If we follow this thought, we can interpret the moment when the contradictory orders became available as a breakdown. If we refer to Mathiassen and Sørensen's framework, at this point the uncertainty shifted from low to high. The information available to the controller and the Tupolew-crew was no longer sufficient. Immediately conflicting ideas on how to interpret the situation and confusion arose. The co-pilot for example had serious doubts about the instructor's decision.

As previously analysed, there were no standard procedures in place to regulate such situations. The crew had no reliable information on which to base their decisions. But sensible decision-making is only possible if different options are known and if the outcome of these options can be at least vaguely estimated (Weick, 1987).

Facing the contradictory orders, it was inadequate to simply use information. Instead it had become indispensable to produce information. This would have required the collaboration between the different actors, creating an exchange of information in order to realise consistent action (Mathiassen, 2008). In other words, a shift from information usage to information production was necessary to resolve the situation, a shift from computational / adaptive service to collaborative service.

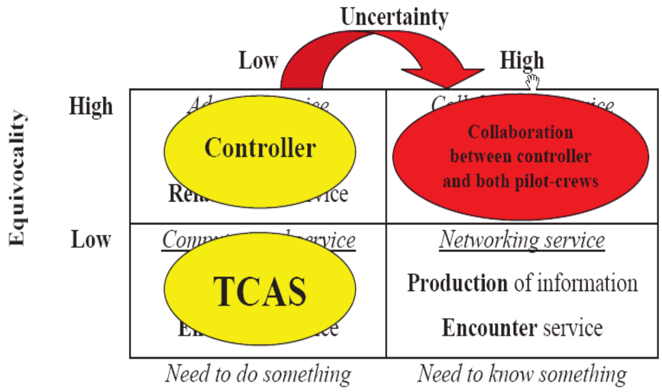

Figure 2: Misfit of information services portfolio in the mid-air collision

It can not be stressed enough that external rules had further restricted the collaboration and thus the resolution of the crucial final situation. Firstly, pilots are not able to directly contact pilots on other airplanes. Therefore, the pilot-crew of the Tupolew could not get in touch with the DHL aircraft. And secondly, controllers are unable to make contact with aircraft that are currently not within the area of their own ACC. As a result the controller in Karlsruhe who had recognised the impending collision could not reach the airplanes directly. He could only call the Zürich ACC which was unavailable due to problems of the telephone system. There is no doubt that these rules have a justification under normal circumstances. In this case, however, they made it even more difficult to resolve the situation as they constrained the collaboration.

With reference to the information services framework, in restricting the collaboration these rules additionally hindered the shift from an encounter to a collaboration service. They hindered the generation, share and usage of information in response to emergent requirements (Mathiassen, 2008). They hindered the adaption of mechanisms in real-time which is necessary to resolve such situations (Hoc, 2000). If some additional time had been available, the situation could have been stabilised and information could have been generated to “precede decision making” (Weick, 1987). This again would have allowed to make a rational decision.

One might argue that this consideration is not applicable because additional time could not be created. However, there are indeed ways to increase time in air traffic management. In unmanageable situations controllers for example can “’spin’ the aircraft in place (fly in circles) to buy time to sort out the mess” (LaPorte, 1991).

If more time had been available and communication had been realised, the Überlingen mid-air collision may have been avoided. To use Mathiassen and Sørensen’s terminology (2008), additional time had enabled the adaption to the misfit of the information services portfolio.

Conclusion

This paper has analysed the Überlingen mid-air collision from two perspectives. In the first part explanations have been provided to understand how the final situation could occur. Therefore, concentrating on the pilot-crew of the Tupolew two questions have been discussed in depth: How could it happen that two contradictory advisories were available to the Tupolew-crew? And why had the Tupolew finally been directed according to the controller’s orders? In the second part an information services perspective has been applied to analyse why the final situation could not be resolved.

With regard to the first part it has been suggested that the Tupolew-crew faced uncertainty as a result of redundancy systems which lacked independence. As under these circumstances a rational decision was impossible to make, social and psychological aspects may have gained in importance. This paper suggests that in situations of uncertainty pilot-crews tend to trust in humans rather than in technical systems. Being in direct contact with air controller Peter Nielsen the Pilot in Command followed the controller’s orders and not those of the technical Traffic Allert and Collision Avoidance System (TCAS). Furthermore the different cultural background of the pilot-crews has been identified as a possible reason for the incoherent interpretation of the orders. Whereas Western pilots generally accept that in such situations TCAS orders ought to be prioritised, Russian operating procedures leave the decision to the pilot whether to follow TCAS or the Area Control Center. Finally the authoritative structures in the cockpit have been highlighted as an influencing factor of the outcome. The disaster could have been prevented if more attention had been given to the co-pilot’s doubts, it is argued.

Based on these interpretations this paper argues in the second part that the uncertainty embedded in the final situation of the Überlingen mid-air collision required an information exchange between the pilot-crews and the controller. Facing the contradictory orders, it was inadequate to simply use information. Only if more information had been produced a joint and consistent decision would have been possible. In situations of high uncertainty organisations need to flexibly adapt their information services portfolio by shifting between computational / adaptive and collaborative / networking services, it is argued. In these cases “the organisation needs to adopt approaches that will help actors produce the information they need for task execution” (Mathiassen, 2008).

As time in the Überlingen case was too short to install collaboration, this paper further emphasises time as an important factor to increase safety in air transportation. This may generate further improvement for example in capacity management of control centres – to gain time for controllers – or to extend the critical TCAS-time-span – to have more time to react.

Hazardous operations are often time critical and have a number of characteristics in common. In so far the findings of this essay might be well transferable to other High Reliability Systems (HRS) and help to increase safety in general (LaPorte, 1996).

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