Bachelor Thesis

How are disasters described in scientific and popular literature? - An exploratory study on how subsequent literature reproduces information about disasters using the example of Tenerife.

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Abstract

English version

When a huge disaster like the airplane collision at Tenerife or the nuclear catastrophe at Chernobyl occurs, one reaction are hundreds of publications, in which authors try to explain the cause and state out the lessons learned from the incident, or use it otherwise as an example to strike home a particular point. These publications are still published decades after the disaster happened. The purpose of the present study is to investigate how authors reproduce information about disasters over the course of time, in scientific and popular publications retrieved from the internet. This question was investigated by using the case of the Tenerife accident (ground collision of two aircrafts with 583 fatal injuries on March 21, 1977). In general, 67 publications retrieved from internet were analyzed by means of content-analysis using a coding scheme. The results show a considerably large reduction of the number of mentioned accident causes in comparison to the number of causes mentioned in the official accident investigation report. Furthermore, some causes are mentioned quite often, while others are not mentioned at all. No difference was detected between scientific and non-scientific literature concerning the number of mentioned causes in general, the number of mentioning different categories of causes or the number of mentioning the gist. Furthermore, no difference regarding the genre was detected concerning the ratio of the number of words of the whole publication and the disaster description on the one hand and the number of words of the disaster description in general on the other hand, with exception of the cause ‘bad weather/ bad visibility’. In addition, no changes over the course of time concerning the mentioning of causes in general, the mentioning of specific categories of causes and the gist were found among all publications. With regard to the number of words no changes over the course of time were found concerning the ratio of the number of words regarding the whole publication and the disaster description on the one hand and the number of words regarding the disaster description on the other hand, with exception of a change in the number of words regarding the accident causes ‘bad weather/visibility’ and ‘miscommunication’. The present exploratory study provides a first insight to this field and can be seen as basis for further research.

Dutch version:

Als een groot ongeluk zoals de vliegtuigbotsing op Tenerife of de nucleaire catastrofe in Tsjernobyl gebeurt, is één reactie dat honderden van publicaties verschijnen waarin de auteurs proberen de oorzaak te verklaren, de geleerde ervaringen te noemen of hun bepaalde argumentatie aan de hand van dit ongeluk te ondersteunen. Deze publicaties worden nog steeds vele jaren na het ongeluk gepubliceerd. Het doel van de voorliggende studie is te onderzoeken op welke manier auteurs in de loop van de tijd informatie over een ongeluk reproduceren, in wetenschappelijke en populaire publicaties verzameld op internet. De onderzoeksvraag werd onderzocht aan de hand van het ongeluk op Tenerife (botsing op het vliegveld van twee vliegtuigen met als gevolg 583 doden op 21 Maart 1977). Met behulp van inhoudsanalyse werden 67 publicaties, verzameld op het internet, geanalyseerd. Daarbij werd gebruik gemaakt van een codeerschema. De resultaten laten een grote reductie van het aantal genoemde oorzaken in vergelijking met het originele ongevalsrapport zien. Verder werden sommige oorzaken heel vaak genoemd terwijl andere oorzaken helemaal niet genoemd werden. Er werd geen verschil tussen wetenschappelijke en populaire literatuur gevonden wat betreft het aantal genoemde oorzaken in het algemeen, het aantal genoemde categorieën van oorzaken en het aantal publicaties dat de hoofduitspraak noemden. Verder werd er geen verschil gevonden met betrekking tot het genre wat betreft de verhouding van het aantal woorden tussen de publicatie als geheel en de beschrijving van het ongeluk enerzijds en het aantal woorden ten opzichte van de beschrijving van het ongeluk anderzijds, met uitzondering van de oorzaak 'slecht weer/ slechte zicht'. Bovendien werden geen veranderingen in de loop van de tijd ontdekt wat betreft het noemen van oorzaken in het geheel, het noemen van specifieke categorieën van oorzaken of het noemen van de hoofduitspraak. Met betrekking tot het aantal woorden werden ook geen veranderingen in de loop van de tijd ontdekt wat betreft de verhouding van het aantal woorden tussen de publicatie als geheel en de beschrijving van het ongeluk enerzijds en het aantal woorden ten opzichte van de beschrijving van het ongeluk anderzijds, met uitzondering van een verandering in de loop van de tijd ten opzichte van het aantal woorden met betrekking tot de oorzaken 'slecht weer/slechte zicht' en 'miscommunicatie'. De voorliggende vererkennende studie geeft een eerste inzicht in dit onderzoeksveld en kan gezien worden als basis voor verder onderzoek.

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Introduction

When a huge disaster like the airplane collision at Tenerife, the crash of the Challenger space shuttle, or the nuclear catastrophe in Chernobyl occurs, one reaction are hundreds of publications, in which authors try to explain the cause, state the lessons learned from the incident or use it otherwise as an example to strike home a particular point. These publications are still published decades after the disaster happened. But can we be sure that these publications contain correct information regarding the main facts of the disaster as conveyed in the official investigation report? After all, decades of research in cognitive psychology consistently confirm a certain limitation of human memory: the impossibility to remember details of an event, facts or the contents of a text without any distortion. A common example is research into eye-witness-testimony (e.g., Schacter, 2001), which shows that episodic memory processes are far from perfect (Wickens, Lee, Liu, & Becker, 2004). Another common example is Bartlett's (1932) seminal work on constructive memory (schema theory). Besides Bartlett's schema theory, recent research from Feltovich and colleagues (e.g., Feltovich, Hoffman, Woods, & Roesler, 2004) showed that errors in reproduction of information are due to a tendency to reduce complex information to its most understandable components: the so called 'reductive tendency'. Bartlett's schema theory and Feltovich et al.'s reductive tendency theory are both general approaches of trying to find an explanation for the fact that distortions of recalled and reproduced information often appear. Additionally, more recent research concerning accident investigation (manuals) (Cedergren & Petersen, 2011; Lundberg, Rollenhagen, Hollnagel, 2009, 2010; Rollenhagen, Westerlund, Lundberg, & Hollnagel, 2010) offers an approach to find the source of distortions with regard to this specific domain: the context and habits of investigation practices and underlying accident models. The present paper will rely on this latter approach, whose state of research will be described next.

The state of research contains investigations concerning professional accident investigators and laypeople. On the one hand, studies tried to explore the investigators' personal beliefs regarding the main causes of accidents and the mental accident models found in investigation manuals. This will be presented first. On the other hand, research also tried to explore the mental accident models of laypeople (non-professionals regarding accident investigation). The results of this approach will be presented subsequently.

Carrying out an accident investigation and subsequently writing down the most important findings is an act of creating a reconstructed reality and always contains a reduction of facts of what in reality happened. Of course, it is not possible to know every detail of the disaster, because the investigators were not part of it and even in the case they were, the possibility of distorted memory would still exist (see the findings of eye-witness-testimony research, e.g., Schacter, 2001). Rollenhagen and colleagues (Rollenhagen et al., 2010) tried to shed some light on the contexts and habits that could have an influence on the accident investigation practices, and thus whether disasters are investigated in an adequate manner. Therefore, they surveyed questionnaire data from 108 Swedish accident investigators in the healthcare, transportation, nuclear and rescue sectors. Regarding the investigators' personal beliefs about accident causation, they found that the 'human factor' was believed to be a main cause of accidents, mostly in the transportation and rescue sub-sample. 'Organizational factors' (organizational weaknesses including 'system errors') were mentioned more often in the nuclear and hospital sub-sample. These results suggest that professional investigators have two main causes in their mind (human factors and organizational factors), while performing an accident investigation. Nevertheless, to our knowledge no previous research addressed the question which causes do authors of publications referring to a particular accident (and thus non-professionals regarding accident investigation) decide to mention?

Accident investigation practices always entail statements about how the accident happened, what factors played a role and, consequently, recommendations about what should be done to prevent a future accident (Lundberg et al., 2009). Thus, accident models of the investigators play an important role. As a result, investigation manuals are also based on these underlying accident models. Considering the complexity of modern systems in which disasters might happen these days, appropriate accident models should be more demanding than in the past. (Lundberg et al., 2009). Lundberg and colleagues (Lundberg et al., 2009) explored the underlying accident models in accident investigation manuals. According to the authors, an accident investigation always follows a particular approach. This particular approach "will direct the investigation to look at certain things and not at others. It is simply not possible to begin an investigation with a completely open mind just as it is not possible passively to 'see' what is there" (p. 1298). According to Hollnagel (2008), the influence of a specific approach used in an investigation on the causes, that are actually found, is called the What-You-Look-For-Is-What-You-Find (WYLFIWYF) principle. To explore the underlying accident models, Lundberg and colleagues (Lundberg et al., 2009) carried out a qualitative analysis of eight investigation manuals of various Swedish organizations with accident investigation activities. They found that all manuals were based on complex linear system models, which state that accidents are the consequence of both latent failures (weaknesses) and active failures (cf. Reason's Swiss Cheese model, 1997). The underlying accident models mentioned by the majority of manuals were sharp end causes (aspects of people), blunt end organizational causes and environmental factors (such as failed barriers). Thus, the findings fit with the components that are characteristic for the Swiss Cheese model developed by Reason (1997). In general, the causes mentioned in the investigation manuals reflect the underlying accident model and thus follow the WYLFIWYF principle. As with the study mentioned above, it is useful in the context of the present study to shed light on the causes mentioned by authors of subsequent literature.

Dekker, Nyce and Myers (2012), in contrast, came to a different result concerning the beliefs about the main causes of accidents in the field of professional accident investigation. They state that although a change of perspective from the sharp end to the blunt end took place in safety science and accident investigation, there still appears to be more emphasis on human error. The reason for focusing on the sharp end, according to Dekker and Nyce (2011), is due to the "Western moral enterprise which focuses on responsibility, choice and error, something that is derived inevitably from Christian and especially Protestant perspectives" (p. 211). Finding a cause when an accident or an incident happens is inherent to human nature. The authors conclude that not being able to find a cause provokes uncertainty and anxiety, because of the felt loss of control and understanding concerning the complex systems built by man himself. This is why it seems to be more acceptable to blame someone at the sharp end as 'a scapegoat', rather than not having a cause at all and thus being exposed to the anxiety of losing control.

Taken together, research on finding potential sources of distortions in accident investigation (manuals) confirms the existence of such sources. More precisely, the findings suggest that investigators have a complex linear accident model in mind and state both human error (sharp end) and organizational factors (blunt end) as main causes of disasters. It does not seem clear though, if the emphasis thereby is lying on the sharp end or blunt end.

Besnard and Hollnagel (2012) came to a result contrary to the research mentioned above, when exploring the view of laypeople. According to the authors, most laypeople, in contrast to professional accident investigators, still believe in human error as the root cause of disasters. They focused in their study on common assumptions used in the management of industrial safety. According to the authors, safety is often viewed as simply the absence of harmful events and failures. They presented six common myths, which they believed to be taken for granted in industrial safety management: Human error (human error as a single cause of accidents); Procedure compliance (if workers follow the procedures, systems will be safe); Protection and safety (more barriers and protection layers will increase the safety); Mishaps and root causes (root cause analysis is an appropriate method for analyzing mishaps in complex socio-technical systems); Accident investigation (accident investigation is a rational and logical process, which can identify causes); and Safety first (in organizations safety always takes priority and would never be threatened). All myths include the belief that safety can be achieved by using appropriate engineering systems, including the people that work in them. Furthermore, "the myths describe well-tested and well-behaved systems where human performance variability clearly is a liability and where the human inability to perform in an expected manner is a risk" (p. 9). According to the authors, these kinds of assumptions are not reasonable anymore today. The complexity of today's systems requires a more sophisticated view of safety. Complex modern socio-technical systems are able to work "because people are flexible and adaptive, rather than because the systems have been perfectly thought out and designed" (p. 10). Then, the current view of safety is not satisfying the requirements that workers face at their complex workplaces: multiple interacting technical, cultural, political and financial constraints. To overcome this 'old fashion' definition, the authors suggest for every myth an alternative view. Within the scope of this paper the alternatives are not further described.

In sum, the current state of research provides an overview of the contexts and habits of accident investigation practices (Lundberg et al., 2010; Rollenhagen et al., 2010), the use of underlying accident models in accident investigation manuals (Lundberg et al., 2009) and assumptions used in the management of industrial safety (Besnard & Hollnagel, 2012). But to our knowledge, no research has been carried out on the comprehension and subsequent reproduction of the causes and events constituting the disaster itself. The purpose of this study is to investigate how authors reproduce information about disasters over the course of time, in scientific and popular publications retrieved from the internet. We investigated this question by using the case of the Tenerife accident (ground collision of two aircrafts with 583 fatal injuries on March 21, 1977). Because the state of research does not provide any previous research on this field, we cannot rely on a theory. Thus, the current study has an exploratory character. It is useful to extend the knowledge about how disasters are described in scientific and popular publications for several reasons. First, it is of concern that hundreds of publications referring to certain disasters could contain distorted information. This could result in an erroneous influence on the public opinion. Second, if the assumption of distorted information is true, it becomes important to create a consciousness about this also in the scientific world in order to prevent future distortions (see Vicente & Brewer, 1993). A third reason is that it is possible that through distorted information about disasters also wrong conclusions and recommendations arise. That can in turn lead to a prevention of an effective way of creating training programs or improved technologies, because the background information is just wrong. The phenomenon of "What-you-find-is-not-always-what-you-fix" has been described previously (Lundberg et al., 2010), but in the context of accident investigation reports themselves, not in the context of subsequent publications drawing lessons from these reports.

Therefore, the aim of the present study is to shed light on the question of how authors of scientific and non-scientific subsequent literature describe disasters over the course of time. To investigate this question, we will focus on three main aspects: the genre of the publications, their year of publishing and the content of the disaster description (in general and more precisely). In the following the sub-questions concerning these main aspects will be explained more precisely.

According to the main aspects mentioned above, we lay the focus in the first sub-question on the genre by investigating the question whether a difference exists in the number of mentioned causes between scientific and non scientific literature. The working styles between scientific and non-scientific authors are assumed to be different. Scientific publications have to comply with the norm set by the scientific community. That implies, amongst other, rules for searching and using sources. This means that authors of scientific texts should use a reliable source to get the information about a disaster and thus describe it more precisely. Furthermore, scientific texts should contain more objective information and this also means listing more details than a popular text would probably do. That is why we hypothesize a greater extent of reduction regarding the mentioning of causes in non-scientific publications.

Another option, besides the number of mentioned causes, to investigate differences regarding the genre is to focus on the number of words. This enables the comparison with others studies that investigated the research question by means of other disasters. We will focus on the number of words by asking on the one hand whether a difference exists between scientific and non-scientific literature in the number of words concerning the ratio of the number of words regarding the whole publication and the disaster description and in the number of words concerning just the disaster description. On the other hand, to connect the two indicators ‘number of mentioned causes’ and ‘number of words’, we ask whether a difference exists between scientific and non-scientific literature in the number of words concerning the causes in general within the disaster description and in the number of words concerning the specific causes.

With the second sub-question we focus on the aspect of time. We try to shed light on the question whether a difference exists in the number of mentioned causes between publications published closer in time to the disaster and publications released later. The phenomenon that contents of stories change over the course of time was shown by previous research by Bartlett (1932). He asked his subjects in his experiments on serial reproduction to reproduce a folk story, whose reproduction then was recalled by another subject and again this reproduction was recalled by a third subject and so on. With the growing number of reproductions the number of distortions increased. People are not able to remember every detail of an event. That is why they create a general impression of an original event and then use this general impression to create the forgotten details. Thus Bartlett showed that what is stored in the long-term memory is not an identical picture of the real event “but rather a ‘reconstructed’ memory of past events coloured by past experience, and (…) when people remember an event from their past it is this ‘reconstructed’ version that is recalled” (Wynn & Logie, 1998, p. 1). Bartlett’s study is not directly applicable to the present study, because we cannot know what kind of source the authors used (the original investigation report, a secondary written source or their memory). But his study shows that contents can change over time and this is an interesting aspect that will be investigated in the present study.

Again, in regard to the time aspect another option besides the number of mentioned causes is to focus on the number of words. We will ask the question whether a difference exists between publications published closer in time to the disaster and publications released later regarding the following aspects: the ratio of the number of words regarding the whole publication and the disaster description; the number of words concerning the disaster description; the number of words concerning the causes in general within the disaster description; and the number of words concerning the specific causes.

The third and fourth sub-question will lay the focus on the content. The third sub-question investigates the content in regard to the type of causes mentioned by the authors. Thereby, we ask if there appears to be a difference in the number of mentioned causes that happened temporally closer to the actual moment of the disaster and causes that happened further away in time. The phenomenon of reducing complex information to specific parts of the content was shown by previous research by Feltovich et al. (1994, 2004). They showed that people tend to simplify complex information, even in a way that leads to erroneous understandings and misconceptions. By doing so, the mental effort needed for understanding is reduced. This inclination is called the ‘reductive tendency’. According to the authors, these oversimplifications consist of specific components. Two of them are that people give one single (linear) explanation for the relationships between processes and the naming of just one part of the system instead of the whole one. Again, this study is not directly applicable in the context of the present study. Nevertheless, it gives rise to investigate the kind of reduction more precisely on the example of causes temporally closer vs. causes temporally further away. The third sub-question concerning the content can also be investigated regarding the genre and time. Therefore, we ask two more sub-questions. First, if there is a difference between scientific vs. non-scientific literature (genre) regarding the mentioning of causes that happened temporally closer and temporally further away to the actual moment of the disaster. Second, if the number of mentioned causes closer in time and further away in time to the actual moment of the disaster, change over the years.

Another way of focusing on the content is to look at the gist. The fourth sub-question will do this by asking whether a reduction takes place by reducing the complex cause-effect relations inherent in the disaster to a specific core ‘message’. Previous research by Thorndyke (1977) suggests that people generate specific schemata in their mind while reading a text. This story grammar provides rules for the representation and makes it easier to recall it after a while. We refer to this specific core as the ‘gist’ of the disaster. According to Thorndyke (1977) a story consists of the following four necessary components: setting, theme, plot and resolution. The setting consists of information about the time, location and main characters. The theme contains the general focus (or goal) on which the plot is based. The plot concerns a number of episodes that in turn includes the actions needed to achieve a goal. The resolution implies the definite outcome of the story concerning the theme. Again, this research is not directly applicable in the context of the present study, because we cannot know what sources the authors used. But it still provides a point of reference to categorize the content into the different parts of the gist and thus it is interesting to be investigated. Furthermore, in the context of this sub-question, we will also study the genre and time aspects. First, we ask whether there is a difference between scientific and non-scientific literature regarding the mentioning of the gist. Second, regarding the time aspect, we investigate whether the number of publications mentioning the gist changes over the course of years.

Method

Materials

For the purpose of the present study, it was necessary to identify suitable publications on the internet. Suitable publications should concern a brief description of the Tenerife accident. The databases used were Google and Google scholar (www.google.com, www.scholar.google.com), because of the possibility to search in the full text of publications. The search queries were “pdf Tenerife march 27 1977” (with 1.550.000 hits on Google and 2.980 hits on Google scholar) and “Tenerife accident” (with 5.220 hits on Google scholar), which were supposed to be the most frequently used words in publications concerning a brief description of the Tenerife accident. This first search procedure included publications from 1977 until 2012. To be able to make a choice out of this large number of hits certain eligibility criteria were used. First, the brief description Google and Google scholar shown under every result (internet-link) was screened for words from the search query. If the short description included these words, the internet-link was opened and the publication was screened for a suitable description of the Tenerife accident. A second eligibility criterion was that the full text was available via the connection of the University of Twente. The length of the passage concerning the description of the Tenerife accident (between 100 and 500 words) was the third eligibility criterion. The descriptions with this number of words were supposed to be long enough to give an appropriate description without repeating all details of the investigation report. This way we could be sure to find a reduction. Other eligibility criteria were the language of the publication (English), the presence of an author (or at least the name of the institute) and the stability of the link (one should be able to find the publication in the future). The first search procedure was stopped, when it became increasingly unlikely to find an appropriate publication. More precisely, the search on Google with the search query “pdf Tenerife march 27 1977” was stopped on page 50 (after screening nearly 500 results); the search on Google scholar with the search query “pdf Tenerife march 27 1977” was stopped on page 10 (after screening nearly 100 results); the search on Google scholar with the search query “Tenerife accident” was stopped on page 50 (after screening nearly 500 results). As a result of this first search procedure, 61 publications were retrieved.

An overview of the 61 retrieved publications from the first search procedure showed an inequality concerning the year of publication. Most of the publications were published in 2000 or later. Because of that, a second search procedure was started by using the database Google scholar. Google scholar was chosen, because of the full text search option and the possibility to search within certain years. The search query for respectively the years 1980-1990 and 1991-2000 were “Tenerife accident”, “pdf Tenerife march 27 1977”, “Tenerife disaster” and “Tenerife collision”. More search terms were used, because the hit rate was low (between 133 and 803 hits). The results were also screened for appropriate publications. As a result of this extended search, 67 publications were identified in total through database searching (see Appendix A for all text passages), which were all included in the content analysis.

Coding scheme

To be able to answer the research question and to test the hypotheses, a coding scheme was developed (see Appendix B). Its development was an iterative process. The coding scheme was adapted several times by the ideas of four researchers and with the purpose to improve the inter-rater reliability (Cohen’s kappa). The first version of the coding scheme showed a fair to good (Banerjee, Capozzoli, McSweeney, & Sinha, 1999) agreement beyond chance between two raters (Cohen’s kappa of .58). This was tested by coding a description (307 words) of the Tenerife accident from Rudolph & Repenning (2002). The second version included more specific descriptions of the causes to make them more distinguishable for the raters. It also showed a fair to good agreement beyond chance with a Cohen’s kappa of .65 (tested by using a 115 words passage by Green (1983)). The third version of the coding scheme was adapted in the descriptive part about the publication to increase clarity for the rater. The inter-rater reliability here suggested again a fair to good agreement beyond chance with a Cohen's kappa of .50 (tested by using a 105 words passage by Rao, 2007). The final version included a completely new part concerning the gist with 12 new items. It showed a fair to good agreement beyond chance with a Cohen's kappa of .68. For that, two coders analyzed a text passage of 106 words out of an article from Wood (1989) (see Appendix C for an example of a filled out coding scheme).

The final coding scheme consists of four parts. The first part concerns descriptive information about the publication. More precisely, the descriptive part includes the publication ID, the source (e.g., author and year), the internet link, the total number of words of respectively the whole publication and the description of the disaster, the potential source concerning the disaster mentioned by the author and the genre. The genre is divided into two parts: scientific and non-scientific. Publications were scored as scientific, when they were published by a peer-reviewed journal, in proceedings of a scientific conference or as a dissertation. Non-scientific publications were all the other publications.

The second part of the coding scheme was developed to measure the reduction concerning the causes of the disaster. To identify all causes for the Tenerife case, we used the official human factors investigation report of the Air Line Pilots Association (Roitsch, Babock, & Edmunds, 1978). The causes were adapted in a way that they constituted mutually excluding categories. In total, 16 causes were identified. The coding scheme includes items about whether a cause is mentioned; to write down the absolute number of words mentioning a specific cause; to note the total number of words concerning the causes; to write down the percentage of words mentioning a specific cause, related to the total number of words concerning causes. Furthermore, the coder was asked to note causes that are mentioned in the publication, but not in the coding scheme.

The third part was developed to measure the gist of the publications. For that, the coding scheme includes items, which ask, according to Thorndyke (1977), respectively if the setting, theme, plot, resolution and the gist in general are mentioned in a publication. The setting part consists of items asking if the location, the characters (KLM/ PanAm aircraft and tower controllers) and the date is mentioned. The theme part includes items concerning the bad weather/ visibility on the day the disaster happened, the miscommunication and the assumption of the KLM captain to have the take-off clearance. The plot part is asking if it is mentioned, that the KLM captain actually started the takeoff, while the PanAm was still taxiing on the same runway. The resolution part consists of two items asking if the collision between the KLM aircraft and the PanAm aircraft is mentioned and if the number of deadly victims is stated. The conditions for the mentioning of the gist in general, were: at least one of the setting parts had to be mentioned (location, characters, date), two of the theme parts had to be mentioned (bad visibility and miscommunication), the plot had to be mentioned and finally both parts of the resolution had to be mentioned (the collision and the number of deadly victims). If all of these conditions applied, the question if the gist in general was stated in the publication was confirmed. If not all of these conditions applied, we concluded that the gist was not mentioned.

The purpose of the fourth part of the coding scheme is to get an overview of relations between causes mentioned in the publications. This means, the text passages had to be screened for statements about causes that led to other causes. One example is, that an author states in his text passage, that the bad weather led to the 'third gateway left confusion' of one aircraft (this means the aircraft failed to leave the taxiway on the third gateway due to the bad visibility). The coder was asked to write down these relations into a table. The Tenerife accident includes complex relations between causes. The table enables us to get an overview of the reduction of these complex strings.

Analysis

The 16 causes identified in the official accident investigation report (Roitsch et al., 1978) were categorized in respectively causes that happened temporally closer vs. further away from the actual moment of the accident (see Appendix D for the complete classification). This classification was made by defining 'closer factors' as causes, which happened after the start of the takeoff and had a direct influence on the accident. As an example, cause 9 states that the bad weather/ visibility at the time of the accident were so bad, that neither of the pilots or air traffic controllers could see each other. Factors further away were defined by causes that happened before the start of takeoff. An example of a factor further away is cause 15: due to the bomb explosion in Las Palmas, the aircrafts had to be diverted to the smaller airport on Tenerife.

Table 1 gives an overview of the items included in the analysis. The variable 'ratio of the number of words regarding the whole publication and the disaster description (in percentage)' was computed by dividing the number of words concerning the disaster description through the number of words concerning the whole publication and to multiply the result by 100.

The analysis included descriptive statistics to give an overview of the dataset. Independent samples T-tests were used to detect differences between scientific and non-scientific publications. A Chi-square test was conducted to test the relation between the genre and the mentioned gist. To detect changes between the years of publishing a simple linear regression was conducted. All these analyses were performed with the program *IBM SPSS Statistics 20*. To get a more precise picture of the development over the years, we additionally made a change point analysis. The program used then was *Change Point Analyzer* (Wayne, 2000).

In general, all 67 publications were included in the analysis. Exceptions are the analyses including the variable 'year', which contained 5 missing data (these 5 publications did not mention the year of publishing) and the variable 'ratio disaster description', which contained 21 missing data (the number of words concerning the whole publication could not be counted for 21 publications). Because of this, the publications included in the analyses concerning the development over the course of time and the ratio of the number of words regarding the whole publication and the disaster description, were reduced to respectively 62 and 46 publications.

Table 1.

Overview of items used in the analysis.

Item	Categories of answer	Mdn	M	SD	Level of measurement
Genre of publication	Scientific Non-scientific				Dichotomous
Gist mentioned	Yes No				Dichotomous
Year of publishing	1977 - 2012	2006	2004	7.98	Scale
Number of mentioned causes per publication	0 - 16	3	3.28	1.89	Scale
Number of mentioned causes that are temporally closer to the moment of accident (per publication)	0 - 5	2	2.22	.98	Scale
Number of mentioned causes that are temporally further away to the moment of accident (per publication)	0 - 11	1	1.05	1.38	Scale
Ratio of the number of words regarding the whole publication and the disaster description (in percentage)	0 - 100	3.68	5.14	6.53	Scale
Total number of words of the disaster description	1 - 500	190	230	120	Scale
Number of words concerning the causes in general within the disaster description	1 - 500	105	114	66	Scale

Results

General information about the sample is shown in table 1 (see page 17) and 2. In the average of all publications, the disaster description occupied about 5% of the whole text. The average of the disaster descriptions contained about 230 words and within the disaster description an average of 114 words was used to describe causes. The distribution regarding the year of publishing of the publications is quite irregular. Nearly half of all publications were published between 2000 and 2012. The sample contained slightly more scientific than non-scientific publications. Furthermore, the gist was mentioned by about one third of all publications.

Table 2.

Overview of absolute number of publications (percentage in parentheses) for the genre (N=67), gist (N=67) and year (N=62)

Year of publication			Mdn	M	SD
1980-1989	1990-1999	2000-2012	2006	2004	7.98
4 (6.5)	11 (17.7)	47 (75.8)			
Genre					
Scientific	Non-scientific				
38 (56.7)	29 (43.3)				
Gist					
Mentioned	Not mentioned				
27 (40.3)	40 (43.3)				

Regarding the question of how the content is reproduced in general by authors of subsequent literature (main aspect ‘content’) our data show that a reduction in mentioning causes takes place in comparison to the official investigation report. Figure 1 shows how many causes were mentioned per publication. From 16 identified causes in the official investigation report (Roitsch, Babock, & Edmunds, 1978) none of the publications (N= 67) mentioned more than 9 causes simultaneously in their description of the Tenerife accident. The reduction of causes compared with the official investigation report was quite large: 74.6% of all publications mentioned 4 or less causes (see table 3 in Appendix E).

Figure 1.

Absolute number of causes mentioned per publication.

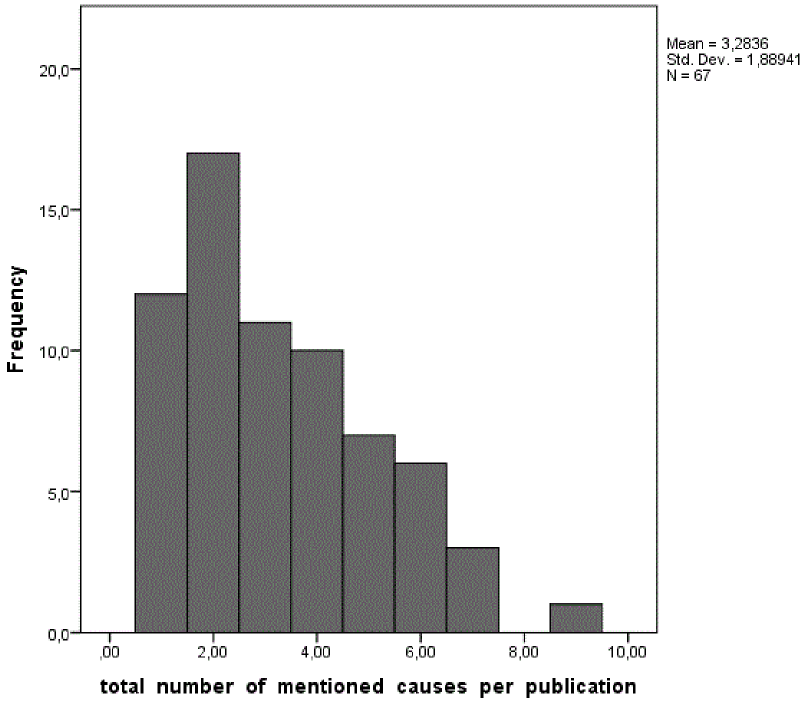
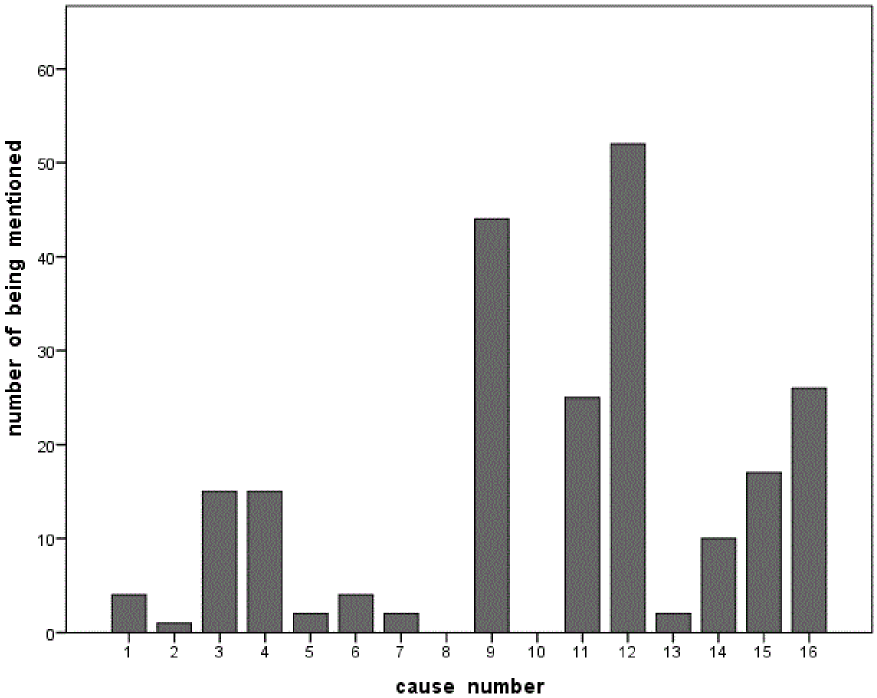


Figure 2 gives an overview with regard to the question of what causes were mentioned and how often regarding all publications (N=67). Most frequently mentioned causes among all publications were the miscommunication/ confusing auditory information (cause 12, 77.6%) and the bad weather/ -visibility (cause 9, 65.7%). No publication mentioned cause 8 (stress of the air traffic controllers due to the explosion in Las Palmas and a possible bomb threat at Tenerife airport) and cause 10 (the fear of KLM passengers due to the explosion in Las Palmas). Also quite often mentioned were the false assumption of the KLM pilot of having received a take-off clearance (cause 16) and the crew management factors of the KLM and Pan Am crews (cause11) with respectively 38.8% and 37.3%. In sum, these four causes (cause 12, 9, 16 & 11) together with causes 3 (22.4%; large delay of KLM flight brought along worries about working time limitations) and 4 (22.4%; third gateway left confusion: Pan Am crew missed the correct gateway) represented 80.35% of all most frequently mentioned causes (see table 4 in Appendix E).

Figure 2.

Absolute number of the specific causes being mentioned.



Regarding the first sub-question that asked if there appears to be a difference in the number of mentioned causes between scientific and non-scientific publications, the data show that indeed, 31.5% of all scientific publications mentioned 5 causes or more, while only 17.2% of all non-scientific literature did so (see table 5). Furthermore, scientific publications mentioned most frequently two causes (34.2%) or one cause (21.1%). In contrast, non-scientific publications mentioned most frequently three (31%) or four (24.1%) causes. However, an independent samples T-test showed that the observed difference between the genres regarding the number of named causes was not significant (t (65) = .159, p= .875). The hypothesis stating that scientific literature would mention more causes than non-scientific publications has to be rejected.

Table 5.

Absolute number of causes mentioned per genre (percentage in parentheses).

Number of causes mentioned in a publication	Genre	
	Scientific [a]	Non-scientific [b]
1	8 (21.1)	4 (13.8)
2	13 (34.2)	4 (13.8)
3	2 (5.3)	9 (31)
4	3 (7.9)	7 (24.1)
5	4 (10.5)	3 (10.3)
6	4 (10.5)	2 (6.9)
7	3 (7.9)	0 (0)
9	1 (2.6)	0 (0)

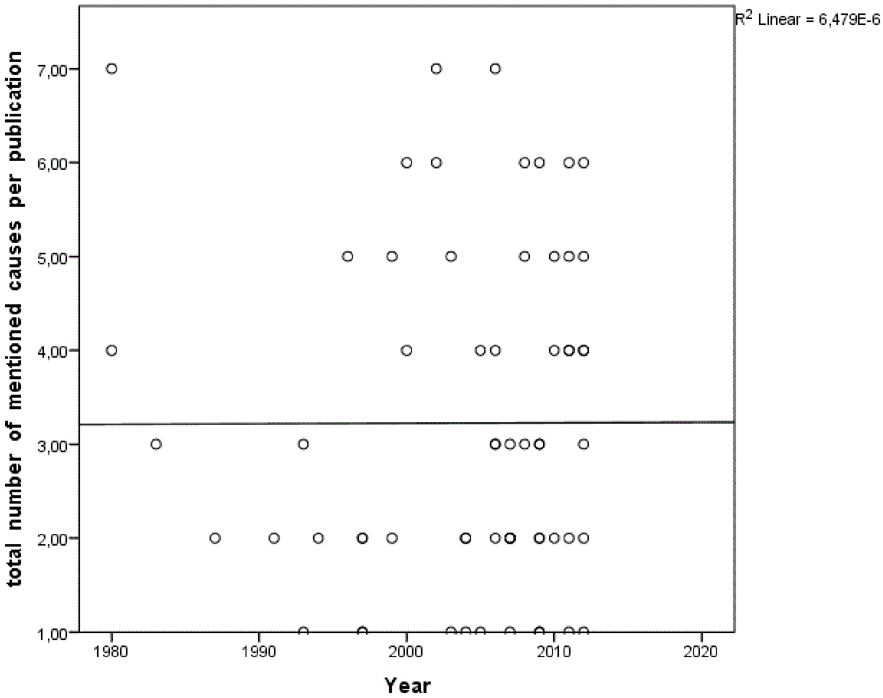
[a] n=38 (56.7); [b] n=29 (43.3)

Furthermore, just one difference (regarding cause 9) could be detected between scientific and non-scientific literature concerning the indicator ‘number of words’. The results of independent samples T-tests showed no difference per genre with regard to the ratio of the number of words regarding the whole publication and the disaster description (t (25.08) = -1.56, p = .131); with regard to the number of words of the disaster description (t (64.71) = -.28, p = .78); with regard to the number of words concerning the causes in general within the disaster description (t (64.03) = .00, p = 1); and with regard to the number of words concerning the specific causes (see table 6 in Appendix E for the results per cause), except for cause 9 (bad weather/ bad visibility). The data suggest that non-scientific publications (M = 26.17, SD = 20.84) mentioned significantly more words when describing cause 9 than scientific literature (M = 15.76, SD = 15.35), t (49.55) = -2.26, p = .02.

The second sub-question asked whether there appears a difference in the number of mentioned causes between publications published closer in time to the disaster and publications released later. A simple linear regression suggests that the year did not predict significantly the number of mentioned causes in the publications, b = .001, t (61) = .02, p = .984), and did not explain any variance in the number of mentioned causes, R^2 = .000, F(1,61) = .000, p = .984. This finding was confirmed by the change point analysis, which did not show any significant changes over the course of years regarding the number of causes mentioned in the publications (see figure 3).

Figure 3.

Distribution of total number of mentioned causes per publication over the course of time.



Furthermore, we asked whether a difference exists between publications published closer in time to the disaster and publications released later regarding the indicator ‘number of words’. A simple linear regression showed that the year did not predict the number of words with regard to the ratio of the number of words regarding the whole publication and the disaster description, b = .064, t (42) = .51, p = .61; R^2 = .006, F (1,42) = .26, p = .61 (see figure 4); the year did not predict the number of words regarding the disaster description, b = .414, t (61) = .22, p = .83; R^2 = .001, F (1,61) = .05, p = .83 (see figure 5); and the year did not predict the number of words concerning the causes in general within the disaster description, b = -.67, t (61) = -.72, p = .48; R^2 = .009, F (1,61) = .52, p = .48 (see figure 6). These results were confirmed by a change point analysis: no significant changes over the years were detected.

Figure 4.

Distribution of the ratio of the total number of words in the whole publication and the total number of words of the disaster description over the course of time.

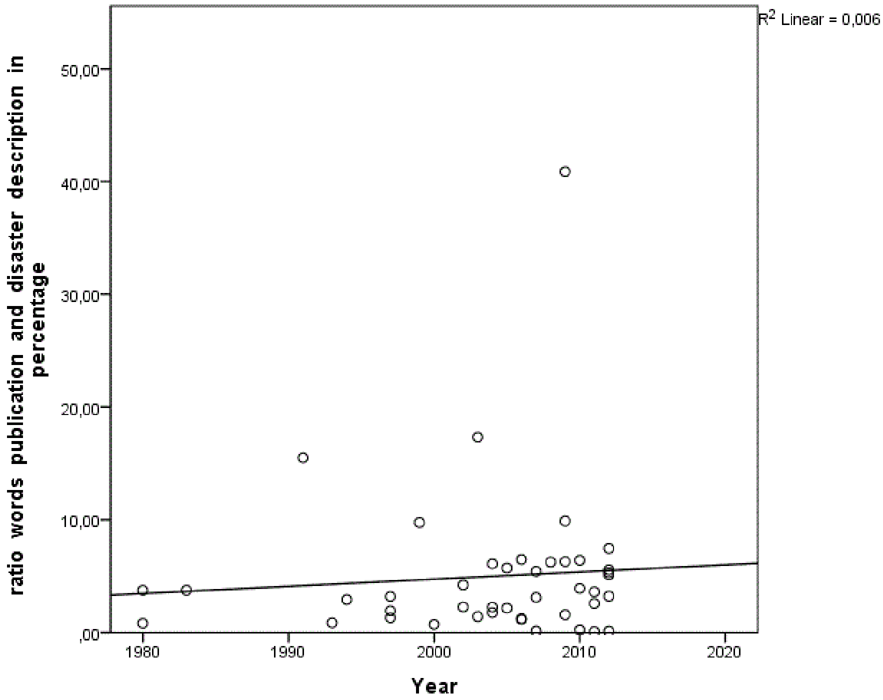


Figure 5.

Distribution of the total number of words of the disaster description over the course of time.

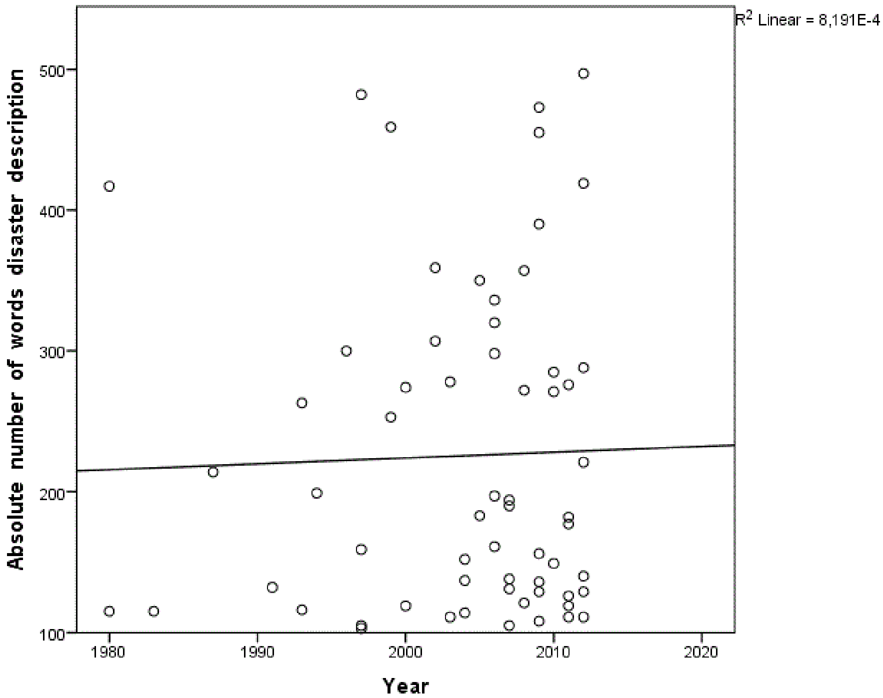
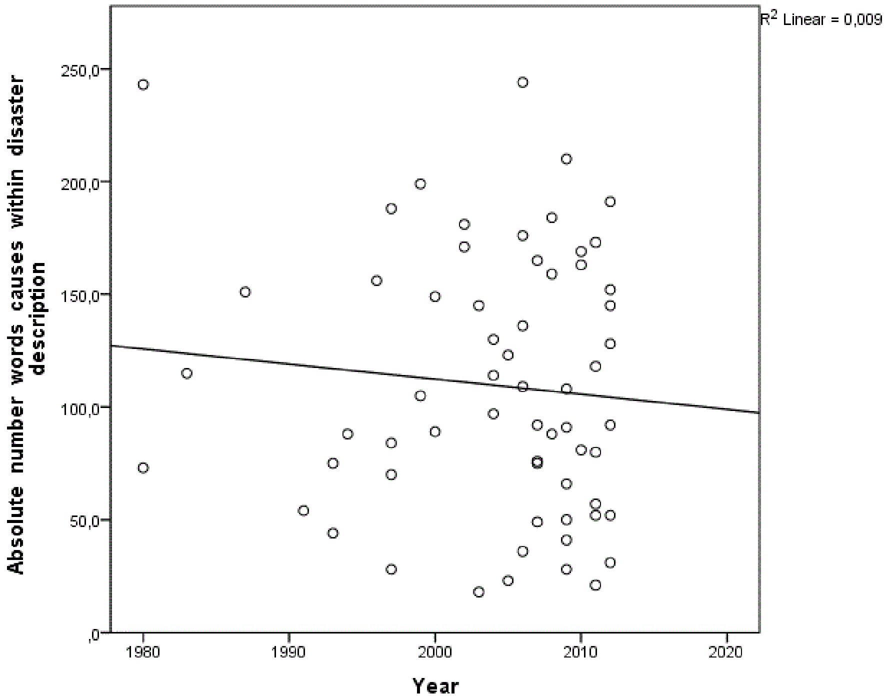


Figure 6.

Distribution of the number of words regarding the causes in general within the disaster description over the years.



With regard to the number of words concerning the specific causes a simple linear regression suggests that the year predict the number of words for cause 1 (‘Training syndrome’) (*b* = -.75, *t* (61) = -2.86, *p* = .006; R^2 = .12, *F* (1,61) = 8.19, *p* = .006) and cause 13 (threat of negative economic consequences) (*b* = -.102, *t* (61) = -2.75, *p* = .008; R^2 = .11, *F* (1,61) = 7.57, *p* = .008) (see table 7 in Appendix E for the results of the other causes). These results were not confirmed by a change point analyses. No changes over the years could be detected for cause 1 and cause 13. However, these results should be considered as not meaningful, because of the quite small frequency of publications mentioning the causes 1 and 13. They were just mentioned by respectively 3 and 2 publications out of 62 publications.

Furthermore, the change point analyses suggested a significant change in the number of words over the years for cause 9 (bad weather/ bad visibility) and cause 12 (miscommunication). For cause 9 a change in the number of words is estimated to have occurred in 2005 with 93% confidence. A confidence interval suggests that the change occurred with 95% confidence between 2002 and 2010. Before the change, the average number of words mentioned regarding cause 9 was 11 words and after the change 26 words. For cause 12 a change in the number of words is estimated to have occurred with 95% confidence in 2008. A quite wide confidence interval suggests that the change occurred with

95% confidence between 1980 and 2010. Before the change, the average of words mentioned regarding cause 12 was 44 words and decreased to an average of 25 words after the change occurred.

The third sub-question asked whether a difference exists in the number of mentioned causes that happened closer in time to the actual accident, in comparison to causes temporally further away. The data show that causes closer in time to the disaster were mentioned in 98.5% of all publications (N=67), while further away factors were mentioned in 52.2 % of all publications. This difference cannot be tested statistically by a chi-square test, because the basic assumptions of a chi-square test are violated[1]. The findings agree with the results mentioned above concerning what factors are generally mentioned and how often. Again, the most frequently mentioned causes (cause 12 miscommunication and cause 9 bad weather) belong to the category 'nearby factors' and the causes never mentioned (cause 8 and 10) belong to the category 'factors further away'. Further investigation by means of an independent samples T-test showed no significant difference between scientific and non-scientific literature in the number of named causes temporally closer to the accident (t (63.766) = -1.155, p = .252) or further away (t (65) = 1.132, p = .262).

The results of a simple linear regression suggests that the year did not significantly predict the number of named causes closer in time to the actual moment of accident (b = .001, t (61) = .069, p = .946) and did not explain any variance in the number of mentioned temporally closer causes, R^2 = .000, F(1,61) = .005, p = .946. The same picture was found with causes temporally further away (b = -.003, t (61) = -.126, p = .90; R^2 = .000, F(1,61) = .016, p = .90 (see figures 7 & 8). These findings were confirmed by a change point analysis, where no significant changes over the years concerning the number of causes temporally closer or further away were found.

[1] The minimum expected count is .48. 50% of the expected count is less than 5.

Figure 7.

Distribution of the number of causes mentioned closer in time to the actual moment of accident over the course of time.

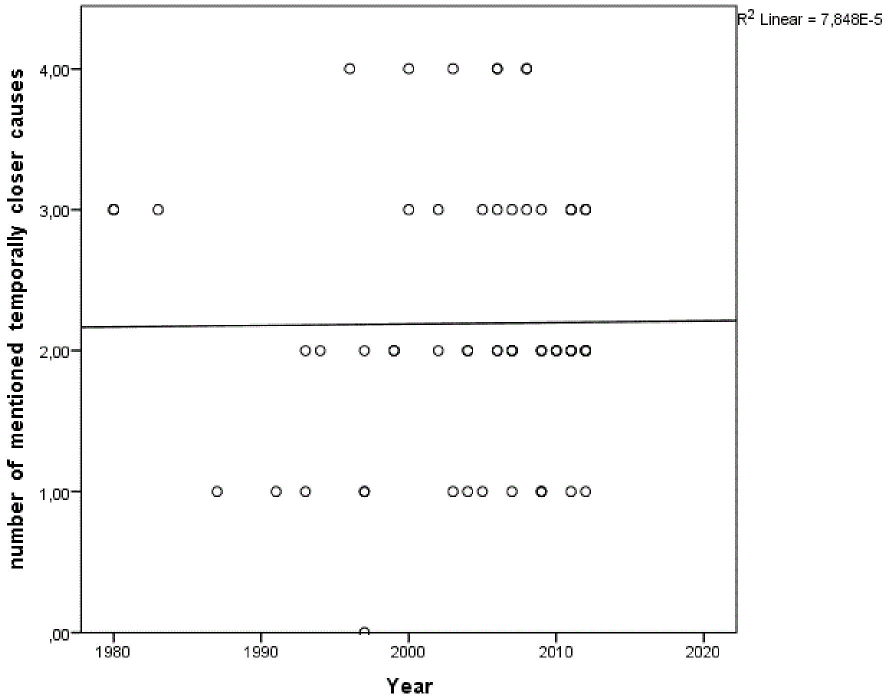
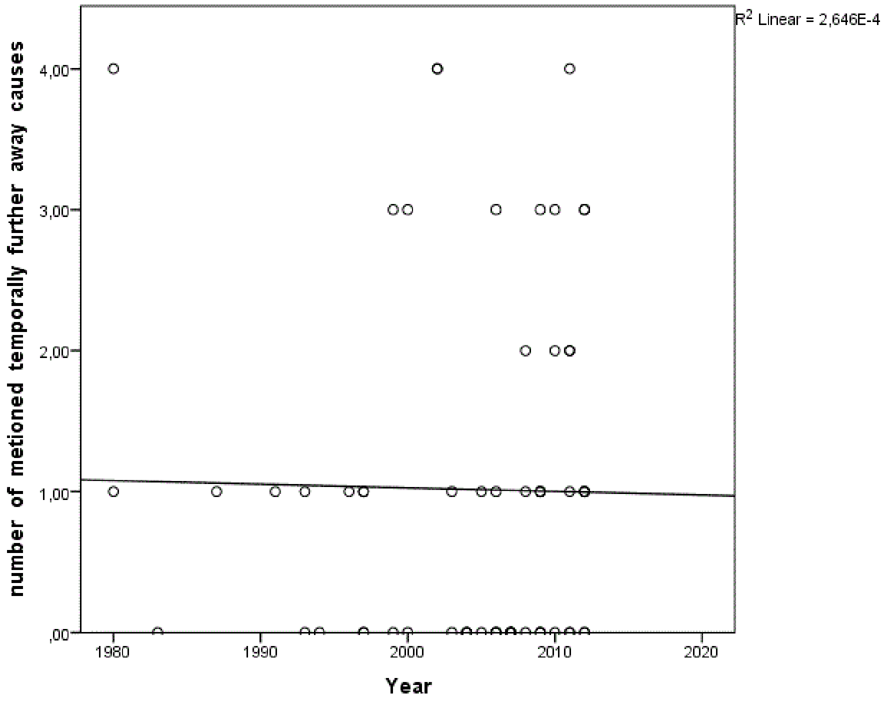


Figure 8.

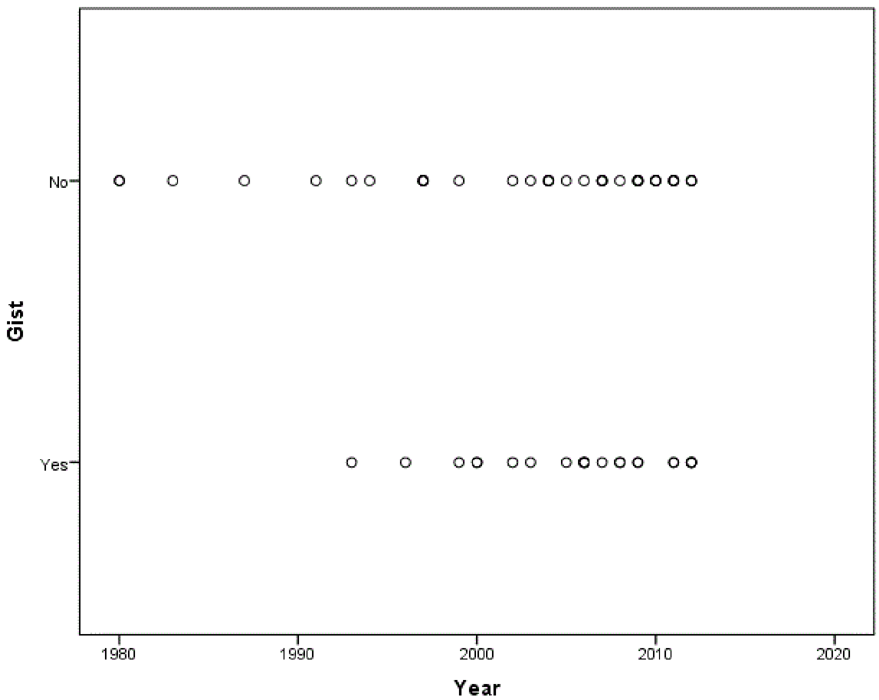
Distribution of the number of causes mentioned further away in time to the actual moment of accident over the course of time.



The fourth sub-question, asking whether reduction takes place by reducing the complex cause-effect relations inherent to the disaster to a specific gist has to be answered in a differentiated way. In 40.3 % of all publications (N=67) authors mentioned all four elements of the gist. In 59.7% of all publications this was not the case. There was a slight and non-significant difference between scientific and non-scientific publications mentioning the gist: 39.5% of all scientific literature was naming the gist, while 41.4% of all non-scientific literature was doing so. A Chi-square test confirms this result: the number of publications that mentioned the gist did not differ significantly with the genre (X^2 (1, N = 67) = .025, p = .875). Furthermore, a change point analysis was conducted to investigate changes over the course of years regarding the number of publications that named the gist. No significant changes were found (see figure 9).

Figure 9.

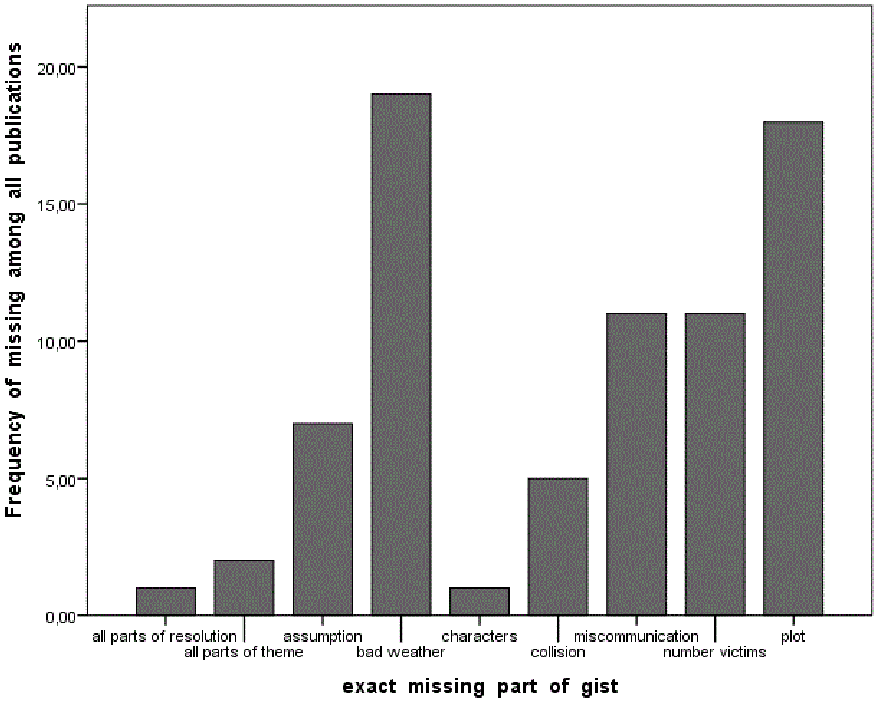
Distribution of number of mentioned gist and years of publications.



Further analysis showed what specific components of the gist were not mentioned (see figure 10). Most publications, which did not mention all elements of the gist, were not stating the components 'bad weather' as a part of the theme (19 publications) and the plot (18 publications). 'Miscommunication' as a part of the theme and 'number of victims' as a part of resolution were not mentioned by respectively 11 publications.

Figure 10.

Absolute number of not being mentioned of the specific parts of the gist among all publications.



Discussion

The purpose of the current study was to investigate how authors reproduce information over the course of time about disasters in scientific and non-scientific publications retrieved from the internet and to detect, if existent, a pattern among these disaster descriptions. The research question is answered regarding the case of the Tenerife accident. The data show a quite large reduction of causes and the most frequently mentioned causes were the bad weather and miscommunication. Concerning the main aspect 'genre', the results suggest that authors of scientific literature did not mention significantly more causes than those of non-scientific literature. Furthermore, no difference in the number of words between scientific and non-scientific literature were found with regard to the ratio of the number of words regarding the whole publication and the disaster description, the number of words of the disaster description in general, the number of words concerning the causes in general within the disaster description and the number of words concerning the specific causes, with exception of cause 9 (bad weather/ bad visibility). Authors of non-scientific publications used more words to describe this cause than authors of scientific publications. With regard to the main aspect ‘time’, no difference in the number of mentioned causes between publications published closer to the year of the disaster and literature released later could be detected. Furthermore, no differences between publications published closer in time to the disaster and publications released later were detected with regard to the ratio of the number of words regarding the whole publication and the disaster description, the number of words regarding the disaster description and the number of words concerning the causes in general within the disaster description. With regard to the number of words concerning the specific causes, the data suggest that a change in the number of words regarding cause 9 (bad weather/visibility) and cause 12 (miscommunication) occurred over the years. After the change, authors used more words to describe cause 9 and fewer words to describe cause 12. The results regarding the main aspect ‘content’ suggest on the one hand, that authors rely more on temporally closer causes than causes temporally further away of the actual moment of accident. But it remains unclear if this difference is statistically significant. On the other hand, more than a half of the authors did not mention all parts of the gist. The data suggest neither a change over time concerning the mentioning of causes temporally closer vs. temporally further away causes, nor concerning the mentioning of the gist. Furthermore, no difference was detected between scientific and non-scientific literature concerning mentioning the different categories of causes or the gist.

Taking the results together, the data show with regard to the main aspect ‘content’ in general a quite large reduction in the number of mentioned causes and that some causes are mentioned quite often, while others are not mentioned at all. From 16 identified causes in the official investigation report (Roitsch, Babock, & Edmunds, 1978) none of the publications mentioned more than 9 causes simultaneously in their description of the disaster and 74.6% of all publications mentioned 4 or less causes. Cause 8 (stress of the air traffic controllers due to the explosion in Las Palmas and a possible bomb threat at Tenerife airport) and cause 10 (the fear of KLM passengers due to the explosion in Las Palmas) were mentioned by no publication. Among all publications the miscommunication/ confusing auditory information (cause 12) and bad weather/ bad visibility (cause 9) were mentioned most frequently. Also quite often mentioned were the false assumption of the KLM pilot of having received a take-off clearance (cause 16) and the crew management factors of the KLM and Pan Am crews (cause11). In sum, these four causes (cause 12, 9, 16 & 11) together with causes 3 (large delay of KLM flight brought along worries about working time limitations) and 4 (third gateway left confusion: Pan Am crew missed the correct gateway) represented 80.35% of all most frequently mentioned causes.

With regard to the main aspect ‘genre’, no difference was detected between scientific and non-scientific literature in mentioning causes in general, in mentioning the gist and in naming temporally closer/ temporally further away causes. An explanation for this result can be the way scientific authors used the accident description: in many publications the description was used with the purpose of giving an example to a specific topic. For doing so it was not necessary to inform the reader about many causes. Furthermore, only one difference was detected between scientific and non-scientific literature with regard to the number of words concerning the specific cause 9 ‘bad weather/ bad visibility’. Authors of non-scientific publications used more words to describe this cause than authors of scientific publications. This result suggests that authors of non-scientific literature regard the bad weather and visibility as an important aspect of the accident. In fact, that finding agrees with the result that cause 9 was one of the most frequently mentioned causes by all publications. However, the question remains, why authors of popular literature used more words to describe the bad weather. Further research is necessary to find an answer to this question.

Regarding the main aspect ‘time’, publications published closer to the year of the accident did not include more causes, than publications published years later. A possible explanation hereby is the deeply irregular distribution concerning the publications per year in our sample. A very small number of literature was found between 1977 and 1999. Probably a lot of publications were published in the years shortly after the accident occurred and also thereafter. But these publications were not digitized yet and so it was just not possible to retrieve them during the search process. This should caution the reader to generalize the findings of the current study regarding the changes over the course of time. Further research should take this into account e.g. by using archives of important newspapers. Furthermore, the results suggest that changes over the years took place in the number of words concerning cause 9 (bad weather; estimated change in 2005) and cause 12 (miscommunication; estimated change in 2008). Authors used more words to describe the bad weather and fewer words to describe the miscommunication after the change. Still, the confidence intervals are quite large, probably as a result of the irregular distribution over the years.

The pattern of reduction mentioned above agrees with the results of the findings regarding the third sub-question. The four most frequently mentioned causes (cause 9, 11, 12 and 16) were categorized as causes happening after the start of take-off and thus as happening closer to the actual moment of accident. This fits with the finding that authors in general mentioned more causes closer in time to the actual accident than causes further away to the accident. As stated briefly in the description of the third sub-question (see introduction), a possible explanation could be the reductive tendency (Feltovich et al., 1994, 2004). Authors try to reduce the complex events of the Tenerife accident by connecting causes that happened directly before the actual moment of the accident easier to the disaster, than causes, that were temporally further away. It requires less mental effort to see just this one directly connected part than understanding the whole complexity inherent to the accident. But it has to be emphasized that the present study cannot give an explanation for thus findings. For that, further experimental research is necessary.

Regarding the fourth sub-question the results showed that all four parts of the gist were mentioned by more than about a third of all publications. Furthermore, the data show the parts of the gist, which were most frequently not mentioned. That most of the publications were not mentioning all parts of the gist can have different reasons. First, the elements of the gist do not contain the 'true' gist. We oriented the development of the gist towards the theory of story grammar (e.g., Thorndyke, 1977), but there still remains place for discussion about what elements the specific parts of the gist should contain. Second, Thordndyke's theory of story grammar refers to a memory effect. As stated in the introduction, this finding indicates that authors did not use exclusively their memory by writing the accident description. Third, the descriptions of the Tenerife accident were often used by authors to strike home a particular point. By doing so, it was not absolutely necessary for them to state the whole story of the accident and as a result to mention all parts of the gist.

Previous research categorized the main causes of accidents into sharp end vs. blunt end (e.g. Lundberg et al., 2009, 2010; Rollenhagen et al., 2010; Besnard & Hollnagel, 2012). According to Besnard and Hollnagel (2012), human error is still believed to be the main cause of accidents among laypeople. In the context of the present study, the categorization of causes into sharp end vs. blunt end is not possible. Regarding the most frequently by authors mentioned causes, the placing of these causes in respectively sharp end vs. blunt end factors is open to discussion. We suggest on the one hand that causes 12 (miscommunication), 4 (third gateway left confusion) and 16 (the KLM captain's false assumption about having the take-off clearance) belong to the sharp end factors, assuming that sharp end factors are defined as aspects of people. On the other hand, that causes 3 (worries about working time limitations) and 11 (crew management factors) should be placed to the blunt end factors, assuming that blunt end factors are defined as organizational aspects. Nevertheless, the question remains, where to put cause 9 (bad weather) and a statement is thus not possible.

The results of the present study are not suitable for making statements about the possible implications, because the aim was to give a description of the reproduction of information about disasters and not to find explanations. It is not possible to make a statement about whether the way of reproducing the information about the Tenerife accident results in a distorted picture of the public and/ or scientific opinion. Further research is needed to get a more precise picture of what findings will be confirmed and in addition, what implications these findings bring along. One limitation of the current study is that a generalization from the case of Tenerife to other disasters is not possible, because it is one example among many others. However, the indicator 'number of words' makes it possible to compare this case to other disasters and thus to come closer to an answer of the general research question. A second limitation is the sample size (N=67), which seems not large enough for making generalizations. A third limitation is the irregular distribution regarding the publications per year in the sample. Finally, a reason is simply the missing of other studies to be compared with.

To our knowledge no previous research investigated the reproduction of information about disasters in subsequent literature. Hence, it is difficult to set the results in relation to the state of research. Our exploratory study has begun to shed light on this field, so it can be seen as a basis for further research.

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Appendix A: Text parts for analysis

Publication ID: 001

Reference: Sharma, A. (2012). *Physician Matters*. Professional Staff Newsletter published by the Chief of Staff Office. Grand River Hospital.

Internet-link and date:
http://www.grhosp.on.ca/uploads/Careers,%20volunteers%20and%20students/PDFs/201207%20Physician%20Matters%20_Mar%2012%20Final.pdf (retrieved on 28.11.2012)

Publication:
Tenerife airport disaster occurred on March 27, 1977, when two Boeing 747 passenger aircraft collided on the runway of Los Rodeos Airport. With a total of 583 fatalities, the crash is the deadliest accident in aviation history. The aircrafts involved, KLM Flight 4805 and Pan Am Flight were, along with many other aircrafts, diverted to Tenerife from Gran Canaria Airport after a bomb exploded there. Further complicating the situation, while authorities waited to reopen Gran Canaria, a dense fog developed at Tenerife greatly reducing visibility. When Gran Canaria reopened, Tenerife required both of the 747's parked on the runway to taxi in to position for takeoff. Due to the fog, neither aircraft could see the other, nor could the controller in the tower see the runway or the two 747s on it. As the airport did not have ground radar, the only means for the controller to identify the location of each airplane was via voice reports over the radio. As a result of several misunderstandings in the ensuing communication, the KLM flight attempted to take off while the Pan Am flight was still on the runway; resulting in collision that destroyed both aircraft, killing all 248 aboard the KLM flight(including the captain van Zanten) and 335 of 396 aboard the Pan Am flight. The investigation would reveal that the primary cause of the accident was the captain, Jacob van Zanten of the KLM flight, taking off without clearance from Air Traffic Control (ATC). However, the investigation identified that the captain did not intentionally take off without clearance; rather he fully believed he had clearance to take off due to misunderstandings between his flight crew and ATC. Ultimately KLM would admit their crew was responsible for the accident.

*Publication ID***:** 002

*Reference***:** Bouquet, C. & Bryant, B. (2009). The Notion Of Mindfulness – For better self-management and better leadership. *Forbes*.

*Internet-link and date***:** http://www.imd.org/research/challenges/TC029-09.cfm (retrieved on 29.11.2012)

Publication:

On March 27, 1977, two Boeing 747s, one KLM and the other Pan Am, collided on the runway at the Tenerife airport in the Canary Islands, killing 583 people. The KLM captain was deemed to be largely responsible for what remains the worst accident in aviation history. He had taken off before receiving official clearance to do so, failed to heed the air traffic controller's instruction to stand by for takeoff, ignored his copilot's requests for clarification and didn't abandon takeoff even though he had evidence that the Pan Am aircraft was still taxiing. Yet he was one of KLM's most able and experienced pilots, with nearly 12,000 flight hours to his credit. What could have gone wrong? The Spanish Ministry of Transport and Communication's investigation of the crash found that the KLM captain had acted as if he "was a little absent from all that was heard in the cockpit." He communicated several times with air traffic controllers, but ultimately appeared to be immune to their instructions.

(…) Fixation
It is always likely in any crisis situation that managers will become so preoccupied with a few central signals that they largely ignore things at the periphery. In the case of the Tenerife disaster, the KLM pilot was undoubtedly focused on three important matters: (1) the need to proceed with a quick takeoff (the KLM crew was approaching the legal limit of time it was allowed to fly in a month), (2) the complex maneuvers of turning around a 747 on a short runway and (3) clouds that reduced visibility in important traffic areas. Because the crew members were so preoccupied, they didn't give sufficient attention to the presumably very important communications coming in from air traffic controllers.

Relaxation
This is almost the opposite problem, and it tends to follow sustained periods of high concentration. Managers who have achieved a certain level of success often become less vigilant toward subtle changes in the situations they face. This was also explicitly cited as a likely contributing factor in the Tenerife disaster. The Spanish Ministry of Transport reported: "Relaxation - after having executed the difficult 180-degree turn, which must have coincided with a momentary improvement in visibility, the [KLM] crew must have felt a sudden feeling of relief, which increased their desire to finally overcome the ground problems: the desire to be airborne."

Publication ID: 003

Reference: Badon, L.C., Oller, S.D., Yan, R. & Oller, J.W. (2005). Gating Walls and Bridging Gaps: Validity in Language Teaching, Learning, and Assessment. *TESOL & Applied Linguistics*, 5, 1-15.

*Internet-link and date***:**
http://www.google.com/url?sa=t&rct=j&q=pdf%20tenerife%20march%2027%201977&source=web&cd=44&cad=rja&ved=0CDMQFjADOCg&url=http%3A%2F%2Fjournals.tc-library.org%2Findex.php%2Ftesol%2Farticle%2Fdownload%2F73%2F80&ei=NWiWUKCvBceY1AXG1oHgCg&usg=AFQjCNGs6AYILqVeGR_xkAFpVl2uBufU8w (retrieved on 29.11.2012)

Publication:

On March 27, 1977, the worst air traffic fatality in the history of aviation killed 583 persons. It occurred at Tenerife Airport in the Canary Islands when two passenger-laden Boeings 747 collided on a runway. A Dutch KLM flight was taking off while a Pan Am 747 was crossing the runway. We use this example to argue that some of the walls between language teaching, language learning, and assessment (testing) need to be torn down or else we need to put gates in them. In cases where gaps exist between the activities of teaching, learning and assessment, we believe that some bridges are needed. Our arguments for doing all this are theoretical, and yet they can have profound consequences as our example of the Tenerife accident shows in several ways:

- For one, the accident was evidently caused by misunderstood communications in English, a second language for the pilots and air traffic controllers involved. It could have been prevented with better, more valid teaching, learning, and assessment. Efforts are being made to that end, as we will see later on in this paper.

*Publication ID***:** 004

*Reference***:** Ellis, S. & Gerighty, T. (2008). *English For Aviation for Pilots and Air Traffic Controllers*. Oxford University Press.

*Internet-link and date***:** http://elt.oup.com/elt/students/express/pdf/exp_00_ca_unit_1.pdf?cc=cz...cs (retrieved on 29.11.2012)

*Publication***:**

On March 27, 1977, two Boeing 747s collided on the runway at Tenerife. Among contributing factors to the accident was the use of non-standard phrases in radio communication. This led to confusion about whether or not a clearance for take-off had been granted. In most circumstances, any misunderstanding would be quickly clarified, however on this day, there was dense fog. The tower controller couldn't see either of the two planes, nor could the planes see one another. In addition, simultaneous radio transmissions meant that some messages were not heard. The use of ambiguous words made the already bad situation much worse. Clear communication is extremely important – and can be a matter of life or death – for pilots and air traffic controllers.

*Publication ID***:** 005

Reference: Rudolph, J.W. & Repenning, N.P. (2002). Disaster dynamics:
Understanding the role of quantity in organizational collapse. *Administrative Science Quarterly,* 47, 1-30.

*Internet-link and date***:** http://asq.sagepub.com/content/47/1/1.full.pdf+html (retrieved on 29.11.2012)

Publication:

The first is Weick's (1993a) vivid depiction of a series of small interruptions, none of which was particularly novel in and of itself, that combined to produce the Tenerife air disaster. On March 27, 1977, two Boeing 747s, one from KLM and one from Pan Am, were diverted to Tenerife because the Las Palmas airport, where they had been scheduled to land, was closed due to a terrorist bomb attack. Weick's analysis highlights how the diversion resulted in a myriad of small interruptions to existing plans and normal procedures: diverting the plane to Tenerife interrupted the plan to get back to Amsterdam within the KLM crew's strict duty time constraints; a cloud drifting 3 000 feet down the runway interrupted the lower-order plan to leave the airfield; narrow runways (not designed for 747s) interrupted normal maneuvering protocols; and non-standard and garbled transmissions from the control tower interrupted usual preflight communications.
Invoking George Mandler's interruption theory of stress, Weick (1993a: 180) suggested that each of these interruptions increased the level of autonomic arousal in the KLM crew, absorbing information processing capacity, decreasing cognitive efficiency, and reducing the number of cues they were able to notice and process. As the situation progressed and the number of interruptions accumulated, the crew's ability to manage the increasingly complex system they were facing declined. The KLM crew communicated less and less clearly and developed a narrow and incomplete view of their situation, until, in direct violation of standard procedure, the KLM captain cleared himself for take-off. Then, to outrun a cloud rolling up the runway toward him, he began accelerating for take-off. Unfortunately, the approaching cloud concealed the Pan Am aircraft, which had missed its parking turn-off due to the low visibility. The resulting collision killed all of the 583 people on both planes, one of the worst accidents in aviation history.

Publication ID: 006

Reference: Flin, R., O'Connor, P. & Crichton, M. (2008). Safety at the Sharp End – A Guide to Non-Technical Skills. Ashgate Publishing Limited.

Internet-link and date: http://www.ashgate.com/pdf/samplepages/safety_at_the_sharp_end_intro.pdf (retrieved on 29.11.2012)

Publication:

The best known of these events is the Tenerife crash in 1977, when two jumbo jets crashed on an airport runway, as described below.
Box 1.1 Tenerife Airport Disaster
At 17:06 on 27 March 1977, two Boeing 747 aircraft collided on the runway of Los Rodeos airport on the island of Tenerife. The jets were Pan Am flight 1736 en route to Las Palmas from Los Angeles via New York and KLM flight 4805 from Amsterdam, also heading for Las Palmas. Both had been diverted to Tenerife because of a terrorist incident on Las Palmas. After several hours, the airport at Las Palmas re-opened and the planes prepared for departure in the congested (due to re-routed aircraft), and now foggy, Los Rodeos airport. The KLM plane taxied to the end of the runway and was waiting for air traffic control (ATC) clearance. The Pan Am plane was instructed to taxi on the runway and then to exit onto another taxiway. The KLM plane was now given its ATC clearance for the route it was to fly – but not its clearance to begin take-off. The KLM captain apparently mistook this message for a take-off clearance, released the brakes, and despite the co-pilot saying something, he proceeded to accelerate his plane down the runway. Due to the fog, the KLM crew could not see the Pan Am 747 taxiing ahead of them. Neither jet could be seen by the control tower and there was no runway radar system. The KLM flight deck engineer, on hearing a radio call from the Pan Am jet, expressed his concern that the US aircraft might not be clear of the runway, but was over-ruled by his captain. Ten seconds before collision, the Pan Am crew noticed the approaching KLM plane but it was too late for them to manoeuvre their plane off the runway. All 234 passengers and 14 crew on the KLM plane and 335 of 396 people on the Pan Am plane were killed. Analyses of the accident revealed problems relating to communication with ATC, team co-ordination, decision-making, fatigue and leadership behaviours. See Weick (1991) and Box 5.4. for further details.

*Publication ID***:** 007

*Reference***:** Howard, J. (2012). Member Spotlight. In: Stapp, C. (2012). The Whale's Tale. *Newsletter Ballena Bay Yacht Club*, Volume 2.

*Internet-link and date***:** http://bbyc.insidecitylimits.com/images/newsletter/BBYC_Feb2012.pdf (retrieved on 29.11.2012)

Publication:
With a total of 583 fatalities, the crash is the deadliest accident in aviation history. The Tenerife airport disaster occurred on March 27, 1977 when two Boeing 747's collided on the runway of Tenerife, one of the Canary Islands. The aircraft involved, KLM Flight 4805 and Pan Am Flight 1736, were, along with many other aircraft, diverted to Tenerife from Gran Canaria Airport after a bomb exploded there. The threat of a second bomb forced authorities to close the airport and divert all air traffic to the smaller Tenerife airport where air traffic controllers were forced to park many of the airplanes on the taxiway. Further complicating issues, a dense fog developed, and neither aircraft could see each other nor could the controller in the tower see the runway or the two 747s on it. They had to rely on communications via voice reports. When the Gran Canaria Airport reopened, both aircraft were required to taxi on the only runway at Tenerife to get ready for take-off. As a result of several misunderstandings between the controllers and the pilots of each plane, the KLM flight attempted to take off while the Pan Am flight was still on the runway. The resulting collision destroyed both aircraft, killing all 248 aboard the KLM flight and 335 of 396 aboard the Pan Am flight.

*Publication ID***:** 008

*Reference***:** Kirk, J. (2012). Limitations and Dangers of the use of the English Language in Aviation Communications. AVIA 300 Aviation Safety – Week Seven. In: *EMS Pilot Blog*.

*Internet-link and date***:** http://emspilot.wordpress.com/2012/04/03/limitations-and-dangers-of-the-use-of-the-english-language-in-aviation-communications/ (retrieved on 29.11.2012)

*Publication***:**

The KLM/ Pan Am disaster at Tenerife airport (Los Rodeos) on March 27th 1977 was the worst accident in aviation history in terms of loss of life. A major contributory factor was the failure in communication using the English language. The KLM aircraft had taken off without take-off clearance, in the absolute conviction that this clearance had been obtained, which was the result of a misunderstanding between the tower and the KLM aircraft. This misunderstanding had arisen from the mutual use of usual terminology, which gave rise to misinterpretation. In combination with a number of other coinciding circumstances, the premature take-off of the KLM aircraft resulted in a collision with the Pan Am aircraft, because the latter was still on the runway since it had missed the correct intersection.

*Publication ID***:** 009

*Reference***:** Helleberg, J.R. & Wickens, C.D. (2003). Effects of Data-Link Modality and Display Redundancy on Pilot Performance: An Attentional Perspective. *The International Journal of Aviation Psychology*, 13, 189-210.

*Internet-link and date***:** http://www.interruptions.net/literature/Helleberg-IJAP03.pdf (retrieved on 29.11.2012)

Publication:
On March 27, 1977 a Pan Am 747-121 (flight number 1736) and a KLM 747-206B (flight number 4805) collided while still on the runway at Los Rodeos airport on Tenerife of the Canary Islands. This disaster resulted in the largest loss of life (583 people) that has ever occurred from a single aviation accident. The probable cause, cited by Roitsch, Babcock, and Edmunds (1978), was the KLM pilot taking off without takeoff clearance. How could a senior captain make such an error? There were many contributing factors that led up to this accident. However, miscommunication of the auditory-voice loop played a significant role and is the major focus of this article.

*Publication ID***:** 010

*Reference***:** Silvey, A.B. (2009). Introduction to Root Cause Analysis (RCA) – Understanding the Causes of Events. Power Point Presentation. *Health Services Advisory Group (HSAG)*. Publication No. AZ-9SOW-XC-080609-01

*Internet-link and date***:**
http://www.hsag.com/app_resources/documents/pru_ls4_rca_understandingevents.pdf (retrieved on 29.11.2012)

Publication:
High Profile Accidents
The Tenerife collision took place on March 27, 1977, at 17:06:56, when two Boeing 747 airliners collided at Los Rodeos on the island of Tenerife, Canary Islands, Spain, killing 583 people. The accident has the highest number of fatalities (excluding ground fatalities) of any single accident in aviation history. The aircraft involved were Pan American World Airways Flight 1736, under the command of Captain Victor Grubbs, and KLM Royal Dutch Airlines Flight 4805, under the command of Captain Jacob Veldhuyzen van Zanten. KLM 4805, taking off on the only runway of the airport, crashed into the Pan Am aircraft which was taxiing in the opposite direction on the same runway.
Accident Findings

- No subordinate authority to stop the captain
- Crew members were hesitant to tell the captain something he did not want to hear
- Terminology was not consistent
- Multiple conversations at the same time made it difficult to hear

Publication ID: 011

Reference: Westendorp, P. & van der Waarde, K. (2003). From avionics to aviation information architecture. *Information Design Journal*, 11, 1-3.

Internet-link and date: http://benjamins.com/series/idj/11-1/art/01wes.pdf (retrieved on 29.11.2012)

Publication:
On March 27, 1977, around 17:05, a KLM Boeing 747 was about to depart from Tenerife Airport at Canary Islands, off the West African coast. Many planes were queuing to take off and it was foggy. The pilot repeated to the tower the instructions that he had just received: 'We are cleared to the papa beacon, climb and maintain flight level 90 until intercepting the 325.' Then he said: 'We are now at takeoff.' The tower replied: 'OK...Stand by for takeoff. I will call you.' During these last two short sentences there was a squeal on the line. The KLM plane sped up on the runway, where a Pan Am 747 was still taxiing after landing. The two 747s collided and 583 people died. It is still the worst accident in aviation history. As often, the accident was probably caused by a combination of factors. It was foggy, so the pilots did not have an overview of the runway. There was pressure on the pilots to leave quickly because weather conditions would grow worse again and all planes were late already; the chief KLM pilot was convinced the runway was free, but his co-pilot was not, etcetera. But in this case miscommunication was probably the main factor causing this tragic incident. The KLM pilot's native language was Dutch, the controller's native language was Spanish; they were talking in English over a radio with squeals and in very noisy surroundings, especially the pilot. With the sentence 'We are now at takeoff,' the KLM pilot meant 'We are taking off'. The controller in the tower understood that the plane was standing still at takeoff point. Collision because of linguistic ambiguity.

Coder ID: Hanna

Publication ID: 012

Reference: Tsai, S.-C., Huang, Y.-K. & Chen, Y.-H. (no year mentioned). Risk Management for Runway Incursions. Paper.

Internet-link and date: http://203.72.2.115/dbook/101547001.pdf (retrieved on 30.11.2012)

Publication:

Date: March 27, 1977; Operator: Pan AM & KLM; Type/call sign: B747/PA1736 & B747/KL4805; Site: Los Rodeos Airport on Tenerife Island; Flight type: Charter; Stage: Taking off, Taxiing; Factor: Weather, human; Result: Two planes ruined totally; Damage level: The world's worst aviation disaster; No. of Passenger/crew: Pan Am 16/378, KLM 14/234; No. of crew injury/fatality: Pan Am 7/9, KLM 0/14; No. of passenger injury/fatality: Pan Am: 52/326, KLM 0/234.

A bomb exploded at Las Palmas Airport on Canary Islands. For safety reason, much of the traffic was diverted to the nearby Los Rodeos Airport on Tenerife Island. Thus, the parking area at the latter airport was crowded with airplanes, including Pan Am flight PA1736 and KLM flight KL4805. Once Las Palmas Airport reopened, because of the crowded holding area, the airplanes were instructed to wait at the end of the only runway (Runway 30) and made a 180 degree turn to take off. At that time, the foul weather worsened the visibility, and the Los Rodeos Airport was not equipped with ground radar. While the Pan Am airplane was ready to back taxi to the runway to take off, the KML captain had applied for refueling in the taxiway to save time, out of anxiety to get in the air before crew duty time limits would preclude the flight. At the time KLM airplane had finished refueling and started its takeoff run in Runway 30; the tower instructed the Pan Am to stand by at Runway 12 and then taxi along the runway till the third exit into taxiway. When the KLM airplane was taking off, the Pan Am airplane was still taxing in the path of KLM. Coincidentally, simultaneous communication from tower and Pan Am interfered the KLM's radio frequency. Despite the attempt to avoid collision, two airplanes crashed with 583 deaths and 59 injuries.

Causes

1. KLM took off without clearance
2. The misinterpretation of communication between controllers and pilots (the accent and the obscure radio frequency)
3. KLM failed to receive the request from tower to stand by
4. KLM missed to abort departing when Pan Am was on the runway

Analysis

1. Pressure factor: KLM's pilots worried the duty time limits. Pan Am's pilots were exhausted by the long-time work. The controller looked after more airplanes than usual.
2. The fixed training courses: Some training programs in flight simulator may omit several procesures in reality, and the teaching materials are uniform and invariable far from reality.
3. Cockpit resource management: In KLM, the authority falled in the captain and the co-pilot only dealt with pre-flight inspections. As to Pan Am, they exchanged views with each other
4. Ambiguity of interpretation: The controller responded "okay" to request KLM for stand-by, but KLM took it for approval of takeoff.

Suggestion

1. The standardization of communication should be improved.
2. The training programs are supposed to be executed in real flight as well
3. Unless in the well-equipped airports, the business airplanes are forbidden to taxi under the visibility

Publication ID: 013

Reference: Deboo, K.N. (no date mentioned). Maritime Resource Management. Based on the world renowed SAS-BRM Course). A Nautical Institute project, sponsored by Lloyd's Register Educational Trust.

Internet-link and date: http://www.he-alert.org/documents/published/he00270.pdf (retrieved on 30.11.2012)

Publication:

The airline industry was jolted into action by a terrible tragedy that took place on Sunday, March 27th 1977 at Tenerife's Los Rodeos airport. Two jumbo jets belonging to KLM and Pan Am collided on the runway in foggy conditions causing loss of 583 lives. Senior investigator Capt. Paul Roitsch concluded that there was nothing wrong with the aircrafts, all systems working well, no malfunctions. Nothing to poke holes at the technical competence of the pilots of the two aircrafts, in fact the KLM flight commander was the senior and most respected captain in KLM. It was a case of plain human error.

Publication ID: 014

Reference: Ludovic, A. (no date mentioned). Words that can be hazardous to your Health. Original idea from Steve Cushing, copyright by Smartcockpit.com.

Internet-link and date:
http://selair.selkirk.ca/Training/CRM/documents/Words_Than_Can_Be_Hazardous_To_Your_Health.pdf (retrieved on 30.11.2012)

Publication:

On 27 March 1977, the pilot of a KLM Boeing 747 radioed, "*We are now at take-off*", as his aircraft began rolling down the runway in Tenerife, the Canary Islands. The air traffic controller mistook his statement to mean that the aircraft was at the takeoff point, waiting for further instructions, and so did not warn the pilot that another aircraft, a Pan American Airways B747 that was invisible in the thick fog, was already on the runway. The resulting crash killed 583 people in what is still the most destructive accident in aviation history.
The KLM pilot's otherwise perplexing use of the nonstandard phrase "at take-off", rather than a clearer phrase such as "taking-off", can be explained as a subtle form of what linguists refer to as "code switching". Careful studies of bilingual and multilingual speakers have shown that they habitually switch back and forth from one of their languages to another in the course of a conversation, not because of laziness or lack of attention, but because of inherent social and cognitive features of how language works, that are still poorly understood.
In the KLM pilot's case, the form of a verb that is expressed in English by the suffix "-ing" happens to be expressed in Dutch by the equivalent of "at" plus the infinitive (the uninflected form of the verb, e.g., "fly" as contrasted with "flies", "flying" or "flew"). For whatever reason, perhaps because of fatigue or the stress of having to work in conditions of low visibility, the normally Dutch-speaking pilot inadvertently switched into the Dutch grammatical construction while keeping the English words. The Spanish-speaking controller, proficient in English but not in Dutch, and unattended to subtle linguistic phenomena, had no clue that this shift was going on. He interpreted the "at" in a literal way, indicating a place, the take-off point.
The controller at Tenerife had, a few seconds earlier, inserted another kind of ambiguity into the control tower-KLM pilot exchange. The controller had said, "KLM eight seven zero five you are cleared to the Papa beacon, climb to and maintain flight level nine zero, right turn after take-off ..." The tower intended the instruction only to mean that the KLM aircraft was vectored to the Papa beacon following a takeoff clearance that was still to come, rather than that the pilot was given permission to take-off. But that was not how the KLM pilot understood "you are cleared".

*Publication ID***:** 015

Reference: Torres, K. R., Metscher, D. S. & Smith, M. (2011). A correlational Study of the Relationship between Human Factor Errors and the Occurrence of Runway Incursions. *International Journal of Professional Aviation Training & Testing Research*, 5, 3-25.

*Internet-link and date***:**
http://www.google.nl/url?sa=t&rct=j&q=&esrc=s&source=web&cd=169&ved=0CGEQFjAIOKAB&url=http%3A%2F%2Fojs.library.okstate.edu%2Fosu%2Findex.php%2FIJPATTR%2Farticle%2Fdownload%2F428%2F406&ei=q8STUPX3LIWx0QW30YD4Dg&usg=AFQjCNFQq8tKVClA3NNTopgwUsAdK8tLoA&cad=rjt (retrieved on 30.11.2012)

Publication:

The most studied runway incursion in aviation history to date occurred on March 27, 1977 at Los Rodeos (Tenerife) airport (Ministerio De Transportes Y Communcaciones, 1977). A KLM Boeing 747 and a PanAm 747 collided on the runway killing 583 people. The KLM 747 was cleared into position and hold to wait for takeoff clearance while the PanAm 747 was back taxiing on the same runway. Dense fog made it impossible for the tower to see the runway or for the two aircraft to see each other. The captain of the KLM 747 started his takeoff prior to receiving clearance from the tower. The two planes collided in the middle of runway 30 (Ministerio De Transportes Y Communcaciones, 1977).

*Publication ID***:** 016

*Reference***:** Cherry, R.G.W. & Associates Limited (2009). A Study of the Effects of Engine Configuration, Fuselage, Breage and Ruptures in Aircraft Accidents Involving Ground Pool Fires. Final Report.

*Internet-link and date***:** http://www.fire.tc.faa.gov/pdf/09-19.pdf (retrieved on 30.11.2012)

Publication:

On 27-Mar-1977 a PAA B747 registered as N736PA attempted to taxi onto a taxiway at Tenerife Airport in fog conditions and was forced to stop across the runway. A KLM B747 was taking off from the same runway and due to the fog did not observe the stationary PAA aircraft. The KLM aircraft started its take-off roll and was just airborne when it collided with the PAA aircraft.
The KLM aircraft started its take-off roll and was just airborne when it collided with the PAA aircraft, which was about 45 deg relative to the centre of the runway. It is possible that the PAA aircraft continued to move after the impact.
Apparently the KLM No. 1 engine only grazed the tip of the PAA aircraft's right side; the nose and front landing gear overshot and the main landing gear smashed against it in the area of its No. 3 engine. The KLM fuselage skidded over the PAA fuselage, destroying it and shearing off the empennage. The KLM aircraft came down beyond the runway. Some sections of the right side of the PAA aircraft were found near the KLM one.

Of the 16 crew and 380 passengers aboard 9 crew and 326 passengers suffered *Fatal Injuries*. Seven crew and 52 passengers suffered *Serious Injuries*. Two passengers escaped with minor or no injuries. There is insufficient information available to develop completely the survivability chain.

Fuselage Breaks & Ruptures
The first class lounge disappeared as a result of the impact, as well as nearly the whole of the top of the fuselage. The KLM fuselage skidded over the PAA fuselage, destroying it and shearing off the empennage. There is also evidence, from the description of occupant evacuation, that there was a sizable Fuselage Rupture on the left hand side. However, the number and location of *Fuselage Breaks* cannot be determined precisely.
Occupant Egress & Fire Entry
According to the survivors, the shock of impact was not excessively violent, leading them to believe that the cause was an explosion. They jumped to the ground through openings in the left side or through door L2. A large number of passengers escaped off this wing, jumping from it to the grass. The crew had to jump to the first class section and get out through a hole in the left wall behind the L1 exit. This hole was the main escape route for the passengers located in the forward part of the aircraft. The *Fuselage Breaks* assisted occupants in the evacuation of the aircraft.

The aircraft was destroyed by fire and it is likely that the *Fuselage Breaks* provided an entry route into the cabin for the fire. However, this cannot be confirmed from the information contained in the accident report.

*Publication ID***:** 017

*Reference***:** Manion, M. & Evan, W. M. (2002). Technological catastrophes: their causes and prevention. *Technology in Society*, 24, 207-224.

*Internet-link and date***:**http://ac.els-cdn.com/S0160791X02000052/1-s2.0-S0160791X02000052-main.pdf?_tid=38998ad4-2764-11e2-aa61-00000aab0f27&acdnat=1352132397_5c216b2eed72c8d2400651a6233f5113 (retrieved on 01.12.2012)

Publication:

2.6. Tenerife runway collision

On March 28, 1977, two jumbo jets — a Pan American 747 and a KLM Royal Dutch Airlines 747 — collided on the runway as they were attempting to take off from Tenerife airport in the Canary Islands off the west coast of Africa. The Pan Am 747 had 378 passengers on board and the KLM 747 was transporting 235 passengers. The death toll of 583 makes the Tenerife runway collision the worst accident in aviation history. The circumstances of the disaster suggest human failure, and not technical failure, as the cause of the disaster. Both airliners were ready for takeoff at about the same time. The Pan Am jet was turning onto the main runway when the KLM jet, already beginning to lift off, slammed into it almost head-on. Both airplanes were, in fact, diverted to the Tenerife airport because of a bomb threat at their intended destination of Las Palmas. The small airport at Tenerife was already crowded with other aircraft diverted from Las Palmas, and the arrival of the two 747s only complicated matters. Both aircraft were crowded with weary passengers and crews who wanted to proceed to their final destinations. The captain of the KLM jet was particularly concerned about time because he wished to complete his round trip to Amsterdam before the number of hours he could legally fly between rest periods expired lest he or his crew would be fined. According to the Netherlands Department of Civil Aviation, in an official report released by the *Subsecretaria de Aviacion Civil* in Spain, the probable cause of the disaster was as follows: The KLM aircraft had taken off without take-off clearance, in the absolute conviction that this clearance had been obtained, which was the result of a misunderstanding between the tower and the KLM aircraft. This misunderstanding had arisen from the mutual use of usual terminology, which, however, gave rise to misinterpretation. In combination with a number of other coinciding circumstances, the premature takeoff of the KLM aircraft resulted in a collision with the Pan Am aircraft because the latter was still on the runway since it had missed the correct intersection [32].

*Publication ID***:** 018

*Reference***:** Karl E. Weick . Reprinted from *The Collapse of Sensemaking in Organizations: The Mann Gulch Disaster* by Karl E. Weick published in Administrative Science Quarterly Volume 38 (1993): 628- 652 by permission of Administrative Science Quarterly. 0001-8392/93/3804-0628.

Internet-link and date:
http://www.nifc.gov/safety/mann_gulch/suggested_reading/The_Collapse_of_Sensemaking_in_Organizations_The_Mann_Gulch.pdf (retrieved on 30.11.2012)

Publication:

For example, in the Tenerife air disaster (Weick, 1990), the copilot of the KLM aircraft had a strong hunch that another 747 airplane was on the takeoff runway directly in front of them when his own captain began takeoff without clearance. But the copilot said nothing about either the suspicions or the illegal departure. Transient cockpit crews, tied together by narrow definitions of formal responsibilities, and headed by captains who mistakenly assume that their decision making ability is unaffected by increases in stress (Helmreich et al., 1985), have few protections against a sudden loss of meaning such as the preposterous possibility that a captain is taking off without clearance, directly into the path of another 747.

Publication ID: 019

Reference: Gaffney, F. A., Harden, S. W. & Seddon, R. (2005). *Crew Resource Management: The Flight Plan for Lasting Change in Patient Safety*. Published by HCPro, Inc., United Stated of America. ISBN-13: 978-1-57839-712-9.

Internet-link and date: http://www.hcmarketplace.com/supplemental/3676_browse.pdf (retrieved on 30.11.2012)

Publication:

On March 27, 1977, Captain Jacob Van Zanten expertly guided his B-747 jumbo jet onto the fog-shrouded runway on Tenerife Island in the Azores. Stern experienced and knowledgeable—he was the senior B-747 instructor pilot for his airline. His copilot for that flight had received his training to operate the B-747 from Captain Van Zanten just six months earlier. Despite his 30-plus years of experience, Captain Van Zanten was about to make a fatal error: he began his takeoff roll without clearance from the control tower. Neither his copilot nor his flight engineer were certain whether a takeoff clearance had been received, and both strongly suspected that another airplane was on the runway hidden in the fog. Both made weak hints to their captain, seemingly reluctant to offend or anger him. The captain brusquely dismissed both hints and shoved the throttles forward bringing to life hundreds of thousands of pounds of thrust and accelerated the jet toward destruction. Moments later, its speed increasing rapidly, the 747 emerged from the fog. In that awful moment, Captain Van Zanten most assuredly realized his error as his windscreen filled with a horrible sight—another 747 blocking his path on the runway. In that instant, the aircraft commander realized he was moving too quickly to stop before smashing into the other airplane and too slowly to get airborne and fly over it. Death for him, his crew, and all his passengers was just seconds away. In the other airplane, the copilot was the first to see the onrushing jet. He began to scream to his captain, “Get off! Get Off! Get Off!” as he shoved the throttles forward in a desperate attempt to taxi off the runway and onto the grass. He was too late. Moments later, the airplanes collided in a thunderous fireball. The resulting fire consumed 583 lives, making it the worst disaster in aviation history. The resulting accident investigation (similar to a root-cause analysis in healthcare) revealed a tragic chain of events rooted in human error. Poor communication, flawed teamwork, rushed procedures, and time pressure all contributed to the deadly outcome.

Publication ID: 020

Reference: Rosness, R., Håkonsen, G., Steiro, T. and Tinmannsvik, R.K. (2000): The vulnerable robustness of High Reliability Organisations: A case study report from an offshore oil production platform. Paper presented at the *18th ESReDA seminar Risk Management and Human Reliability in Social Context*. Karlstad, Sweden, June 15-16, 2000.

Internet-link and date: http://risikoforsk.no/Publikasjoner/Vulnerable%20robustness.pdf (retrieved on 30.11.2012)

Publication:

This point is illustrated by the plane crash at Tenerife on March 27 1977. Because of limited visibility and communications difficulties between air traffic control and a KLM 747 aircraft, the KLM 747 started its takeoff while a Pan Am 747 aircraft was on the same runway. All 234 passengers and 14 crew were killed in the KLM 747. Nine of the 16 crew and 321 of the 380 passengers on the Pan Am flight were killed. The Spanish investigation report gives the following analysis of the communication in the KLM 747 cockpit immediately after the plane had started takeoff:

The communication from the tower to the PAA aeroplane requested the latter to report when it left the runway clear. In the cockpit of the KLM aeroplane which was taking off, nobody at first confirmed receiving these communications (Appendix 5) until the Pan Am aeroplane responded to the tower's request that it should report leaving the runway with an "O.K., we'll report when we're clear." On hearing this, the KLM flight engineer asked: "Is he not clear then?" The captain didn't understand him and he repeated: "Is he not clear that Pan American?" The captain replied with an emphatic "Yes" and, perhaps influenced by his great prestige, making it difficult to imagine an error of this magnitude on the part of such an expert pilot, both the co-pilot and the flight engineer made no further objections. The impact took place about thirteen seconds later.

The presence of three competent persons in the cockpit provided the structural and instrumental preconditions for organisational redundancy. However, according to this analysis, the cultural preconditions left the system vulnerable.

*Publication ID***:** 021

*Reference***:** Valimont, R. B. (2006). Active Noise Reduction versus Passive Designs in Communication Headsets: Speech Intelligibility and Pilot Performance Effects in an Instrument Flight Simulation. Dissertation: April 20, 2006 in Blacksburg, Virginia.

*Internet-link and date***:** http://scholar.lib.vt.edu/theses/available/etd-04252006-110703/unrestricted/Valimont_Dissertation.pdf (retrieved on 30.11.2012)

Publication:

In fact, the worst accident in aviation history was the result of a misinterpreted radio transmission, and a subsequent unintelligible transmission. These simple, common communications errors led to the death of 538 passengers and crewmembers abroad two Boeing 747s, as follows. The field at Tenerife, Canary Islands, on March 27, 1977, was socked in with thick fog, dropping runway visibility range to less than a quarter of a mile, which permitted only departing airliners to use the active runway. KLM flight 4805 was instructed to backtaxi the active runway, make a 180 degree turn and hold their position awaiting take-off clearance. Meanwhile, Pan Am flight 1736 was cleared to backtaxi the active runway until they reached one of the last runway turn-offs. There, Pan Am 1736 was to exit the runway to allow room for KLM 4805 to initiate its take-off roll. While Pan Am 1736 was backtaxiing on the active runway, the air traffic controller issued KLM only its departure clearance, which KLM correctly readback. The controller then transmitted an additional statement, “Stand by for take-off, I will call you.” Tragically, this statement was garbled and presumably unintelligible to the KLM pilots, whom did not reply to the command and most likely believed they were already cleared for take off. Instead of a pilot readback to the previous controller command, the ATC audiotapes picked up the squeal of tires as the KLM Boeing 747 released its brakes and began lumbering towards the Pan Am 747 just approaching their taxiway turn-off. Twenty seconds later, the KLM 747 slammed into the Pan Am 747. The resulting impact forces and conflagration claimed the lives of all crewmembers and passengers save approximately two crewmembers and fifty passengers on the Pan Am 747. All occupants of the KLM 747 perished (Aviation-Safety.net, 1996).

*Publication ID***:** 022

*Reference***:** Schaaf, M. M. (1999). Book Review: Oum, T.H. & YU, C. (1997). Winning airlines: Productivity and cost competiveness of the world's major airlines. Boston Kluwer Academic Publishers. 212 pages. In *Journal of Air Transportation World Wide,* 4, 145-153.

*Internet-link and date***:** http://ntl.bts.gov/lib/000/700/744/jatww4_2review.PDF (retrieved on 30.11.2012)

Publication:

On March 27, 1977, a bomb exploded at Las Palmas airport and the airport was closed to all traffic. Two Boeing 747 aircraft (KLM and Pan Am) were told they could not land and were diverted to Tenerife as were most other aircraft. The elements of fatigue, uncertainty, and frustration were adding to a crowded airport. The KLM captain was the airline's chief flight instructor and was a man of considerable prestige in the company. His copilot had been certified by him in the 747. The Las Palmas airport opened and the Pan Am was ready for departure but found the KLM blocking the runway. The KLM moved up the runway with Pan Am following behind. The weather began to deteriorate with low clouds rolling in. KLM requested a backtrack down the runway and was to make a 180 degree turn to face the take-off direction. The Pan Am had also been cleared to backtrack down the same runway. The KLM captain was anxious to take off and probably has his expiring flight crew duty time in the back of his mind. The captain began to move the throttles as the copilot objected. The captain told the copilot to go ahead and ask for ATC clearance. As the copilot was still trying to get clearance, the captain started the take-off. The Pan Am 747 was still taxiing back up the runway as the KLM began its take-off roll. The KLM flight engineer called out that he did not think the Pan Am was clear of the runway after listening to the radio transmissions from Pan Am to ATC. He was confident the KLM did not have the proper clearance and had two options: question the captain or take action himself by shutting down the throttles and braking. Unfortunately, he chose to challenge the captain's decision while the take-off roll was occurring and it was now too late as "VeeOne" was called out. The crew of Pan Am saw the KLM's landing lights through the low clouds and realized they were directly in the path of the oncoming aircraft. No one on board the KLM 747 survived and 235 died on the Pan Am 747.

The copilot of the KLM had doubts about the ATC clearance as did the flight engineer but neither one was able to overcome the captain's ego. Had the flight engineer seen any signs of support from the copilot he would have taken action. The copilot gave in to the captain's impatience to take off and his authority. No other profession is tested and challenged as often as that of a pilot. A pilot must routinely go through medical and flight checks and at any time he or she may lose their licence and their livelihood.

Publication ID: 023

Reference: Ericson, M. & Martensson, L. (2010). *The Human Factor?* In Risks in Technological Systems. Springer Series in Reliability Engineering, 245-254.

Internet-link and date: http://link.springer.com/chapter/10.1007%2F978-1-84882-641-0_15?LI=true#page-1 (retrieved on 30.11.2012)

Publication:

On March 27, 1977, an aircraft disaster occurred in Tenerife on the Canary Islands that sheds some light on the concept of the human factor. The background to the accident was a terrorist attack on the airport in Las Palmas, which led to the redirection of all air traffic to Tenerife including one Pan AM aircraft and one KLM aircraft. The crews of the two aircraft were very concerned about the redirection. In the case of the Pan Am aircraft, there was a risk that the regulated working hours would be exceeded before they reached their final destination in Las Palmas. The KLM aircraft was to return to the Netherlands, and delays were not accepted by the airline management. At the time when the KLM flight and the Pan Am flight received clearance to taxi for departure to Las Palmas (where the airport had been opened again) the airport was enveloped in fog. The Pan Am aircraft got too far on the runway and started to turn back. In the KLM aircraft, the captain started the engines, eager to take off. The first officer said: "Wait – we have not yet got the clearance from ATC." The captain: "I know, go ahead and get it." Without waiting for the clearance, he accelerated the engines for take-off, but the Pan Am aircraft was still on the runway and the two aircraft collided. This was the biggest accident in the history of civil aviation; 583 people died, 58 survived. The Accident Investigation Board found that the accident was caused by the fact that the Dutch captain, who was said to be very authoritarian, did not listen to his first officer but started the engines on his own responsibility.

Publication ID: 024

Reference: McCarthy, J. C., P. G. T. Healey, P. C.Wright, and M. D. Harrison (1997). Accountability of work activity in high-consequence work systems: Human error in context. *International Journal of Human-Computer Studies 47*(6), 735–766.

Internet-link and date:
citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.39.369&rep=rep1&type=pdf (retrieved on 30-11-2012)

Publication:

3.1. TENERIFE AIR ACCIDENT
Our description of the Tenerife accident, in the following paragraphs, draws heavily on Weick (1990). He discusses a large number of factors which are likely to have contributed to the collision. For the purposes of our more limited analysis, we will focus on the organisation of the take off with particular reference to factors influencing the decision to commence take-off roll in the absence of formal clearance.
The Tenerife Example
[Source: Weick, 1990]
On March 27 1977, flights KLM 4805 and Pan Am 1736 were both diverted to Los Rodeos, Tenerife as Las Palmas airport, their original destination, was closed because of a bomb explosion. Limited taxi space at Los Rodeos meant that the Pan Am plane had to park behind the KLM plane in such a way that it could not depart until the KLM plane left. When they were ready to leave to continue to Las Palmas, KLM began its taxi for takeoff and was initially directed to proceed down a runway parallel to the takeoff runway. This directive was amended shortly thereafter and KLM was requested to taxi down the takeoff runway and at the end to make a 180 degree turn and await further instruction. Pan Am was requested to follow KLM down the takeoff runway and to leave the takeoff runway at taxiway C3, use the parallel runway for the remainder of the taxi, and then pull in behind the KLM flight.
On arriving at the end of the runway, and making the 180 degree turn to place himself in takeoff position, the KLM captain was advised by the copilot that he should wait because they still did not have an ATC clearance. The captain asked him to request it and he did, but while the copilot was still repeating the clearance, the captain opened the throttle and started to takeoff. Then the copilot, instead of requesting takeoff clearance or advising that they did not yet have it, added to his readback “We are now at takeoff”.
The tower, which was not expecting the aircraft to take off because it had not been given clearance, interpreted this sentence as ‘we are now at takeoff position’. The controller replied “O.K. ... stand by for takeoff ... I will call you.” Pan Am also appeared unclear about its meaning and, in order to make their own position clear, they said “We are still taxiing down the runway”. The tower requested Pan Am to report when it left the runway clear. Pan Am responded to the Tower, “O.K., we’ll report when we’re clear.” On hearing this, the KLM flight engineer asked, “Is he not clear then?” The Captain did not understand him and the engineer repeated “Is he not clear, that Pan American.” The Captain replied with an emphatic “Yes”. The copilot and flight engineer made no further objections. The planes collided about 13 seconds later.

Publication ID: 025

Reference: de Jonge, V. & Sint Nicolaas, J. (2012). Understanding Outstanding – Quality assurance in colonoscopy. Dissertation: April, 20th. Department of Gastroenterology and Hepatology, Erasmus MC University Medical Center, Rotterdam, the Netherlands.

Internet-link and date:
http://repub.eur.nl/res/pub/32162/120420%20Understanding%20Outstanding%20-%20BEWERKT%20-%20J%20Sint%20Nicolaas%20en%20V%20de%20Jonge.pdf (retrieved on 30.11.2012)

Publication:

Following an aeroplane accident with a Pan American 747 and a KLM 747 on Tenerife, Spain, on March 27, 1977, the airline industry became more aware of the importance of the team culture in their industry. During this accident, the air traffic control tower provided the KLM 747 with information meant for the Pan American 747. One of the copilots knew that the information was not intended for the KLM flight, but did not dare to speak-up out of fear to undermine the authority of the senior captain. With 583 fatalities, one of the largest aeroplane accidents in the aviation history made clear how important shared responsibility and team culture is.

Publication ID: 026

Reference: Kerri, H., McRandle, B. & Brokenshire, I. (2007). *Radiotelephoy Readback Compliance and its Relationship to Surface Movement Control Frequency Congestion.* Australian Transport Safety Bureau. ISBN 978-1-9221164-92-7

Internet-link and date: http://www.skybrary.aero/bookshelf/books/442.pdf (retrieved 30.11.2012)

Publication:

The Tenerife Disaster
One of the most tragic accidents in aviation history involved the runway collision between two Boeing 747 aircraft, Pan Am Flight 1736 and KLM Royal Dutch Airlines Flight 4805, at Los Rodeos Airport on the island of Tenerife, Canary Islands on 27 March 1977. Even though there were a number of significant factors that contributed to this disaster and claimed the lives of 583 people, the fundamental cause was the fact that the captain of the KLM aircraft initiated the takeoff without a clearance and did not heed the 'stand by for take-off' instruction from ATC. This was further compounded by that fact that a transmission from ATC ("stand by for take-off…I will call you") and a transmission from the Pan Am crew ("we are still taxiing down the runway") occurred at the same time. This meant that the transmission was not received with full clarity. The accident investigation also identified the use of inadequate language by the KLM pilot as a contributory factor (Subsecretaria de Aviacion Civil of Spain, 1978). The Tenerife disaster remains the most publicised accident highlighting the crucial role communication plays in aviation.

*Publication ID***:** 027

*Reference***:** no author and date mentioned; Intaver Institute Inc., *Frustrated Developer's Syndrome.* Project Decision and Risk Analysis Whitepapers.

*Internet-link and date***:** http://www.intaver.com/Articles/Article_FDS.pdf (retrieved on 30.11.2012)

*Publication***:**

On March 27, 1977, two Boeing 747s, Pan Am Flight 1736 and KLM flight 4805, were preparing to take off on the only runway of Los Rodeos Airport in Tenerife, one of the Canary Islands. KLM Captain Jacob Veldhuyzen van Zanten was known as a firstclass pilot, and was even the preferred pilot for the airline's publicity shots, such as KLM's magazine ads. As the KLM aircraft lined up for take-off, the Pan Am flight was still taxiing on the same runway. Due to the fog, the KLM crew was unable to see the Pan Am 747 taxiing on the runway ahead of them. As they lined up for take-off, the KLM crew received clearance from the control tower to fly a certain route after take-off. Captain van Zanten apparently mistook this clearance as the permission for take-off. The KLM flight engineer expressed his concern about the Pan Am flight not being clear of the runway. The engineer repeated his concern a few seconds later, but was overruled by Captain van Zanten, and made no further challenges to this decision. Shortly after taking off, KLM 4805 crashed into the Pan Am aircraft, killing 583 people and injuring 61. The Tenerife disaster resulted in the highest number of fatalities of any single accident in aviation history. According to the subsequent investigation, communication problems and weather conditions were the primary causes of the accident, but another cause for the disaster was identified. Some experts suggested that the KLM captain, van Zanten, may have developed a kind of governance attitude that impaired the decision-making process in the cockpit. The flight engineer apparently hesitated to further challenge him, possibly because van Zanten was not only senior in rank but also one of the most experienced pilots working for the airline.

Publication ID: 028

Reference: Lacagnina, M., Rosenkrans, W., Werfelman, L. & Darby, R.(2006). High Stakes in Language Proficiency. *Flight Safety Digest*, 25. ISSN 1057.5588

Internet-link and date: http://flightsafety.org/fsd/fsd_jan-feb06.pdf (retrieved on 30.11.2012)

Publication:

'We Are Now at Takeoff'
The ground collision cited by ICAO involved two Boeing 747s at Los Rodeos Airport in Tenerife, Canary Islands, Spain, on March 27, 1977.2 Visibility was reduced substantially by fog when a controller issued departure instructions to the flight crew of a KLM 747 that was lined up for takeoff on the runway. The first officer, whose native language was Dutch, read back the controller's instructions and said, "We are now at takeoff." The controller, whose native language was Spanish, did not understand that the first officer's transmission was meant to convey that the KLM crew were conducting a takeoff. Instead, the controller believed that the KLM crew were maintaining the airplane's position on the runway and awaiting takeoff clearance. The controller acknowledged the first officer's transmission by saying, "OK. Stand by for takeoff. I will call you." At the same time, the flight crew of a Pan American 747 radioed, "We are still taxiing down the runway." The simultaneous transmissions by the controller and the Pan Am crew resulted in a whistling sound on the radio frequency that lasted three seconds. The controller told the Pan Am crew to report clear of the runway, and the Pan Am crew acknowledged the instruction. Soon thereafter, the flight engineer aboard the KLM airplane asked his colleagues if the Pan Am airplane was clear of the runway. The KLM captain replied, "Oh, yes." The KLM airplane was being rotated for takeoff when it struck the Pan Am airplane. A total of 583 people were killed in the collision. In its final report, the Spanish government said that the fundamental cause of the accident was that the KLM captain "took off without clearance; did not obey the 'stand by for takeoff' [instruction] from the tower; did not interrupt takeoff when Pan Am reported that they were still on the runway; [and,] in reply to the flight engineer's query as to whether the Pan Am [airplane] had already left the runway, replied emphatically in the affirmative."

Publication ID: 029

Reference: Appel, M. (2010). *Aviation-Style Checklists*. Paper prepared for: Patient Safety Committee, Northeast Georgia Medical Center.

Internet-link and date: http://ww1.prweb.com/prfiles/2011/11/27/8993407/Checklist%20Web.pdf (retrieved on 01.12.2012)

Publication:

On March 27, 1977 in Tenerife, Canary Islands, two Boeing 747's (Pan Am and KLM) collided on the runway, killing 583 people: the worst aircraft accident in aviation history. One of the pilots in the KLM 747 cockpit, waiting in position on the runway, transmitted "we are now at takeoff": a vague phrase which to them meant "we are now taking off", but which was so ambiguous that its true meaning was missed by all others on the frequency. Indeed, the KLM jumbo immediately applied full takeoff power, thus beginning their runway roll and initiating an accident sequence which would have 583 passengers dead in the next 30 seconds. If any others on that radio frequency, including the air traffic controllers, the Pan Am pilots, or even the crews of other aircraft, had properly interpreted the meaning of "we are now at takeoff", the accident might have been avoided.

*Publication ID***:** 030

*Reference***:** Anderson, B. L., "The Psychology of Safety", 29th International System Safety Conference (ISSC), Las Vegas, NV; United States, 8-12 Aug. 2011.

Internet-link and date:
http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20110015735_2011016603.pdf (retrieved on 30.11.2012)

Publication:

This thought process was set into motion by reading of the Tenerife Island aviation disaster (ref. 1). In 1977 a collision between two Boeing 747 craft caused what is still the deadliest aviation accident. The pilot of KLM Flight 4805 began take off without tower clearance in heavy fog on the airport's only runway, crashing into the other Boeing 747 which was back taxiing on the runway. Ironically the pilot of KLM Flight 4805 had just returned from teaching a six month safety class for pilots. Why would a pilot so well trained and known for his safety record throw all that experience and knowledge away in a moment, leading to the death of 583 people? There are straightforward answers such as schedule pressures, cost, and so forth. However, it seemed that there must be something more. The pilot, in all likelihood, considered the opposite side of the equation. Certainly he had been under pressure in the past and had not made a disastrously unsafe choice before. Again, he was well known for his safety record. A simple answer seemed too simple.

*Publication ID***:** 031

*Reference***:** Hughes, R. (2007). Aviation Human Factors News, Vol 3, Issue 23. jetBlue Airways.

*Internet-link and date***:** http://www.system-safety.com/Aviation%20HF%20News/2007/Aviation%20HF%20News%202307%20.pdf (retrieved on 30-11-2012)

*Publication***:**

The NASA research presented at a meeting found that the primary cause of majority of aviation accidents was human error, and that the main problems were failures of interpersonal communication, leadership, and decision making in the cockpit. A textbook example of such an event was the catastrophic accident the infamous Tenerife disaster. (Los Rodeos, Tenerife's North airport is, unfortunately, famous for the fateful accident which occurred on March 27, 1977, in which 583 people died when KLM and Pan Am 747s collided on a crowded, foggy runway in Tenerife, Canary Islands. The incident remains the world's worst aviation accident in history. Many contributing factors, lead up to the crash, but the probable cause, cited by the Air Line Pilots Association (ALPA, 1978), was the KLM pilot taking off without takeoff clearance.

Publication ID: 032

Reference: (no year mentioned) Florez, C. E..ADF Gazzette, 4th Issue published by ADF Airways, Miami.

Internet-link and date: http://www.adfairways.net/wp-content/uploads/ADFGazette_2002-07.pdf (retrieved on 01.12.2012)

Publication:

In March 27th, 1977, 583 people were killed when a Boeing 747 crashed into another Boeing 747 on the runway in Tenerife, Canary Islands. This is still the worst accident in aviation history and it was caused by a lack of situational awareness on all parties. During thick fog, the first 747 did not understand that the other 747 was still on the runway when it initiated take-off. Meanwhile, the crew of the other 747 did not clearly understand which exit to take out of the runway or the fact that the first 747 was about to take-off from the
runway and the danger it posed. The tower controllers were miserably lacking situational awareness since they lacked the understanding that taxiing two Boeing 747s in thick fog was a recipe for disaster.

*Publication ID***:** 033

*Reference***:** Cowlagi R. V. & Saleh, J. H. (2012). Coordinability and Constistency in Accident Causation and Prevention: Formal System-Theoretic Concepts for Safety in Multilevel Systems. *Risk Analysis*, 10, 1-15.

*Internet-link and date***:** http://ares.lids.mit.edu/~rcowlagi/papers/RA12-Coordinability.pdf (retrieved on 01.12.2012)

Publication:

3.1 Civil Aviation: The Tenerife Disaster
The Tenerife accident is considered the worst disaster in aviation history. A brief description of the accident is here provided as it appeared in the accident investigation report (25)
3.1.1 Facts and Description
On March 27, 1977, about 1706 local time, Pan Am Flight 1736, a Boeing 747-121, collided with KLM Flight 4805, a Boeing 747-206B on the only runway of Los Rodeos Airport, Tenerife, Spain. The Pan Am flight was back-taxiing along the runway and was instructed to take exit C-3 off the runway towards the hold-short line, but missed the exit. The KLM flight was holding short at the same runway, and attempted take-off while the Pan Am flight was still on the runway. The KLM flight was traveling at approximately 160 mph when its landing gear and its engines collided with the fuselage of the Pan Am flight. All 234 passengers and 14 members of the flight crew aboard the KLM flight were killed in the accident. Of the 380 passengers and 16 members of the flight crew aboard the Pan Am flight, only 61 passengers and 5 crew members survived. Overall, the accident involved a loss of 583 lives.
The disaster was the result of a significant number of contributing factors: a bomb scare at the original destination of both aircraft (Gran Canaria Airport); a crowded airport at Tenerife as a result of the closing of Gran Canaria; an undermanned ATC that weekend at Tenerife and inexperienced in handling high traffic load; fog descending on the single runway and significantly limiting visibility; and communication problems and ambiguities between ATC and crew. These factors have been thoroughly commented upon in the press and the technical literature and will not be repeated here. Instead, we focus on one aspect of the disaster, described as follows:
The investigation of the accident (25) reveals that the ATC instructed the Pan Am flight crew to begin taxiing to the start of the only runway of the airport at about 1702 local time. Due to congestion at the airport, the Pan Am flight crew was instructed to taxi along a portion of the runway itself in the reverse direction (this process is known as \backtaxiing") and take exit C-3 off the runway. However, the Pan Am flight crew was unable to identify and follow the assigned taxi route, specifically, they were unable to locate exit C-3 and continued backtaxiing along the runway. The fatal coincidence in this disaster was the premature take-off of the KLM7 coupled with the taxing too far of the Pan Am. It is interesting note that the Dutch authorities conducted separate ground tests and concluded \in all probability no fatal collision would have occurred if the Pan Am aircraft had not taxied farther than the third intersection, which was emphatically instructed by the tower controller" (26). Degraded visibility at the airport and other evidence clearly support the conclusion that the exit was not identifiable for the Pan Am crew.

Publication ID: 034

Reference: Penven, D. & Saleet, P. (2012). Carolina WingSpan, The official newsletter of the Civil Air Patrol, North Carolina Wing HQ, U.S. Air Force Auxiliary.

Internet-link and date:
http://www.ncwg.cap.gov/UserFiles/File/PAO/Carolina_WingSpan/April_2012.pdf (retrieved on 01.12.2012)

Publication:

Historically Speaking
Disaster at Tenerife, Canary Islands
This month I am straying from North Carolina Wing History, to the Canary Islands off the Coast of Africa to tell the story of the worst airline disaster in history. It is also a story of the courage of one young woman
who was in the midst of this horrible accident. This disaster occurred on March 27, 1977. Two Boeing 747 aircraft collided on the runway of Los Rodeos Airport on the Spanish Island of Tenerife. 583 people died that day. The aircraft involved were KLM Flight 4805 and Pan Am flight 1736. These two aircraft were diverted with many others to Los Rodeos because a bomb had exploded at Gran Canaria Airport their original destination. Due to the size of Tenerife's airport the Air Traffic Controllers were forced to park many of the airplanes on the taxiway, thereby blocking it. Further complicating the situation a dense fog developed greatly reducing visibility. With fog rolling in and no ground radar the only way the controllers could know the location of aircraft was by radio communication. As a result of several misunderstandings in communications the KLM flight attempted to take off while the Pan Am aircraft was still on the runway. The resulting collision destroyed both aircraft and cost the lives of all 248 passengers onboard KLM and 335 passengers onboard Pan Am. Sixty-one people did miraculously survive on Pan Am, including the pilots, flight engineer and four flight attendants. When Gran Canaria, reopened the aircraft at Los Rodeos were given permission to begin preparations for takeoff. To begin the process KLM and Pan Am were both given permission to taxi out onto the runway. KLM, was cleared to taxi to the end of the runway and hold until the Pan AM aircraft turned off the runway at taxiway number 3. In the fog Pan Am missed taxiway 3 and mistook taxiway 4 as their turnoff point. The Captain onboard KLM misunderstood the tower communication telling Pan Am to clear the runway as clearance for him to takeoff. KLM 4805 rolled down the runway and did not see Pan Am 1736 until it was too late to abort. The Captain did his best to clear the Pan AM 747 pulling back so hard on the stick that the tail struck the ground as they tried to climb. The landing gear of the KLM 747 took the Upper Deck Lounge off, and caused the right wing off Pan AM 1736 to burst into flame.

*Publication ID***:** 035

*Reference***:** Batteau, A. W. (2009). Technological Peripheralization. *Science, Technology &Human Values,* 35, 554-574.

*Internet-link and date***:** http://sth.sagepub.com/content/early/2009/10/27/0162243909345834.full.pdf (retrieved on 01.12.2012)

Publication:

The most notable of these, and the worst disaster in aviation history, occurred on March 27, 1977, on the ground in Tenerife, when the stresses of a crowded airport were compounded with an irregular procedure, with use of nonstandard communication phraseology, and with schedule pressures, resulting in a breakdown of crew coordination and the collision of a Pan Am and a KLM 747 on the runway. The Tenerife disaster, in which 583 passengers and crew died, illustrates the fragility air transport in which unexpected complexities (in this case, of language and geography) exceed the tolerances of the system. In Karl Weick's analysis, a normally robust system was ‘‘vulnerable’’ to rapid degradation into the combination of complexity and tight coupling that leads to a ‘‘normal accident’’ (Perrow 1984; Weick 1990).

*Publication ID***:** 036

*Reference***:** Ford, J. R. (2010). *The Effects of Joint Flight Attendant and Flight Crew CRM Training Programmes on Intergroup Teamwork and Communication*. A thesis submitted for the Degree of Doctor of Philosophy at the University of Otago, Dunedin,New Zealand

Internet-link and date:
http://otago.ourarchive.ac.nz/bitstream/handle/10523/1614/JaneFordR2011PhDpdf..pdf?sequence=1 (retrieved on 01.12.2012)

Publication:

CASE 2: TENERIFE
Another accident occurred in Tenerife, Canary Islands in May 1977 when a KLM B747 Flight 4805 started to take off in heavy fog without ensuring the runway was clear. It crashed into a Pan American B747 already on the runway. There was confusion over whether Air Traffic Control (ATC) had cleared the aircraft for take off as there was other talk happening at the same time. This included the Pan American flight reporting that they were still on the runway. Unfortunately this transmission was not heard by the KLM B747 crew who reported that they were now at takeoff. There was a brief discussion on the KLM flight deck as to whether the Pan American aircraft had turned off the runway. This accident was an example of the need for training which recognized that crew performance involves group performance rather than an individual working without listening to the opinions of other crew members (O'Hare and Roscoe, 1990).
The Dutch Aircraft Accident Report stated that the direct cause of the accident occurred due to the Captain's decision to take off without ensuring the runway was clear (Kayten, 1993). Additional possible contributory factors were commercial pressure to take off as delays had meant that a new crew would need to be dispatched due to crew flight time limitations. Poor visibility on the runway would have made it difficult to see that the Pan Am flight had not left the third runway intersection. A third factor could have been poor reception which meant that the crews had difficulty hearing Air Traffic Control (ATC) instructions clearly (O'Hare, St George & Isaac (1993).

Publication ID: 037

Reference: McElhatton, J. & Drew, C. (1993).'Hurry-up' Syndrome Identified as a Causal Factor in Aviation Safety Incidents. *Human Factors & Aviation Medicine,* 40. Flight Safety Foundation.

Internet-link and date: http://flightsafety.org/hf/hf_sep-oct93.pdf (01.12.2012)

Publication:

Aviation's worst disaster, the catastrophic KLM-Royal Dutch Airlines/Pan American World Airways (Pan Am) accident at Tenerife, Canary Islands, in March 1977, involved time pressure, which contributed to a disregard or a failure to recognize safety hazards by the flight crews.
[Two Boeing 747's, one operated by KLM and the other by Pan Am, collided when the KLM flight was taking off and the Pan Am flight was taxiing on the runway. Both aircraft caught fire and were destroyed; there were 61 survivors. A total of 583 people were killed in the accident. An investigation cited the KLM pilot for not following approved procedures and not aborting the takeoff. Misunderstanding of orders and instructions, and low ceiling and fog were also cited as causal factors.]
The Air Line Pilots Association (ALPA) conducted an 18-month, three country investigation of the accident, with an emphasis on the human factors of flight crew performance. ALPA found that the KLM crew members had strong concerns that they would be able to return to Amsterdam that evening and remain within their complex duty-time regulations. Crew members also expressed concern about weather and its potential to delay the impending takeoff. The cockpit voice recorder indicates the captain said, "Hurry, or else it [the weather] will close again completely."
The Pan Am crew was equally concerned with potential poor-weather delays. They experienced a delay of more than an hour because the KLM flight crew decided to refuel – the KLM aircraft and fuel trucks blocked the taxiway, thus preventing Pan Am's departure. These time-pressure problems set the stage for the Hurry-up catastrophe.

Publication ID: 038

Reference: Norman, D. A. (1980). Twelve Issues for Cognitive Science. *Cognitive Science,* 4, 1-32.

Internet-link and date: http://www.sciencedirect.com/science/article/pii/S036402138180002X#
(retrieved on 01.12.2012)

Publication:

Tenerife
In March of 1977, two Boeing 747 airliners collided on a runway at Tenerife, in the Canary Islands. The crash killed 582 people. What caused the accident? No single factor. The crash resulted from a complex interaction of events, including problems of attentional focus, the effects of expectation upon language understanding that combined with an inability to communicate effectively over a technically limited communication channel when there were major difficulties in language (although all involved were speaking English), the subtle effects of differences of social structure among the participants, the effects of stress, economic responsibilities and social and cultural factors upon decision making. All in all, it is a fascinating-if horrifying-story for Cognitive Science.

*Publication ID***:** 039

*Reference***:** de Jonge, V., Sint Nicolaas, J., van Leerdam, M. E. & Kuipers, E. J. (2011). Overview over the quality assurance movement in health care. *Best Practice & Research Clinical Gastroenterology,* 25, 337-347.

*Internet-link and date***:** http://www.sciencedirect.com/science/article/pii/S1521691811000539# (retrieved on 01.12.2012)

Publication:

Following an aeroplane accident with a Pan American 747 and a KLM 747 on Tenerife, Spain, on March 27,1977, the airline industry became more aware of the importance of the team culture in their industry [45]. During this accident, the air traffic control tower provided the KLM 747 with information meant for the Pan American 747. One of the copilots knew that the information was not intended for the KLM flight, but did not dare to speak-up out of fear to undermine the authority of the senior captain. With 583 fatalities, one of the largest aeroplane accidents in the aviation history made clear how important shared responsibility and team culture is.

*Publication ID***:** 040

Reference: Frush, D. P. & Frush, K. S. (2006). In s New Kind of Light: Patient Safety in Pediatric Radiology. *Clinical Pediatric Emergency Medicine,* 7, 255-260.

*Internet-link and date***:** http://www.sciencedirect.com/science/article/pii/S1522840106000802# (retrieved on 01.12.2012)

Publication:

On March 27, 1977, 583 people were killed as a result of a collision in the Canary Islands between KLM and Pan Am 747 aircraft. There were multiple predisposing factors that conspired to cause this tragedy. (1) Unexpected conditions: there was a terrorist threat that caused one of the planes to divert from the airport in the Canary Islands to a smaller airport at Tenerife (this was necessary for refueling, and the threat ended up being incorrect). There were also poor weather conditions that prevented the 2 aircraft on the runway from seeing each other and the control tower from seeing these planes. The taxiing and takeoff runways at the
regional Tenerife airport were the same. (2) Miscommunication: the KLM aircraft crew did not all speak English as their first language. Arguably, misinterpretation of the communication, which was in English, was a factor, including the KLM captain who mistook clearance for a takeoff route for the Pan Am jet as permission for takeoff for the KLM jet. There was also simultaneous communication between the airliners and the tower that prevented the communication from the tower from being heard by the pilots. (3) Lack of preparation: there was no runway radar. (4) Change in protocol: the Pan Am jet was taxiing to an exit but went past the exit they were instructed to use, assuming that the next exit (offering a less difficult maneuver) was the one that was really their intended exit. (5) Authority: the KLM flight engineer questioned that the communication from the Pan Am jet from the tower meant that the Pan Am crew would report when the runway was clear. This was overruled by the captain saying that the runway was clear, with no challenge by the appropriate individuals. This was an experienced, well-respected pilot. (6) The event: the planes collide on the runway. The probability of all these factors coming together was remote, but still happened.

*Publication ID***:** 041

*Reference***:** Eggert, J. R., Howes, B.R., Picardi Kuffner, M., Wilhelmsen, H. & Bernays, D. J. (2006). Operational Evaluation of Runway Status Lights. *Lincoln Laboratory Journal,* 16, 123-146.

Internet-link and date:
citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.72.8084&rep=rep1&type=pdf (retrieved on 01.12.2012)

Publication:

In fact, the world's worst aviation accident was the 1977 collision between two Boeing 747 aircraft on Runway 30 of the Los Rodeos airport in Tenerife, Canary Islands. Figure 1 illustrates this accident, which resulted in the loss of 583 lives.

FIGURE 1. (a) Airport plan of Los Rodeos Airport, Tenerife, Canary Islands, detailing the movement of the two planes before the accident on 27 March 1977. (b) Survivors and fire after the Tenerife accident. Miscommunications between crews and the air traffic control (ATC) tower led to a collision between two heavily loaded Boeing 747 airliners. Not realizing that the runway was blocked by a taxiing aircraft (Pan Am Flight 1736) on Runway 30, the crew of KLM Flight 4805 began their takeoff roll after believing that ATC had issued a takeoff clearance. Visibility was so poor that neither crew saw the other until a collision was unavoidable. In the collision and resulting fire, 583 people perished. (Photograph courtesy of www.1001crash.com.)

*Publication ID***:** 042

*Reference***:** Green, R. (1983). Aviation Medicine - Aviation psychology – II: Assessing workload and selecting pilots. *British Medical Journal,* 286, 1947-1949.

*Internet-link and date***:** http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1548299/pdf/bmjcred00558-0031.pdf (retrieved on 01.12.2012)

Publication:

The worst accident in aviation history occurred when two Boeing 747s collided in fog at Tenerife. The captain of the aircraft that was taking off believed that he had received radio clearance to do so. The cockpit
voice recording makes it clear that the first officer had heard no such clearance, and while he did express a reservation to the captain he did not force the captain to wait until he had ensured personally that take off clearance was confirmed. Why he did not can only be surmised, but the reluctance of a first officer to
express doubt in the competence of his captain is natural and has been clearly shown in a recent survey.

*Publication ID***:** 043

*Reference***:** Hummels, H. (1997). Safety and Aircraft Maintenance: A Moral Evaluation. *International Journal of Value-Based Management*, 10, 127-146.

*Internet-link and date***:** http://link.springer.com/article/10.1023%2FA%3A1007793521376?LI=true (retrieved on 01.12.2012)

Publication:

On March 27, 1977, KLM flight 4805 and Pan Am flight 1736 were both heading for Las Palmas when they were diverted to Los Rodeos airport at Tenerife. At 16.56 KLM began its taxi for takeoff to Las Palmas, but was shortly thereafter ordered to taxi down the takeoff runway and at the end to make a 180 degree turn. It should then wait for further instruction. Pan Am was requested to follow KLM down the takeoff runway and to leave the runway at taxi way C3. After they had made the 180 degree turn, the KLM plane started moving – instead of holding as instructed – reporting 'we are now at takeoff.' The collision occurred 13 seconds later at 17.06 hours. None of the 234 passengers and 14 crew on the KLM flight survived. Of the 380 passengers and 16 crewmembers on the PanAm plane, 70 survived, although 9 died later, making a total loss of 538 lives (Weick, 1990).

*Publication ID***:** 044

*Reference***:** Nemeth, C. P. (2008). Improving Healthcare Team Communication – Building on Lessons from Aviation and Aerospace. Ashgate Publishing Limited: England.

Internet-link and date:
http://books.google.nl/books?hl=de&lr=&id=_FQMiM5P_ygC&oi=fnd&pg=PA47&dq=Tenerife+accident&ots=dgwyBNWhMj&sig=rzsug69W1mJwyw4no44MPXC7d8U&redir_esc=y#v=onepage&q=tenerife&f=false (retrieved on 03.12.2012)

Publication:

Four years later, on March 27, 1976, a Royal Dutch Airlines (KLM) 747 and a Pan American Airlines (Pan Am) 747 collided on the runway in Tenerife. Between the two aircraft, 583 lives were lost in what is still the single worst aviation accident in history. The chain of events leading to this disaster is more complex than that of Eastern Flight 401, yet again, the behavior of crew members during the final moments was determined by investigators to be a critical factor in the evolution of this accident. These two aircraft were among several jetliners that had been diverted to Los Rodeos Airport in northern Tenerife when a terrorist bomb blast temporarily closed the main airport, Gran Canaria International. This diversion combined with long duty hours and bad weather, set the stage for confusion during taxiing and take-off when Gran Canaria reopened after several hours. Non-standard radio communication and the dangerous practice of clearing aircraft to taxi and depart when no one had clear visibility of aircraft positions were both felt to be contributory to this accident. The collision occurred as the KLM aircraft accelerates on its take-off roll and as the Pan Am jet taxied along the same runway, the Dutch jet attempting to lift off over the American aircraft as it emerged from the fog. This accident is significant to the history of ARM in that a steep command hierarchy and a lack of mutual agreement about the decision to proceed with take-off on the flight deck of the KLM 747 were felt to be the key contributing factors to this accident (CAIAC 1978; International Civil Aviation Organization 1984).

Publication ID: 045

Reference: Rao, S. (2007). Safety culture and accident analysis – A socio-management approach based on organizational safety social capital. *Journal of Hazardous Materials*, 142, 730-740.

Internet-link and date: http://www.sciencedirect.com/science/article/pii/S0304389406007515 (retrieved on 03.12.2012)

Publication:

4.1.3. The Tenerife Air Tragedy [26,27]
On a foggy early evening of 27 March 1977 two Boeing 747s—Pan Am 1736 and KLM 4805 collided on the runway of Los Rodeos Airport on the Tenerife Island. Five hundred and sixty people lost their lives, over 60 were injured and the airplanes were completely charred. The immediate cause of the accident was the impact of KLM 4805 on the Pan Am 1736 due a take-off operation by the KLM captain, without obtaining the final clearance from ATC. That non-compliance, catalyzed by a general communication gap and an unexpected thick fog finally resulted in the air tragedy.

Publication ID: 046

Reference: Antoniou, A.-S. G., Cooper, C. L., Chrousos, G. P., Spielberger, C. D. & Eysenck, M. W. (2009). *Handbook of Managerial Behavior and Occupational Health*. Edward Elgar: UK.

Internet-link and date:
http://books.google.nl/books?hl=de&lr=&id=Idw2QA8VPNgC&oi=fnd&pg=PA130&dq=Tenerife+accident&ots=DRK2HbC_F1&sig=hIEaMcYqIMgc4lVXh0HERi1W0f0&redir_esc=y#v=onepage&q=tenerife&f=false (retrieved on 03.12.2012)

Publication:

In the late 1970s, the aviation industry realized that failures in non-technical skills were linked to aircraft safety, when a series of major accidents occurred that did not have a primary technical cause. The most significant of these occurred in Tenerife in 1977, when two Boeing 747 aircraft (operated by KLM and Pan Am) crashed on a runway at Los Rodeos airport, killing 583 passengers and crew. Analysis of the accident revealed problems relating to communication with air traffic control, team coordination, leadership and decision making on the KLM flight deck, plus effects of fatigue (Weick, 1990). In other countries, similar accidents showing non-technical causes had been reported. In the USA, three United Airlines planes crashed in the late 1970s, and like the Tenerife accident, these were attributed to 'pilot error' rather than to technical faults.

Publication ID: 047

Reference: Cook, M. J. & Ward, G. (1997). Decision making, Planning and Teams. *The Institution of Electrical Engineers,* 1-22.

Internet-link and date: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=643094&tag=1 (retrieved on 03.12.2012)

Publication:

All too often first officers, like that on the KLM 747 which crashed at Tenerife, can be hesitant but even if they talk they may be ignored. In the Tenerife crash the Captain ignored the initial warning of the first officer and the first officer did not attempt a second challenge, when the Captain started the engines to begin takeoff failing to insist that they were not cleared for take-off. The faulty decision-making by the Captain was preceded by an ominous silence and this absence of communication should have indicated a problem prior to the crash with another Pan Am 747 taxiing up the runway.

Publication ID: 048

Reference: Vernaleken, C. (2011). Autonomous and Air-Ground Cooperative Onboard Systems for Surface Movement Incident Prevention. Dissertation: Technische Universität zu Darmstadt

Internet-link and date: http://tuprints.ulb.tu-darmstadt.de/2611/1/Dissertation_Vernaleken_2011.pdf (retrieved on 03.12.2012)

Publication:

(Table 2.)

Date	Location	Aircraft #1	Aircraft #2	Dead Victims	Meteorological Conditions
27.03.1977	Los Rodeos Airport (GCXO) Tenerife	KLM B747-200 PH-BUF KLM 4805	PanAm B747-100 N736PA	583	Daytime IMC Fog and low clouds

During take-off in dense fog, the KLM Boeing 747 collided with the Pan Am aircraft, which was still backtracking RWY 30 (cf. Figure 8) because all taxiways were crammed with other aircraft after a massdivertion [ICA80].

- The KLM crew was not aware that Pan AM was still on the runway (Lack of Traffic Awareness).
- The KLM captain commenced take-off erroneously believing he had the appropriate clearance (Issue with ATC Instructions/ Clearances).
- There was a misunderstanding as to whether ATC clearance included t/O clearance or not. R/T communication impaired by squeal (Communication Issue).

*Publication ID***:** 049

*Reference***:** Morrison, J. B. & Rudoplh, J. W. (2011). Learning from Accident and Error: Avoiding the Hazards of Workload, Stress, and Routine Interruptions in the Emergency Department. *Academic Emergency Medicine,* 1246-1254.

*Internet-link and date***:** http://onlinelibrary.wiley.com/doi/10.1111/j.1553-2712.2011.01231.x/pdf (03.12.2012)

Publication:
The focal case for developing the theory represented here is Weick's report and analysis of a major disaster, an account that chronicles a series of small interruptions that combined to produce the Tenerife (Canary Islands) air disaster that occurred on March 27, 1977. On that day, the Las Palmas airport was unexpectedly closed due to a terrorist bomb attack. Two Boeing 747s, one operated by KLM and the other operated by Pan Am, were diverted to Tenerife because of this. The diversion resulted in a series of small interruptions to plans and standard procedures. The KLM crew had strict duty time constraints, but the diversion interrupted the plan to return to Amsterdam within those limits. Plans to leave the airfield were interrupted by a cloud drifting 3000 feet down the runway. The runways at Tenerife were not designed for 747s, so their narrow widths interrupted protocols for normal maneuvering. Transmissions from the central tower were both garbled and nonstandard, interrupting the usual preflight communications patterns and protocols. As the situation progressed, the KLM crew communicated less and less clearly, and eventually the KLM captain, directly violating standard procedure, cleared himself for takeoff. He began accelerating the plane in an effort to outrace a cloud floating toward him at the other end of the runway. Meanwhile, the Pan Am aircraft had missed its parking turnoff due to the limited visibility and was parked at the other end of the runway, obscured by the very cloud the KLM pilot was trying to outrun. The KLM plane collided with the Pan Am plane, killing all 583 people on both planes in one of the worst accidents in aviation history.

*Publication ID***:** 050

*Reference***:** Campbell-Laird, K. (2004). Aviation English: A review of the Language of International Civil Aviation. *IEEE*, 253-261.

*Internet-link and date***:** http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1375306&tag=1 (retrieved on 03.12.2012)

Publication:

Varantola related the 1977 Tenerife aviation accident and provided a brief transcript of the misleading communications just prior to the collision of a KLM 747 on take off into a Pan Am 747 which had not yet cleared the active runway [7, pp.180-181]. The transcript noted the KLM pilot as stating, "We are now ready on (or at) takeoff." Other literature supports the ''ready at takeoff quote and also states that in Dutch syntax "at takeoff would be the same thing as ''taking off." Most native speakers of English would not know this distinction. It is understandable that the first language Spanish-speaking controller was equally unaware of the meaning of the Dutch KLM pilot.

Publication ID: 051

Reference: Hoppe, E. A. (2011). *Ethical Issues in Aviation*. Ashgate: England.

Internet-link and date:
http://books.google.nl/books?hl=de&lr=&id=G1d1ZLG4Fk4C&oi=fnd&pg=PA19&dq=Tenerife+accident&ots=SITZ6pE-pB&sig=ctcq_2NoM7OjRtg7_MZoC3XpQMQ&redir_esc=y#v=snippet&q=tenerife&f=false
(retrieved on 03.12.2012)

Publication:

The worst commercial air disaster occurred in 1977 when a Pan Am 747 and a KLM 747 collided in Tenerife, Canary Islands; an accident in which 583 people lost their lives. Like most tragedies, what happened must be described as the result of multiple contributing causal factors. The aircraft had been diverted to Tenerife because of a terrorist incident at the larger Las Palmas airport, and the smaller Tenerife facility was being stretched by the quantity and size of the equipment. Fog and light rain had enveloped the airport. And there were communication problems, both involving language and equipment. Investigators have generally agreed that at the crucial moment, KLM Captain Jacob van Zanten's impatience, overconfidence and unquestioned authority amongst his crew, all played a significant role in the accident. In an important sense, then, it was van Zanten's character traits that precipitated the accident. If he had been more patient, if he had been more open-minded to ambiguity, if he has been willing to listen to his crew's input and questioning, the accident would not have happened.

Publication ID: 052

Reference: Boschen, A. C. & Jones, R. K. (2004). Aviation Language Problem: Improving Pilot-Controller Communication. *IEEE*, 291-299.

Internet-link and date: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1375313&tag=1
(retrieved on 03.12.2012)

Publication:

The accident at Tenerife in 1977 is another example of runway incursions. The Dutch KLM pilot started down the runway and crashed into a 747 full of people. He had misunderstood an information statement from the tower to be permission to take off. Then he thought he advised the tower that he was in the process of taking off. His actual wording of English, "3AT takeoff 2" signified to the tower that he was obediently sitting in position to start flight when given permission, but the AT in the Dutch language carries the same meaning as -ING in English. So he thought that he told the tower that he was taking off; but the tower thought he was motionless and didn't warn the other plane. The result was 583 fiery deaths, the worst accident in aviation history.

*Publication ID***:** 053

*Reference***:** Wright, P. C. (1994). *The Pragmatics of Interaction*. Notes from the January IRS (Interactionally Rich Systems) Meeting, Magdeburg, Germany.

Internet-link and date:
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.51.8187&rep=rep1&type=pdf (retrieved on 03.12.2012)

Publication:

As an example of ambiguous transmission, we can consider the Tenerife air crash in which two Boeing 747 aircraft collided on the ground in thick fog. One aircraft was taxiing at the end of the runway while another was idling at the start of the runway waiting for the runway to become clear. The pilot of the waiting aircraft began the take-off roll unexpectedly before the other aircraft was clear of the end of runway. Suspecting a problem the second officer informed the tower that they were at takeoff . This utterance is not in what Falzon (op. cit.) terms the operational language of air traffic control. That is to say it is not a standard utterance in this situation. As Falzon points out in surprising and emergency situations people often do move outside this standard language. The problem here is that the thin meaning of the utterance is ambiguous and could be taken to mean either 'we are beginning our take-off roll or 'we are at the take off point (i.e. the end of the runway). Neither the air traffic controllers at the time of the accident nor the accident analysts subsequently, were able to disambiguate this transmission.

Publication ID: 054

Reference: Bergeon, F. (2009). Swiss cheese and the PRiMA model: what can information technology learn from aviation accidents? *The Journal of Operational Risk*, 4, 47-58.

Internet-link and date: http://www.risk.net/digital_assets/4653/jop_v4n3a3.pdf (retrieved on 03.12.2012)

Publication:

Tenerife, Canary Islands, March 1977. A bomb scare at the busy Las Palmas airport on Spain's Grand Canary Island closed the airport to all operations (Owen (2002)). Numerous heavy airliners were diverted to the smaller Tenerife airport. The regional airport was not prepared to handle so many large aircraft. Unable to park on the overflowing airport ramp, several airliners were held on a portion of the main taxiway while they waited for the Las Palmas airport to reopen. During normal operations, departing aircraft would make their way down the parallel taxiway until reaching the end, and then enter the runway to line up for takeoff. But on this day, parked airliners blocked the taxiway. Departing airplanes had to taxi onto a portion of the active runway to get around the congested area.

1 THE WORST ACCIDENT IN AVIATION HISTORY

A Dutch KLM Boeing 747 is finishing its turn to line up on the departure runway. Meanwhile, a Pan Am Boeing 747 is in the process of taxiing on a portion of the same runway for a subsequent departure. The Pan Am aircraft is supposed to exit the runway and join the parallel taxiway once clear of the congested area (see Figure 1). Visibility is bad, as atmospheric conditions have brought in dense fog from the ocean. The controller calls the KLM crew on the radio to give them the routing to Las Palmas. Both pilot and controller speak English during the course of their daily duties but not as their native language – the pilot speaks Dutch, the controller Spanish. The pilots acknowledge the routing but think that they have also been cleared for takeoff. The Pan Am crew, on the other hand, is unclear about its aircraft's position on the runway or where to exit in order to rejoin the taxiway. Fog prevents both crews from seeing each other's aircraft, and there is no view of either airliner from the control tower. The KLM Boeing starts its takeoff roll while the Pan Am 747 is still on the runway. The two jumbo jets collide before anyone realizes what is happening. The 589 victims among passengers and crewmembers of both airliners make this the worst accident in aviation history – and a landmark case that is thoroughly studied for years to come. Aviation safety analysts agree that this disaster could have been averted in a number of ways. The ensuing investigation revealed, for example, that many misinterpretations and false assumptions took place. For instance, cockpit voice recorder transcripts showed that the KLM pilot was certain that he had been cleared for takeoff. The surviving Pan Am pilot, on the other hand, was convinced that they had been instructed to take an exit located further down the runway. As a consequence of this tragedy, sweeping changes were made to operating procedures and regulations governing airline travel.

*Publication ID***:** 055

*Reference***:** Strother, J. B. (1999). Communication Failures Lead to Airline Disasters. *IEEE*, 29-34.

*Internet-link and date***:** http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=799097 (retrieved on 03.12.2012)

Publication:

In fact the worst aviation disaster in history resulted from a simple communication error. The date was March 27, 1977, the place Tenerife, Canary Islands. When the pilot of a KLM 747 started his take-off roll down a foggy runway, he radioed the tower "We are now at takeoff." With those words the fate of 583 passengers was sealed. The controller misunderstood this ambiguous statement and incorrectly interpreted it to mean "We are at our take-off position and holding." After all, that was what the tower had instructed the KLM pilot to do. Therefore, he did not warn the Dutch pilot that a Pan American 747, which was invisible in the thick fog, was still on the runway. The Pan American crew saw the lights from the KLM plan approaching them and made a desperate but unsuccessful attempt to clear the runway before the now barely airborne KLM plane sliced through them (Cushing, 1998). Part of the miscommunication problem that occurred at Tenerife was the result of the Dutch pilot doing what linguists call code switching. Cushing (1994) explains that code switching occurs when bilingual and multilingual speakers habitually switched back and forth from one of their languages to another in the course of a conversation. Essentially the KLM pilot was speaking English words but using Dutch grammatical sentence structure. For him, the phraseology "taking-off is the Dutch equivalent of "at" plus the infinitive "(to) take-off." He really meant that he was taking off, not that he was holding at the take-off point.

*Publication ID***:** 056

*Reference***:** Bargiela-Chiappini, F. (2009). *The Handbook of Business Discourse*. Edinburgh University Press: Edinburgh.

Internet-link and date:
http://books.google.nl/books?hl=de&lr=&id=wOTcr9mrtEUC&oi=fnd&pg=PA180&dq=Tenerife+accident&ots=x_wcWsWNiQ&sig=uO-6jeh3LKGqZmflfafj0VeFjic&redir_esc=y#v=onepage&q=Tajima&f=false (retrieved on 03.12.2012)

Publication:

As reported by Tajima (2004), for instance, the worst accident ever in aviation history was the crash between two Boeing 747 Jumbo Jets in Tenerife in 1977, and this was due to a communication breakdown in a BELF situation. The Dutch captain said in English ‘We are now at takeoff’, a phrase that was interpreted by the Spanish controller as ‘We are now at the takeoff position.’ What the Dutch captain meant to say, however, was ‘We are now actually taking off.’ The English sentence the captain uttered was an unusual phrase in English aviation terminology and this was due to interference from his native language of Dutch.

*Publication ID***:** 057

*Reference***:** Mohd, N. G. (2007). *Air Traffic Control Radiotelephony Safety: Investigating the English Second Language Users' Perspective*. Dissertation: Cranfield University.

Internet-link and date:
https://dspace.lib.cranfield.ac.uk/bitstream/1826/2697/1/N%2520G%2520Mohd.pdf (retrieved on 03.12.2012)

Publication:

The worst aviation accident in which two Boeing 747s collided on the runway at Los Rodeos Airport, Tenerife in 1977 is an example of a non-English syntax being used. The phrase "WE ARE AT TAKE-OFF" as used by the KLM pilot in the Tenerife accident was Dutch in syntax, referring to the actual action of a takeoff roll. The pilot was concluded to have misunderstood the phrase 'after takeoff' used by the controller in issuing the departure instructions as an actual takeoff clearance. Meanwhile the phrase 'at takeoff' as used by the pilot in his readback didn't alert the controller that it meant a takeoff roll is in progress. It was also unfortunate that the controller has a habit of starting his transmissions with the word 'OK' which had been taken as an agreement to the takeoff roll. Unfortunately, a pause after 'OK' and a clash with another transmission had obliterated the controller's 'standby' instruction (meaning not to takeoff yet) and the additional information that another aircraft was still on the runway. There were other contributing factors; however, communications and language played an important if tragic part in the accident (Secretary of Aviation, 1978).

*Publication ID***:** 058

*Reference***:** Petkovska, V. (2004). ESP Courses to Air-Tansportation Students – A Challenge for the Teacher, 93-99. 378.147.36:811.111 (497.7)

*Internet-link and date***:** http://www.mnd-bitola.mk/files/broj%203-4/09%20ESP%20Courses.pdf (retrieved on 04.12.2012)

Publication:

The other case, whose consequences were far more serious, the so called Tenerife case, was also based on ambiguity arising from misunderstanding of such a simple speech part – preposition. In fact, the KLM pilot had informed the Tower that the aircraft *was at take off* at that moment, whereas the controller had not assumed that his previous instruction, *Stand by for take off* would actually be understood as a permission to take off. To the Tower, the phrase *at take off* only meant that the aircraft was ready to leave, but would not actually attempt a take off. This led to one of the gravest disasters ever to happen in aviation: a ground collision of two planes which took 583 lives. The use of other unambiguous phrases would certainly have enabled the controller to advise a different action and contribute towards the prevention of this worst accident in the history of aviation.

*Publication ID***:** 059

*Reference***:** Mc Greevy, J., Otten, T., Poggi, M., Robinson, C. Castaneda, D. & Wade, P. (2006). The Challenge Of Changing Roles And Improving Surgical Care Now: Crew Resource Management Approach. *General Surgery News*, 109-115.

Internet-link and date:
http://www.generalsurgerynews.com/download/GSNSE2006_wm.pdf#page=109 (retrieved on 04.12.2012)

Publication:

On March 27, 1977, the weather at the Los Rodeos Airport on Tenerife Island of the Canary Islands created poor visibility on the ground. There was fog, light drizzling rain, and the pilots of a KLM Boeing 747 could see less than a quarter of a mile. The pilot in command (PIC) of the KLM Airliner was a senior officer in charge of training at KLM. As such, he did not fly as much as the other pilots, and yet he felt the pressure to be the ultimate authority. In addition, he had a reputation as a domineering personality characteristic of early aviators: “Keep quiet and watch me!” Though a series of events, the KLM captain took off without clearance, while a Pan-Am 747 was still taxiing on the same runway. The ensuing collision, just after the KLM 747 became airborne, killed 583 people including everyone on the KLM airliner. One of the many findings from this accident was the remarkable fact that the first officer had a good understanding of the situation and challenged the captain once, but he could not break through the hierarchy to forcefully convince the pilot in command that he was wrong.

*Publication ID***:** 060

*Reference***:** Aiguo, W.(2007). Teaching aviation English in the Chinese context: Developing ESP Theory in a non-English speaking country. *English for Specific Purposes*, 26, 121-128.

Internet-link and date:
http://lms.ctl.cyut.edu.tw/sysdata/31/24231/doc/f8d447d523e772be/attach/1272244.pdf (retrieved on 04.12.2012)

Publication:

Language-related misunderstandings of various kinds have been a critical contributing factor in aviation accidents, as is often illustrated by the familiar fatal accident in Tenerife in 1977 where the death of 583 people resulted in part from misunderstanding of the phrase at takeoff, which was used by the flight crew to indicate that they were ‘‘in the process of taking off’’, but was understood by the tower controller as meaning ‘‘at the takeoff point’’. So the pilot was not warned that another Boeing 747, shrouded in fog, was already on the runway. It seems that the reason for the wrong usage on the part of the Dutch pilot was his code switching between Dutch and the English language, translating the Dutch idiom (preposition ‘‘at’’ + the infinitive) instead of using the present continuous tense of the English language.

Publication ID: 061

Reference: Cardosi, K., Chase, S. & Eon, D. (2012). Runway safety. *Air Traffic Control Quarterly*, 18, 303–32.

Internet-link and date: http://ntl.bts.gov/lib/35000/35000/35095/Cardosi_Runway_Safety_2010.pdf (retrieved on 04.12.2012)

Publication:

The potential for use of the landing light as a signal that the aircraft is taking off is powerfully endorsed by Captain Robert Bragg, who was the Pan Am first officer in the 1977 crash of two B-747s on the runway in Tenerife. In this accident, a KLM flight taking off in heavy fog, crashed into the top of a Pan Am aircraft that was taxiing down the runway in the opposite direction. In Captain Bragg's words, "we saw the KLM airplane; it didn't surprise us too much, because we were aware that he was down there. And the first thing that got my attention was that his landing lights were on." (tenerifecrash.com). He later stated that they couldn't tell that the aircraft was moving toward them until it came closer and they saw the landing lights jiggle (Bragg, 2009).

Publication ID: 062

Reference: Norman, Donald A (1980). Error in Human Performance. Final Report. Accession Number : ADA091925

Internet-link and date: http://www.dtic.mil/dtic/tr/fulltext/u2/a091925.pdf (retrieved on 07.12.2012)

Publication:

Tenerife
An excellent example of the multiple causes of accidents is the collision of the Pan American 747 and the KLM 747 at Tenerife, March 27, 1977. (The following analysis comes from the ALPA report: Roitsch, Babcock, & Edmunds, 1979.) A number of different factors contributed to the crash, no single one being sufficient to have triggered the accident.

1. Both aircraft crews had been on duty for a long time period.
2. The KLM crew was concerned about duty time, and was worried about not being able to return to Amsterdam without changing crews and putting passengers up in (insufficient) hotel space.
3. The weather was closing in fast.
4. The Pan Am flight was ready to go an hour before KLM, but had to wait because it couldn't clear the taxi-way until the KLM plane moved out of the way.
5. The pilot of the KLM flight was the chief pilot of KLM, with strong opinions about flying, but who had in actuality few duty hours as an operational pilot (he was mostly involved in training). The KLM co-pilot had been recently checked out for the 747, by the pilot.
6. The communication with Air Traffic Control (ATC) was not optimum and there is evidence that the Pan American flight gave up trying to change its runway assignment because of this problem.
7. There was confusion as to the point at which the Pan Am aircraft should leave the runway (to a taxi-strip, thereby permitting the KLM plane to take off). The ATC said the third exit, but this was not possible (the required turn was too sharp), and so Pan Am, after several attempts at clarification, evidently assumed it was the fourth exit that was meant.
8. The KLM pilot attempted to take off without tower clearance, but was stopped by the co-pilot. The KLM plane then told the tower that it was " ... now ready for takeoff and we are waiting for our ATC clearance." The tower responded with the ATC clearance, and the KLM plane acknowledged the clearance and took off. However, the tower acknowledgement was not for takeoff, only for the flight plans.
9. The tower did not stop the takeoff, but rather asked Pan Am to state when it was clear of the runway.
10. Fog prevented the KLM plane and the Pan Am plane from seeing each other, or the tower from seeing either plane.

These factors all intermixed to cause the incident. No single one was responsible.

*Publication ID***:** 063

*Reference***:** Parker, J.B.R. (1987). The effects of fatigue on physician performance – an underestimated cause of physician impairment and increased patient risk. *Candian Journal of Anesthesia*, 34, 489-495.

Internet-link and date:
http://download.springer.com/static/pdf/946/art%253A10.1007%252FBF03014356.pdf?auth66=1355062364_7f1a77e4d8e270e3aba4d931f74f6b77&ext=.pdf (retrieved on 07.12.2012)

Publication:

In 1977, a Boeing 747 taking off from Tenerife failed to wait for take-off clearance from the control tower in the conditions of poor visibility. The pilot started his take-off run and crashed at 150 miles an hour into another 747 still taxiing on the runway, killing 577 of the 637 passengers and crew on the two aircraft. The very experienced pilot of the Dutch aircraft who did not wait for take-off clearance was the head of KLM’s flight-training department and during the previous six years had spent some 1,500 hours in a simulator. He had not flown for twelve weeks prior to the flight. In the simulator, to reduce operational costs, he, as the instructor, would issue the take-off clearance to the student pilot who was never required to hold on the runway. It is likely that, under the stress of the situation, he reverted to the behavior pattern of the predictable world of the simulator instead of reacting to the real circumstances. An appropriate habit in the normal working day of this pilot had been applied in inappropriate circumstances with disastrous results. It is probable that reversion to habits which are normally quite appropriate, but not when applied in situations requiring specific behavior adapted to the situation, is more common than suspected.

Publication ID: 064

Reference: Telle, B., Vanderhaegen, F. & Moray, N. (1996). Railway System Design in the Light of Human and Machine Unreliability. *IEEE*, 2780-2785.

Internet-link and date: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=561380 (retrieved on 07.12.2012)

Publication:

The accident at Tenerife airport
The case of Tenerife is illustrated on figure 3. A KLM Boeing 747 was waiting on the runway for permission to take off. A Pan AM 741 had finished loading and was told to taxi up the runway and turn off at the third exit onto the taxiway. While it was taxiing the KLM plane received instructions from the control tower about the course to fly after takeoff. The pilot, who was under pressure to take off as soon as possible, misheard the message, which was delivered in heavily accented English (1) over a radio channel which badly distorted the message (2), and interpreted it as permission to take off (3). The copilot told him they had not received permission, and the pilot throttled back the engines. The Pan Am plane misidentified the exit to the taxi way because the turn was too sharp for the big jet, (4,5) and continued towards the KLM plane through the cloud and fog which covered the runway, so that neither plane could see the other (6). During this time the KLM plane could not hear communication between the tower and the Pan Am plane because of poor radio communication channels (7). A further message a few minutes later again led the KLM pilot to begin his takeoff, and this time the copilot, who was very junior, did not apparently have the courage to tell his much more senior captain to stop (8). Instead he said that they were rolling (9), and the KLM plane accelerated (10). Some way down the runway the KLM crew saw the Pan Am plane directly ahead and tried to take off, while the Pan Am plane tried to turn off the runway. The planes collided and several hundred people were killed.

Publication ID: 065

Reference: Reason, J. & Bernsen, N.O. (1991). *Errors in a team context*. Mohawe Belgirate Workshop.

Internet-link and date: http://www.nislab.dk/Publications/TeamError9.1.92.pdf (retrieved on 08.12.2012)

Publication:

A similar pattern of errors, but on a larger scale, contributed to the Tenerife runway disaster in 1977. The Pan American crew taxied past Exit 3, the turn-off directed by the air traffic controller. The KLM captain started his takeoff run before receiving takeoff clearance. The KLM co-pilot allowed the takeoff to proceed, even though he was aware that an error had been committed. Together, the two sets of errors were sufficient to bring the two jumbos into collision on the runway.
There was also an added factor: the social psychology of the cockpit. The KLM captain was the airline's chief training pilot and an extremely senior figure. It seems reasonable to suppose that the very much more junior co-pilot was hesitant to call too much attention to the captain's precipitate takeoff.

Publication ID: 066

Reference: Punch, Maurice (2000). Suite violence: Why managers murder and corporations kill. *Crime, Law & Social Change*, 33, 243-280.

Internet-link and date:
http://download.springer.com/static/pdf/324/art%253A10.1023%252FA%253A1008306819319.pdf?auth66=1355144912_fa12f836ffc901a51bc3ccb7fa75bf25&ext=.pdf (retrieved on 08.12.2012)

Publication:

Weick (1990), for instance, masterfully unravels the worst plane crash in history, when two wide-bodied planes collided on the runway at Tenerife in 1977 with the loss of 583 lives. He takes the decision of a pilot to commence take off – apparently without permission, in thick mist, and with another plane crossing the runway – and ties it into a range of variables including cockpit behaviour and the personalities of the crew, communication difficulties with the control tower, conditions of work in the industry (and penalties for exceeding working times), technology on the airfield, and the creation of a "temporary system" caused by terrorist activity elsewhere leading to a diversion of aircraft to Tenerife and increased pressure on all concerned.

Publication ID: 067

Reference: Leveson, N., et al., Safety Analysis of Air Traffic Control Upgrades, NASA TR, September 1997.

Internet-link and date:
citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.38.7250&rep=rep1&type=pdf (retrieved on 08.12.2012)

Publication:

The 1977 accident at Tenerife in the Canary was attributed to a confusion about the term "at take off", which was used by the flight crew to mean they were in the process of taking off and interpreted by the controller to mean at the point of taking off. As a result of this confusion, the aircraft in question collided with another aircraft taxiing onto the same runway. A contributing factor was an earlier confusion in which the pilot assumed he was cleared for take off when he received a communication describing the route for which he was cleared *after* take off [Cus94].

Appendix B.: Coding scheme

Coding scheme

Unit of Data Collection: Each publication which a) contains a description of the particular disaster with a minimum of 100 words and a maximum of 500 words, b) was searched by particular search terms c) has an author mentioned, d) is retrievable by a third-party.

Coder ID: Indicate the number of the person who coded that sheet.

Publication ID: Give each publication a unique 3-digit number, beginning with 001 and proceeding upward without duplication across all episodes.

Reference: Give a reference in APA style.

Internet-link and date: Give the internet link with which you can retrieve the publication and the date of finding it.

Total number of words publication: Give the total number of words of the whole publication including heading, abstract and references. Use the copy/paste-function to be able to count the words in Microsoft Word.

Total number of words disaster: Give the total number of words concerning the description of the disaster. Count all words in the whole paragraph(s) and make no distinction on the basis of the content.

Source: Is the author mentioning a source of information concerning the disaster?

0 Yes 1 No

If yes, which source?

____

Publication: Use the copy/paste-function here to put in the whole description of the disaster.

1. Genre: Say to what genre the publication belongs.

0 scientific (peer-reviewed journal, conference paper, dissertation)

1 non-scientific (popular)

2. Number of causes and their proportions

Instruction:

-All words within a sentence in which a cause is mentioned, should be counted.

Example: 'The KLM aircraft had to take-off (with destination Amsterdam Schiphol), through a wall of dense fog'. Coding should be: cause number 11; 16 words.

-Each space between letters marks a new word.

Example: 'Las Palmas' are 2 words.

'Take-off' is 1 word

-If one sentence contains more than one cause, the words should be divided evenly over those causes.

Example: 'The Pan Am crew confusion about which taxi lane to take, was partly due to unclear communication with the Tenerife traffic tower and partly due to the low visibility'.

This sentence should be coded as cause 4; 9 2/3 words

cause 11; 9 2/3 words

cause 14 9 2/3 words

Causes	Number of words mentioning a specific cause	Percentage of words mentioning a specific cause, related to the total number of words concerning causes *(round the number behind the comma up or down to get an even number)*	Is the cause mentioned in the text? 0 = Yes 1 = No
1. 'Training syndrome' of KLM			

captain (blurring of line between 'training world' and 'real world')			
2. Concern about families of the KLM airplane crew that might be worried because of the explosion in Las Palmas			
3. Large delay of KLM flight: working time limitations			
4. Third gateway left confusion Pan Am airplane; airplane was longer than expected on taxi way			
5. Unusual high workload Tenerife's traffic tower crew			
6. Increasing fatigue KLM crew, Pan Am and air traffic controllers			
7. KLM crew's and Pan Am's Filter effect (missing information due to focus on special terms)			
8. Stress air traffic controllers due to explosion in Las Palmas and a possible bomb scare at Tenerife airport			
9. Bad weather/ visibility			
10. Fear of KLM passengers due to Las Palmas explosion			
11. KLM crew (hierarchy) and Pan Am crew (no strict hierarchy) management factors			
12. Confusing auditory information/ miscommunication: ambiguous words (take-off versus taking off); language problems (Spanish versus English); difficulty understanding taxi instructions KLM - traffic tower and/or Pan Am - traffic tower; confusion due to the use of 3 frequencies by two controllers in Tenerife air traffic tower			
13. Threat of chaotic conditions that would result if the KLM flight was terminated (economic factors, not enough hotel rooms, aircraft			

scheduling problems)			
14. Airport facilities: transition to parallel taxiway for Pan Am aircraft too small;airport not designed to accommodate the large number of aircrafts on the day of accident			
15. No landing on Las Palmas due to explosion			
16. False assumption about take-off clearance (KLM captain)			
Total	..... words	100%	
<u>Factors that are mentioned in the publication but not in the accident report</u> *(just write them down, do not rank them among the total word above)*:			
17.			
18.			
19.			
20.			
21.			

3. Setting

3 a) Is the location (Tenerife and/ or Los Rodeos) mentioned?

0 Yes 1 No

3 b) Characters

Is the KLM/ Pan Am aircraft mentioned? 0 Yes 1 No

Are the Tower controllers mentioned? 0 Yes 1 No

3 c) Is the date mentioned (March, 27, 1977)? 0 Yes 1 No

4. Theme

4 a) Is the bad weather/ bad visibility mentioned? 0 Yes 1 No

4 b) Is the miscommunication mentioned? 0 Yes 1 No

4 c) Is the assumption of the KLM captain mentioned, to have the take-off clearance?

0 Yes 1 No

5. Plot

Is it mentioned, that the KLM captain actually started the takeoff, while the Pan Am was still taxiing on the same runway?

0 Yes 1 No

6. Resolution

6 a) Is the collision between the KLM aircraft and the Pan Am aircraft mentioned?

0 Yes 1 No

6 b) Is the number of deadly victims mentioned?

0 Yes 1 No

7 Gist/ story grammar

7. a) Is the gist/ story grammar mentioned by the author(s)? *The gist/story grammar consists of the parts*

1. Setting: location Tenerife/ Los Rodeos AND/OR characters KLM/ Pan Am aircrafts, tower controller AND/OR date of disaster (March, 27, 1977)

2. Theme: bad weather/ bad visibility AND miscommunication AND/OR certainty of KLM captain to have a take-off clearance

3. Plot: take-off by the KLM captain, while Pan Am was taxiing on the same taxi way

4. Resolution: collision between Pan Am and KLM airplane AND number of dead victims.

0 Yes 1 No

If the last question was answered with ‘No’ go on with item 4. b). If the last question was answered with ‘Yes’ go on with item 5.

7. b) What part(s) from the story grammar is (are) missing? (Setting, Theme, Plot, Resolution)?

____

8. Relation between causes

Strings of causes. Xa led to Xb led to Xc etc.

Instruction:

- Find mentioned relations between the different causes. Be alert for cues such as:

- *... led to ...*
- *... leads to ...*
- *... due to ...*
- *... resulted in ...*
- *... results in ...*
- *... as a result ...*
- *... because ...*
- *etc.*

- Strings of causes should be filled out as follows:

Example:

Cause Xa	Cause Xb	Cause Xc	Cause Xd	Cause Xe	Cause Xf	Effect	Number of X's per string	Highest number of causes per X
3	6, 8,11	1	7			14.	4	3
2, 5, 13, 14						15.	1	4

Meaning:

- Cause 3 led to causes 6, 8 & 11. Causes 6, 8 & 11 led to cause 1. Cause 1 led to cause 7. Cause 7 led to cause 14. In schema:

Xa(3)>Xb(6,8,11)>Xc(1)>Xd(7)>Effect(14)

- Causes 2, 5, 13 & 14 together led to causes 15. In schema:

Xa(2,5,13,14)>Effect(15)

- Only fill out the longest option of a particular string.

Example: *when Xa(1)>Xb(4)>Xc(5)>Effect(12), only fill out that string.*

So do not note: *Xa(1)>Xb(4)>Effect(5), or*

Xa(4)>Xb(5)>Effect(12), or

any other possible separation

Cause Xa	Cause Xb	Cause Xc	Cause Xd	Cause Xe	Cause Xf	Effect	Number of X's per string	Highest number of causes per X
						1.		
						2.		
						3.		
						4.		
						5.		
						6.		
						7.		
						8.		
						9.		
						10.		
						11.		
						12.		
						13.		
						14.		
						15.		
						16.		
Total number of strings:						Total:		

Appendix C: Example of a filled in coding scheme

Coding scheme

Unit of Data Collection: Each publication which a) contains a description of the particular disaster with a minimum of 100 words and a maximum of 500 words, b) was searched by particular search terms c) has an author mentioned, d) is retrievable by a third-party.

Coder ID: Hanna

Publication ID: 021

Reference: Valimont, R. B. (2006). Active Noise Reduction versus Passive Designs in Communication Headsets: Speech Intelligibility and Pilot Performance Effects in an Instrument Flight Simulation. Dissertation: April 20, 2006 in Blacksburg, Virginia.

Internet-link and date: http://scholar.lib.vt.edu/theses/available/etd-04252006-110703/unrestricted/Valimont_Dissertation.pdf (retrieved on 30.11.2012)

Total number of words publication: 25 974

Total number of words disaster: 298

Source: Is the author mentioning a source of information concerning the disaster?

0 Yes

If yes, which source?

________ Aviation-Safety.net, 1996____________

Publication:

In fact, the worst accident in aviation history was the result of a misinterpreted radio transmission, and a subsequent unintelligible transmission. These simple, common communications errors led to the death of 538 passengers and crewmembers abroad two Boeing 747s, as follows. The field at Tenerife, Canary Islands, on March 27, 1977, was socked in with thick fog, dropping runway visibility range to less than a quarter of a mile, which permitted only departing airliners to use the active runway. KLM flight 4805 was instructed to backtaxi the active runway, make a 180 degree turn and hold their position awaiting take-off clearance. Meanwhile, Pan Am flight 1736 was cleared to backtaxi the active runway until they reached one of the last runway turn-offs. There, Pan Am 1736 was to exit the runway to allow room for KLM 4805 to initiate its take-off roll. While Pan Am 1736 was backtaxiing on the active runway, the air traffic controller issued KLM only its departure clearance, which KLM correctly readback. The controller then transmitted an additional statement, “Stand by for take-off, I will call you.” Tragically, this statement was garbled and presumably unintelligible to the KLM pilots, whom did not reply to the command and most likely believed they were already cleared for take off. Instead of a pilot readback to the previous controller command, the ATC audiotapes picked up the squeal of tires as the KLM Boeing 747 released its brakes and began lumbering towards the Pan Am 747 just approaching their taxiway turn-off. Twenty seconds later, the KLM 747 slammed into the Pan Am 747. The resulting impact forces and conflagration claimed the lives of all crewmembers and passengers save approximately two crewmembers and fifty passengers on the Pan Am 747. All occupants of the KLM 747 perished (Aviation-Safety.net, 1996).

1. Genre: Say to what genre the publication belongs.

0 scientific (peer-reviewed journal, conference paper, dissertation)

2. Number of causes and their proportions

Instruction:

-All words within a sentence in which a cause is mentioned, should be counted.

Example: 'The KLM aircraft had to take-off (with destination Amsterdam Schiphol), through a wall of dense fog'. Coding should be: cause number 11; 16 words.

-Each space between letters marks a new word.

Example: 'Las Palmas' are 2 words.

'Take-off' is 1 word

-If one sentence contains more than one cause, the words should be divided evenly over those causes.

Example: 'The Pan Am crew confusion about which taxi lane to take, was partly due to unclear communication with the Tenerife traffic tower and partly due to the low visibility'.

This sentence should be coded as cause 4; 9 2/3 words

cause 11; 9 2/3 words

cause 14 9 2/3 words

Causes	Number of words mentioning a specific cause	Percentage of words mentioning a specific cause, related to the total number of words concerning causes *(round the number behind the comma up or down to get an even number)*	Is the cause mentioned in the text? 0 = Yes 1 = No
1. 'Training syndrome' of KLM captain (blurring of line between 'training world' and 'real world')			**1**
2. Concern about families of the KLM airplane crew that might be worried because of the explosion in Las Palmas			**1**
3. Large delay of KLM flight: working time limitations			**1**
4. Third gateway left confusion Pan Am airplane; airplane was longer than expected on taxi way			**1**
5. Unusual high workload Tenerife's traffic tower crew			**1**
6. Increasing fatigue KLM crew, Pan Am and air traffic controllers			**1**
7. KLM crew's and Pan Am's Filter effect (missing information due to focus on special terms)			**1**
8. Stress air traffic controllers due to explosion in Las Palmas and a possible bomb scare at Tenerife airport			**1**
9. Bad weather/ visibility	**38**	**35**	**0**
10. Fear of KLM passengers due to Las Palmas explosion			**1**
11. KLM crew (hierarchy) and Pan Am crew (no strict hierarchy) management factors			**1**
12. Confusing auditory information/ miscommunication: ambiguous words (take-off versus taking off); language problems (Spanish versus English); difficulty understanding taxi	**56**	**51**	**0**

instructions KLM - traffic tower and/or Pan Am - traffic tower; confusion due to the use of 3 frequencies by two controllers in Tenerife air traffic tower			
13. Threat of chaotic conditions that would result if the KLM flight was terminated (economic factors, not enough hotel rooms, aircraft scheduling problems)			**1**
14. Airport facilities: transition to parallel taxiway for Pan Am aircraft too small;airport not designed to accommodate the large number of aircrafts on the day of accident			**1**
15. No landing on Las Palmas due to explosion			**1**
16. False assumption about take-off clearance (KLM captain)	**15**	**14**	**0**
Total	**109** words	100%	
<u>Factors that are mentioned in the publication but not in the accident report</u> *(just write them down, do not rank them among the total word above)*<u>:</u>			
17.			
18.			
19.			
20.			
21.			

3. Setting

3 a) Is the location (Tenerife and/ or Los Rodeos) mentioned?

0 **Yes**

3 b) Characters

Is the KLM/ Pan Am aircraft mentioned? **0** **Yes**

Are the Tower controllers mentioned? **0** **Yes**

3 c) Is the date mentioned (March, 27, 1977)? **0** **Yes**

4. Theme

4 a) Is the bad weather/ bad visibility mentioned? **0** **Yes**

4 b) Is the miscommunication mentioned? **0** **Yes**

4 c) Is the assumption of the KLM captain mentioned, to have the take-off clearance?

0 **Yes**

5. Plot

Is it mentioned, that the KLM captain actually started the takeoff, while the Pan Am was still taxiing on the same runway?

0 **Yes**

6. Resolution

6 a) Is the collision between the KLM aircraft and the Pan Am aircraft mentioned?

0 **Yes**

6 b) Is the number of deadly victims mentioned?

0 **Yes**

7 Gist/ story grammar

7. a) Is the gist/ story grammar mentioned by the author(s)? *The gist/story grammar consists of the parts*

1. Setting: location Tenerife/ Los Rodeos AND/OR characters KLM/ Pan Am aircrafts, tower controller AND/OR date of disaster (March, 27, 1977)

2. Theme: bad weather/ bad visibility AND miscommunication AND/OR certainty of KLM captain to have a take-off clearance

3. Plot: take-off by the KLM captain, while Pan Am was taxiing on the same taxi way

4. Resolution: collision between Pan Am and KLM airplane AND number of dead victims.

0 Yes

If the last question was answered with ‘No’ go on with item 4. b). If the last question was answered with ‘Yes’ go on with item 5.

7. b) What part(s) from the story grammar is (are) missing? (Setting, Theme, Plot, Resolution)?

____

8. Relation between causes

Strings of causes. Xa led to Xb led to Xc etc.

Instruction:

- Find mentioned relations between the different causes. Be alert for cues such as:

- *... led to ...*
- *... leads to ...*
- *... due to ...*
- *... resulted in ...*

- ... results in ...

- ... as a result ...

- ... because ... - etc.

- Strings of causes should be filled out as follows:

Example:

Cause Xa	Cause Xb	Cause Xc	Cause Xd	Cause Xe	Cause Xf	Effect	Number of X's per string	Highest number of causes per X
3	6, 8,11	1	7			14.	4	3
2, 5, 13, 14						15.	1	4

Meaning:

- Cause 3 led to causes 6, 8 & 11. Causes 6, 8 & 11 led to cause 1. Cause 1 led to cause 7. Cause 7 led to cause 14. In schema:

Xa(3)>Xb(6,8,11)>Xc(1)>Xd(7)>Effect(14)

- Causes 2, 5, 13 & 14 together led to causes 15. In schema:

Xa(2,5,13,14)>Effect(15)

- Only fill out the longest option of a particular string.

Example: *when Xa(1)>Xb(4)>Xc(5)>Effect(12), only fill out that string.*

So do not note: *Xa(1)>Xb(4)>Effect(5), or*

Xa(4)>Xb(5)>Effect(12), or

any other possible separation

Cause Xa	Cause Xb	Cause Xc	Cause Xd	Cause Xe	Cause Xf	Effect	Number of X's per string	Highest number of causes per X
						1.		
						2.		
						3.		
						4.		
						5.		
						6.		
						7.		
						8.		
						9.		
						10.		
						11.		
						12.		
						13.		
						14.		
						15.		
12						**16.**		
Total number of strings:						Total:**1**	**1**	**1**

Appendix D: Classification of causes

Factors temporally closer to the actual moment of accident vs. factors further away in time.

Factors temporally further away	Factors temporally closer
Cause 1: 'Training syndrome' of KLM captain (blurring of line between 'training world' and 'real world')	Cause 11: KLM crew (hierarchy) and Pan Am crew (no strict hierarchy) management factors
Cause 2: Concern about families of the KLM airplane crew that might be worried because of the explosion in Las Palmas	Cause 7: KLM crew's and Pan Am's Filter effect (missing information due to focus on special terms)
Cause 3: Large delay of KLM flight: working time limitations	Cause 9: Bad weather/ visibility
Cause 5: Unusual high workload Tenerife's traffic tower crew	Cause 12: Confusing auditory information/ miscommunication: ambiguous words (take-off versus taking off); language problems (Spanish versus English); difficulty understanding taxi instructions KLM - traffic tower and/or Pan Am - traffic tower; confusion due to the use of 3 frequencies by two controllers in Tenerife air traffic tower
Cause 6: Increasing fatigue KLM crew, Pan Am and air traffic controllers	Cause 16: False assumption about take-off clearance (KLM captain)
Cause 8: Stress air traffic controllers due to explosion in Las Palmas and a possible bomb scare at Tenerife airport	
Cause 10: Fear of KLM passengers due to Las Palmas explosion	
Cause 4: Third gateway left confusion Pan Am airplane; airplane was longer than expected on taxi way	
Cause 13: Threat of chaotic conditions that would result if the KLM flight was terminated (economic factors, not enough hotel rooms, aircraft scheduling problems)	

(Table continued on the next page.)

Factors temporally further away	Factors temporally closer
Cause 14: Airport facilities: transition to parallel taxiway for Pan Am aircraft too small; airport not designed to accommodate the large number of aircrafts on the day of accident	
Cause 15: No landing on Las Palmas due to explosion	

Appendix E: Tables

Table 3.

Number of causes mentioned per publication (N=67).

Number of causes mentioned per publication	Absolute number of publications	Amount of publications in percentage
1	12	17.9
2	17	25.4
3	11	16.4
4	10	14.9
5	7	10.4
6	6	9
7	3	4.5
9	1	1.5

Table 4.

Number of specific causes being mentioned among all publications.

Cause number	Absolute number of being mentioned	Amount of being mentioned in percentage (of all publications)	Amount of being mentioned in percentage (of all causes)
1	4	6	1,8
2	1	1.5	0,45
3	15	22.4	6,8
4	15	22.4	6,8
5	2	3	0,9
6	4	6	1,8
7	2	3	0,9
8	0	0	0
9	44	65.7	19,99
10	0	0	0
11	25	37.3	11,36
12	52	77.6	23,6
13	3	4.5	1,36
14	10	14.9	4,5
15	17	25.4	7,7
16	26	38.8	11,8

Table 6.

Results of independent samples T-tests by genre for the number of words concerning specific causes, without causes 8 & 10, because they were not mentioned by any publication.

Cause	Genre				
	Scientific M (SD)	Non-Scientific M (SD)	T	*df*	*p*
Cause 1	5 (21.44)	1 (7.8)	.94	48.99	.35
Cause 2	.25 (1.54)	0 (0)	1	37	.32
Cause 3	6 (14.86)	5 (12.49)	.36	64.35	.72
Cause 4	9 (18.86)	3 (9.58)	1.5	65	.13
Cause 5	.68 (3.16)	0 (0)	1.16	65	.25
Cause 6	.58 (2.53)	.53 (2.02)	.09	64.83	.93
Cause 7	.48 (2.96)	.83 (4.46)	-.36	46.08	.72
Cause 9	15 (15.34)	26 (20.84)	-2.26	49.55	.028
Cause 11	16 (28.14)	17 (26.69)	-.02	61.94	.99
Cause 12	38 (40.15)	39 (50.38)	-.12	52.4	.90
Cause 13	.48 (2.96)	.20 (1.11)	.52	49.74	.60
Cause 14	3 (9.22)	1 (5.52)	1.29	65	.20
Cause 15	9 (14.8)	7 (15.56)	.49	58.81	.62
Cause 16	6 (9.75)	9 (16.22)	-1.1	43.07	.27

Table 7.

Results of simple linear regression by year for the number of words concerning specific causes, without causes 8 & 10, because they were not mentioned by any publication.

Cause	*b*	T	*p*	R^2	F	*p*
Cause 1	-.75	-2.86	.006	.12	8.19	.006
Cause 2	-.002	-.12	.90	.00	.01	.90
Cause 3	-.20	-.97	.33	.01	.95	.33
Cause 4	-.003	-.01	.99	.00	.00	.99
Cause 5	.03	1.01	.31	.01	1.02	.31
Cause 6	.002	.05	.96	.00	.002	.96
Cause 7	-0.8	-1.35	.18	.03	1.8	.18
Cause 9	.58	1.94	.057	.06	3.76	.057
Cause 11	-.76	-1.84	.07	.05	3.39	.07
Cause 12	.09	.16	.88	.00	.025	.88
Cause 13	-.10	-2.75	.008	.11	7.57	.008
Cause 14	.02	.19	.85	.001	.04	.85
Cause 15	.37	1.5	.14	.04	2.26	.14
Cause 16	.13	.59	.55	.006	.36	.55