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Discourse, Identities and Roles in Specialized Communication

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Towards an Integrated Model for the Understanding of Communication Failures in Aviation Accidents: Tenuous Identities under Pressure

1. Introduction

This chapter focuses on a peculiar kind of professional interactions, those involving pilots and air traffic controllers (ATCs), where participants' individual identities are undefined and unstable, as actors participate in them only through their voices, with hardly any other situational element to rely on, and have to deal with ever different interlocutors. Thus, their identities within the interaction are determined exclusively by their use of language and discourse.

Of course, this problematic communicative situation is not unique to pilots and ATCs, but also applies to some other professional categories, e.g. call centre workers and helpline call operators. However, these peculiarities are much more critical in the case of aviation communication, not only because every new conversation involves an effort of recontextualization on the part of pilots, but above all because the decisions made under such demanding circumstances are highly momentous, and misunderstandings may have fatal consequences.[1]

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* This chapter is the result of the joint work of an interdisciplinary research group including sociologists and linguists, investigating the discursive aspects of accident analysis.

1 The communicative conditions under which pilots and Air Traffic Controllers operate will be discussed in-depth in Sections 1.3 and 3.1 below.

Thus, issues relating to professional encounters relying exclusively on verbal exchanges are highly relevant to the study of communication failures in aviation accidents, which are the main object of investigation in this chapter. We propose an integrated model for their analysis where considerations concerning interactional circumstances and linguistic exchanges are given pride of place.

1.1. Aim and scope

For a long time, the investigation of accidents was the undisputed domain of the engineering sciences, which looked primarily at technical aspects for the identification of causal factors. It was only in the 1980s that the explanatory potential of the social sciences (most notably psychology and sociology) for the study of accidents was recognized and the focus of attention shifted from technical to human, and subsequently organizational, factors. Emphasis started to be placed on issues related to the nature of organizations, such as established norms and practices, the level of risk involved, working conditions, the roles and statuses of the different actors interacting within the organization, all aspects that concern the sphere of professional identity.

Despite the benefits brought by this socio-technical turn in the understanding of accident dynamics, however, many of the cognitive and communicative processes which contribute to the etiology of accidents remain to this day largely unexplored, in a context where in the investigation of social behaviour in general, and of accidents in particular, insufficient attention is paid to language, communication and, more generally, to the codes that guide social action. Even in those (rare) cases in which linguistic and discursive aspects have been considered, seldom have they been integrated with human and organizational aspects, a fact which often results in their marginalization.

1.2. The neglected role of language

Language and, more in general, communication, therefore, represent to this day an under-developed area of investigation in the study of accidents, a fact for which three main elements are to blame. First of all, since language is a (universal and necessary) pre-requisite of every society, it is seen as an inconsequential constant inherent in social behaviour, rather than a variable which can contribute to explaining behavioural variation. Secondly, language tends to be conceived instrumentally as a medium used to *transmit* information, and not as a mode apt to *construct* it. In other words, there is a tendency to ignore the fact that through language social actors construct their frames of reference, as well as a shared interpretation of information and the meaning of their actions, thereby producing communication – a phenomenon which so far has not yet been accounted for satisfactorily in its entirety. Thirdly, there still dominates an objectual conception of reality, which attributes a marginal role to language, considering it an ancillary competence.

This dychotomic view of language and reality began to be challenged only in the wake of the 'linguistic turn' which swept through a number of disciplines from the late 1970s onward; thus, also in accident-investigation studies the idea emerged that the linguistic component was worthy of independent consideration.

Linguistic constructionism emerged as a new paradigm for the interpretation of reality: according to it, reality itself is a discursive construction, actions are discursive accomplishments, and communication is a reality-constructing activity. This 'linguistic turn' can be traced back to Wittgenstein's theories and analytic philosophy. However, it became really influential only with the American philosopher Richard Rorty and subsequently other authoritative theorists in diverse fields – philosophy,[2] economics (Deirdre McCloskey), linguistics (George Lakoff and Mark Johnson, John Shotter and Kenneth J.

2 Belonging to the structuralist and poststructuralist tradition are, amongst others, the American philosopher Judith Butler, the French psychoanalyst and philosopher Luce Irigaray, the Bulgarian-French philosopher and literary critic Julia Kristeva, and the French philosopher Jacques Derrida.

Gergen, Jonathan Potter), organizational studies (Gareth Morgan), and the social sciences in general – who demonstrated that language performs a fundamental role in constructing reality. This is contrary to common sense and to most of the Western tradition of philosophy, where the century-old view that words function as labels predominated.

With reference to the investigation of accidents, the adoption of a linguistic-constructivist framework can be expected to contribute crucially to the development of a multidisciplinary, integrated paradigm for the study of organizational accidents which includes – besides linguistics – other analytical perspectives, such as organizational theory, linguistic anthropology, interactional sociolinguistics, cognitive psychology, ergonomics, computer science, and so on.

1.3. The linguistic factor in accidents

Within the wider field of organizational accidents, a subsector for which a framework such as the one described above appears particularly suitable is that of aviation accidents. Pilot-to-pilot conversations, as well as communications between Air Traffic Controllers (ATCs) and pilots, are all interactions in which language plays a crucial role. This is due to a number of reasons.

Firstly, the different actors involved are (often) not visible to each other; these interactions are therefore very different from those that occur face-to-face, in which communication can rely on other-than-verbal means. In the case of communication in aviation, language becomes the main means through which actors located in different places, who can often 'see' each other only through devices such as monitors, displays, and other kinds of visual or acoustic signals, coordinate their actions.

Secondly, none of the actors involved has a complete view of what is going on and of what needs to be done. In these operating conditions, verbal exchanges and communications are crucial to build a shared awareness (Roth *et al.* 2006; Rognin *et al.* 2000).

In light of the key role played by language in all the stages of aircraft operations, and even more crucially at landing and take-off – when most accidents occur – it is therefore imperative that a linguistic

perspective be adopted when investigating aviation incidents and accidents. Such a perspective must be systematically integrated with other approaches in a model capable of accounting for the widest possible range of communication problems that may arise.

1.4. The Linate accident

This study proposes a model for the analysis of aviation accidents based on sound theoretical considerations and illustrated with real-life examples of miscommunication. The examples discussed will be taken from the transcripts of communicative exchanges in the accident that occurred at Milano Linate airport on 8 October 2001, when two airplanes collided causing the death of 118 people. After the Tenerife disaster in 1977, in which 583 people were killed, the Linate disaster is the most serious ground accident in the history of air traffic.

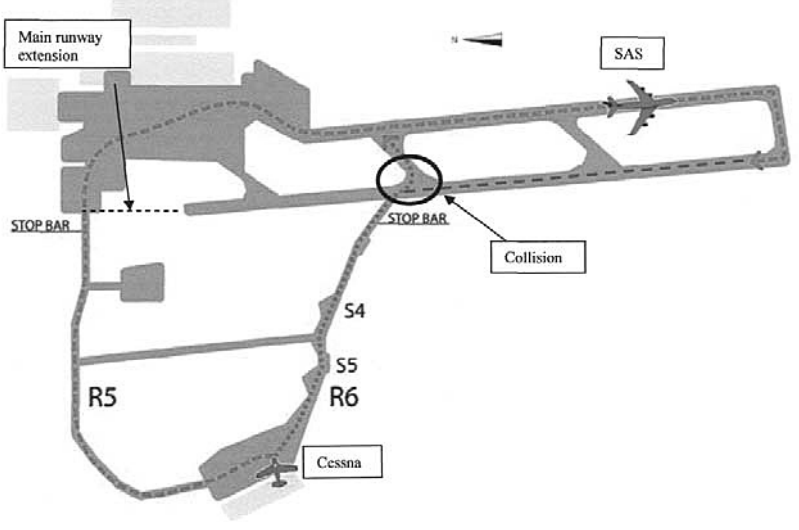

Figure 1. The dynamics of the Linate accident (modified from Catino 2006: 148).

An SAS aircraft was taking off when it collided with a Cessna, a small-sized private airplane with four people on board. There was

thick fog at Linate Airport and runway visibility was about 200 metres. The Cessna took the wrong taxiway, entered the main runway and was destroyed by the impact with the SAS airplane, which was taking off (cf. Figure 1 above).

The Cessna pilots had therefore committed an error; and human error and communicational mismatch were the widely-accepted causes of the accident. The inquiry by the National Air Safety Board (ANSV 2004) highlighted several critical factors that had contributed to the fatal outcome of a mistake which was initially – and primarily, at its inception – linguistic and communicative in nature: a lack of coordination among the different agencies involved (ENAC, ENAV, SEA); non-compliance with the standards for guidance signs; the absence of a safety management system; a punitive environment and a fear of sanctions which discouraged the self-reporting of incidents and individual mistakes; the lack of adequate visual aids; high traffic volume in weather conditions with low visibility (Catino 2008a). The Linate accident qualifies therefore as a representative example – indeed, an extreme one – of the key role played by language in Ground-Pilot communication: on the day of the accident extremely foggy weather conditions, combined with the fact that the ground radar was not working, made it impossible for the controllers to see the Cessna which caused the accident. It is therefore no exaggeration to claim that, at least on that occasion, language actually did construct reality and even non-reality, as the Cessna pilots and the controller wrongly believed a spatial situation to be in place which, in fact, was not, and which eventually caused the accident.

2. Theoretical approaches to the study of aviation accidents: organizational and linguistic perspectives

The increasing complexity of all types of organizations in the contemporary world has prompted a growth in research on how to reduce accident risk. Much of this research has been carried out in an

organization studies perspective, which has generally been considered to be a suitable framework also for the analysis of aviation incidents and accidents. Therefore, before going on to discuss the relevance of linguistic analysis to this type of investigation, an overview will be given of the main organizational theories that have been applied in aviation accident studies.

2.1. Organizational accidents: theories compared

Accidents in complex organizations cannot usually be attributed to any single cause. Analyses of major organizational accidents have revealed the relevance of organizational factors in the etiology of such events (Weick 1990; Vaughan 1996; Turner/Pidgeon, 1997; Reason 1997; Perrow 1999). The importance of organizational factors in the genesis of accidents was first asserted by Barry Turner (1976; 1978; Turner/Pidgeon 1997) with the Disaster Incubation Model. According to Turner, accidents are events characterized by a period of incubation during which a series of signals are emitted. If these signals are recognised in advance, disasters can be prevented or their damage reduced.

Since Turner's theories gained currency (belatedly and to an insufficient extent), several approaches and theories have been developed to explain accidents, a brief outline of which is provided below. According to the Latent Factors Theory (Reason 1997), accidents are activated by human errors, but these errors are embedded in latent conditions that make the disaster possible. Organizational accidents are caused by a rare conjunction of a set of breaches in successive defences. Fortunately these windows of opportunity are rare because of the multiplicity of defences and the mobility of the holes.

The Normal Accidents Theory (Perrow 1984/1999; Sagan 1993) emphasizes the inevitability of accidents in systems characterized by high complexity and the tight coupling which is in place when each part of the system is closely connected to the others, so that a change at one point produces an immediate change in other parts of the system, with rapid and uncontrolled propagation of its effects.

Looking at organizations' points of strength rather than at their points of weakness, High Reliability Theory (Roberts 1993; LaPorte/Consolini 1994; Weick/Sutcliffe/Obstfeld 1999) studies unusually successful complex organizations in search of clues to the cognitive and management processes which enable high-risk organizations to reduce possible errors and accidents.

Resilience Engineering, or Socio-Technical Theory (Rasmussen 1997; Hollnagel/Woods/Leveson 2006) aims to make complex systems more resilient and able to avoid a shift to unacceptable levels of risk. According to this theory, success in the prevention of accidents can be ascribed to the ability of groups, individuals, and organisations to anticipate the changing shape of risk before damage occurs; failure is simply the temporary or permanent absence of such anticipation.

Despite their theoretical and methodological differences, all four theories/approaches outlined above emphasise the organizational nature of accidents. In addition, they all underline the role played by different levels in determining accidents: human, organizational, environmental and organizational-network factors all interact and contribute to the genesis of accidents.

2.1.1. A multilevel model for the analysis of accidents

Building on the theories so far outlined, the organization theory (Scott/Davis 2007: 18) identifies three different levels in the analysis of accidents: an individual level; a level of the organization; and an inter-organizational level or the organizational (ecological) field in which the organization operates. Although this distinction in separate levels is certainly arbitrary, it is intended to be an analytical distinction: in reality, of course, the different levels operate simultaneously and interconnectedly. But the distinction serves to account for the considerable complexity of the phenomenon and the different ways in which it appears.

On this basis, the Linate air disaster can be explained (Catino 2008a) by means of a multilevel (micro/meso/macro) analysis model pointing out failures at different levels which jointly caused the disaster:

1. the *individual* level (people at the front-line; pilots and air traffic controllers);
2. the *organizational* level (Linate Airport);
3. the *interorganizational* level (the different organizations involved in the air transport system).

According to this model, and with specific reference to the linguistic component, the communication failure which caused the Linate accident occurred at the micro-level, but was made possible by the insufficiency of communication procedures at the meso (organizational) level and, possibly, by the inadequacy of standards adopted at the macro (interorganizational) level, most notably language requirements and procedures universally adopted in Civil Aviation. Thus, developing a model capable of explaining the insurgence of problems at the micro-level may also provide insights for the improvement of both meso and macro-level standards and procedures.

2.2. (Mis)communication in aviation: a brief review of the literature

Within this framework, it is odd that relatively limited attention has been given to the linguistic aspects of flight management not only by experts in organization studies and other analysts involved in the study of the dynamics of flight control interactions, but also by linguists. Communication problems are prominent among the factors that in studies of air accidents are usually classified under the heading 'human error', and in most cases they are actually due to specific difficulties and mishaps in linguistic interaction in cockpit conversations or air-ground communication (or both). Tomkins (1991) indicates that over 60% of incident reports include some communication errors, while according to Billings and Cheaney (1981) 73% of incident data contain some kind of information transfer problem.

Research conducted in an organizational studies perspective has sometimes recognized the importance of communicative aspects in effective task performance. More specifically, the key role played by effective communication in the smooth functioning of complex organizations (and, by converse, the high accident risk of communica-

tion failure) was recognized by Weick in his analysis of the Tenerife disaster. He stressed that communication is a structural component of organizations, especially in high-risk contexts. In Weick's words, "an airline is in large part constituted by its speech exchanges. When people […] talk among themselves and with outsiders, not only do they communicate within an organization, they also construct the organization itself through the process and substance of what they say. As their talk varies, the solidity and predictability of the organization itself varies" (Weick 1990: 582).

Giving more attention to the linguistic aspects but with an emphasis on socio-organisational factors, Hutchins and Klausen (1996) studied communicative practices among crew members in a simulated flight, showing that the decisive factor in determining the occurrence, or otherwise, of an accident is not so much the individual pilot's technical ability as what they called 'system performance', i.e. the interaction between pilots and technology in the cockpit (Hutchins/ Klausen 1996: 16).[3] The authors focused therefore on the cognitive properties of the cockpit as a system, and called this a 'distributed cognition system' (*ibidem*: 17), identifying the key aim of cockpit interaction as the construction of a shared understanding of the situation.

An early study commissioned by NASA (Goguen/Linde 1983) also focused on communication issues, for the specific purpose of "reduc[ing] the incidence of those air transport accidents caused wholly or in part by problems in crew communication and coordination". In this case speech act theory was used to identify the communication patterns which appeared to be most effective in crisis situations. Among the findings of the study was that speech mitigation reduced the effectiveness of communication, and that planning and explanations were more common during problems, rather than emergencies. The need therefore emerged to make pilots aware of communication issues, and of the necessity to engage in more explicit communication during emergencies in order to enhance the crew's shared awareness of the situation.

3 Cf. also Bergmann (2006) and Bergmann *et al*. (2005) for more recent studies along this line.

Other studies have combined speech act theory with conversation analysis (Ward 1992; Krifka/Martens/Schwarz 2003; Sassen 2005), or relied on conversation analysis alone (Silberstein/ Dietrich 2003; Dietrich/von Metzen 2003; Nevile 2004, 2006, 2007) to produce an account of effective cockpit communication. While these works have provided interesting insights into the analysis of cockpit and – more rarely – ATC-pilot communication, they have been mostly prevalently descriptive, or have had limited practical impact on ordinary routine procedures.

In this sense, a few more insights have been offered by studies which have approached the problem on a case-by-case basis, looking for possible explanations for each type of miscommunication problem. An aspect highlighted in the literature, for instance, is the role played by expectations and assumptions (Krivonos 2007: 5-6) in giving rise to misunderstandings, which in turn may lead to loss of situation awareness (cf. Orasanu/Fisher/Davison 1997) and, hence, accidents.

But what really lies at the heart of miscommunication is, as Cushing pointed out in an early article (1989: 4),

> the complexity and flexibility of language [...], because of the confusion and misunderstandings that can result as a result of ambiguity, unclear reference, intonation peculiarities, implicit inference and presupposition.

2.2.1. Miscommunication and Airspeak

Thus, it is language itself – its very nature – which is the main potential cause of communication problems. In aviation, these problems have been tackled by restricting the range of linguistic resources to be used in flight management thus giving birth to Airspeak (or 'aviation English'), a 'purposebuilt language' (Varantola 1989: 173-175) to some extent similar to *Seaspeak*, the 'restricted' language of maritime navigation (cf. Gotti 2003: 281-282). More in detail, it is a highly specific register of aeronautical English based on restricted phraseology (Crystal 1997: 78-112). It is noteworthy that the use of English is not mandated by ICAO (itself formally an advisory rather than regulatory organization), but only recommended, which helps account for the lack of standardization and the uneven proficiency in the use of English that characterizes the air transport

industry. A first step towards improvement was the Council's adoption in March 2003 of ICAO English language proficiency requirements with implementation deadline on 5 March 2008 (partially extended to 2011), so in line of principle achievement and demonstration of Operational Level 4 of the ICAO Rating Scale is today mandatory for all air traffic controllers and pilots involved in international traffic. Although the setting of mandatory requirements in language proficiency is inherently positive, the standard set is still objectively rather low, corresponding broadly to European Framework level B2.

Although Airspeak contains specialized vocabulary, it is not really *strictu sensu* a domain-specific language, being rather more similar to a 'trade language', consisting of a restricted range of limited modules based on a highly simplified, indeed nearly pidginised use of the language, often disjunctive and abbreviated. It can thus be utilized by limited users of English to cooperate in the necessary tasks in aviation and flight management, as it involves predictable transactions which are part of the prescribed protocol for pilots and controllers. According to Varantola (1989), with this restricted repertoire non-native English speakers might communicate even better than native speakers because they would be less likely to use spontaneous – and unpredictable – wording (cf. also Tajima 2004). Thus, for instance, the standard Airspeak command 'taxi into position and hold' is less ambiguous than the corresponding colloquial expression 'line up and wait', and similarly 'on your frequency' is much clearer than the conversational English expression 'with you' (Sullivan/Girginer 2002: 404). Therefore, there has been an effort in the direction of greater standardization of verbal exchanges in the conviction that standardisation of the language used leads to clarity making the crucial difference during a crisis.

Although it is a fact that in routine situations recourse to standardized modules can avoid misinterpretations (above all when non-native speakers are involved), it is undeniable that facing emergency situations and finding solutions to unexpected problems may require a wider inventory of linguistic forms, and the ability to use language under stress and in conditions of cognitive pre-occupation. In addition to being highlighted in specific studies (Emery

2008: 46; 2009: 14), this is openly recognized in the ICAO Standard Phraseology Quick Reference Guide:

> Phraseology has evolved over time and has been carefully developed to provide maximum clarity and brevity in communications while ensuring that phrases are unambiguous. However, while standard phraseology is available to cover most routine situations, not every conceivable scenario will be catered for and RTF users should be prepared to use plain language when necessary following the principle of keeping phrases clear and concise. (EUROCONTROL 2007: 2)

A further problem is that the effective use of the purpose-built language involves the accurate and meticulous implementation of standardized procedures, but in actual practice it is unrealistic to expect that in prolonged and repeated routines of interaction people never deviate from the standardized forms prescribed. In fact deviations occur quite frequently, and although they do not always lead to miscommunication, they are potentially dangerous (Howard 2008: 375).

Another crucial element is compliance with prescribed discursive practices and procedures. They include obligation of identification in every single contribution by means of a conventional denomination combined with numbers (e.g. ATC: "Big Jet 345, contact Metro Tower 119.2", Pilot: "Contact Metro Tower 119.2, Big Jet 345"), the need to ask for/grant clearance for most actions [4] and readback requirements, which regard most important actions[5] (cf. EUROCONTROL 2007: 4). Unfortunately, real life conditions are far from ideal, and communication bottlenecks can arise, as both controllers and pilots are usually exposed to intense workload, especially during the phases of landing, take off and ground operations. The

4 Clearance is required for crossing the main runway or intermediate runways, and for other movements on the ground, line up, take off, landing, etc., and relative amendments. There are also conditional clearances, which are potentially confusing.

5 These include taxi instructions, level instructions, heading instructions, speed instructions, airways/route clearances, approach clearances, runway in use, all clearances affecting any runway, ssr operating instructions, altimeter settings, VDF [Very High Frequency Direction-Finding] information, type of radar service, transition levels.

tower controller, on his side, is engaged in radio contact with several aircraft at a time – up to twenty per controller – that need to be kept apart while expediting overall traffic (Amaldi *et al.* 2005a, 2005b). For each aircraft the controller has to take quick decisions on direction, speed, and flight level, and deliver the resulting instruction promptly, so he or she can move to the next aircraft (Wong *et al.* 2006).

At the other end of the system, the pilot is engaged in the demanding task of configuring aircraft settings according to the specific phase of flight and on controller's instructions. Due to this complex scenario, it is not unusual for readbacks to contain errors, variations or omissions,[6] nor is it the case that accurate readback does guarantee that instructions in the message have been given adequate attention and will be carried out correctly.

Improvement in main actors' proficiency in language use will certainly contribute to reducing incidents and accidents in air transport. As a matter of fact, many authors are convinced that the inadequate command of the language by pilots and ATCs is the main cause of disasters (cf. e.g. Mathews 2003; Campbell-Laird 2004).[7] But, of course, inadequate language proficiency is only an aggravating factor in a general picture where – as already pointed out above – the conditions themselves under which the interaction occurs are inherently problematic for native and non-native speakers alike. Blaming only inadequate knowledge of the language for disaster-causing misunderstandings would be to some extent simplistic.

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6 It is to be noted that readback requirements do not demand a complete readback of all instructions. Although for some (i.e. clearances to take any action on a runway, or altimeter settings, or heading and speed instructions) a full readback is mandatory, ICAO norms prescribe that "other clearances and instructions, including conditional clearances, shall be read back or acknowledged *in a manner to clearly indicate that they have been understood and they will be complied with*. […] The controller shall pay attention to the correctness of the readback and take immediate action to correct any discrepancy" (ICAO doc. 4444; emphasis added).

7 Cf. also Ragen (2007), who insists on cross-cultural, as well as cross-linguistic, factors in miscommunication occurrences.

3. Towards an integrated model

As can be seen from the above, there does exist some literature on the role of language in aviation (mis)communication and, more specifically, in the etiology of individual accidents. Most of it, however, is rather isolated, focussing on individual aspects, and only rarely does it attempt an integration with other levels of analysis. It is the purpose of this study to move a step forward trying to provide such an integrated model.

3.1. Contextual factors affecting language use in Pilot–ATC interaction

As shown in the review of the literature on miscommunication in aviation provided in Section 2.2, in studies giving specific attention to language-related problems pilot-ATC interaction has been much less extensively investigated than cockpit conversations, in spite of its crucial importance for the successful outcome of flights. However, there are reasons to believe that systematic linguistic analysis is essential in order to shed light on the dynamics of air accidents, also with a view to preventing future disasters.

Even more than ordinary cockpit communication, air-ground communication takes place under very special circumstances, which to some extent may help account for the inherent incident/accident potential characterizing it, as is demonstrated by the many episodes where communication problems have cost lives (cf. Howard 2008). As concerns specifically pilot-ATCs conversations, they are typically task-oriented interactions in sociotechnical settings (Nevile 2004: 198). According to Howard (2008: 372), the discursive space in which pilots and ATCs operate is defined by four socioenvironmental factors:

1. it is completely mediated;
2. it is highly regulated;
3. it is an intense environment;

4. it has primary actors (flight crews and ATCs) that emerge from different organizational structures and cultures.

In actual fact, these four factors fail to account for the extreme complexity of this discursive space: it is worth spending a few more words on its peculiarities and the constraints it poses on the quality of linguistic exchanges. As mentioned above (§2.2.1), all actors involved work under pressure and under high cognitive workload (Sexton/ Helmreich 1999, 2003; Silberstein/ Dietrich 2003) in a very high risk environment, where even one second's inattention can cause serious consequences. The high level of regulation of the environment, subject as it is to strict procedural rules both in terms of actions and of communication (fixed scripts, readback requisites), does certainly have the effect of minimizing uncertainties, but at the same time does not guarantee the ability to competently cope with uncertainties; indeed, according to some authors, standardization may even have problematic effects on team behaviour (Grote *et al.* 2003: 131).

As also observed by Howard (2008; cf. the fourth of the socio-environmental factors listed above), the pilots and ATCs that have to collaborate in a takeoff or landing operation come from different backgrounds and often from different nationalities. For each specific landing or takeoff task they have to 'team up', that is, behave as a team and "work together adaptively to achieve specified and shared goals" (Brannick/Prince 1997), co-ordinating their actions and sharing the necessary information to attain such shared goals.

But in cognitive terms each of the two groups of professionals is in a very different position vis à vis the communicative task to be performed collaboratively. The ATCs are resident in the sites where operations take place and know the local environment very well. This profound knowledge has its linguistic counterpart in their familiarity with local contextual elements, for which there are often shared denominations and conventional Community-of-Practice (cf. Wenger 1999) forms – often shorthands – used to refer to them. On the other hand, pilots have to operate in settings of which in many cases they have never had any first-hand experience. So, they use direct visual input (whenever possible), also counting on a degree of standardization in airport design, and – above all – they rely on maps and on the

recognition of landmarks (natural or artificial, e.g. signs on the ground).

All these contextual conditions of air-ground communication are further complicated by a series of more specifically linguistic and paralinguistic factors. Pilots and ATCs interact exclusively through radio communication,[8] which not only inherently distorts sound quality (timbre), but is often defective and subject to various types of noise and disturbances, not to count the clamour that often characterises Control Tower rooms. Given that the language that is mostly used is English, in many cases there is a problem with the non-native or sub-standard – and often unclear – accents of non-native participants in the conversation, pilots and ATCs alike.

A whole range of linguistic misunderstandings, errors and mistakes involving both native and non-native speakers is examined by Cushing (1994). In what is virtually the only book-length study of linguistic aspects of air incidents and accidents so far, he lists a series of core linguistic – and predominantly micro-linguistic – problems in aviation communication, which in most cases can be accounted for by the inherent indeterminacy of meaning that requires the recipient to 'fill in' to some extent what is not made explicit in linguistic expression.

Considering that some of the phenomena identified by Cushing (1994) overlap to a certain extent, the various categories can be grouped under few general headings: errors in basic language decoding ('ambiguity': pages 7-11; 'reference': 17-22; 'terminology': 29-34), errors in inference and or interpretation of utterances ('inferences': 23-29; 'false assumptions': 34-37), and problems connected with phonological aspects, both at the phonetic and at the suprasegmental levels ('homophony': 12-14; 'punctuation/intonation': 15-16). But, ideally, it would be most effective to subsume all these problematic aspects within a single framework. This would make for a theoretically

8 Ground radars enable ATC personnel to visualize the position of aircrafts on the ground; pilots, however, have no means of seeing their positions, nor those of other aircrafts out of sight. Even when all the relevant technology is in place, however, the only direct means of communication is the verbal one.

sounder approach, as it would enable the explanation of a large number of phenomena using a single, limited, set of assumptions.

3.2. A pragmatic perspective

In this chapter, we propose an analytical approach that takes account of the complexity of the context where the interaction among pilots and ATCs unfolds and of their communicative coordinates as well as of the strictly operational nature of language use in this type of exchanges. This approach is based on pragmatics (or more specifically pragmalinguistics) which in our view is the theoretical framework that seems to be best suited to this function because, differently from other theoretical approaches which describe language on the basis of abstract systems of rules, it is aimed at the analysis of language in use and sheds light on the relationships between communicative occurrences and the relevant context. This implies that it hinges on extralinguistic variables such as the notions of 'speaker' and 'context'.

Recourse to pragmatics allows to focus on all those absolutely fundamental aspects of communication which cannot be explained in purely semantic terms or relying only on grammatical or lexical or textual criteria, and in particular illocutionary force, deixis, and implicatures. All such phenomena are generated by the correlation between language and context, and can be explained only on the basis of such correlation. Thus they are suitable to explain the actual meaning of an utterance as determined by the specific context where it is produced, which can be very different from the meaning it would have if considered in isolation, on the basis of purely grammatical (morphological, syntactic, lexical) considerations. This difference is pinpointed effectively in the concept of speaker meaning (or meaning n-n [non-natural meaning]) as opposed to natural meaning as put forth by Grice (1957).

The suitability of some essential analytical tools based on pragmalinguistics will now be introduced, and illustrated by applying them to the Linate accident, showing that this approach can help shed light on some crucial aspects of the pilot-ATC conversation in the few fatal minutes preceding the crash. Even a cursory reading of the

transcripts contributes to confirming the relevance of pragmatics to this type of analysis, as the sense of the conversation exchanges cannot be grasped from their plain linguistic/semantic meaning, being inextricably connected with the physical context to which they refer and the interactants' intentions, expectations and interpretations. Particularly strict is the relationship between the verbal exchanges and the spatial dimension of the context, a fact that is made evident by the inherent difficulty, indeed impossibility, to decode the meaning of the conversation without some degree of 'geographical' acquaintance with airport structure and design.

3.3. The cooperative principle: excess cooperation

A principle of pragmatics which can provide a general framework capable of explaining many misunderstandings in aviation communication is Grice's 'cooperative principle' (Grice 1975), which contributes to shedding light on one of the basic mechanisms that make linguistic interaction possible even under problematic conditions. This is the cooperative principle:

> Make your conversational contribution such as is required, at the stage at which it occurs, by the accepted purpose or direction of the talk exchange in which you are engaged. (Grice 1975: 45)

As is well known, this principle is then broken down into maxims that speakers are expected to observe in order to make a conversation work, falling into four main categories:

1. Quantity (1. Make your contribution as informative as is required for the current purposes of the exchange; 2. Do not make your contribution more informative than is required);
2. Quality (Try to make your contribution one that is true);
3. Relation (Be relevant);
4. Manner (Be perspicuous).

Thus, Grice's principles succeed in explaining how verbal exchanges consisting in utterances which in terms of conventional (i.e. purely

linguistic) meaning are scanty, incomplete or fragmentary can be decoded by the interlocutors involved in a conversation. In particular, the cooperative principle highlights the fact that in linguistic interaction the interlocutors' attitude is characterised by a clear determination to make the conversation 'function', putting to the best possible use all linguistic clues available, even when the speakers' contributions are inadequate in informative, linguistic (e.g. grammatical, phonetic) or textual terms, or when reliance has to be made on shared knowledge, inferences or on presuppositions.[9] To tackle these problems, recipients generate implicatures, endeavouring to reconstruct speaker's intention, i.e. what the speaker has intended to imply (or suggest) in his utterance, without explicitly saying it.

In critical situations overdoing the cooperative principle may be a source of errors or incorrect implicatures, and this can be especially problematic in high-risk contexts. If one looks at the scripts of the Linate disaster, for instance, the hypothesis can reasonably be put forth that the miscommunications that eventually led to the tragedy were ultimately caused by what we propose to call 'excess cooperation', i.e. by the interlocutors' excessive willingness to make sense out of the communicative exchange and make it function. This willingness can be accounted for through a whole series of contingent elements outside the interlocutors' control, essentially due to organizational factors, first and foremost the habit to operate all the time on the basis of communicative exchanges characterised by a below average – if not totally inadequate – quality of all linguistic components, at the phonetic level with very poor audio quality, made worse by multiple voice overlap and background noise, and non-native substandard pronunciation of actors involved and at the level of the general command of the language as illustrated above. In the Linate case – as unfortunately was also the case in other aviation disasters – other important factors inducing excess cooperation were the inadequacy of all the elements contributing to a pilot's correct physical orientation, his understanding of the surrounding environment

9 This happens quite often in Airspeak, generating false hypotheses which, in turn, can lead to crisis situations, as shown by Weick (1999) following Davis (1958) and O'Reilly (1978).

and of his aircraft's position (absence of functioning radar system, inadequacy of signs and landmarks, foggy weather, etc.).

The notion of excess cooperation is set at a very general level of generalization and can help explain the overall behaviour of pilots and ATCs involved in very serious communication errors at all levels, belonging to all the different categories described by Cushing (1994).

3.4. Interpretive procedures: some essential features of common understanding

The pragmatic approach outlined in the previous paragraph is made even more cogent when combined with theoretical proposals developed in the fields of phenomenology, ethnomethodology and cognitive sociology. According to Goffman (1956: 49), interactions are based on a complex interplay of mutual 'obligations' and 'expectations'. Obligations and expectations are two sides of the same coin: in every interaction, a participant's expectation becomes the other participant's obligation, and viceversa. As Schutz put it, each participant assumes that his interlocutor assumes what he assumes and, by the same token, the interlocutor does the same. This mutual interplay of 'presuppositions' is based on some essential features of common understandings which were first described by Schutz (1945, 1953) as tacit instructions which participants in an interaction assign each other, assuming that everybody does the same. These 'rules' include the following:

1. *the reciprocity of perspectives* (Schutz 1953; Garfinkel 1963: 212-213, 1967: 89; Cicourel 1973: 85-6): speaker and hearer take for granted that their points of view and experiences are interchangeable, based on the assumption that everybody interprets the world in substantially the same way. By the same token, they assume that their descriptions are clearly understandable and recognizable, and that therefore until further notice they can disregard any differences that might arise from their respective personal ways of assigning meaning to objects and events;
2. *normalization* (Garfinkel 1967: 91-92; Cicourel 1973: 86): when discrepancies or ambiguities appear, the speaker will attempt to normalize the presumed discrepancies, thereby eliminating small

cognitive dissonances. This, however, may lead to disasters, as was the case with the controller in Linate: despite hearing an anomaly in the pilot's readback, after a brief moment's hesitation he normalized the information he received from the pilot; unfortunately, it was precisely this piece of information which might have stopped the Cessna on its route to collision (cf. § 3.5.2 below).

3. *the 'et cetera' assumption* (Garfinkel 1967; Cicourel 1973: 87): speaker and hearer assume the existence of common understandings not only on occasions when the descriptive accounts are seen as obvious, but also when they are not immediately obvious. This tolerance serves the function of allowing utterances to pass despite their ambiguity or vagueness, so that communication can continue to flow instead of being constantly interrupted. This communication principle is realized through three procedures:

a) letting unclear information pass while clarifying information is sought (Garfinkel 1967: 3, 20-4, 90-1);
b) filling in the ambiguity of indexical expressions through contextual information (Garfinkel 1967: 90-1);
c) using retrospective-prospective means in order to fill in the ambiguity of indexical expressions (Garfinkel 1967: 89-90);

4. *expectation of future explanations* (Cicourel 1973): this procedure inhibits potential objections or requests for explanations on the part of the interlocutor by establishing the assumption that explanations will be provided in the course of the interaction. As with the previous one, this procedure enables the smooth flow of the interaction, guaranteeing the continuity of the conversation;

5. *reflexivity of accounts* (Garfinkel 1967: 1): speaker and hearers, when acting, continually and simultaneously produce both descriptions and explanations of what they are doing, instructing each other on both the meaning of their actions and their reasons for performing them.

6. *indexicality*: it is another invariant feature of actions, which *points* to (or *indicates)* the relationship between different actions. Indexical expressions (or deictics) highlight the contextual features of organizational activities.

3.5. Deictics

Among the aspects included in the rules above, for the purposes of this discussion special attentions is deserved by indexicality, or 'deixis',[10] which concerns the ways in which languages encode or grammaticalise features of the context of utterance of a speech event (Levinson 1983: 54ff). Symmetrically, the recipients' understanding of utterances will depend on their interpretation, which by definition involves an analysis of the context.

Deictics are words that do not have an absolute referent, as they are variable placeholders for some categories of meaning, the most important instantiations being the categories of person, place and time. As Levinson (2004) points out, indexicality is normally associated with linguistic expressions that are semantically insufficient to achieve reference without contextual support, and introduces subjective, attentional, intentional and of course context-dependent properties into natural languages. Thus, in practical terms it is a problematic aspect of communication, and it also poses complex theoretical problems.

3.5.1. Deictics at work

In the case of cockpit and air-ground communication, it is spatial deixis in its complex interaction with the organization of space (units of measurement, place description and landmarks, indications of direction, etc.) that is particularly relevant – and often problematic, as it includes all elements of anchorage of the communicative event in the spatial domain (Levinson 1983: 79).

In aviation communication, and in particular in pilot-ATC communication, because of the peculiarity of the environment and the conditions of professional interaction, even the interpretation of much of the vocabulary used is effected on a deictic basis: if in abstract

10 According to Levinson (2004), "the terms 'deixis' and 'indexicality' […] simply come from different traditions (Bühler 1934 and Peirce 1955) and have become associated with linguistic and philosophical approaches respectively." There is a tendency to use 'indexicality' to label the broader phenomena of contextual dependency, and 'deixis' for the narrower linguistically-relevant aspects of indexicality. Here the two words will be used interchangeably.

terms the semantic meaning of denominations like 'the main taxiway', 'the main runway' and 'the main apron' is clear to all actors involved, in actual fact in each single case such meaning is often insufficient to provide clear reference without contextual support, in a situation where often pilots do not have a specific spatial knowledge of the airport grounds. In particular, if one considers the noun phrases above, their meaning within a given airport area is made univocal thanks to the deictic value of the definite article that anchors the utterance to the local spatial domain, in combination with the adjective 'main', which restricts reference to the most important or largest entity within a group of similar entities whose existence is postulated by pre-supposition.

In addition to spatial deictics proper, in pilot-ATC conversation there are other elements that can be decoded correctly only on an indexical basis, and this contributes to the potential ambiguity of messages. Some examples can be seen in the following extracts from the transcript of ground-pilot communication a few minutes before the Linate air crash:

06:08:32	GROUND	Delta Victor X-ray roger, maintain *the stopbar*, I'll call you back.
06:09:16	GROUND	Delta Victor X-ray continue your taxi[11] … *on the main apron* follow the Alpha line
06:09:34	D-IEVX	Call you *on the main taxiway*.

Transcript 1.

The expressions highlighted in italics are relative and anchored to specific spatial reference points which of course are familiar to ground operators, but have to be recognized by pilots on the basis of their experience with airport topography. The most problematic is the reference to 'the stopbar' in Transcript 1 above, as while both the ATC and the pilot obviously classify it mentally as 'the stopbar towards which Delta is taxiing', mentally each of them sees Delta as being in a different position, with a total failure of deictic reference.

11 *Taxi* v. = Of an aircraft or pilot: move slowly along the ground or water under the machine's own power before take-off or after landing. (OED)

In general terms, in the three examples above the interpretation given by each of the two main actors unrealistically presupposes a spatial alignment between them, and this is a potential source of misunderstandings, which is all the more serious as in many cases – as in that of the Linate accident where visibility was seriously reduced – the situation provides insufficient clues to such incorrectness, decreasing the possibilities that it may be amended or redressed in a sufficiently short time.

3.5.2. Signs as deictics

In consideration of these inherent difficulties, and keeping in mind the fact that many of the pilots operating in a given airport area have no direct knowledge of its topography, in airports the different runways, taxiways, aprons, etc. are marked with special numbered signs on the ground which should make them easily identifiable also for those pilots who have never been there before or so rarely that indexical decoding would be problematic for them.

As emerged from the inquiry, there are reasons to believe that in the Linate accident the pilot exchanged taxiway R6 (Romeo 6) for R5 (Romeo 5), although each of them was marked with the relevant sign, but both signs were so deteriorated as to be hardly readable and the fonts used were not in conformity with international ICAO standards. A shortcoming which had some weight in the adverse outcome of the incident. Actually on R5 there were two other signs on the asphalt, S4 (Sierra 4) and S5 (Sierra 5), which Delta did read, referring to one of them in the conversation with Ground:

06:08:20	D-IEVX	Delta... India Echo Victor X-ray is approaching Sierra four.
06:08:25	GROUND	Delta Victor X-ray confirm your position?
06:08:28	D-IEVX	Approaching the runway... Sierra four.
06:08:32	GROUND	Delta Victor X-ray roger, maintain the stopbar, I'll call you back.

Transcript 2.

But the Sierra signs were leftovers from a previous set of signs not in use any more that had remained uncancelled, so the ATC does not give attention to the reference made to them by Delta. If heeded, such a reference might have made him aware of the pilot's mistake. The

basic misunderstanding that led to the disaster mainly resulted from a disalignment in aircraft position perception between ground on the one hand and the Cessna on the other. See the exchanges that had preceded the dialogue in the following extract

06:05:40	GROUND	Delta Victor X-ray taxi *North* via Romeo five, QNH one zero one three, call me back at the stopbar of the... *main runway extension.*
06:08:28	D-IEVX	Roger via Romeo five and... one zero one three and call you... back before reaching main runway.

Transcript 3.

Ground instructs the Cessna to take taxiway R5 which leads to the main apron and hence to the onset of both the main runway and the main taxiway, and to stop at the stopbar at the point of access to the main apron from Romeo 5.

The expression 'stopbar of the main runway extension' refers to a stopbar which is set at the intersection between the taxiway and the extension of the main runway; in this respect, a problematic fact is that the latter is not actually a real asphalted lane extending the runway course, but rather a track on the ground which geometrically represents a prolongation of the runway (cf. Figure 1 above). Although this kind of expression and the relative reference, albeit not part of the standard vocabulary, seem to be common amongst airport staff, it cannot be taken for granted that the pilot of the Cessna indentified correctly the point where he was being directed. So one possible hypothesis to explain the causes of the accident is that in deictic terms the Ground's instructions failed, and this was also made possible by the German pilot's total neglect of the indication of the direction to follow (North).

This could also be confirmed by the inaccuracy of the readback in Transcript 3, which however Ground did not correct, quite obviously interpreting it on the basis of the maxim of quantity – and evidently exceeding in cooperation – as a sort of condensation of the actual content of his instructions.

3.6. Language typology problems

A further factor in this unproblematic acceptance of a reduced repetition is also that, since in Italian the head of a noun phrase takes the first position to the left, for an Italian native speaker reducing a noun group to its left-most element is quite normal and does not change the nature of the thing to which the noun group refers. A reduction of this kind can be found in the Linate transcripts at minute 6:06:07 when the expression 'la messa' is used to mean 'messa in moto' (lit. 'the set into motion') both by Ground and by the pilot of one of the planes taking off that morning. On the contrary, in English the head of the noun group has the last position to the right, which means that the suppression of any element starting from the right is highly problematic, as it eliminates the head of the group and maintains only the premodifiers: e.g. the 'main runway extension' would become the 'main runway", although the head is an 'extension' and not a 'runway'.

Incidentally, the possibility afforded by English of simply 'assembling' nominal elements into complex phrases or 'noun strings' thanks to pre-modification – a typical trait of Germanic languages – makes it paradoxically less suitable for use as a *lingua franca* in a sensitive setting like that of air transport, given that in radiotelephony communication the normal prosodic profile of utterances can make the last part of a statement less audible. Another problem with noun strings is that, although they are highly functional to economy of expression and therefore widely utilized in scientific and technical communication, using them "one tends to lose most of the ideational-semantic information, because all that the nominal group provides is a long string of modifying words" (Halliday 1997: 36) on account of the suppression of prepositions, which have the function of encoding the relationship between the different constitutive elements.

In light of these observations, it is evident that in aviation communication it would be highly advisable to refrain from the use of noun phrases apart from those that are codified as standard. In the case at hand, saying 'the extension of the main runway' instead of 'the main runway extension', although less quick, would have meant a clearer indication and, above all, an indication which, if deprived of its

final element because of inaudibility or of attention lapse, would have maintained its correct reference.

4. Conclusions

In this study we have proposed an integrated model for the analysis of communication failures in aviation accidents, which draws both from organizational models and from existing accounts of communication problems in aviation, starting from the premise that exchanges between pilots and air-traffic controllers take place in very peculiar circumstances. Although pilots and air controllers belong to professional communities that by definition collaborate with each other closely, relations among them are established on a temporary basis and, as far as pilots are concerned, in ever changing spatial contexts and with ever different interlocutors, on the basis of interactions that are limited to verbal exchanges, uttered from remote and non-mutually accessible positions. Therefore, the ensuing professional identities are tenuous and unstable, in keeping with the growing awareness of the "conjunctural, relational or dialogic" character of identity (Clifford 1988: 338; Rogers 2006: 495) that has emerged in contemporary scholarship. In this respect the pragmatic approach characterising the model proposed in this study succeeds in pinning down the invariant features in each situation focusing on the interface between the mutability of discourse and the need for practical actions to be based on a stable construction of reality.

The model, accompanied by examples of miscommunication taken from the transcripts of the Milan-Linate accident of October 8, 2001, integrates the results of the latest studies of the etiology of accidents with pragma-linguistic tools capable of giving an account of language use in different contexts. Its most important contributions to the field of accident studies are the integration of the organizational dimension with the linguistic one, and the fact that – differently from most analytical approaches applied so far – it has not only a descriptive, but also an explanatory relevance. Thus, it can go beyond

the mere description of communication failures to tackle the much more relevant issue of why they occur, providing much-needed information that can be used to enact measures aimed at preventing any further occurrences from happening. While human error remains – to an extent at least – unpredictable, and sometimes unexplainable, knowing the reasons why misunderstandings happen is crucially important if we want to reduce the margin for communication failures.

A key premise of the model is the assumption that linguistic factors play a crucial role in the history of accidents, incidents and near-misses. This is something which has been only marginally recognized, and has rarely been given adequate attention even in the investigations following aviation accidents. In this respect, we believe that the use of pragma-linguistic instruments of analysis can be particularly useful, as it can shed light on aspects that so far have often been only described, but not accounted for.

A further assumption is that the organizational and the linguistic components are strictly intertwined and interdependent. On the one hand, organizational criticalities can be overcome thanks to linguistic exchanges; but on the other they can be made worse by misunderstandings and communication failures, thus leading to fatal outcomes. Strictly connected to this aspect is also the fact that often, when faced with organizational criticalities, actors try to compensate them through patterns of behaviour that are potentially dangerous; one prominent example is excess co-operation often resulting from insufficiency of organizational supports (signs, signatures, ground radar, etc.), whereby actors do their best to make inadequate communication function, with the risk of misinterpretations and inappropriate actions.

In light of these considerations, the various organizations involved in air transport – airlines, ATCs and service providers; regulators (ICAO and national agencies) and air safety agencies – should become more acutely aware of the central role of language and communication factors in air safety, as until now this aspect has been only formally considered, but in actual fact rarely taken care of. This is confirmed by the virtual absence of expertise in this area in their organizational chart, and by the fact that the adequacy of the ICAO requirements generally taken as given, rather than as something which is amenable to testing.

Another spin-off for this type of studies can be in the area of prevention. An adequate awareness of the importance of linguistic problems is essential in staff training. Not only could higher levels of command of the English language be required for access to the different air transport professions (pilots, ATCs), but simulation activities reflecting the actual working conditions and the organizational context could be included in linguistic training programmes. Moreover, in a context where there seems to be no realistic alternative to English as a *lingua franca*, it would be advisable to make operators aware of the typological differences between their own mother tongue and English, which are a potential source of interference and misunderstandings.

In consideration of the above discussion, we believe that the most relevant lesson to be learnt from a systematic analysis of how complex systems work and fail is the importance of joint design between technical-organization and pragma-linguistic aspects. This has been the guiding notion in the construction of our integrated model. Of course, further research is necessary in order to test and consolidate this model; but we believe that its application to both the analysis of accidents and the development of language policies and protocols, may contribute to reducing accident risk in complex organizations.

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