CO-OPERATIVE DEMANDS ON PILOTS AND CONTROLLERS DUE TO WEATHER

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Abstract

The co-operative demands placed on airborne crews and ground controllers due to the onset of adverse weather conditions in approach sectors are presented in this report. Five (5) incident/accident investigation reports were analysed using an Emergent Themes Approach. Four (4) emergent themes were finally identified with respect to the co-operative demands of controllers and crews, namely: 1) Monitoring of activities, 2) Redirection of attention, 3) Delegation of responsibilities, and 4) Assignation of activities. We suggest that each theme represents requirements for improving the integration of weather information in approach sectors – the implications of the co-operative themes suggests multiple systemic weaknesses in the ways weather information is managed and distributed in the approach incident/accident scenarios analysed.

1 Introduction

Weather conditions within small and localised regions of space are factors that remain hard to predict even during relatively good weather. In adverse weather conditions such as windshear, fog, precipitation as well as combinations of all those elements in thunderstorms, weather becomes chaotic and is inherently impossible to predict for extended periods of time. However, the localised incidence of those weather conditions and their temporal dynamicity form part of the operational environment which passenger and cargo aircraft travel across everyday as part of their flight plans. The airborne crews that are forced to deal with adverse meteorological conditions have the help of both the humans and the technological systems forming part of the Air Traffic Management (ATM) domain. While system entities communicate their knowledge of weather prevailing at geographical regions of interest, the crews receiving the information still need to integrate it into their own representation of the flight situation for the goals of planning and decision-making. In this document, the flight crew as well as the ground controllers are qualified as air-ground teams – a systemic analysis of the co-operative nature of work in ATM treats groups of controllers and crews as cohesive teams engaged in the accomplishment of the common, global goals of operational safety and efficiency.

2 Analysis: Co-operative needs of air-ground teams

Integrating a new technology into an existing socio-technical system involves a prior understanding of the relationships which the observable human activities hold with respect to the operational goals of the persons. Whether the technology being integrated takes the form of a new tool or the enhancement of existing ones, the constraints which underlie their construction and application in the work environment need to be identified and minimised. As a means of informing the design of shared weather information in approach Air Traffic Control (ATC) sectors, the starting phase of this doctoral study investigates the demands which weather information might hold with the co-operative needs of air-ground teams.

Schmidt describes co-operative activities as a response to the intricacies and difficulties of certain types of work by people who would not be able to accomplish them on their own [1]. This view of co-operation presumes a number of reasons for the mutual dependence of people namely an augmentation of their capacities; the differentiation and combination of their specialties; mutual critical assessment; and the confrontation and combination of their perspectives [2]. This view also presumes that people generally prefer an individualistic means of accomplishing their work as long as it is within their competences. Therefore, the co-operation of people is regarded in this paper, as being an undesired activity which is somehow imposed by the demands of the workplace. Schmidt qualifies co-operative activities according to the observable interactions of workers. Hence those interactions have been analysed according to their modal and mechanistic properties. Schmidt's 'modes of interaction' are defined with the goals of maintaining reciprocal awareness; directing attention and assigning tasks. The 'mechanisms of interaction' are gestures and conversations that are mediated by objects in the work environment [3].

2.1 Analysing co-operative activities of air-ground teams from incident/accident investigation reports

Investigation reports of air traffic incidents and accidents utilise CVR (Cockpit Voice Recorder) recordings as part of the analytical process. The verbal exchanges which occur among air-ground teams are transcribed along with sound cues from mechanical systems such as alarms, beeps, clicks, Morse codes during approaches to airfields and so on. The elicitation of verbal exchanges, flight recorder data as well as post-incident/accident information has enabled investigators to reconstruct the temporal evolution of flight scenarios and subsequently detect the contributory causes of incidents/accidents.

2.1.1 Progressive and hindsight information

The verbal exchanges gathered from the transcriptions of CVR recordings provide an indirect account of air-ground activities which need to be analysed carefully since they are only representative of the verbal portion of human communication. However, verbal information exchanges provide progressive, real-time data from the humans involved in the situation and such types of data cannot be gathered from other sources and are potentially important. Investigation reports also consist of a temporally different type of information which is gathered in hindsight concerning the incident/accidents. Forensic information gathered from investigation labs and agencies are performed to determine the causal reasons underlying an incident/accident. The objective data reported can represent a measure of system states during the evolution of scenario but has to be

corroborated with the analysis of CVR recordings as a means of understanding the contributions of humans to the incidents/accidents.

2.1.2 Are verbal exchanges representative of human actions?

The analysis of CVR transcripts for understanding the nature of incidents/accidents is based on a starting assumption. This assumption states the relation between the verbal data and the actions performed by the human beings during the situation, in other words, it maps the semantic significance of verbal exchanges onto human actions.

One of the more common assumptions grounded in the extensive works of Searle presumes that the unit of verbal exchanges is a speech act [4, 5]. Prinzo proposes a measure of the differences which specific categories of speech acts have with respect to prescribed aviation phraseology. Hence, this approach is believed to uncover the verbal inconsistencies which lead to communication failures and finally contribute to incident/accidents [6]. The strict usage of speech acts as a means of gaining a clearer insight into the activities of people during the evolution of an incident/accident has recently been challenged [7]. Indeed, non-standard verbal exchanges might hold a contributory cause in incidents/accidents but might also be the results of larger and more significant causes. In such a case, the breakdown of standard phraseology during incident/accidents would not denote a failure in the humans, but instead a failure for the phraseology to allow the rich expression of unplanned events.

More recently the term conversation analysis was introduced into ATM incident/accident investigations. Conversation analysis considers a number of properties of verbal exchanges to hold tacit information about a scenario [8]. The temporal delays which underlie communication handovers among humans, the stutters which are believed to underlie an uncertain mental state and the frequent verbal repetitions which might denote a sense of urgency are some of the verbal properties analysed. The methodology claims to provide detailed analytical accounts, while preserving the context of the verbal data [9, 10]. Nevile describes verbal mechanisms which are frequently recurrent across incident/accident investigation reports as providing a useful starting point for analysing the activity patterns of air-ground teams. Nevile and Dekker both propose a detailed conversation analysis of CVR recordings as a means of understanding the activities of crews and controllers [8, 9]. The limitation of this approach is mainly seen to arise from the provision of original CVR recordings such that rich sound cues can be transcribed. Indeed, most CVR transcripts exclude subtle cues such as the tonal variations and word accents in human sentences which conversation analysts treat with as semantically significant.

2.2 Methodology: Emergent themes approach (ETA)

The Emergent Themes Approach (ETA) takes its roots from a scientific approach known as Grounded Theory (GT) [11]. GT developed after 1984 as a means of dealing with some of the limitations of hypothesis testing for analytical-based investigations. The main claim of GT is that it foregoes the initial starting hypothesis usually elicited in conventional analyses as a means of removing potential analytical biases. The ETA, for instance collates recurrent themes from numerous types of information which surround real-world, operational situations. Themes are not limited to any specific analytical perspective such as action-based sequences, verbal-cue identification, corrective-exchanges or the relation of those by a hypothesis, but are instead collected non-discriminately.

2.2.1 Steps of the ETA

The first stage of the ETA renders very broad themes which might each be based on a different analytical perspective of the information such as its sources, the repetition of certain information in time and the mistakes in read-back protocols. The next stage extends each broad theme into sub-themes which are evidenced from the data. Subsequent stages attempt a collation of common sub-themes under categorical headings – this process makes use of evidence collected under a certain broad theme to support new, emergent themes. In the analysis of complex, inter-related information, the ETA is expected to generate evidence which have varying degrees of relevance to a specific focus of analysis. Hence, the same theme which is used to provide evidence for decision-making in an operational context might hold significance for a co-operative focus of analysis within the same work context. The final stage of the ETA defines the focus or framework of analysis and collates the evidence from the data in the form of emergent themes.

2.2.2 Data yield and limitations

The ETA is said to increase the data yield of qualitative research exercises which entail large amounts of raw data from rich sources of information [12]. Wong describes the ETA as resembling a distillation process where broad, emergent themes are identified initially and drawn into specific themes. The usage of ETA in safety-critical domains such as ambulance dispatch allowed the thematic identification of decision-based activities as well as the re-specification of key concepts such as situation awareness for informing the design of new systems [13].

An important consideration of the ETA lies in the 'emergence' process – the emerging themes are constrained by the richness of the data itself. For instance, if verbal exchanges from CVRs are transcribed for a subsequent analysis in terms of Prinzo's speech acts, then only word and sentence exchanges need to be available. However, if the CVR transcriptions are needed for a conversational analysis, then they also have to provide subtle cues such as interruptions, tonal variations and others which form the qualitative richness of the data. Subsequently, it is assumed in this document that the emerging of themes from verbal data by the ETA might be limited by the richness of the sources of conversation used. However, the ETA remains a fast means of handling large amounts of qualitative data, without imparting a starting assumption on that data at the very beginning of the analytical process.

2.2.3 ETA of air traffic incident/accident CVR transcripts

An ETA of five (5) incident/accident investigation reports was performed to analyse the effects of weather information on the co-operative patterns of ground controllers and airborne crews, during and after the incident/accident. Table 1 shows the selected reports and their sources namely the National Transportation Safety Board (NTSB) in the United States and the Bureau d'Enquetes et d'Analyses (BEA) in France.

Source	Date	Location	Plane ID	Type
NTSB	1991	Colorado, US	N999UA	737-200
BEA	1992	Istres - France	5N-MAS	707
NTSB	1999	Arkansas, US	N215AA	MD-82
NTSB	2002	Florida, US	N497FE	727-232
BEA	2003	Brest, France	F-GRJS	CL600

Table 1: Details of incident/accident reports and source database information

2.3 Results

The results present the four (4) final emergent themes identified. Five (5) initial broad themes were presented in [14] and are not reproduced in this report.

- Monitoring Activities – weather related communications are observed to interrupt the activities of air-ground teams due to added monitoring demands of each others' work.
    - Air-ground verbal exchanges through the common radio channel shared by everyone in the vicinity are monitored and seem to provide an indication of controller activity. Crew members, namely PNF (Pilot non-flying) seem to be aware of weather information spoken over the radio to other aircraft. PNFs might interrupt their own conversations or even delay a reply to the PF (Pilot flying) while listening to the verbal exchange. It is presumed that the perceived priority of weather information in different situations re-structures co-operative verbal exchanges.
    - Controllers also keep track of crew activities although for different reasons. The knowledge of rapidly changing weather conditions which can affect an approaching aircraft might require a controller to query for the crew's awareness of the conditions, namely when no verbal mention has been made by the crew of updated weather information. Controllers do not seem to be aware of the information given to crews either during or before the flight and this is confirmed through verbal queries.
- Redirecting Attention – humans can redirect their own attention as well as those of others according to the perceived priorities at a moment in time; weather might have an impact on the management of perceived priorities in the cockpit and also the ground control stations.
    - The incidence of cloud formations are often seen to prime requests for Flight Level (FL) changes – this also occurs with thunderstorms and localised regions of turbulence. The FL change request is attended to by the PNF, usually on the PF's demand or after corroboration of both. Expedited procedures like an early descent or a direct visual approach due to an approaching weather front or a rising fog also command the PNF's immediate attention for talking to the controller.
    - Upon en-countering adverse visibility conditions, the PNF's attention is almost always redirected by the PF towards the identification of landmarks; corroboration of visuals with the controller and less frequently, consultation of approach charts and airline flight documentation.
- Delegation of Responsibilities – the incidence of some weather conditions during early approach or landing phases of flight seems to lead to a delegation of specialised abilities among the crew as well as between the air-ground workers.
    - When encountering bad weather before or during an approach, crews request for the ability to manoeuvre freely; this formal request enables the crew to evade localized regions of perceived turbulence without needing to continuously inform of momentous heading changes to the controller.

- The choice of a runway for landing and approach patterns is often handed over to the crew in conditions of bad visibility and rapidly changing wind speeds and direction.

- Assignation of Activities – it is observed that a re-distribution of activities occurs during the approach sequence due to the incidence of adverse weather conditions and namely between the PF and PNF.
  - The estimation of an approach sequence during adverse meteorological conditions is a demanding activity which is most often re-assigned between PNF and the PF. Although controllers give expectations for the sequence before the final phase of approach, crew members are observed to be able to pre-empt that information.
  - The estimation of runway limitations as a measure of wind, precipitations and other information is assigned to the PNF – the PF usually initiates the discussion.

3 Conclusion

The analysis of the incident/accident reports has provided an initial number of considerations concerning the collaborative work of air-ground team activities while faced with the onset of weather conditions. A global observation during this qualitative analysis concerns the effects of weather on the ATM system: the collaborative demands placed on air-ground teams by weather can be viewed as the start of a rippling effect across the system such that the behaviour of humans as well as their interactions varies. To illustrate, a PF might delegate some duties to the PNF to be able to focus more intensely on navigation tasks due to adverse weather – this purportedly allows a redistribution of the workload within the cockpit. However, we can also observe that the PNF now manages an additional activity and incurs the cost of selecting and reporting the information back to the PF. Hence, the simple onset of un-planned weather conditions can imply a very complex re-distribution of numerous interacting factors in the system, including collaborative patterns. This study has identified the co-operative demands on air-ground teams due to the onset of weather in approach ATM sectors. The four (4) emergent themes grounded in the qualitative analysis of five (5) incident/accident reports provides evidence of co-operative activities influenced by the onset of weather in approach ATM.

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