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Assessing organisational factors in aircraft accidents using a hybrid Reason and AcciMap model

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ABSTRACT

Despite the use of high safety standards in aircraft design and operations, accidents do occur. In a process of continuous improvement it is essential that we learn from each accident so we can take measures to prevent such accidents from happening in the future. It is often the case that an accident is the result of a sequence of, seemingly minor and often unrelated, events. The challenge is to identify the major causes, which can include deficiencies in organisational processes which may have been present well before the accident itself. This paper discusses tools which can be used to identify key organisational factors which contribute to aviation accidents. The research uses a thoroughly-investigated helicopter accident as a case study, to determine the extent to which analytical and visualisation tools can be used to assess maintenance organisational issues which contributed to the accident.

1. Introduction

High levels of technological development in aviation have made it particularly difficult to analyse aircraft accidents involving extensive structural damage. Even when engineering and technological issues are resolved, there are complex management systems which need to be analysed to ensure that we identify the factors which initiated the accident. Unfortunately, history shows that it is often easier to focus on technological causes rather than deficiencies at an organisational level. These deficiencies, such as in training and maintenance services, the work environment and the often complex cultural issues which can influence human behaviour, can be difficult to identify and analyse, particularly when the investigation reveals a myriad of causal factors. Nevertheless, the purpose of the investigation is to prevent recurrence of the accident, and it is essential to identify all of the key underlying causal factors. The benefits are obvious – providing a basis for improvement in efficiency and overall safety, and maintaining public confidence in aviation.

This paper includes a discussion of the tools available for identifying and visualising the organisational factors that contribute to aviation accidents. It uses a major helicopter accident as a case study to assess some of these tools, and to determine which tools would assist with achieving organisational improvement to prevent recurrence. Finally, it develops a hybrid approach which could be applied to audits of maintenance performance, by analysing the many small maintenance breakdown events which are rectified before an accident occurs.

2. Case study

In April, 2005, during a humanitarian aid mission after a major earthquake, a Royal Australian Navy Sea King helicopter N16-100 call sign *Shark 02* crashed on the island of Nias, Indonesia (Fig. 1). Nine personnel were fatally injured and two were seriously injured in the accident.

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Fig. 1. RAN Sea King Accident Site, Nias [1].

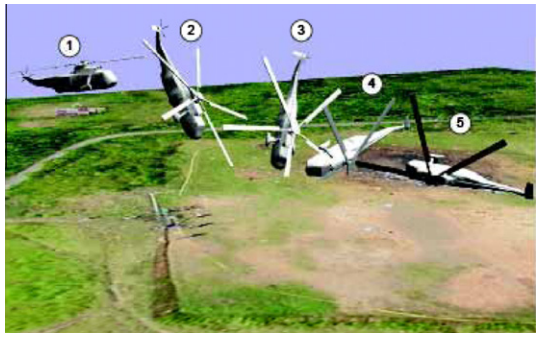

Fig. 2. Accident Sequence of *Shark 02* [1].

The key event immediately before, and leading to, the accident was identified as a control linkage disconnect [1]. This was attributed to incomplete maintenance done some 2 months before the accident, but the Board of Inquiry (BOI) found that the root cause went far beyond a simple maintenance error [1]. Amongst the findings were many causal events including serious organisational as well as engineering deficiencies. The report also made approximately 250 recommendations with the aim of improving the overall management system for the fleet.

The helicopter *Shark 02* was on approach for landing, when witnesses observed it suddenly pitching down and the aircraft impacting the ground in a steep nose-down attitude. Fig. 2 illustrates schematically the sequence of the accident. The mechanical cause was separation of a critical control system linkage, after a bolt slipped out of a joint. The bolt and nut should have been secured by a split pin, which was missing or ineffective.

The crash was reported extensively in the media, and while the primary cause of the accident was the failure of mechanical linkages, there were also contributory causes including:

- Deficiencies in maintenance practices in both the Sea King detachment and the Squadron.
- Errors made by the Naval command and management systems.
- Deficiencies in the levels of support provided by Navy and the Defence organisation's safety, airworthiness, training and logistics management systems [2].

Furthermore, a report was written before the RAN Sea King accident, stating that the Squadron had insufficient staff and assets and was headed for 'an accident' [3]. The subsequent BOI report [1] highlighted a complex interaction of individual and systemic failings across the Australian Defence Organisation, and [4] that senior commanders and managers did not fully understand their responsibilities for airworthiness [4]. These issues, *inter alia*, give an indication of the nature of the causal factors identified in the investigation, and which were explored further in this research.

3. Model

3.1. Background

Modern models of accident causation take a systems approach, where accidents can be attributed to a combination of active operator-level errors [5]. This change from ''single causal event'' scenarios highlights the fact that there are some lim-