Reliability Engineering and System Safety 127 (2014) 86–96

Contents lists available at ScienceDirect

Reliability Engineering and System Safety

journal homepage: www.elsevier.com/locate/ress

An analysis of flight Quick Access Recorder (QAR) data and its applications in preventing landing incidents

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ARTICLE INFO

Article history:
Received 11 June 2013
Received in revised form
26 March 2014
Accepted 31 March 2014
Available online 8 April 2014

Keywords:
Long landing
Quick Access Recorder (QAR) data
Human reliability
Flight operation
Flight safety
Incident

ABSTRACT

A long landing is one type of flight incident that will multiply the risk of a runway excursion. It occurs frequently but receives little attention in research due to difficulty in obtaining the real flight data. The aim of this paper is to discover key flight parameter features of long landing incidents by analyzing Quick Access Recorder (QAR) data and put forward prevention measures from the perspective of pilot operation at the same time. First, 73 flight performance parameter variables and 4 operation parameter variables were defined, covering major landing stages from 1500 ft to touchdown. Then 128 cases of selected QAR data were divided into two groups according to the threshold of identifying normal and long landing. Second, each flight parameter variable of these 128 flights was compared between groups and then the logistic and linear regression models were developed respectively to further examine the links between touchdown distance and these flight parameter variables. Third, potential flight operation causing performance difference of long landing incidents was also analyzed. Finally results indicate that the period of 200 ft to touchdown is the key stage of landing and flare is the most critical operation affecting touchdown distance. It is suggested that the pilot should inspect the ratio of descent rate and groundspeed carefully at the height of 50 ft and pilot's faster and steady pulling up columns is probably helpful for an excellent flare and landing. The findings are expected to be applied into flight operation practice for further preventing long landing incidents and even the runway excursion accidents.

1. Introduction

1.1. Long landing incident and QAR

A long landing, which is one type of flight incident, is defined as an aircraft's contact with the runway over the normal touchdown area. Touchdown distance is generally used as a standard baseline for judging whether a landing is long or not. Long landing itself would not lead to major loss of life directly but will increase the occurrence probability of runway excursion accident greatly. A National Aerospace Laboratory of The Netherlands (NLR) study revealed that if the landing is long, the landing overrun accident risk is 55 times greater than when it is not long [17]. Meanwhile, the runway taxiing time of aircraft will be prolonged if the landing is long and this will decrease efficiency of runway utilization and increase probability of runway conflict.

Quick Access Recorder (QAR) is a system which can acquire aircraft operational data easily and quickly. It includes an airborne equipment for recording data and a ground software station for storing and analyzing data. QAR could record all kinds of position parameters, movement parameters, operation and control parameters, and alarm information in the whole flight phase.

Generally long landing incident is monitored by using QAR data in most commercial airlines, but these data are also confidential for them. Meanwhile, it is not all aviation administrators who have enforced their carriers to install QAR equipment on every commercial jet. Therefore, QAR data have been rarely utilized into research. Civil Aviation Administration of China (CAAC) has implemented the program of Flight Operations Quality Assurance (FOQA) since 1997, with all commercial airplanes of Chinese airlines obliged to install QAR or a similar equipment. The practice has proved that QAR data were helpful for improving flight safety management and quality control. The real flight QAR data also provides us with a new way of analyzing landing incidents and further studying on landing safety.

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http://dx.doi.org/10.1016/j.ress.2014.03.013
0951-8320/

1.2. Landing safety issues

The final approach and landing is cited as the most important flight stage where the human pilot needs to deal with more operations, decision-making, and workloads than other stages [19,37]. Accident statistics have indicated that the approach and landing was the most dangerous phase of flight, in particular, the landing phase alone accounted for 23% of total fatal accidents occurring from 2003 to 2012, despite the fact that the landing phase accounts for just 1% of average flight time [7]. Although lots of new safety measures have been implemented throughout the last decade worldwide, landing accidents have not only continued, but have increased slowly, as shown in Fig. 1 [15].

Runway excursion, including runway overrun and runway veer-off, is the second most frequent type of fatal Approach and Landing Accidents (ALAs). Runway excursions have been considered as a major threat to aviation safety, as they always lead to major damage of aircraft and even loss of life. According to the Flight Safety Foundation [14], over the 14-year period from 1995 to 2008, 431 accidents (30%) of commercial transport aircrafts were runway-related, 417 of which (97%) were runway excursion and 712 people died in runway excursion accidents.

Runway excursions generally were caused by multilevel factors, such as a pilot's operations, the weather or runway conditions, and so on [2,22]. However, a large number of runways excursion accidents in landing phase shared a same feature of long landing [17,23,32]. Long landing is one of the most important contribution factors to runway excursion accidents [14]. Meanwhile referring to the Iceberg Theory and the Heinrich Accident Triangle [20,21], a runway excursion accident is the smallest visible part of ice above the surface of water, while long landing incidents are the large invisible part of ice beneath the surface of water which is always omitted. Statistics also showed that long landing incidents regularly accounted for the largest part of QAR exceedance incidents [34]. Long landing incidents should be afforded more concerns from aviation carriers and safety researchers. Research findings on long landings would be helpful not only for preventing incidents but also for runway excursion accidents.

Regarding landing safety issues, there have been much more researches focusing on visual factors affecting analysis [16,26,29,36], landing operation analysis [4,5,27,28], runway overrun risk modeling [24,32,38] and so on. However, special research on long landing incidents was relatively less. In particular, the literatures with performance and operation analysis based on real flight data were not found.

1.3. Aim and structure of this study

Aiming to find differences of flight parameters between normal landing and long landing, the real flight QAR data were collected and used to analyze performance feature of long landing incidents in this study. Meanwhile, the critical flight operation leading to these differences was also analyzed in further and related prevention measures on long landing incidents were put forward from the perspective of flight operation. The whole work of this study is made up of three parts with Sections 2–4.

2. Methods

The core task of this study is using QAR data to examine flight performance and flight operation characteristics of long landing incidents. For achieving this aim, methods of statistical analysis and modeling were introduced in Sections 2.3 and 2.4. Section 2.3 focuses on the analysis of flight performance parameters such as groundspeed, descent rate and so on. For further finding potential human factors causing flight performance parameter change, the flight operation and human performance variables would be analyzed in Section 2.4. Before analyzing, flight parameter variables of landing were defined and selected in Section 2.1 and collected QAR data were also processed with programing in Section 2.2.

2.1. Flight parameter definition and selection

Generally, aircraft in flight is affected by many factors such as external atmospheric environment (wind direction, wind speed, temperature, etc.), the aircraft itself (the position of all control surfaces, engine status, etc.), the pilot's basic capabilities and skills (cognitive reliability, flight operations skills, etc.) and the pilot mental state (fatigue, emotional status, etc.). These factors continue changing over time and bring an extremely complex influence on whole flight activity. Regardless of how these factors change, however, their effects ultimately are reflected in the change of aircraft attitude and kinematic parameters, including attitude angle, speed, and acceleration in three dimensions of longitudinal, vertical and lateral [12]. The kinematic analysis of flight is shown in Fig. 2. For studying flight performance of civil aircrafts, usually the linear motion along with longitudinal and vertical axes and rotation around longitudinal and lateral axes are concerned [8]. Particularly the flight phase of this study is the final landing stage, where, aircrafts always fly within a profile of landing glide path, and position change on the lateral axis is quite limited.

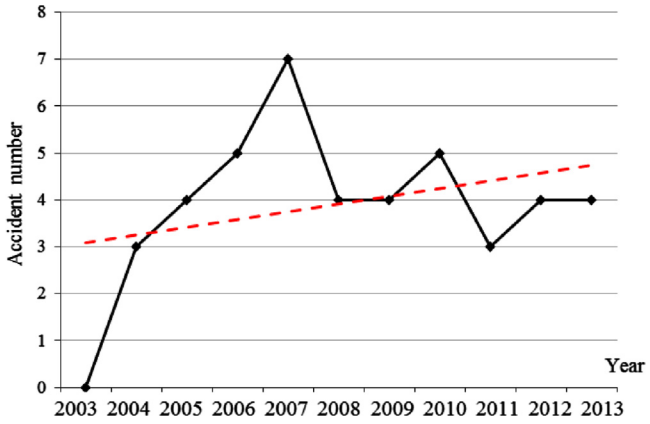

Fig. 1. Trend analysis plot for airlines fatal hull loss in landing phase [Data from Ref. [15]].

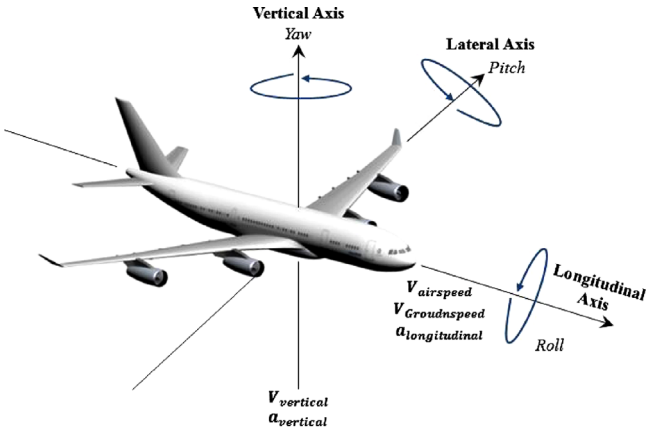

Fig. 2. Kinematic analysis of flight.