Songklanakarin J. Sci. Technol.
32 (5), 489-496, Sep. - Oct. 2010

Songklanakarin Journal
of Science and Technology
http://www.sjst.psu.ac.th

Original Article

Hull loss accident model for narrow body commercial aircraft

Somchanok Tiabtiamrat and Supachok Wiriyacosol*

School of Management,
Shinawatra University, Chatuchak, Bangkok, 10900, Thailand.

Received 20 October 2009; Accepted 3 August 2010

Abstract

Accidents with narrow body aircraft were statistically evaluated covering six families of commercial aircraft including Boeing B737, Airbus A320, McDonnell Douglas MD80, Tupolev TU134/TU154 and Antonov AN124. A risk indicator for each flight phase was developed based on motion characteristics, duration time, and the presence of adverse weather conditions. The estimated risk levels based on these risk indicators then developed from the risk indicator. Regression analysis indicated very good agreement between the estimated risk level and the accident ratio of hull loss cases per number of delivered aircraft. The effect of time on the hull loss accident ratio per delivered aircraft was assessed for B737, A320 and MD80. Equations representing the effect of time on hull loss accident ratio per delivered aircraft were proposed for B737, A320, and MD80, while average values of hull loss accident ratio per delivered aircraft were found for TU134, TU154, and AN 124. Accident probability equations were then developed for each family of aircraft that the probability of an aircraft in a hull loss accident could be estimated for any aircraft family, flight phase, presence of adverse weather factor, hour of day, day of week, month of year, pilot age, and pilot flight hour experience. A simplified relationship between estimated hull loss accident probability and unsafe acts by human was proposed. Numerical investigation of the relationship between unsafe acts by human and fatality ratio suggested that the fatality ratio in hull loss accident was dominated primarily by the flight phase media.

Keywords: narrow body aircraft, aircraft accident, hull loss accident, flight phase, risk estimation

---

1. Introduction

Accidents involving commercial aircraft are often disastrous and extremely costly. It will be useful if a simple model for accident probability and risk can be developed so that the likelihood of accident can be predicted more effective decision can be made to enhance safety. In this paper, a model for hull loss accident probability and risk will be reported. Hull loss is defined as the accident that causes severe damage to the aircraft the aircraft is. Accident risk usually defined as a measure of how frequently an accident is likely to occur probability multiplied by hazard. The level of hazard may be described in any appropriate unit such as number of fatal accidents or number of hull loss accidents. The level of risk for one hull loss accident is therefore the product of the probability of hull loss accident per flight and the number of flight, or the product of the probability of hull loss accident per unit airplane delivered multiplied by the number of delivered at the time of accident.

In this investigation the authors focus on the hull loss accidents as used in an earlier work (Tiabtiamrat, 2008). There are many indicators may be used to represent the frequency of accidents such as the ratio of fatality per million of passenger kilometers, the number of accidents per number of flight hours as used by Janic (2000). The ratio of hull loss per million departure flights was used by Baksteen (1995). The hull loss accident ratio (H_l), which is the number of aircraft of a certain family written off as the result of accident per number of aircraft unit in that family delivered, and the number of accidents per hour time, were used by Boeing in

---

* Corresponding author.
Email address: supachok@siu.ac.th

Boeing 737 (http://www.b737org.uk/accident_reports.htm, November 2008). In this study, the authors chose to use the hull loss accident ratio (HLAR) to represent the frequency of accidents due to its simplicity.

The narrow body type is the most used aircraft in commercial aviation, therefore needs special attention of the existing commercial narrow body families of aircraft for medium range flights are considered, i.e. Boeing (B737), Airbus (A320), McDonnell Douglas (MD80), Tupolev (TU 134 and TU154) and Antonov (AN124). B737 is the most used aircraft family and the number of accident cases are sufficient for statistical analysis, while A320 airplanes are relatively new and the number of accident are therefore. The production of MD80 family aircraft has been stopped since Boeing took over McDonnell Douglas Corphowever, many MD80 family airplanes are still flying. or more complete picture of narrow body commercial aircraft families the Russian made TU134, TU154 and AN124 will also be studied.

It has been recognized that the flight phase of aircraft as well as the exposure time may affect the risk and cause of aircraft accident (Janic, 2000). Besides the flight phase of aircraft and the exposure time, many factors also be involved in an aircraft accident. It would be useful if aircraft accident probability and risk can be estimated in a simple way with a reasonable degree of accuracy. In developing risk indicators it is inevitable that past accident statistics have to be studied. However, proactive safetyor prevention rather than cure and not too much should be given to the past statistics (McFadden and Towell, 1999).

There are two major approaches used by researchers in assessing aviation risk and safety as noted by Shyur (2008). The first approach is to study the number of accidents carefully and then offer some indicators for improvement in safety using deterministic models. This approach was used by Braithwaite (1998). The second approach is to build a probabilistic mathematical model of accident by assuming that the occurrence of accident follows the Poison process. The second approach was used by Shyur. However, when it comes to application, simplicity and quantification is necessary. The authors chose to follow the first approach by studying relevant statistical data and quantifying the relationships between factors in a simplified deterministic model.

Many possible alternatives in probability and risk estimation have been mentioned in http://www.birdstrike.org/comlink/risk.faq.htm (February 1, 2009) using historical data, modeling, breaking down the system into known subsystem using techniques event trees or fault trees, with similar situations, or compar with similar activities. There are a wide range of possible approaches and all approaches seem acceptable to some degree. In this paper a more refined model than the former one (Tiabtiamrat, 2008) will be developed. The hull loss accident model will also be extended to cover not only B737 family but also six of the narrow body commercial aircraft families.

2. Methodology

Aircraft accident investigation process is a difficult task due to the scarcity of evidence, the difficulty due to geographical accessibility, destroyed evidence, time and cost constraints. Often the final accident report are left unclear and questions remained unanswered. Many accident investigations presented the accident reports in a preliminary or interim form only. From the final, interim, and preliminary accident reports available, the authors will use statistical methods to analyze and interpret the results and then will propose an accident probability estimation model for hull loss accident of narrow body commercial aircraft. any relevant factors reported by the National Transportation Safety Board (NTSB, 1998) will be included in the model.

2.1 The probability of hull loss accident in each flight phase

It is generally accepted that different flight phase are associated with different degree of probability of accident (NTSB, 1999/1). For example the landing phase is known to higher probability of accident than standing or taxiing. The major flight phases considered are as: standing, pushback, taxiing, take off, climbing, cruising, approaching and landing. Minor flight phases are combined to the most similar phase i.e. descending is combined with cruising, and maneuver is combined with approaching.

For the flight phase effect which appears to be the most dominant effect, a risk indicator for each flight phase is developed by considering the effect of media and environment, aircraft speed, acceleration, and altitude change. For each flight phase the risk factor (V_i) is assigned a number of 1 to 5 on Likert scale to represent the degree of risk. The scale 1, 2, 3, 4 and 5 represents no risk, risk, medium risk, high risk and very high risk respectively. A multiplicative model is used where the assigned value of each motion factors are multiplied to get the value of risk indicator, i.e.

$$I_i = \prod_{j=1}^{6} V_{ij} \tag{1}$$

where I_i is the risk indicator for flight phase i. Then i = 1, 2, 3, 4, 5, 6, 7, and 8 represents the phase stand, pushback, taxi, take off, climb, cruise, approach, and land respectively. V_{ij} stands for the risk value of the media and environment of the flight phase, aircraft speed, acceleration, altitude change, phase duration time, and the relative weighting of the flight phases which ha not been completely accounted for by the first variables. Each of the value of each risk factor V_{ij} was assigned between 1 and 5 according to the perceived risk for any narrow body aircraft. The estimated risk level L_i for each flight phase which is the estimation of relative accident probability for each flight phase can be computed from the risk indicators Ii by the following equation:

$$L_i = \frac{I_i}{\sum_{i=1}^{8} I_i} \tag{2}$$

Using data from Accident Statistics 2008), the relative accident probability for each flight phase was plotted against the estimated risk level, and the linear regression line through the origin was fitted to the data. A very good curve fitting was found for the B737 aircraft family with $R^2 = 0.9260$ as illustrated in Figure 1, and for combined families of aircraft with $R^2 = 0.8937$ as illustrated in Figure 2.

2.2 Effect of weather

The effect of weather on hull loss accident is . The weather alone may be considered the cause of accident, or weather may be a factor acts in association with other causes such as pilot error, mechanical failure and . The weather factor 45.46% narrow body commercial aircraft (Accident Statistics, 2008 close to the weather effect in general aviation 47.56% (NTSB, 1999). information for narrow body aircraft. For simplification, the partial probability of hull loss accident due to weather P_w is then assigned as: $P_w = 0.5 + 0.5(0.4546) = 0.7273$, if at least one the weather factors is present and $P_w = 0.5 - 0.5(0.4546) = 0.2727$,(7)

2.3 Effect of time

The apparent time effect on hull loss accident in general aviation was reported by NTSB (1999). curve fitting data this report equation for the time effect was found. The partial probability of hull loss accident due to the effect of hour of day can be represented by:

$$P_{hd} = 0.045 + 0.045 \sin \pi \left(\frac{h}{12} - 1.25\right) \quad (8)$$

where h is the hour of day and P_{hd} is the partial probability due to time of day from 0.01 to 24.00 hour. Equation 8 the data with $R^2 = 0.9713$. The effect of day of week is represented by:

$$P_{dw} = 0.15 + 0.045 \sin \frac{2\pi}{7}(d+1) \quad (9)$$

d is day of week Monday as 1 Sunday as 7. P_{dw} is the partial probability due to day of week. Equation 9 fairly the data with $R^2 = 0.7111$. The effect of month of year is shown by 10:

$$P_{my} = 0.038 \sin \frac{\pi}{12}(2m - 7) + 0.085 \quad (10)$$

m is month of year from 1 to 12 for January to December. P_{my} is the partial probability due to month of year. Equation 10 the data with $R^2 = 0.8532$. Although 8, 9 and 10 are based on general aviation data until contrary evidence is found analogy.

2.4 Effect of the pilot age and experience

The effect of pilot age all types of accident has been reported for general aviation by NTSB (1999). The relationship between pilot age and probability of accident can be represented by:

$$P_{pa} = -0.038 + 2.613\text{x}10^{-2}y - 2.679\text{x}10^{-4}y^2 \quad (11)$$

where y is the age in year of the pilot and P_{pa} is the partial probability of accident due to pilot age. Equation satisfactorily data with $R^2 = 0.8532$.The partial probability of hull loss accident related to pilot experience (P_{pe}) is known by:

$$P_{pe} = 1.737\text{x}10^{-1.427}h_p^{-1.427} \quad (12)$$

where total number of pilot flight hour (h_p) represents the pilot experience. This equation yields a very good fit the data with $R^2 = 0.9713$.

2.5 Combined aircraft family, flight phase, weather, time and pilot effect

The combined effect of aircraft family and flight phase has already been accounted for by P_f in Table 2. The effect of weather, time of day, day of week, month of year, pilot age, and pilot flight hour experience can be taken into account by successive multiplications resulted in the relative probability due to combined factor P_{cb}

$$P_{cb} = P_f\ P_w\ P_{hd}\ P_{dw}\ P_{my}\ P_{pa}\ P_{pe} \quad (13)$$

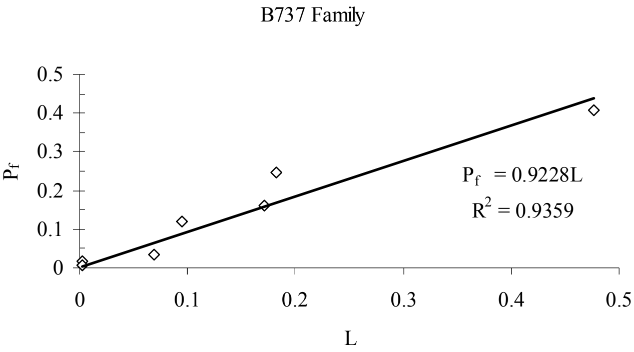

Figure 1. Relationship Between Relative Accident Probability and Risk Level for Boeing B737 Family of Aircraft

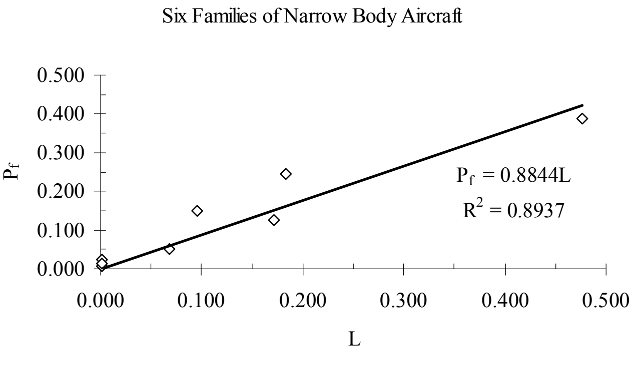

Figure 2. Relationship Between Relative Accident Probability and Risk Level for Six Narrow Body Families of Aircraft

Table 1. Risk Factors, Risk Indicators and Risk Levels for Each Flight Phase

Flight Phase	Risk Factor							Risk Indicator	*Risk Level*
	i	V_1	V_2	V_3	V_4	V_5	V_6	I_i	L_i
Stand	1	1	1	1	1	1	1	1	*0.00190*
Pushback	2	1	1	1	1	1	1	1	*0.00190*
Taxi	3	1	1	1	1	1	1	1	*0.00190*
Take off	4	5	3	2	3	1	1	90	*0.17143*
Climb	5	3	2	2	3	1	1	36	*0.06857*
Cruise	6	2	1	5	1	5	1	50	*0.09524*
Approach	7	3	1	4	4	1	2	96	*0.18286*
Land	8	5	1	5	5	1	2	250	*0.47619*
Sum								525	1.00

Table 2. Relative Probability of Accident at Each Flight Phase for Six Families of Narrow Body Aircraft

Flight Phase		Risk Level	*Probability of Hull Loss Accident Due to Flight Phase*						
			B737	A320	M80	TU134	TU154	AN124	*All*
	i	L	P_f	P_f	P_f	P_f	P_f	P_f	P_f
Stand	1	0.0019	0.0085	0.1333	0.0909	0.0000	0.0189	0.0000	*0.0228*
Pushback	2	0.0019	0.0170	0.0000	0.0000	0.0000	0.0000	0.0000	*0.0076*
Taxi	3	0.0019	0.0085	0.0667	0.0454	0.0196	0.0000	0.0000	*0.0152*
Take off	4	0.1714	0.1610	0.0667	0.0909	0.0784	0.1321	0.0000	*0.1255*
Climb	5	0.0686	0.0339	0.0667	0.1364	0.0588	0.0377	0.0000	*0.0494*
Cruise	6	0.0952	0.1186	0.0000	0.0909	0.1569	0.2642	0.2500	*0.1483*
Approach	7	0.1829	0.2458	0.2667	0.2364	0.3137	0.2075	0.2500	*0.2433*
Land	8	0.4762	0.4068	0.4000	0.4090	0.3725	0.3396	0.5000	*0.3878*
Hull Loss Cases		n	118	15	22	51	53	4	*263*
k In Equation P_f= kL		k	1.0467	0.8426	0.8359	0.8809	0.6983	1.1014	*0.8844*
		$R^2 =$	*0.9359*	*0.6587*	*0.8175*	*0.7519*	*0.5037*	*0.7477*	*0.8937*

2.6 The hull loss accident ratio of narrow body aircraft

The trend of hull loss accident ratio (H_l) for each family of narrow body commercial aircraft against time in year of accident occurrence after 1900, i.e. (t = year - 1900), can be found by regression analysis and curve fitting of reported data (http://www.planecrashinfo.com/cause.htm, February 16, 2009). The index l = 1, 2, 3, .., 6 represents B737, A320, MD80, TU134, TU154, and AN124 respectively. The curve of H_l against t for B737 is illustrated in Figure 3. H_l decreases initially sharply with time and then levels off, which reflects the increasing safety in commercial aircraft operations. Similar trends are found for A320 and MD80 families. The equations for H_l as functions of time and their R^2 are summarized in Table 3.

For Russian aircraft we could only find the average values for H_l. The average values of H_l for Russian narrow body aircraft families in the year 2008 (http://www.aviation-safety.net/database.html, April 23, 2008) were also shown in Table 3. The equations representing the relationship between H_l and t for B737 family with coefficient of determination R^2 = 0.8265 suggests a good fit to data. The equation representing A320 and MD80 families indicate lower R^2 values which is apparently the result of the abnormal sharp initial drop of H_l with time.

2.7 Estimation of the probability of an aircraft involving in a hull loss accident

The average probability of an aircraft involving in a hull loss accident is equal to the hull loss accident ratio H_l as shown in Table 3. When the combined effect of aircraft family, flight phase, weather, time of day, day of week, month of year, pilot age, and pilot flight hour experience is

Table 3. Relations Between H_l and t for Each Family of Aircraft

	Aircraft Family	Equation for H_l	R^2
1	Boeing 737	$H_1 = 7.00x10^{18}\, t^{-11.102}$	*0.8265*
2	Airbus A320	$H_2 = 3.00x10^{16}\, t^{-9.3634}$	*0.6222*
3	McDonnell Douglas MD80	$H_3 = 1.00x10^{22}\, t^{-12.386}$	*0.4572*
4	Tupolev TU134	$H_4 = 0.059,86$	-
5	Tupolev TU154	$H_5 = 0.056,69$	-
6	*Antonov AN124*	$H_6 = 0.070,18$	-

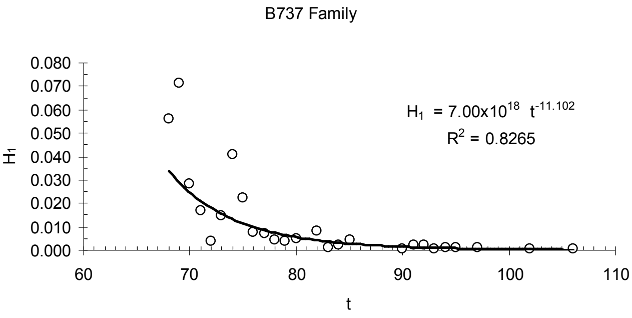

Figure 3. Hull Loss Accident Ratio of B737 Family Aircraft

accounted for, then the probability of an aircraft involved in a hull loss accident is the product of H_l and P_{cb} as follows:

$$P_{hl} = H_l P_{cb} \tag{14}$$

or

$$P_{hl} = H_l\ P_f\ P_w\ P_{hd}\ P_{dw}\ P_{my}\ P_{pa}\ P_{pe} \tag{15}$$

The unit of probability of accident P_{hl} in equation (15) is unit of aircraft involved in a hull loss accident per number of aircraft in the same family delivered.

3. Evaluation of the hull loss aircraft accident model

Reason (1990) suggested that an accident was a result of combined effect of latent unsafe conditions and unsafe acts by human. A simplified hull loss accident model following Reason's reasoning is as shown in Figure 4. To quantify the relationship, an assumption is made that a hull loss accident occurs when the estimated accident outcome (AO), which is the product of probability of hull loss accident (H_l) and the severity of unsafe acts (UA) reaches of surpasses unity, as represented by equation (16).

$$AO = P_{hl} \times UA > 1 \tag{16}$$

Once a hull loss accident happens, there may or may not be fatality. Fatality is represented by fatality ratio (FR), i.e. the ratio of people, on board the aircraft and on the ground, losing life divided by the number of people on board. At this stage it is not possible to theoretically relate hull loss accident to FR.

3.1 Numerical investigation of the model

The accident probability model will now be used to investigate what factors that can affect FR. On-line search discovers 24 cases of hull loss accident final and relatively

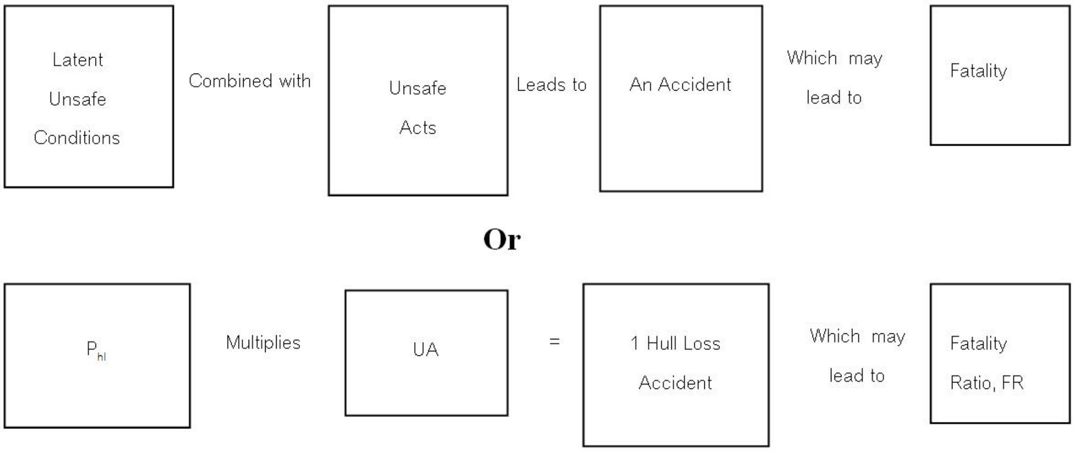

Figure 4. A simplified hull loss accident model based on Reason's accident model.

Table 4. Sources of Data and Information about Hull Loss Accident of Narrow Body Commercial Aircraft and Year of Issue

Source	Year	Source	Year	Source	Year
Accident Investigation Branch, Yugoslavia	1973	Aeronautical Accident Investigation and Prevention Center, Brazil	2008	Aeronautical Development Agency, India	2001
Agenzia Nazionale Per La Sicurezza Del Volo, Italy	2004	Air Accident Investigation and Aviation Safety Board, Greece	2006	Air Accidents Investigation Branch, UK	1990
Bureau d' Enquetes et d' Analyses pour la securite de l' aviation civile, France	2004	Department of Civil Aviation, Sri Lanka	2002	Federal Ministry of Aviation, Nigeria	1997
Federal Ministry of Aviation, Nigeria	2000	German Federal Bureau of Aircraft Accident Investigation	2004	Interstate Aviation Committee, USSR	2006
Main Commission Aircraft Accident Investigation Warzaw, Poland	1995	NTSB, USA	1982	NTSB, USA	1997/1
NTSB, USA	1997/2	NTSB, USA	1999	NTSB, USA	2001/1
NTSB, USA	2001/2	NTSB, USA	2002	National Transportation Safety Committee (NTSC), Indonesia	2003
NTSC, Indonesia	2008/1	NTSC, Indonesia	2008/2		

Note: See references for more details.

completed interim reports concerning narrow body commercial aircraft, which provide data and information that can be used. The sources of data and information are very briefly listed in Table 4 and more details are given in the references. These data and information are used to evaluate variables in the model.

The accident probability model is used to investigate the possible relationship between fatality ratio (FR) and the severity of unsafe act UA and flight phase. Plotting FR against UA as illustrated in Figure 5, two distinct clusters appears. One cluster involves low FR i.e. FR ≈ 0, and another involves high FR i.e. FR ≈ 1. Plotting FR against flight phase sequence number in the order of flight media and flight sequence, three clusters of data becomes apparent as shown in Figure 6. The accident cases with FR ≈ 1 involved climb, cruise, and approach phases which involved "air" as the medium. The accident cases with FR values in between, i.e. 0 < FR < 1, are those involved take off and land phases with the medium of "ground/air interphase". Lacking hull loss accident data concerning standing, pushback, and taxiing implies that these phases, where the aircraft is firmly on the "ground", represent negligible number of hull loss accident and therefore no fatalities, which implies FR ≈ 0. These explanations seem very logical. Although this accident probability model has not been able to link UA to FR, it suggests the important effect of flight phase on FR.

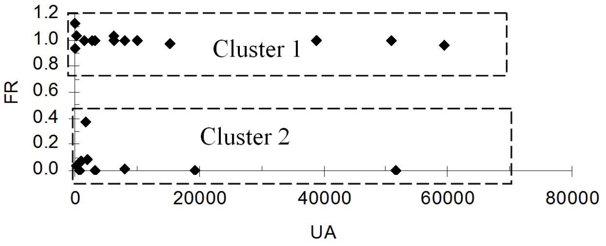

Figure 5. Relationship Between Fatality Ratio and Severity of Unsafe Act

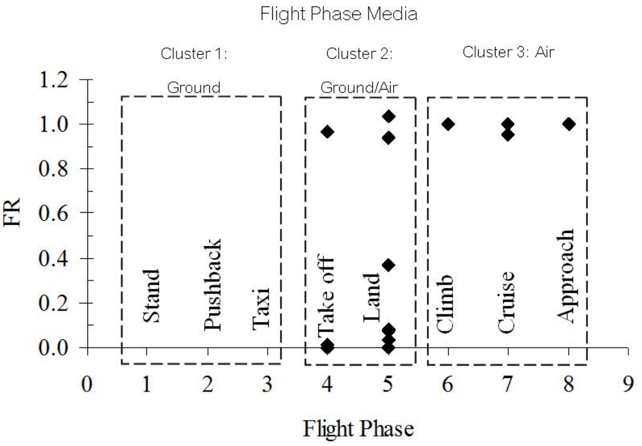

Figure 6. Relationship between fatality ratio and flight phase

6. Conclusions

A hull loss accident model for narrow body commercial aircraft has been presented and it seems to fit well with aircraft accident data. The model was used with Reason's accident model to investigate the relationship between probability of an aircraft involving in a hull loss accident, unsafe acts, accident occurrence, and fatality ratio. The model suggests the important effect of flight phase media on fatality ratio.

Effect of unsafe acts by human (human error) on fatality ratio has not been detected by the proposed accident model. A more refined model that can link human error to accident risk, accident occurrence, and fatality ratio should be attempted.

Further investigation should also be carried out on more types of aircraft. The accident types should be expanded to cover all types of accidents and incidents, to get a more comprehensive understanding of aircraft accident. A more refined model that can link human error to accident risk, accident occurrence, and fatality ratio should be attempted.

Acknowledgment

Thanks are due to Shinawatra University for the support for this research in terms of scholarship and other expenses, and to organizations including aviation-safety.net, b737org.uk, birdstrike.org/comlink and planecrashinfo.com that provide databases so that the authors can get access to many valuable information used in this research.

References

Accident Investigation Branch, Yugoslavia. 1973. Civil Aircraft Accident Report No. EW/B 122, Aviogenex TU-134A, YU-AHZ, Rijeka Airport, 23 May 1971. Accident Investigation Branch, Department of Trade and Industry, Yugoslavia.

Accident Statistics. 2008. http://www.planecrashinfo.com/cause.htm [March 16, 2008].

Aeronautical Accident Investigation and Prevention Center, Brazil. 2008. Final Report A-00X/CENIPA/2008. Aeronautical Accident, B-737 8EH registration PR-GTD and EMB-135 BJ Legacy registration N600XL, Mato Grosso State, Brazil, 29 September 2006. Aeronautical Accident Investigation and Prevention Center, Command of Aeronautics General Staff of the Aeronautics, Brazil.

Aeronautical Development Agency, India. 2001. Report on Accident to Alliance Air Boeing 737-200, Aircraft VT-EGD on 17th July, 2000, at Patna. Aeronautical Development Agency, Bangalore, Ministry of Civil Aviation, India.

Agenzia Nazionale Per La Sicurezza Del Volo, Italy. 2004. Final Report, N.A/1/04, Boeing MD-87, SE-DMA and Cessna 525-A, D-IEVX, Milano Linate Airport, 8 October, 2001. Agenzia Nazionale Per La Sicurezza Del Volo, Italy.

Air Accident Investigation and Aviation Safety Board, Grecce. 2006. Aircraft Accident Report, 11/2006, Helios Airways Flight HCY522, Boeing 737-31S, Grammatiko, Hellas, 14 August 2005. Air Accident Investigation and Aviation Safety Board, Hellenic Ministry of Transport and Communications, Greece.

Air Accidents Investigation Branch, UK. 1990. Aircraft Accident Report 4/90, Report on the accident to Boeing 737-400 G-OBME near Kegworth, Leicestershire on 8 January 1989. Air Accidents Investigation Branch, Department of Transport, U.K.

Baksteen, B. 1995. Flying Is Not Safe, Safety Science. 19, 287-294.

Boeing 737 Accident Reports. www.b737org.uk/accident reports. htm [November 24, 2008].

Braithwaite, G.R., Caves, R.E. and Faulkner J.P.E. 1998. Title of paper missing here. Journal of Air Transport Management. 4, 55-62.

Bureau d' Enquetes et d' Analyses pour la securite de l' aviation civile, France 2009. Interim Report, ISBN:978-2-11-098614-6, XL Airways Germany, Airbus A320-232, D-AXLA, Carnet-Plage (66), 27 November 2008. Bureau d' Enquetes et d' Analyses pour la securite de l' aviation civile, France.

Department of Civil Aviation, Sri Lanka 2002. Final Report, AN 12 Aircraft Accident on 24.03.2000 at Negambo, Sri Lanka. Department of Civil Aviation, Sri Lanka. Federal Ministry of Aviation, Nigeria 1997. Civil Aviation Accident Report No. 04/354, Nigeria Airways Boeing 737, 5N-AUA, Kaduna Airport, November 1995. Federal Ministry of Aviation, Nigeria.

Federal Ministry of Aviation, Nigeria. 2000. Civil Aviation Accident Report No. 04/365, Changchangi Airlines Boeing 737-200, YU-ANU, Kaduna Airport, 22 February 1998. Federal Ministry of Aviation, Nigeria.

German Federal Bureau of Aircraft Accident Investigation, Germany 2004. Investigation Report, AX001-1-2/02., Tupolev TU154M and Boeing B757-200, Ueberlingen/Lake of Constance/Germany, 1 July 2002. German Federal Bureau of Aircraft Accident Investigation, Germany.

http://www.aviation-safety.net/database.html [April 23, 2009]

http://www.b737org.uk/accident_reports.htm [November 24, 2008]

http://www.birdstrike.org/comlink/risk_faq.htm [February 1, 2009]

http://www.planecrashinfo.com/cause.htm [February 16, 2009]

Interstate Aviation Committee Air Accident Investigation Commission, USSR 2006. Final Report on the Investigation into the Accident Involving the Armavia A320 near Sochi Airport on 3 May 2006, Moscow. Interstate Aviation Committee Air Accident Investigation Commission, USSR.

Janic, M. 2000. An Assessment of Risk and Safety in Civil Aviation. Journal of Air Transport Management. 6, 43-50.

Main Commission Aircraft Accident Investigation Warzaw, Poland Undated. A320-211 Warzaw Accident Report, Report on the Accident to Airbus A320-211 Aircraft in Warzaw on 14 September 1993. Main Commission Aircraft Accident Investigation Warzaw, Poland.

McFadden, K.L. and Towell, E.R. 1999. Aviation Human Factors: A Framework for the New Millennium. Journal of Air Transport Management. 5, 177-184.

NTSB, USA 1982. Aircraft Accident Report, NTSB/AAR-82-6, PB82-910408, Air Florida Inc., Boeing 737-222, N62AF, Washington D.C., 13 January 1982.

NTSB, USA 1997/1. Aircraft Accident Report, PB98-910401, NTSB/AAR-98/01, Delta Airlines Flight 1288, McDonnell Douglas MD-88, N927DA, Pensacola, Florida, 6 July 1996.

NTSB, USA 1997/2. Aircraft Accident Report, PB97-910403, NTSB/AAR-97/03, NYC97MA005, Delta Airlines Flight 554, McDonnell Douglas MD-88, N914DL, Laguardia Airport, New York, 19 October 1996.

NTSB, USA 1999. Aircraft Accident Report, NTSB/AAR-99/01, PB99-910401, DCA94MA076, US Air Flight 427, Boeing 737-300, N513AU, Aliquippa, Pennsylvania, 8 September 1994.

NTSB, USA 1999. Annual Review of Aircraft Accident Data, U.S. General Aviation, Calendar Year 1998.

NTSB, USA 2001/1. Aircraft Accident Report, NTSB/AAR-01/01, PB2001-910401, DCA91MA023, United Airlines Flight 585, Boeing 737-200, N999UA, Colorado Springs, Colorado, 3 March 1991.

NTSB, USA 2001/2. Aircraft Accident Report, PB2001-910402, NTSB/AAR-01/02, American Airlines Flight 1420, McDonnell Douglas MD-82, N215AA, Little Rock, Arkansas, 1 June 1999.

NTSB, USA 2002. Aircraft Accident Report, NTSB/AAR-02/01, PB2002-910402, Notation 7263E, Alaska Airlines Flight 261 McDonnell Douglas MD-83, N963AS, Anacapa Island, California, 31 January 2000.

NTSB, USA 2008. Annual Review of Aircraft Accident Data, U.S. General Aviation, Calendar Year 2007.

NTSC, Indonesia. 2003. Aircraft Accident Investigation Report, KNKT/02.01/ 023.03.011, PT. Lion Airs MDL 493, Boeing B737-200 PK-RIL, Sultan Syarif Kasim II Airport, Pekanbaru, Riau, South Sulawesi, 14 January 2002.

NTSC, Indonesia 2008/1. Aircraft Accident Investigation Report, KNKT/99.06/02.04.008, Mandala Airlines MDL493, Boeing B737-200 Adv PK-RIL, Hasanudin Airport, Ujungpandang, South Sulawesi, 5 April 1999.

NTSC, Indonesia 2008/2. Aircraft Accident Investigation Report, KNKT/07.01/ 08.01.36, Boeing 737-4Q8, PK-KKW. Makassar Strait, Sulawesi, 1 January 2007.

Reason, J. 1990. Human Error, Cambridge University Press, United Kingdom.

Shyur, H.J. 2008. A quantitative model for aviation safety risk assessment. Computers and Industrial Engineering. 54, 34-44.

Tiabtiamrat, S., Wiriyacosol, S. and Niyomthai, N. 2008. Investigation of Commercial Aircraft Accident: A Study of Boeing 737 Family. Royal Thai Air Force Academy Journal. 4, 36-41.