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Aircraft Collisions and Bird Strikes in Nepal Between 1946-2016: A Case Study

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Abstract

The purpose of this paper is to give a summary of aircraft collision/accidents and bird strikes in Nepal. It presents national and international registered aircraft statistics of bird strikes and aircraft collisions between 1946 and 2016 in Nepal. The paper enlightens bird strike probe risk and challenges of aircraft operations in Nepal, details of victim/collided aircraft with/and aircraft brief specification/models. The data was collected by reviewing different sources from Civil Aviation Authority of Nepal (CAAN), International Civil Aviation Organization (ICAO), European Aviation Safety Agency (EASA), Bureau of Aircraft Accident Achieves (B3A), World Bird-Strike Association (WBA) and qualitative approach articles/newspaper/ interviews. Finally, this paper enhances safety measures to be taken by CAAN, obligation to investigate accidents with professional method of detection with prevention of such accidents in the near and the distance future from hull losses-hull fatalities to be enshrined regulators of ICAO and EASA.

Keywords: Nepal; Aircraft accident; Bird strike; CAAN; EASA; ICAO; B3A; WBA

Acronyms

AIB: Accident Investigation Bureau; AMSL: Above Mean Sea Level; B3A: Bureau of Aircraft Accidents Achieves; CAA UK: Civil Aviation Authority of United Kingdom; CAAN: Civil Aviation Authority of Nepal; CFIT: Control Flight in Terrain; CRM: Crew Resource Management; DNA: Deoxyribonucleic Acid; EASA: European Aviation Safety Agency; EGPWS: Enhanced Ground Proximity Warning System; FAA: Federal Aviation Authority; FAR: Federal Aviation Regulations; FOD: Foreign Object Damage; HFACS: Human Factor Analysis and Classification System; IATAs': International Air Transport Association; ICAO: International Civil Aviation Organization; NA: Nepal Airlines; NAC: Nepal Airline Corporation; RNAC: Royal Nepal Airline Corporation; SARPs: Standards and Recommended Practices; SMS: Safety Management System; STOL: Short Take-off and Landing; VFR: Visual Flight Rule; WBA: World Bird Strike Association

List of Abbreviations of Aircraft and Engine Categories

1P: Single-Engine Reciprocating; 1T: Single-Engine Turbopropeller; 2P: Twin-Engine Reciprocating; 2T: Twin-Engine Turbopropeller; 3+T: 3+ -Engine Turbopropeller; JT: Other Turbofan Transport Category; A320: A320-series, Turbofan Transport Category; A330: A330-Series, Turbofan Transport Category; A340: A340-Series, Turbofan Transport Category; AT45: AT45, 2-Engine, Turbopropeller; AT72: ATR72, 2-Engine, Turbopropeller; B712: B712 Turbofan; B737: B737-Series, Turbofan Transport Category; B757: B757-Series, Turbofan Transport Category; E170: Embraer A170, Turbofan Transport Category; E190: Embraer E190, Turbofan Transport Category; F100: F100 Turbofan; MD11: MD11, Turbofan Transport Category; MD80: MD80-Series, Turbofan Transport Category; MD90: MD90-series, Turbofan Transport Category RJ85: Avro Regional Jetlines 85, Turbofan Transport Category; SF34: SF340, 2-Engine Turbopropeller; MIL: military; HECO: Helicopter

Introduction

Nepal, officially the Federal Democratic Republic of Nepal, is a landlocked central Himalayan country in South Asia. It has a population of 29 million and is the 93rd largest country by area. Bordering China in the north and India in the south, east and west, it is the largest sovereign Himalayan state, which is unique in Asia in that it combines its climate with large variety natural beauty, amazing flora-fauna, rich cultural, historical heritage and constant alternation of biotopes and many more [1].

As a landlocked nation, air transportation is the only means to link the country to the outside world. The vitality of air transport industry in the economic growth and development of a nation is more pronounced in today's globalized world.

Civil Aviation Authority of Nepal (CAAN) was established on 31 December 1998 under Civil Aviation Act, 1996. Civil Aviation Authority of Nepal (CAAN) realizes that one of the key elements to maintaining the vitality of civil aviation's is to ensure safe, secure, efficiently at the national, regional and international level. As a regulator of civil aviation activities in the country, CAAN has the responsibility of ensuring safety and promoting air transportation in the country Nepal. CAAN sets requirements based on the Standard and Recommended Practices (SARPs) stipulated in various Annexes to the convention of International Civil Aviation. Based on these requirements, air transport industry needs to deliver safe and quality services in their respective areas of operation while maintaining a high level of capacity and efficiently in their endeavours. It is also important to spotlight the state visit of ICAO Council President Mr. Roberto Kobeh Gonjalez to Nepal in 2012, which provided enough leverage for the state and CAAN in their initiatives towards segregating service provider functions from the regulatory regime of CAAN, strengthening safety oversight capability of the Regulator and reviewing the legal framework in the line with Chicago Conventions and other ICAO Regulations [2].

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Regulator's Literature Review

Men have started sharing sky with birds after the invention of aircrafts. This mutual sharing is prone to accidents. Although there are various other elements like hails, debris etc. but today majority of incidents caused by foreign object damage (FOD) is to be reported as bird strike. Although the size of bird is very small as compared to aircraft, but high speed of aircraft makes the bird strike event as a dangerous phenomenon. First record of bird strike was documented by Wright brothers, the inventors of aircraft. In 1912, bird strike claimed first human fatality when Cal Rogers crashed in to sea after hitting a gull and jamming aircraft flight controls. Since then such accidents are increasing due to in air traffic. These accidents have claimed many human lives along with monetary and material losses. From 1990 to 2013, in a period of 24 years, at least 66 aircraft and 26 lives have been lost in civil aviation due to bird strikes. Statistical indicates that 73% of all collision occurs near the ground below 500 ft. and 94% under 2500 ft., making the take-off and landing phases especially critical to bird strike [3,4].

Front facing components of aircraft are exposed to bird strike. These include windshield, random, wing leading edge, engines, forward fuselage, empennage, landing gear, propeller etc. Figure 1 shows vulnerability of aircraft components to bird strike according to data provided in [5]. Furthermore, 29% bird strikes for engine and 26% for wing cause damage making these areas of aircraft highly damaged due to bird strike. Due to dangerous consequences of bird strike, aviation authorities like Federal Aviation Administration (FAA) demand all forward-facing components of aircraft to have a certain level of resistance against bird strike. Some Federal Aviation Regulations (FAR) relating bird strike are listed in Table 1 [6].

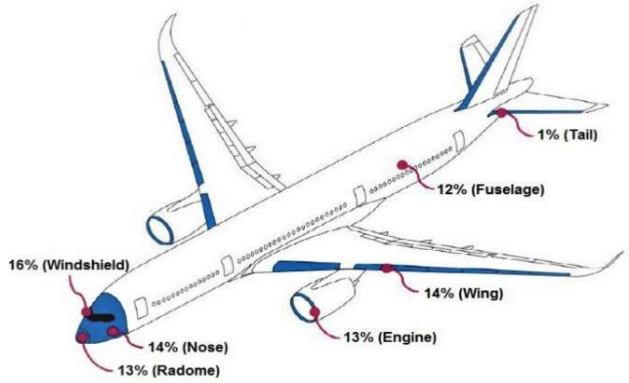

Figure 1: Vulnerability of aircraft-components to bird strike.

Component	FAR	Requirements
Windshield	25.775 (b)	Bird of 4 lb. at cruise speed of aircraft at sea level does not penetrate windshield.
	25.775 (c)	Minimize danger to pilots from flying windshield fragments. Successful completion of flight after hit by a 4-lb.
General Structure	25.571	Bird at cruise speed of aircraft at sea level or 85% of cruise speed at 8000 feet, whichever is more critical.
Empennage	25.631	Successful completion of flight after hit by an 8-lb. Bird at cruise speed of aircraft at sea level.
Duplicate Pitot tubes	25.1323(j)	Bird does not damage both tubes

Table 1: FAA bird strike requirements.

The subject of aircraft accidents and bird strike against aircraft is under discussion since the invention of aircraft in the field of Airworthiness and different regulators recognizing the importance of aviation accident investigations, has also established common basic obligations through various council directives.

Early 20th century, safety has been a constant byword in aviation development [7]. Data published by the ICAO (International Civil Aviation Organization) show that the safety of aviation has substantially improved from 1945 onward [8]. In 2009, according to the International Association of Transport Airlines, the western-built hull-loss accident rate was one accident per 1.4 million flights.

However, with air traffic steadily increasing, accidents do happen, despite the best effort of regulators and industry. The investigation of accidents and the determination of the causes and contributing factors, as well as producing recommendations for preventing similar situations in the future, are essential elements in the process of continuous safety improvement. For this reason, among others, this transport mode retains a globally low accident rate [9-14].

To make flying safer, independent investigation into accidents is essential, as it is the surest way of identifying the causes of an accident and answering the fundamental question of what really happened and what can be done to prevent similar incidents in the future [15-17].

The investigation of civil aviation accidents was regulated internationally is the first instance by ICAO, through the existing Convention on International Civil Aviation signed in Chicago in 1944 guidance and its Annex 13 [18]. Since then, ICAO has produced manuals and guidance material to advise states on the conduct of aviation accident investigations: for example, ICAO documents 6920 [19] and 9756 [20], Circular 298 [21] and many others [22].

The regulation sets out the roles of European Aviation Safety Agency (EASA) in accident and incident investigations. EASA carries out, on behalf of the member states, the functions and tasks of the state of design, manufacture, and registry when related design approval, as specified in the Chicago Convention and its Annexes. Therefore EASA, in accordance with Annex 13 [18] to the Chicago Convention invited to participating safety investigation as well as national civil aviation authorities.

Bird strikes and aircraft collisions in Nepal have not been analysed in any previous studies. This study attempts to identify the existing finish reporting system and culture.

Aims and Objectives

The aim of this research is to produce a complete research report data of bird strike against aircraft, aircraft accidents (types of Aircraft, Place of Accidents happened, and number of fatalities and survival occurred) in Nepal between the years 1946-2016. Along with this research analysis, the author suggested enhances safety measures to be taken by CAAN to reduce such problems from hull-losses of human lives, fatalities to aircraft, hull-losses of cost airlines industry.

Method

The data was collected by reviewing different aviation regulators and council directive sources such as: International Civil Aviation Organization (ICAO), European Aviation Safety Agency (EASA), World Bird-Strike Association (WBA), Bureau of Aircraft Accidents Achieves (B3A), and Civil Aviation Authority of Nepal (CAAN) along with qualitative approach via articles, newspaper.

This paper is based on the elaboration of statistical data collected from above mentioned sources and research analysis done ensuring safe airways in Nepal. As regards of analysis, the current problem is that no reports exist for all accident of aircrafts, bird-strikes and where they do, not all the data has been filled in Nepal's Airways Achieves. Significantly voids are noted in parts of the form referring to bird strikes data. We must understand that the reporter is always the commander (pilot in command).

Aircraft Operations in Nepal

Aircraft operation in Nepal can be categorized basically in four categories as follows:

(I) **Schedule**

a) International

b) Domestic

(AI) **Non-schedule**

(BI) **Helicopter (IV) recreational**

Nepal Airlines, a State-owned carrier, operates internationally with B757 and A320 aircraft. Himalaya Airlines, a joint venture with Tibet Airlines of China, is a new international airline operating with A320 aircraft. Buddha Air, a major contributor in domestic front, is operating its regional flights to Varanasi (India) from Kathmandu with ATR-72 aircraft.

Domestic airlines operate with ATR-72/42, Jet Stream, CRJ 200, MA-60 and B1900C/D fleet on trunk-routes connected domestic airports situated in the plain areas. Whereas, small turbo-prop aircrafts like DHC-6 300/400, DO-228, Y-12E, LET 410 operate mostly to STOL airfields situated in mountainous high-altitude areas, ranging from 8000-10,000 feet above mean sea level (AMSL).

Small single-engine aeroplanes C-208 B and PAC 750 XL operate passenger and cargo charter services mostly to and from remote airfields in the mountainous areas. Such aeroplanes are not authorized to operate scheduled flights.

Helicopters are mostly engaged in high altitudes rescue operations and also providing logistic support for needy trekkers and expeditions. Majority of helicopters operating in Nepal are AS350 series, BELL 206, AS332, MI-8 MTV/AMT, etc.

Recreational aviation is based in Pokhara, the most exotic tourist destination of Nepal. Small piston engine ultra-light aircraft are operating to support leisure tourism.

Domestic Operating Airlines and Fleet

Aircraft operation in Nepal can be categorized basically in four categories as (1) Schedule, (2) Non-Schedule, (3) Helicopter, and (4) Recreational (Tables 1-5).

Results and Discussion

This section of this research paper presents the results and interpretation of aircraft accident and bird-strikes occurred in Nepal between 1946-2016 year's data analysed in this study. Among total of 50 airports of the country, including an international airport, 32 airports are in operations. Many airports in Nepal are lying either in the narrow valley of high mountain or on the top of hill with elevation ranging from 8,000 to 10,000 feet AMSL.

S. No.	Types of operation/operator international operation	A/C type
1	Nepal Airlines	A320-233, B757-200
2	Himalaya Airlines	A320- 214
3	Buddha Air	ATR72- 212A

Table 2: Schedule international operation.

S No.	Types of operation/ operator domestic operation	A/C type
1	Buddha Air	ATR72-212A, ATR42-320,BEECH 1900D
2	Goma Air	LET410UVP-E20 C208B
3	Nepal Airlines	DHC 6/300, Y 12E MA60
4	Simrik Airlines	DO-228-202K, DO-228-212 BEECH 1900C
5	Sita Air	DO-228-202K
6	Tara Air	DHC6-300, DHC6-400
7	Yeti Airlines	DO-228-212 JETSTREAM 4100

Table 3: Schedule domestic operation.

S No.	Types of operation/operator non-schedule	A/C type
1	Air Kasthamandap	PAC 750XL
2	Makalu Air	C208B
3	Saurya Airlines	CRJ 200

Table 4: Non-schedule domestic operation.

S No.	Types of operation/ operator helicopter	A/C type
1	Air Dynasty	AS350BA, AS350B2, AS350B3e
2	Fishtail Air	BELL-206B AS 350B3e
3	Manang Air	AS350B3e
4	Mountain Helicopters	AS350B2, AS350B3e, EC 130B4
5	Prabhu Helicopters	R44 II, R 66
6	Shree Airlines	MI 8 AMT, MI 8 MTV1, AS350B3e
7	Simrik Air	AS350B3e
8	VVIP	BELL-206-L3, BELL-206-L4, AS-332L1

Table 5: Helicopters domestic operation.

Small turbo-prop aeroplanes like DHC-6 300/400, Do-228 and single engine aeroplanes operate in these airfields flying through uneven terrain and narrow gorges. So, flying to these vulnerable STOL airfields in such a hostile environment is challenging in itself however controlled-safe flight is necessary to establish an adequate regulatory frame to allow the safe operation of these aircrafts. Accidents with hull-losses, hull-fatalities in number taking places in Nepal between 1946-2016 years occurring from different national and international aircrafts are depicted bellows

Accident of Aircrafts in Nepal Territory

Accidents of Nepalese turbo-prop multi-engine aeroplanes

There have been 37 serious accidents and incidents with hull losses fatalities of Nepalese registered turbo prop multi-engine Aeroplanes (14 different operator Company) of Nepal from year 1961-2016. Eleven operating company delivered fatal accidents results while three company's turbo-prop multi-engine aeroplane tasted accidents with zero losses of human lives which is shown in Figure 1 and graph 2 respectively. The largest number of fatalities in time frame was between 1961-to-2016, i.e., Nepal Airlines records of accident took place and number of hull-losses fatality is highest with 65 in number, Tara Air records of accident took place only twice with hull-losses fatalities number 22 and 23 in 15/12/2010 and 24/02/2016 respectively i.e., 45 in total number of fatalities. Yeti Airlines and Agni Airlines maintained

very close number of hull-losses fatalities i.e., 30 and 29 in number respectively. Similarly, Everest Air and Shangri-La Air both air fatality 18 in number while Buddha Air, Sita Air and Necon Air 20, 19 and 15 fatalities in number as shown in Figure 2 respectively (Tables 6-13).

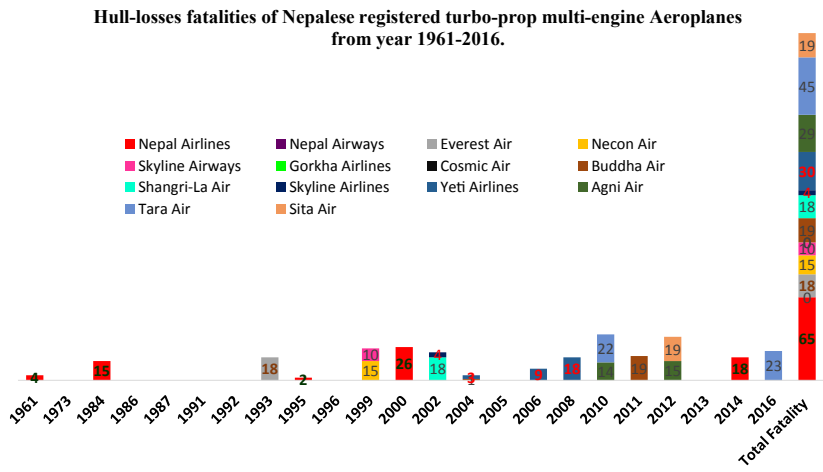

Figure 2: Accidents with hull-losses 1961-2016 (37 incidents).

S No.	Types of operation/operator recreational	A/C type
1	Avia Club Nepal	BIMANIM, EDGEX Classic, CRUIS 582, Dragonfly
2	Fishtail Ultra Flight	A-221, A-22L2, Quick GT 450
3	Pokhara Ultralight	Ikarus C42B, Aeros 2

Table 6: Recreational domestic operation.

S No.	Date	Type of A/C	Operator/Owner	Place	Fatality	Survival
1	11-05-1961	DC-3	Nepal Airlines	Bhairahwa	4	None
2	14-05-1973	DHC-6/300	Nepal Airlines	Lukla	None	-
3	22-12-1984	DHC-6	Nepal Airlines	Cheklatidanda	15	8
4	02-05-1986	DHC-6	Nepal Airlines	Sanfebagar Airport	None	-
5	19-08-1987	DHC-6	Nepal Airlines	Dolpa	None	-
6	09-06-1991	DHC-6	Nepal Airlines	Lukla	None	-
7	26-09-1992	Y-12	Nepal Airlines	Lukla	None	-
8	08-11-1993	Y-12 II	Nepal Airlines	Jomsom	None	-
9	31-07-1993	DO-228	Everest Air	Solighopte	18	None
10	14-01-1995	DHC-6	Nepal Airlines	Kathmandu Airport	2	23
11	14-07-1995	Y-12	Nepal Airlines	Bharatpur	None	-
12	25-04-1996	HS-748	Nepal Airlines	Meghauli	None	-
13	23-12-1996	Y-12	Nepal Airlines	Dolpa	None	-
14	05-09-1999	HS-748	Necon Air	Thankot, Kathmandu	15	-
15	25-12-1999	DHC-6	Skyline Airways	Burjo Lake, Makwanpur	10	-
16	26-02-2000	DHC-6	Nepal Airlines	Bajhang	1	-
17	27-07-2000	DHC-6	Nepal Airlines	Jogbuda, Dadeldhura	25	None
18	03-11-2000	DO-228	Gorkha Airlines	Lukla	None	-
19	19-11-2000	DO-228	Cosmic Air	Tumlingtar	None	-
20	05-04-2000	DHC-6/300	Yeti Airlines	Tumlingtar	None	-
21	17-07-2000	DHC-6/300	Skyline Airlines	GadgadeDanda, Surkhet	4	None
22	22-08-2002	DHC-6/300	Shangri-La Air Pokhara	Pokhara	18	None
23	21-04-2004	B 1990D	Buddha Air	TIA Airport	1	None
24	25-05-2004	DHC-6/300	Yeti Airlines	Lamjura, Solukhumbu	3	None
25	30-06-2005	DO-228	Gorkha Airlines	Lukla Airport	None	-
26	12-06-2006	DHC-6/310	Yeti Airlines	Jumla Airport	9	None
27	03-07-2006	DHC-6/310	Yeti Airlines	Bajura Airport	None	-
28	08-10-2008	DHC-6/300	Yeti Airlines	Lukla Airport	18	1
29	24-08-2010	DO-228	Agni Air	Sikharpur, Makawanpur	14	None
30	15-12-2010	DHC-6/300	Tara Air	Okhaldhunga	22	None
31	25-09-2011	Beech 1900D	Buddha Air	Kotdanda, Lalitpur	19	None
32	14-05-2012	DO-228	Agni Air	Jomsom Airport	15	6
33	28-09-2012	DO-228	Sita Air	Manohara, Bhaktapur	19	None
34	16-05-2013	DHC-6/300	Nepal Airlines	Jomsom Airport	None	-
35	01-06-2013	DO-228	Sita Air	Simikot Airport	None	-
36	16-02-2014	DHC-6/300	Nepal Airlines	Masinelek,Arghakhanchi	18	None
37	24-02-2016	DHC-6/400	Tara Air	Dana, Myagdi	23	None

Table 7: Accidents of Nepalese registered turbo-prop multi-engine aeroplanes (Source: CAAN).

S No.	Date	Type of A/C	Operator	Operation	Place	Fatality	Survival
1	31/03/1975	PC-6	Nepal Airlines	Charter	Bouddha, Kathmandu	5	None
2	30/10/1981	PC-6	Nepal Airlines	Charter	Biratnagar	10	None
3	20/11/1998	PC-6/B2-H4	Nepal Airlines	Charter	Phakding	1	None
4	17/01/1999	C208	Necon Air	Charter	Jumla	5	7
5	21/11/2011	C208	Makalu Air	Cargo	Talcha Airport, Mugu	None	-
6	26/02/2016	PAC750XL	Air Kashthamandap	Charter	Chilkhaya, Kalikot	2	9
7	04/08/2016	C208B	Makalu Air	Charter	Heldung Khola, Humla	None	-

Table 8: Accident of Nepalese registered single-engine Aeroplanes (Source: CAAN annual report 2016).

S No.	Date of Accident	Type of A/C	Operator/Owner	Place	Fatality	Survival
1	27-12-1979	Allutte-III	VVIP	Langtang	6	None
2	27-04-1993	Bell-206	Himalayan Helicopter	Langtang	None	-
3	24-01-1996	MI-17	Nepal Airways	Sotanf	None	-
4	17-01-1999	AS-350	Karnali Airways	Thupten Choling	1	4
5	13-12-1997	MI-17	Gorkha Airlines	Kalikot	None	-
6	04-01-1998	Bell-206	VVIP Flight	Dipayal	-	-
7	24-10-1998	AS-350B	Asian Airlines	Mul Khark	3	None
8	30-04-1999	AS-350BA	Karnali Air	Lisunkhu, Sindhupalchowk	None	-
9	31-05-1999	AS-350B2	Manakamna Airways	Ramechhap	None	-
10	11-09-2001	MI-17	Air Ananya	Mimi	None	-
11	12-11-2001	AS-350B	Fishtail Air	Rara Lake, Mugu	4	2
12	12-05-2002	AS 350B2	Karnali Air	Makalu Base Camp	None	-
13	30-09-2002	MI-17 (MI8- MTV)	Asian Airlines	Solukhumbu	None	-
14	28-05-2003	MI-17 IV	Simrik Air	Everest Base Camp	2	6
15	04-01-2005	AS-350BA	Air Dynasty Heli Service	Thhose VDC, Ramechhap	3	None
16	02-06-2005	MI-17	Shree Airlines	Everest Base Camp	None	-
17	07-05-2006	MI-17 MTV1	Heli Hansa Service	Dhawalagiri Base Camp	None	-
18	08-08-2006	MI-17	Karnali Air	TI Airport, KTM	None	-
19	03-09-2006	AS-350BA	Air Dynasty Heli Service	Dhawalagiri Base Camp	None	-
20	23-09-2006	MI-17	Shree Airlines	Ghunsa, Taplejung	24	None
21	23-11-2006	MI-17	Simrik Airlines	Raralihi, Jumla	None	-
22	29-06-2008	AS-350	Fishtail Air	Annapurna Base Camp	None	-
23	15-11-2009	MI-8	Manang Air	Rudikot, Humla District	1	5
24	07-11-2010	AS 350B3	Fishtail Air	Amadablam Mountain	2	None
25	29-11-2011	AS 350B	Fishtail Air	Solukhumbu	None	-
26	19-06-2013	AS 350B3	Fishtail Air	Simikot, Muchu	1	5
27	03-08-2014	AS 350B3	Fishtail Air	Sindhupalchok	1	None
28	02-06-2015	AS 350B3	Mountain Helicopter	Yamuna Danda,	4	None
29	22-06-2015	AS 350B3e	Simrik Air	Samdo, Gorkha	None	-
30	17-03-2016	AS 350B3	Fishtail Air	Langtang	None	-
31	08-08-2016	AS 350B3	Fishtail Air	Betani Nuwakot	7	None

Table 9: Accident of Nepalese registered helicopters (Source: CAAN).

S No.	Date of Accident	Type	Category	Airlines	Place	Fatality	Survival
1	03-10-2013	A-22L2	Sports	Avia Club	Santi Stupa, Pokhara	2	None
2	10-08-2015	Aeros 2	Sport	Pokhara Ultralight	Kathmandu	2 Missing	-

Table 10: Ultralight aircraft accident (Source: CAAN).

S No.	Date of Accident	Type	Category	Airlines	Place	Fatality	Survival
1	08-03-1955	DC-3	Fixed	Kalinga Air	Simara, Narayani	2	1
2	15-05-1956	DC-3	Fixed	Indian Airlines	Kathmandu, Bagmati	14	19
3	24-03-1958	DC-3	Fixed	Indian Airlines	Patnebhnajyang	20	None
4	31-07-1992	Airbus-310	Fixed	Thai Airways	Gyanphedi	113	None
5	28-09-1992	Airbus-310	Fixed	PIA	Bhattedanda	157	None
6	07-07-1999	B727(200)	Fixed	Lufthansa	Bhasmasur Hill, Kathmandu	5	None
7	04-03-2015	A330-300	Fixed	Turkish Airlines	TIA	None	-

Table 11: Foreign aircraft accident in Nepal (Source: CAAN).

S No.	Date	Type of A/C	Operator	Place	Fatality
1	May 7, 1946	Douglas C-47 Skytrain (DC-3)	Royal Air Force	Simara, Narayani	0
2	Aug 30 1955	Douglas C-47 Skytrain (DC-3)	Kalinga Airlines	Simara, Narayani	2
3	May 15, 1956	Douglas C-47 Skytrain (DC-3)	Indian Airlines	Kathmandu, Bagmati	15
4	Mar 24, 1958	Douglas C-47 Skytrain (DC-3)	Indian Airlines	Kathmandu, Bagmati	20
5	May 5, 1960	Pilatus PC-6 Turbo Porter	Swiss Dhaulagiri Expendition	Nepal	0
6	Nov 5, 1960	Douglas DC-3	Royal Nepal Airlines	Nepal	4
7	Mar 22, 1961	Douglas DC-3	PIA	Nepal, Nepal	0
8	Mar 9, 1961	De Havilland DHC-6 Turbo Porter	Royal Nepal Airlines	Nepal, Nepal	0
9	Aug 1, 1962	Douglas C-47 Skytrain (DC-3)	Royal Nepal Airlines	Tulachan Dhuri, Nepal	10
10	Aug 26, 1962	Pilatus PC-6 Turbo Porter	Royal Nepal Airlines	Nepal	0
11	Feb 8,1967	Pilatus PC-6 Turbo Porter	Swiss Government	Nepal	0
12	July 12, 1969	Douglas C-47 Skytrain (DC-3)	Royal Nepal Airlines	Nepalgunj, Bheri	0
13	July 12, 1969	Douglas DC-3	Royal Nepal Airlines	Hetauda, Narayani	35
14	Feb 27, 1970	De Havilland DHC-6 Twin Otter	Royal Nepalese Air Force	Jomshom Dhawalagiri	1
15	Sep 13, 1972 At 1200 LT	Douglas C-47 Skytrain (DC-3)	Royal Nepalese Air Force	Kathmandu, Bagmati	31
16	May 10, 1973	Douglas DC-8	Thai	Kathmandu, Bagmati	1
17	Oct 15, 1973	De Havilland DHC-6 Twin Otter	Royal Nepal Airlines	Lukla, Sagarmatha	0
18	Mar 31, 1975	Pilatus PC-6 Turbo Porter	Royal Nepal Airlines	Kathmandu, Bagmati	5
19	Apr 7, 1978	Short SC.7 Skyvan Variant	Royal Nepalese Air Force	Rukumkot, Rapti	0
20	Nov 19, 1981	Pilatus PC-6 Turbo Porter	Royal Nepal Airlines	Biratnagar, Koshi	10
21	Dec 22, 1984	De Havilland DHC-6 Twin Otter	Royal Nepal Airlines	Bhojpur, Koshi	15
22	Dec 30, 1985	Short SC.7 Skyvan Variant	Royal Nepalese Air Force	Nepal, Nepal	25
23	May 3, 1986	De Havilland DHC-6 Twin Otter	Royal Nepal Airlines	Namche Bazar, Sagarmatha	11
24	Jul 10, 1991	De Havilland DHC-6 Twin Otter	Royal Nepalese Air Force	SurKhet, Bheri	3
25	Jun 20, 1991at 1224 LT	De Havilland DHC-6 Twin Otter	Royal Nepal Airlines	Simikot, Karnali	0
26	Jun 9, 1991 at 1010 LT	De Havilland DHC-6 Twin Otter	Royal Nepal Airlines	Lukla, Sagarmatha	0
27	Sep 28, 1992 at 1430 LT	Airbus A300	PIA	Kathmandu, Bagmati	167
28	Sep 26, 1992	Harbin Yunsunji Y-12	Royal Nepal Airlines	Lukla,	0
29	Jul 31, 1992 at 1245LT	Airbus A310	Thai	Kathmandu, Bagmati	113
30	Jul 5, 1992	De Havilland DHC-6 Twin Otter	Royal Nepal Airlines	Jumla, karnali	0
31	Nov 8, 1993	Harbin Yunsunji Y-12	Nepal Airways	Jomsom, Dhawalagiri	0
32	Jan 17, 1995 at 1359 LT	De Havilland DHC-6 Twin Otter	Royal Nepal Airlines	Kathmandu, Bagmati	2
33	Apr 25, 1996 at 1158 LT	Avro 748	Royal Nepal Airlines	Meghuli, Narayani	0
34	Nov 6, 1997	Avro 748	Necon Air	Pokhara, Gandaki	0
35	Nov 19, 1998 at 1538 LT	Pilatus PC-6 Turbo Porter	Royal Nepal Airlines	Namche Bazar, Sagarmatha	1
36	Aug 21, 1998 at 1124 LT	De Havilland DHC-6 Twin Otter	Lumbini Airways	Pokhara, Gandaki	18
37	Dec 25, 1999 at 1502 LT	De Havilland DHC-6 Twin Otter	Skyline Airways	Simara, Nararayani	10
38	Sep 5, 1999 at 1030 LT	Avro 748	Necon Air	Kathmandu, Bagmati	15
39	Aug 7, 1999 at 0635 LT	Short SC.7 Skyvan Varient	Royal Nepalese Air Force	Surkhet , Bheri	0
40	Jul 7, 1999 at 1951 LT	Boeing 727-200	Hinduja Cargo	Kathmandu Bagmati	5
41	Jan 17, 1999 at 1630 LT	Cessna 208 Caravan	Necon Air	Jumla, Karnali	5
42	July 27, 2000 at 1035	De Havilland DHC-6 Twin Otter	Royal Nepal Airlines	Dhangadi, Seti	25
43	Aug 22, 2002 at 1005 LT	De Havilland DHC-6 Twin Otter	Shangri-la	Pokhara, Gandaki	18
44	Jul 17, 2002 at 1422 LT	De Havilland DHC-6 Twin Otter	Skyline Airways	Surkhet, Bheri	4
45	25 May, 2004 at 1356 LT	De Havilland DHC-6 Twin Otter	Yeti Airlines	Lukla, Sagarmatha	3
46	30-Jun-05	Dornier DO228	Gorkha Airlines	Lukla	0
47	Jun 21, 2006 at 1203 LT	De Havilland DHC-6 Twin Otter	Yeti Airlines	Jumla, Karnali	9
48	Oct 8, 2008 at 0731 LT	De Havilland DHC-6 Twin Otter	Yeti Airlines	Lukla, Sagarmatha	18
49	Dec 15, 2010 at 1530 at 1530 LT	De Havilland DHC-6 Twin Otter	Tara Airlines	Nepal, Nepal	22
50	Aug 24, 2010 at 0725 LT	Dornier DO228	Agni Air	Kathmandu, Bagmati	14
51	Oct 18, 2011 at 1906 LT	Britten-Normal Islander	Royal Nepalese Air Force	Nepal, Nepal	6
52	Sep 25, 2011 at 0731 LT	Beechcraft 1900D	Buddha Air	Kathmandu, Bagmati	19
53	Sep 28, 2012 at 0618 LT	Dornier DO228	Sita Air	Kathmandu, Bagmati	19
54	May 14, 2012 at 0945 LT	Dornier DO228	Agni Air	Jomsom, Dhawalagiri	15
55	Jun 1, 2013 at 0714 LT	Dornier DO228	Sita Air	Simikot, Karnali	0
56	May 27, 2013 at 1042 LT	Cessna 208B Grand Caravan	Goma Air	Simikot, Karnali	0
57	May 16, 2013 at 0833 LT	De Havilland DHC-6 Twin Otter	Nepal Airlines	Jomsom, Dhawalagiri	0
58	Feb 16, 2014 at 1315 LT	De Havilland DHC-6 Twin Otter	Nepal Airlines	Arghakhanchi, Lumbini	18
59	Sep 24, 2016 at 1656 LT	Bae Jetstream 41	Yeti Airlines	Siddharthanagar, Lumbini	0
60	Feb 26, 2016 at 1656 LT	PAC 750XL -Pacific Aerospace Corporation	Air Kashtamandap	Chilkhaya, Karnali	2
61	Feb 24, 2016 at 0800 LT	De Havilland DHC-6 Twin Otter	Tara Air	Dana, Dhawaagiri	23

Table 12: Aircraft accident/incident achieves of Nepal (Source: ICAO, EASA, FAA, B3A).

Accident of Nepalese single-engine aeroplanes

An example of disorder, negligence and lack of responsibility is the accident cause in Nepal Airlines in operation of charter "single-engine" aeroplane approach leads highest number of accidents occurred in between 1975-to-1998 delivering fatal accident and incidents with fatal hull-fatalities of 16 in number, Necon Air accidents with hull-fatalities 5 with survival number 7, Air Kasthamandap accidents with hull-fatalities 2 and survival 9 and Makalu air accidents with zero hull-fatalities in year 17/01/1999, 26/02/2016, and (21/11/2011-04/08/2016) respectively depicted in Figure 3.

Statistics shows that most aircraft accidents and incidents have occurred by Operator Nepal Airlines. Aircraft occurrence investigation agencies around the world estimate that 70~90% of accidents are due to non-adherence of procedure lack of training, bad decision-making and incorrect actions of personal involved in maintenance, operations or design of aircrafts [23-25].

Figure 4 statistic history proves above [23-25] and Nepal Airlines operator in Nepal is responsible for highest accidents and incidents by 11% in single-engine aeroplanes significantly reveals their human errors responsible of these accidents with hull-losses fatality number

S No.	Date of Accident	Type	Airlines (Operator)	Place	Fatality
1	Sep 28, 2012	Dornier DO 228	Sita Air	Kathmandu Bagmati	19
2	March 23, 2014	A737	Malaysia Airlines	Kathmandu	0
3	Dec 29, 2014	B737	Jet Airways	Kathmandu (TIA)	0
4	Jun 30, 2014	XIAN MA-60	Nepal Airlines	Biratnagar	0
5	Mar 22, 2015	B777	Thai Airways	Kathmandu (TIA)	0
6	Jul 7, 2016	A320	Nepal Airlines	Kathmandu (TIA)	0

Table 13: Bird strikes in Nepal (Source 1: WBA, Nepal Newspaper Records, Online Web and Interviews).

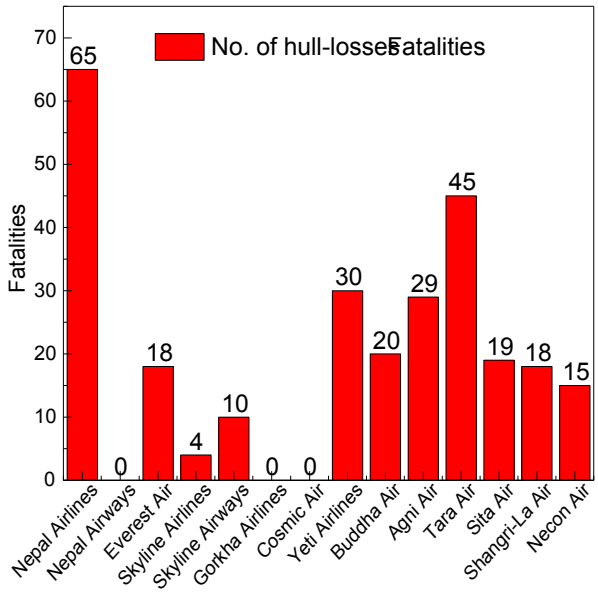

Figure 3: Number of Hull-losses fatalities 1961-2016 (By 14 different turbo-prop multi-engine Airplanes).

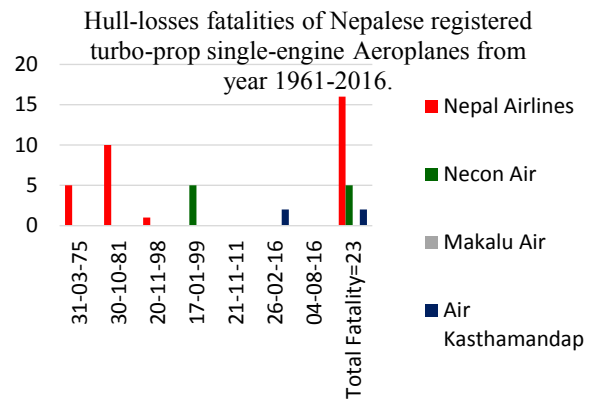

Figure 4: Accidents with hull-losses 1975-2016 (7 incidents).

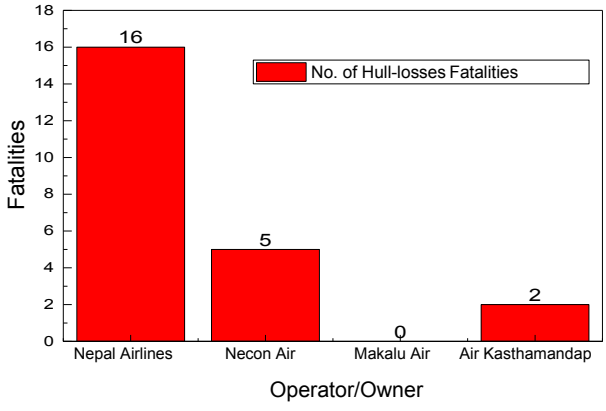

Figure 5: Number of Hull-losses fatalities 1975-2016 (By 4 different turbo-prop single-engine Airplanes).

16, and hull-losses fatality of Necon Air, Air Kasthamandap and Makalu air between 1975-2016 years is 5, 2 and 0 respectively.

Accident of Nepalese registered helicopters

The research is aimed to investigate the causal relationship between human factor and aircraft accidents, incidents happening in Nepal.

A quick glance through the annals of Nepal's aviation history of accident of Nepalese registered helicopters reveals a fairly large number of accidents (8 times between 1979-2016) have been recorded by Fishtail Air with hull-loses ranking second highest in number with 15 hull-losses fatalities. However, Shree Airlines statistics of aircraft accident records only two times (02/06/2005 and 23/09/2006) with highest number of hull-losses fatalities 24 which is shown in Figures 5 and 6. respectively. Incident without hull-losses taking place by operator like Himalayan Helicopter, Nepal Airways, Gorkha Airlines, Manakamna Airways, Air Ananya, Heli Hansa Services while helicopter operator/owner like VVIP, Karnali Air, Asian Airlines, Simrik Air, Air Dynasty Heli Service, Manang Air and Mountain Helicopter recorded hull-losses fatalities number of 6, 1, 3, 2, 3, 1 and 4 respectively in the year between 1979-2016 depicted in Figures 5 and 6 respectively.

Ultralight aircraft accident

Recreational Aviation Nepal (RAN) could be centre for the aviation enthusiast. Indeed, recreational aviation can be focused based on most exotic tourist destination and can be key factors to support states, nation's income along with can support leisure of tourism. Apparently, the risk associated with operation of recreational ultralight aircraft in Nepal will be comparatively higher along with hull-losses fatality number as well till regulator CAAN advised ultra-light aircraft operator until the operator adherence of procedures of enough training, technical-maintenance, responsible to achieve safe flight in weather and sabotage. The first ultralight aircraft accident was recorded in 3rd Oct 2013 with hull-losses fatalities number 2 and second accident in 10th Aug 2015 with hull-losses 2 missing records respectively. Thus, occurrences investigation ensures the risk associated with such operations of flights is higher (Figure 7).

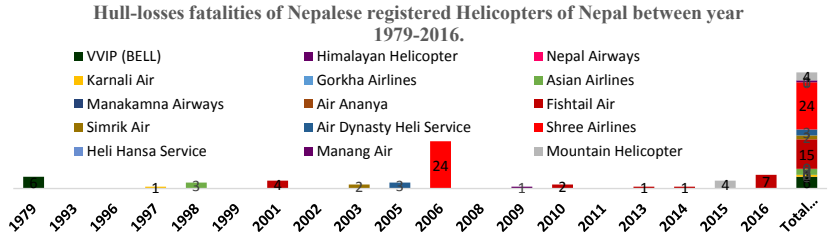

Figure 6: Accidents with hull-losses 1979-2016 (31 incidents).

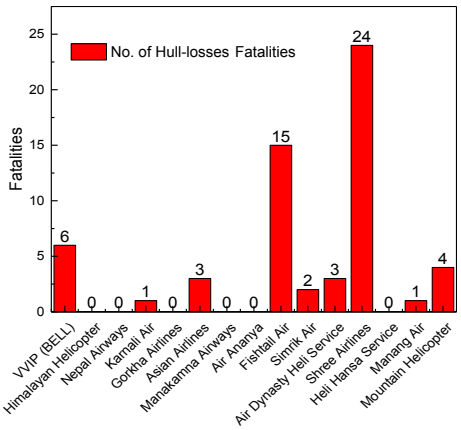

Figure 7: Number of Hull-losses fatalities 1979-2016 (By 15 different Helicopters of Nepal).

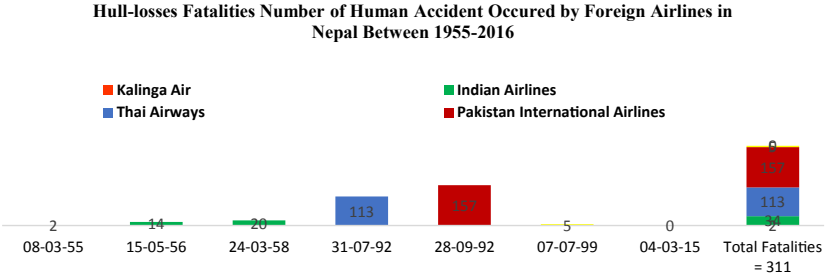

Figure 8: Accidents with hull-losses 1955-2015 (7 incidents).

Foreign aircraft accident in Nepal

Domestic aircraft movement are about to times more than international aircraft movements in Nepalese airports. According to the Civil Aviation Authority of Nepal (CAAN) annual reports analysis and classification of foreign incidence occurred by foreign airlines in Nepal between years 1955-2015 is tabulated in Table 10 as shown in above. The research analysis shows that Indian airlines faced twice accidents (in 15/05/1956 and 24/03/1958) in Nepal in with hull-losses of fatalities 34 in number, Kalinga Air, Thai Airways, Pakistan International Airlines (PIA), Lufthansa and Turkish Airlines with hull-losses 2, 113, 157, 5 and 0 fatalities in number shown in Figures 8 and 9 respectively.

Aircraft Accidents Achieves of Nepal through Council Directives

In this study's assessment period (1946 to 2016) data collected and analysed from aviation accidents investigation records through various council directives like International Civil Aviation Organization (ICAO) [26], European Aviation Safety Agency (EASA) [27], Bureau of Aircraft Accidents Achieves (B3A) [28] and various qualitative approach like online articles, newspaper, interviews etc. which is depicted in below Table 11. The results were expected to provide answer to research questions and tests of hypotheses that are raised in this study. The purpose of this study was to present analysis accidents/incident results, precisely evaluate the trend of aircraft accidents/incidents casualties in Nepal airspace. Attempt quantifying the role of investigation to state human errors in Civil Aviation Authority of Nepal (CAAN) contributes to aircraft accidents/incidents.

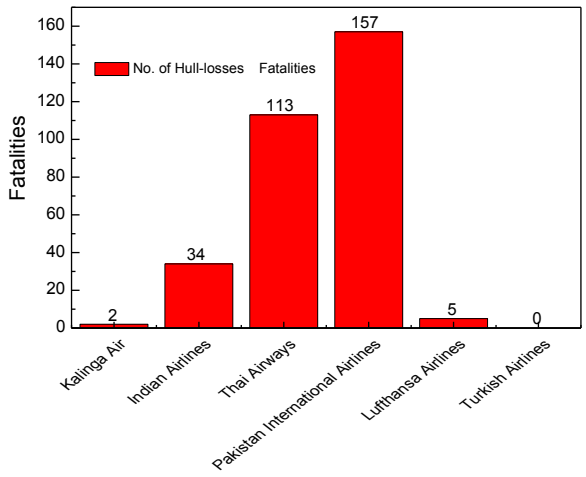

Figure 9: Number of Hull-losses fatalities 1955-2015 (By 6 different foreign aircrafts in Nepal).

Formerly "Nepal Airlines Corporation (NAC)" known as the Royal Nepal Airlines Corporation (RNAC) which was established in 1st July 1958 through enactment of Nepal Airlines Corporation Act 2019 with the intention to provide the air transportation service in Nepal, with one Douglas DC-3. It's the government owned airways company and flagship airways of Nepal is symbolized heritage of the country. The name of the airlines changed from Royal Nepal Airlines to Nepal Airlines in 2006 after democracy movement, King Gyanendra Bir Bikram Shah agreed to relinquish sovereign power to the people [1,29]. Former name modified i.e., "Royal Nepal Airlines Corporation (RNAC)" into "Nepal Airlines (NA)" for the period 1946-2016 in Nepal accident archives database depicted in Table 11.

Civil aviation has a long-standing tradition of investigating accidents, which contributes to making aviation one of the safest forms of the transport. Table 11 presents the nature of accident occurrences within the study period (1946-2016). The result shows that the highest fatalities occurred from the Nepal Airlines (NA); 18 incidents recorded between 1946-2016 out of which 12 recorded as hull-losses fatalities maintaining 2nd highest number of hull-losses fatalities 136 in numbers. Similarly, Royal Nepalese Airforce recorded 7 incidents out of 5 categorized as hull-losses fatalities with 66 in number which is shown in above Figures 10 and 11. Moreover, international airlines companies like Pakistan International Airlines (PIA), Thai Airlines, Indian Airlines, and Hinduja Cargo took accidents with hull losses taking place between 1946-2016 with 167, 114, 35, and 5 hull-losses fatalities in numbers are listed in Table 11, Figures 10 and 11 respectively. Up to 5 aviation accidents were recorded in 1999 with hull-losses fatality 35 in number consecutively 1992 been the highest hull-losses fatalities in the history of Nepal aircraft accident 4 times incidents recorded with fatalities 280 in number. Yeti Airlines (domestic aircraft) maintains 3rd numbers of accident occurrences aircraft recorded in Nepal airspace. The results generally show absence of serious incidents and incident between 1946-to-1960. This might be due to the fact aircraft number in those years in Nepal was rare in number also due to the fact that data for this period were unavailable, but didn't mean that there were no serious incidents or accidents. Lack of effective documentation before the inception of CAAN is the likely attributable reason (Figures 12-22).

Bird Strike against Aircraft

It is estimated that fatal birds strike only occur once in a billion flying hours [30]. It can also be misleading to think that strikes with large birds would always be the most dangerous ones. Even a flock of small birds can easily break an engine, windshield or another aircraft structure shown in Figure 1 Vulnerability of aircraft component to bird strikes provided in [5]. The size of the birds doesn't directly correlate with the damage sustained either. In fact, mass density varies

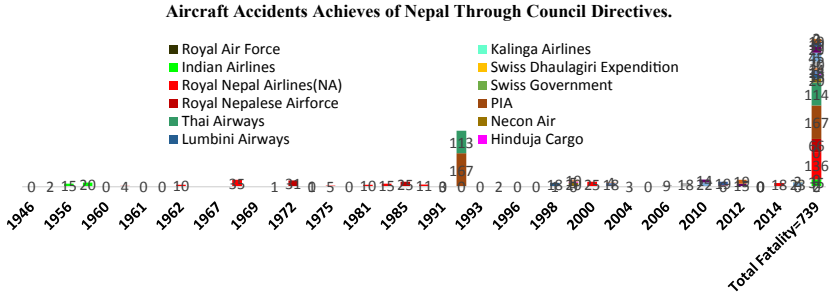

Figure 10: Accidents with hull-losses 1946-2016 (61 incidents by National and International Aircraft in Nepal).

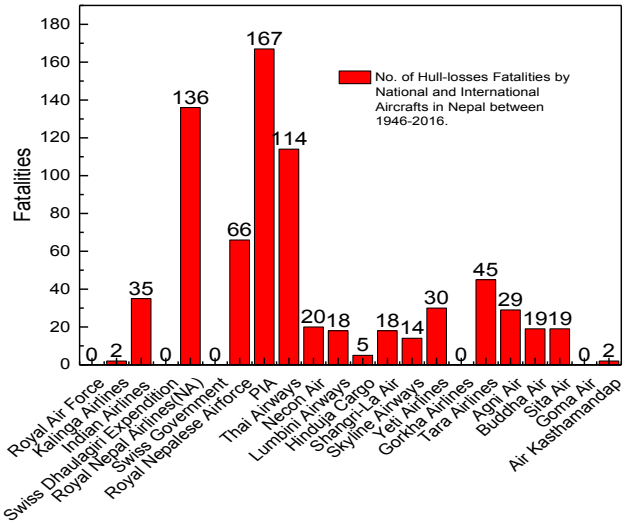

Figure 11: Number of Hull-losses fatalities between 1946-2016 (By 22 national and international aircrafts in Nepal).

Figure 12: July 31, 1992 Airbus A310 Thai Airlines (Fatalities Number 113)

Figure 13: Sep 28, 1992 PIA (Fatalities Number 167).

Figure 14: 17th Jan 1995 NA (Fatalities No 2;1 Crew+1 Passenger).

Figure 15: Sep 5th 1999: Necon Air (Fatalities No 15"5 Crew member+10 Passenger".

a lot according to bird species. To give an example, a Laughing Gull (*Leucophaeus atricilla*) is about 1/3 of the size of a Herring Gull (*Larus argentatus*), but has significantly higher density. Another interesting example is the Starling (*Sturnus vulgaris*). They have a 27% higher mass density than gull and can form flocks with up to 100,000 birds. This is why Starling are sometimes called "feathered bullets" [3,4].

In Nepal, bird strike reporting is not a part of the mandatory incident reporting system, but it is strongly recommended by the Finnish Transport Safety Agency. The rules on whether bird strike reporting is voluntary, or mandatory vary in different countries. For example, the United States have a voluntary reporting system, but in Great Britain, bird strike reporting has been mandatory since the year

Figure 16: 28th Sep 2012: Sita Air (Fatalities No. 19) known as UK Dead Remembered.

Figure 17: 25th May 2004 (Fatalities No.3 Crew Member).

Figure 18: 8th Oct 2008 Yeti Airlines (Fatalities No.18).

Figure 19: 24th Aug 2010 Agni Air (Fatality No. 14).

2004. In fact, on the 1st of January 2008, the CAA UK introduced a new system for reporting bird strikes online [31].

Bird strikes may obviously happen to any kind of aircraft with any kind of engine. Nevertheless, a more precise analysis reveals that bird strike reported at finished reporting data in this study assessment period (1946 to 2016) data collected and analysed from aviation accidents investigation records through various council directives like ICAO, EASA, B3A, FAA, WBA [26-28,32,33] and various qualitative approach like online articles, newspaper, interviews etc. have received from regulator CAAN which is depicted in below Table 12.

Figure 20: 16th Dec 2010 Tara Air (Fatality No. All Bhutanese Tourist 14).

Figure 21: 25th Sep 2011 Buddha Air (Fatality No. 19).

Figure 22: 14th May 2012 Agni Air (Fatality No. 16 including 3 Crew members) (*Note Source (Fig.12-22): Interview Footage of Nepal Television [34] and National Newspapers of Nepal [35,36].

The trend assessment of bird strike against aircraft incidents and casualties in this study confirms that the CAAN need to be practice significantly improved in the sense the documentations of bird strikes and casualty data.

This became obvious regarding the appropriate classification and documentation of aircraft mishaps such as serious incidents. The Table 12 shows that only 6 accidents of aircraft documentation found, the improvements consisted of the deliberate effort by CAAN to collate and document as much as possible accident due to bird strike data that occurred even before it's establishment. Hence, the accident/accident date shown in Table 12 showed improvements in data records investigation need to be done by CAAN. In spite of this all incidents results in casualties, the relation between the number of accidents and

the number of resultant casualties are not correlated due to the number of persons that may be involved in a particular accident [34-36].

Historic Accidents in Nepal (Horrific Hull-losses Accidents in Nepal)

In this section author attempted collecting aircraft horrific accident (data from National News Channel, National Newspaper of Nepal, Interviews etc.) occurs in the Nepalese airspace, and analysis indicate quantify human error involvement of CAAN framework to aircrafts accidents fully documentations accident reports. Also, the analysis state human error involvement in aviation operator was highest with decision errors as the most influential under the category of Unsafe Act of the Operators being the most casual factor, although all factors are to be considered a significant cause of concern. The historic horrific aircraft accidents occurred in Nepalese airspace is depicted below.

Conclusion

Air transport in Nepal can be considered in safest forms of travel with the improvements efforts of CAAN implementing new approaches to investigating accidents and incidents in civil aviation, as this is the key mechanism for preventing future accidents of aircrafts and bird-strikes. Being well aware of this fact, CAAN should be working on a regulation on the investigation and prevention of accidents to ensure efficient and independent inquiries into the cause of air accidents.

The regulation address organizational changes, improvements in the coordination between the authorities responsible for the technical investigation and judicial measures to protect the information obtained in the course of the investigation, improvements in the monitoring of safety recommendations, and the good governs/adopting of ICAO and EASA for each stage of the investigation of civil aviation accidents.

In line with ICAO and IATAs' zero accident and zero fatality program, coupled with Annex 13 of the Chicago Convention, recommendations made to strengthen the function of AIB as well as collaborating agencies in the Nepalese aviation sector. It is hoped that these will be considered as tool for implementing safety recommendations issue by AIB of Nepal.

From the findings of this study, the following recommendations could be drawn:

1. The research study revealed that aircraft accident/incident data not yet improved even establishment of CAAN. This therefore calls for sustainable policy framework to enable the agency to maintain the peace of accident data collection, collation, storage and processing by CAAN.

2. In Nepal, funding is generally a major cause for concern, but funding AIB is immensely required to fully integrate the HFACS framework into use in Nepalese aviation sector, as this will provide adequate resources for specialized training, further research works on incident/accident preventing programs using the HFACS framework.

3. Human error involvement in commercial aviation was shown to be the highest with decision error under the category of Unsafe Act of the Operators being the most causal factor. It is therefore recommended that coupled with the current Safety Management System (SMS) being introduced into the aviation industry in Nepal; these will effectively minimize or prevent aircraft accidents/incidents in Nepalese airspace.

4. Review of CRM and the associated simulator training programs in order to enhance crew decisions especially in situations of abnormal performance. Also, the review crew pairing and scheduling policies in order to ensure a safe cockpit environment is advised.

Limitations and Challenges of the Study

Two major constraints were faced in the cause of undertaking this study. These constraints were mainly financial and consequently time factor. These challenges surmounted with the best of efforts required.

The enormous amount of financial resources required to fund this research was mainly experienced in the several months of engagement with the team on familiarization and categorization of final reports components on to the HFACS framework. Although the set objectives of the study were eventually met, but a deeper analytical approach would have been achieved had been more time.

Second crucial challenge was the issue of accessibility of accident data at the relevant departments and agencies of government involved. A hundred and one calls, and visits are required to the attention amidst their busy schedules). And third challenges were the issues of accessibility of bird-strike accident data: As Pilots are not familiar with bird species and often at the speed at which the strike occurred was such, that the reporter was unable to see or identify the bird species. Therefore, author experienced several months to find reports of bird strikes from national TV channels reporter, national newspaper articles etc., of Nepal. Nevertheless, problem might not appear if modern technologies, identification methods (feather identification, DNA etc.) have been introduced by CAAN in order to have correct data.

Suggestion for Further Studies

1. Further analysis not conducted in the work will be very useful in elucidating finer details such as understanding the five-year trend of human casual factor revealed by HFACS.
2. Application of a more sophisticated predictive models to determine the expected aircraft accident/incident trend in the Nepalese airspace.
3. Comparative analysis of findings within Nepalese airspace of likelihood of location dependent occurrences of aircraft accident.
4. Examination of the main primary and secondary safety measures in development countries and their effectiveness at enhancing safety.
5. An investigation into the constraints associated with aviation safety related issues in developing countries like Nepal in meeting ICAO standards and how these constraints can be reduced or eliminated.

Challenges of Aircraft Operations in Nepal

Challenges of Aircraft operations in terms of safe flying emanate from various intersections of contributing factors. This entails considerations of various parameters which include aircraft type, size of fleet, flying environment associated with remote and trunk route destinations, human factors, etc.

1. CFIT: Major contributors to accidents
2. Hostile terrain and weather phenomenon
3. High altitude STOL operation
4. Unavailability of en-route weather information

5. Limitation associated with VFR operations
6. Accidents-turbo-prop aircrafts with ≤ 19 seats

Safety Recommendations

1. CRM and CFIT reduction training
2. Installation of EGPWS and aircraft tracking system
3. Stringent pilot license requirements
4. Strict provision for visual flight rules (VFR)
5. Human factors training in aircraft maintenance
6. Safety awareness programmed

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