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Critical Literature Review

(ANTA602)

AVIATION ACCIDENTS in ANTARCTICA -A review of literature and examination of dimensions.

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Abstract

Antarctica and its isolation relies heavily upon aviation for accessibility. For accessibility to, and scientific and artistic advancement of the Continent. The rapidly changing extreme weather, which creates environmental in-hostility and inaccessibility give rise to aviation presenting as a challenge in Antarctica. With this challenge come risks from an already high-risk mode of transport. This literature review examines aviation accidents in Antarctica from both the fixed wing and helicopter data. This data is presented in a Table format, from the first accident on 15 March 1929, up to 4th December 2013.

The review answers the following dimensions. Firstly the spatial dimension; where do accidents occur commonly and why? Secondly the causal dimension; what are the main reasons behind aviation accidents? Thirdly the impact dimension, the environmental, political, economic and socio-cultural consequences of accidents. Finally, examination of the temporal dimension, thru asking; has aviation has become safer over time?

The review is introduced with a brief contextual historical overview of Aviation. Followed by the International Geophysical Year-IGY, and its significance to Aviation. The tabulated aviation accident data follows; this is structured in pre International Geophysical Year (IGY), IGY and post IGY. Discussion of dimensions followed by conclusions complete the review.

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Introduction

A brief contextual history of Aviation in Antarctica

Aviation historically is important to the understanding of Antarctica as it is today. Fixed wing and helicopter operations, both intercontinental and continental provide support for logistics in the field for supply drops, for conducting mapping operations, aerial photography for mapping, establishing permanent stations, and conducting scientific and artistic research

The very first flights in Antarctica were recorded on the same day, February 4, 1902 by Scott and then subsequently Shackleton (on the "Discovery" Expedition, 1901-04). The first Aeroplane flight in Antarctica was made on November 16, 1928, by Carl Ben Eielson, pilot, and Sir Hubert Wilkins, the observer. (Grierson, 1964). The first 'helicopter' flight was in the Kellett 'autogyro', *Pep Boy's Snowman!* (NR 2615), the first 'helicopter' to be used in Polar Regions. The first flight to the South Pole, was on November 29, 1929. The first Aircraft landing at the South Pole was 31 October 1956. (Burke, 1994).

Thus the first aircraft accident was inevitable with the advent of discovery and exploration. The Table 1.1 to follow summarizes the aviation accidents in Antarctica followed by a brief discussion of some dimensions and conclusions.

The IGY

The growth of Aviation, around the IGY.

The International Geophysical 'Year' –IGY, July 1, 1957, to December 31, 1958, was an important time for the opening up of growth of Antarctica's Aviation. IGY marked the end of a long period during the Cold War when scientific interchange between East and West had been seriously interrupted.

The IGY was very much an international project involving 12 nations including New Zealand. It was proposed that these nations would set up about 50 stations in the Antarctic region. Aviation was needed to support building this growth, for the transport, construction and operation of the bases.

President Eisenhower approved the US participation in the IGY in 1954. The US Antarctic phase was the responsibility of the US Navy, which created the flying Squadron VXE-6, formed on January 17, 1955. (Phillips, 2001). The VXE-6 Squadron had a large presence in Antarctic aviation history. VXE-6 had a series of aircraft accidents. Appendix- table 1A shows from 1946-1973 a loss of 50 Aeroplanes. (Anderson,1974)

The following table 1.1, is a presentation of all the aviation accidents to this Review. This table is formatted around highlighting, the Pre IGY (Yellow), the IGY (Pink) and the Post IGY (Blue). These 3 segments of time enable structure to this information. Pre IGY accident data of aviation's infancy, the IGY of discovery and advancing exploration i.e. reaching the South Pole for the first time by plane. The post IGY, until today with aviation's further advancements.

1.1 Table of Aircraft Accidents in Antarctica

Code: yellow=pre IGY ; pink=Era of the IGY(1July,1957 to Dec 31, 1958); BLUE=post IGY until today

KEY:

POB=Persons on board

T/O= Take Off

LD= Landing

RWY=Runway

EFATO= Engine failure after take off

EF=Engine failure

WX = weather

HF=Human Factor

UNK= Unknown cause

MECH= Mechanical

EXPOL=Explosion

ANARE= Australian National Antarctic Research Expedition

AAD= Australian Antarctic Division

NSF= National Science Foundation

NYANG = New York Air National Guard

JATO-Jet Assisted Take Off (small solid-fuel rockets to boost the airplane's turboprop engines)

VMC=Visual Meteorological conditions, therefore weather requiring navigational aid or IFR= Instrument Flight Rules (instrument guided flying)

VFR=Visual Flight rules = fair/good “visual” flying weather

UC-1 = US Navy designator for DE Havilland Twin Otter; GA-General Aviation, Non military ops call twin Otter the DH3 and DH6

Table 1.1. *Aircraft Accident in Antarctica*

DATE	Aircraft Type	Accident Location	Fatalities/ Injuries non fatal (type of injury if available)	National Program Operator	Accident Causal factors	Reference
15March 1929	Fokker Super Universal NC4453	Little America Camp- Ross Ice Shelf	0/0	Byrd Antarctic Expedition	Standing and damaged beyond repair Lost in storm	(Burke, 1994)
26 December 1929	De Havilland DH.60M Moth	Near South Pole	2	Nowegian Kosmos Hvalfangsts-elskapet	Operated aboard the Whaler "Kosmos	(Burke, 1994)
7 March 1934 (1ST Air rescue)	Fokker, Universal Mono-plane	Little America II- Camp at Ross Ice Shelf	0	Byrd, (2nd Antarctic Expedition)	T/O WX winds	(Burke, 1994)
January 1941	Condor seaplane Little America iii	Watson Island (Mikkelsen Island)	0	US Antarctic Service Expedition	Engine burned out	(Anderson, 1974)
30 December, 1946	PBM Mariner (OP High-jump)	Thurston Island	3 fatal/6 non-fatal	U.S. Navy	Severe WX	(Huddleston, 2009)
21 December 1947	Walrus amphib-ian	Heard Island	0	ANARE**	Severe WX storm	(Burke, 1994)
22 January, 1955	Bell htl-5 helicopter	Kainan Bay	1 fatal 1POB	US NAVY Off the icebreaker USS ATKA	Whiteout (disorient ation flew off ship and into iceshelf)	(Anderson, 1974)
22 December, 1955	UC-1 Twin otter(142 424)	Near Cape Bird, Ross Island	0fatal/ 1 injury (4POB)	(Deep Freeze 1, 1955-6)	Crashed on T/O-	(Anderson, 1974)
10 February, 1956	UC-1 Twin Otter	Little America V	0 fatal	US VXE-6 Deepfreeze	During offload of cable	(Anderson, 1974)

	(Bruno 144259)			1	break and plunged to iceshelf	
18 Oct 1956	P2V Neptune Lockheed	Mc Murdo Base	4 Fatal	US VXE-6OP Deep Freeze	WX	(Anderson, 1974)
1 December 1957	HUL-1 (Buno 143144)	USS Atka flight deck	0 fatal	Op Deep Freeze	Fire, crashed on deck	(Stephen& Rainville, 1974)
3 December 1957	HO4S-3 (138498)	Ross Ice Shelf	0fatal	Op Deep Freeze	UNK	(Stephen& Rainville, 1974)
15 October 1958	C-124C (52-1017) "City of Christ-church"	Plateau above Cape Hallett crashed into Hill near Cape Roget	6Fatal/ 7 Survivors	Op Deep Freeze	Error in navigat-ion. False Radar returns	(Phillips, 2001)
22 October, 1958	UC-1 Twin Otter	Ross Ice Shelf	0 fatal	VXE-6 Op Deep Freeze	Taxi, fuselage cracked	(Anderson, 1974)
Dec 1958	UC-1 Twin Otter (Bruno 144673)	Marble Point (dirt RWY)	2 fatal	VXE-6 Op Deep Freeze	Wing hit knoll on Glacier UNK	(Anderson, 1974)
Jan 1959	Li-2 Russian Transport Airplane	Mirny Station	0 fatal	UNK	Overran RWY Landing gear failure	(Burke, 1994)
12 February 1959	Sikorsky HRS-3 (Bruno 144257)	USS Glacier	UNK/ 1POB	Op Deep Freeze	Test flight after engine change	(Anderson, 1974)
15 September , 1959	R4D-5 (Bruno 17163)	Hallett Station	UNK	Op Deep Freeze	LDG	(Anderson, 1974)
24 December 1959	R4D-8 (BUNO 17154)	Byrd Station	0 fatal/ 1POB	Op Deep Freeze	LDG-Wing drop stall	(Anderson, 1974)
Jan 1960	DC3-Dakota	Mawson	0 fatal	ANARE	WX-Furious storm	(Burke, 1994)
January 1960	Beaver aircraft (City of	Beaver Glacier Queen Alexandra	0 fatal	NZ Geological Survey Antarctic	Muli-factorial	(F/O Bill Cranfield, pers comms ,07/12/13)

	auckland)	Range McCann Point		Expedition (1959-60)		([1]also sited in Burke 1994)
31 October, 1960	Super Constellation (Buno 126513)	Mc Murdo	2 injuries/ 23POB	Op Deep Freeze , VXE-6	Heavy Landing	(Anderson, 1974)
15 February 1961	HRS-3 Sikorsky Buno 130162	Eights Coast	0 fatal / 2POB	Op Deep Freeze , VXE-6	Fire and EXPOL	(Anderson, 1974)
22 November 1962	LH-34D Helicop-ter	Wright Valley	UNK	Op Deep Freeze , VXE-6	LDG	(Anderson, 1974)
25November 1962	LC-47H (Buno 50777)	Davis Glacier	UNK	Op Deep Freeze , VXE-6	JATO EXPOL	(Anderson, 1974)
23 December 1962	LH-34D (Buno 144658)	Mc Murdo Helipad	UNK	Op Deep Freeze , VXE-6	Engine overs-peed and EXPOL	(Anderson, 1974)
12 January 1963	Beaver VH-PGL	Kemp Land Coast (250nm west Mawson)	0 fatal/ 3POB	ANARE	Went thru sea ice	(Burke, 1994)
28 November 1963	CH-19E (Buno 144255)	Off USS Atka 4 miles from McMurdo	0 fatal/ 2 injuries	Op Deep Freeze , VXE-6	WX White out	(Anderson, 1974)
22October 1964	LC47H (Buno12407)	Lillie Glacier	UNK	Op Deep Freeze , VXE-6	JATO EXPOL	(Anderson, 1974)
8 November 1964	UH-1B Heli-copter	Admiralty Mountains of Victoria Land (38NM from Hallett)	0fatal	US Army	Altitude	(Anderson, 1974)
5 December 1964	UH-13P Helicopter	USS Staten Island	UNK	Op Deep freeze 65	LDG-Fire	(Anderson, 1974)

[1] sited in, Burke (1994) and (pers.comm, F/O Bill Cranfield, TAE, 1957) Two weeks after the RNZAF began operations at Scott Base, the 'Beaver' aircraft went on a supply and airlift mission to a survey team travelling by dog sledge in the rugged Mount Hope area , west of the Beardmore Glacier. White out closed in and the aircraft crashed into the ice. They were finally rescued by their third pilot, Bill Cranfield, in the 'Auster' , ferrying them out one by one to a temporary American weather station near the foot of the Beardmore."

5 December 1965	LC-47H (Buno 17107)	Horlick Mountains	UNK	Op Deep freeze 66	Material Failure	(Anderson, 1974)
5 November 1966	Bell, UH-1D	Marie Byrd Land	0 fatal/ 4POB	Op Deep freeze 67	LDG-hard ,WX – Whiteout	(Anderson, 1974)
22January 1967	HU-13P (Buno 143135)	Glacier Tongue-mission from Coulman Island to Edisto Inlet	0fatal/ 1POB	Op Deep freeze 67	MECH Sudden loos of power	(Anderson, 1974)
19 November 1969	LH-34D helicopter (Buno 150220)	57nm west of MC Murdo	2 fatal/ 8POB	Op Deep freeze 70	EF Auto-rotation	(Anderson, 1974)
8 October 1970	C-121J (Buno131 644)	Williams field	0 fatal/ 80POB	Op Deep freeze 71	LDG/ WX	(Anderson, 1974)
9 January 1971	HH-52A Heli-copter	Eastern slopes of Mt Erebus , enroute to Cape Bird	0 fatal/ 4POB	US Coast Guard	Heli-copter lost power in flight	(Anderson, 1974)
4 December 1971	LC-130 “321”	East Antarctica 1400km from McMurdo	UKN	US, VXE-6	JATO Bottle-EXPOL	(Anderson, 1974)
28 January 1973	LC-130R (Bruno15 5917)	Amundsen-Scott South Pole Station	0 fatal/ 9POB	US, VXE-6, Op Deepfreeze 73	Landing crash and aircraft riteoff	(Anderson, 1974)
2 January, 1979	Aeroflot Il-14	Molodyozhnay, Antarctica	4 fatal/3 non-fatal	Soviet Union	EFATO	(Burke, 1994)
28 November, 1979	MD-DC10	Mount Erebus, Ross Island	257 fatal / 0 non-fatal	Air New Zealand	HF “white-out”	(Hickson, 1980)
2 January, 1986	Cessna Titan 404	King George Island	10 fatal / 0 non-fatal	Chilean crew with American tourist	WX (fog)	(Gettysburg, 1986)
9 December, 1987	US Navy Heli-copter	East Antarctica	2/9	U.S. Navy	JATO EXPOL	(NSF, 1988)
13 October 1992	US Navy Heli-copter	Near NZ-Scott Base	3/2	US Navy helicopter	Severe weather	(Harrowfield, 2007)
12 December 1999	DHC-6 twin otter	1450km E of McMurdo	0	Kenn Borek Air	UNK-was VMC	(Aviation Safety Network (1996-2013)
9 January, 2001	Squirrel	Aboard MV Polar Bird off	0/2	Australia Squirrel	operational	(AAD, 2011)

	Heli-copter	coast of Australian Casey station		helicopter		
17 January, 2003	Bell 212	Near US-McMurdo station	1 serious injuries	US-NSF helicopter	Unknown	(NTSB, 2003)
25 Jan 2005	Dornier 228-101	Rothera, Antarctic Peninsula	0/ 1 back injury	POLAR 4 (D-CICE) (AW= Alfred Wegner Germany Ops)	Heavy Landing	(Pers Comms , Dr Daniel Steinhage, AWI Germany. Email 5/12/201
20 December, 2007	Basler Turbo-67	Mt. Patterson, Antarctica	0 / 10	Kenn Borek Air	mechanical failure	(Aviation Safety Network (1996-2013)
2 March, 2008	MBB Mo 105cbs-4	Neumayer II base	2/3	German helicopter	Unknown	(Aviation Safety Network (1996-2013)
4 January, 2009	Basler BT-67 (modified Douglas DC-3)	Russian Novolazarevska-ya Station (supply flight to research stn)	0/4	Enterprise Air (CLCI Aviation, Canada)	visibility droppe	(Aviation Safety Network (1996-2013)
15 Nov 2010	Heli-copter CASAC-212	Dumont, D'urville Station, Bunger Hills	0	Australian (Davis station ops)	UNK WX poss	(Aviation Safety Network (1996-2013)
23 January 2013	DHC-6 Twin Otter 300	Queen Alexandra Range Mt Elizabeth	3fatal/ 0	Kenn Borek Air Canadian Ops	UNK remote	(Aviation Safety Network (1996-2013)
1 December 2013	Euro-copter Squirrel AS350	Amery Ice shelf over Prydz Bay, 150NM from Davis, Returning from penguin survey.	0/ 3Non fatal	Australia (AAD) (Davis station ops)	UNK WX	(pprune, 2013)
4 December 2013	Russian Heavy Lift Heli-copter	Italian Base Mario ZucchelliTerra Nova Bay	4 (all badly hurt burns and currently in CHCH hospital as at 8/12/13)	South Korean Antarctic Programe	A/C LD on ship Aaron	(Pers comms, LTC C. Norman, Evaluator Pilot, US Ant Program/ US Airforce, NYANG,8Dec 2013

(Table complied by author's research from references)

DIMENSIONS

1. Spatial Dimension

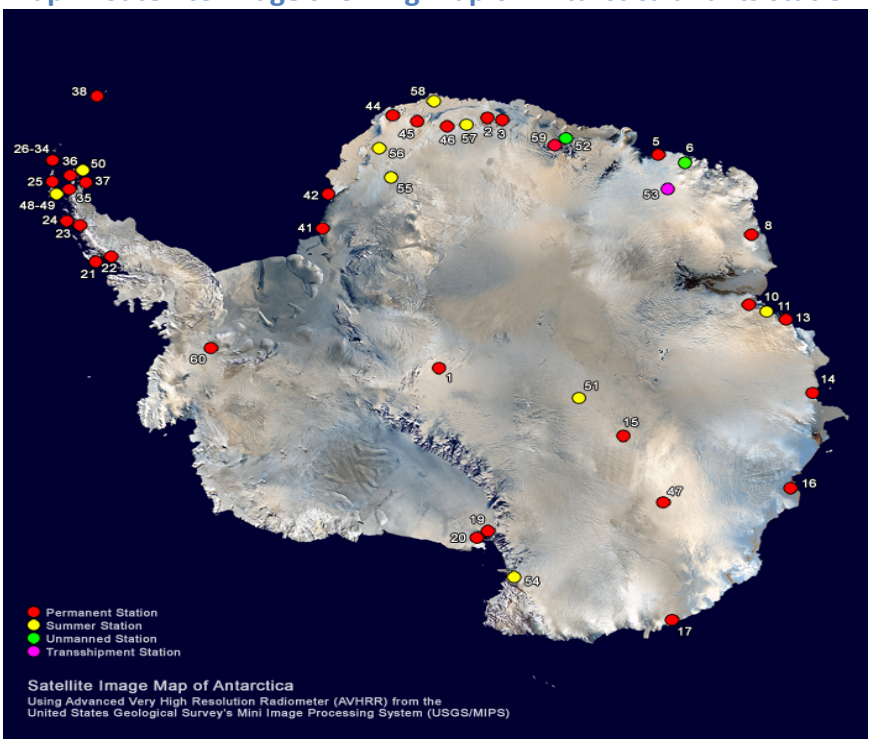
1.1 Where most Accidents occur and why?

The location of the aircraft accidents is generally close to the Bases/Stations from which they took off from, or in the close proximity to the airfields. e.g. Pegasus Field (NZPG). The field is named after "*Pegasus*", a C-121 Lockheed Constellation, which is still visible in the snow near Mc Murdo after crashing in bad weather on October 8, 1970 near the airfield. No one on board was injured. (Photo 1 below (Phillips, 2001).

Photo 1: 1970-71 summer season opening day C-121J Super Constellation crashed near Mc Murdo Station. (Phillips, 2001)

The take off and landing phase is commonly know as the highest risk phase when accidents happen. Also at remote sites of scientist field camps it is also not uncommon to see aircraft accidents. e.g. Davis Glacier, 25 November, 1962 (Anderson, 1974). Map 1- below shows a Satellite image of where the Stations/Bases are largely based and therefore more common accident sites. Theses sites are largely located around the exterior coastal regions.

Map 1: Satellite image showing map of Antarctica and its station (base) locations.



Weaver, C & Salvarezza, M. (1994) Eco-Photo Explorers (EPE). Retrieved from http://www.ecophotoexplorers.com/AntarcticaStations.asp (01/12/2013)

2. Causal Dimension

2.1 What are the main reasons behind aviation accidents?

2.1.1.The Human Factor (HF)

The human factor, decision-making accounts for approximately 80% of aviation accidents (Ewing, 2013). The process of fatal faulty decision making, can arise in many "incidences" to make up the "accident". Many layers of decisions can result in the "Cumulative act effect". There are many layers behind the cause of an accident, complicated by many factors. To follow are some of these factors.

2.1.2 Weather

Operating in the extreme weather environment of Antarctica requires extra vigilance on the part of the crew to minimize accident risk. Weather effects flight planning and SOPS= Standard operating procedures which may have to deviate around weather. e.g. Fuel management for contingency weather, and cold temperatures which can fatigue metals and effect personnel. The weather is very difficult to predict with unique patterns e.g. in East Antarctica region, high-speed, gravity-driven winds (katabatic winds) create ridges in the snow surfaces, these ridges can be a hazard to aircraft. (Anderson, 1974). In analysis of Table 1.1 it can be seen that weather has been the major causal factor, and the associated decision making around this weather has resulted in aircraft accidents.

2.1.3.Fatigue and complacency

Fatigue can be mental and physical operating in Antarctica's extreme cold. Fatigue is a serious problem for all pilots, but its insidious nature and its seriousness are often not fully appreciated by GA (General Aviation) pilots. (Ewing, 2013). Complacency from repetitiveness can lead to loss of concentration, which can have effect on over all performance.

2.1.4 Training, Equipment and resources

Training, and good equipment are vital to accident prevention. For example, the NYANG has extensive training; crews always work with at least one experienced pilot, and operate with new equipment. NYANG has had a "zero accident rate since 2000" (pers.comm, LTC Norman, NYANG, 8/12/2013)

For safety and training in Antarctic Aviation COMNAP, (Council of Managers of National Antarctic Programs), produces the, Antarctic Flight Information Manual, (AFIM), to promote safer aviation practice. COMNAP engages expert groups to exchange information between National Antarctic programs; and there is a "Air" expert group. Thus creating a safer aviation environment is ultimately important to COMNAP, as its purpose is to "develop and promote best practice in managing the support of scientific research in Antarctica". (COMNAP Constitution, 1988)

2.1.5. Situational Awareness

A loss of situational awareness (SA) due to weather and multi-factorial poor decision making, e.g. in the case of the "ANZ Erebus DC-10 Crash" the decision of pilot to descend below the customary MSA="Minimum Safe Altitude" and continuing at this height when unsure of position as situational awareness was lost in the "White-out phenomena" and this resulted in a "temporal distortion and total disorientation". Resulting in a devastating loss of control and life (Guy, 1980)

3. Impact Dimensions

3.1 Environmental

The Antarctic Treaty, ATS has regulation for environmental protection over Antarctica with the Protocol on Environmental Protection to the Antarctic Treaty, the Madrid Protocol, which entered into force on January 14, 1998. It provides for comprehensive protection of the Antarctic environment and dependent and associated ecosystems. Article 15, "Emergency Response Action", in order to respond to environmental emergencies in the Antarctic Treaty area, each Party agrees to provide for prompt and effective response action to such emergencies which might arise, and establish procedures for immediate notification of, and co-operative response to, environmental emergencies.

Aviation does have a large environmental impact on the delicate eco-systems of Antarctica. This impact is through the burning of fossil fuels, possible aircraft fuel spills, and aircraft contamination thru aircraft tires/skis in landings, which may alter delicate bio-diverse ecosystems. The interconnected infrastructure of Aviation, requires roads, fuel stations etc which have a large environmental impact. There are approximately 38 Airfields located on Antarctica and these

alone have a huge environmental impact. With the ice runways; “These need to be long and flat as the pilot cannot use brakes to slow down on the ice and must use reverse thrust instead” (Walton, 2013).

The resources required for the emergency situation require a rapid-team response and co-ordination of a mutli-disciplinary approach. The photograph below, Photo 2, shows this with the fire crew, the NYANG crew, the NSF van and the NYANG LC-130, which is about to transfer the injured on a medical evacuation to Christchurch. This medical evacuation of the South Korean personnel close to coastal Terra Nova Bay (300km from Scott Base) on 4 December 2013 by the NYANG saw a rapid response, approximately 24-30hrs from time of accident to arriving in Christchurch hospital (pers.comm, LTC Norman, NYANG, 8/12/2013). The co-ordination of this rescue being in the NZ SRR (Search and rescue region), shown as Appendix Map 1.A

Photo 2: South Korean Helicopter Rescue; Photo courtesy of NSF, 08/12/2013.

3.2 Political

Politically Antarctica can be a very delicate and influential region, if diplomacy gets strained it can have wider implications into the political arena, such difficulties can fray “international diplomatic relations”. Thus politically aviation accidents in Antarctica have the potential to move countries closer together or apart. Such as in the case of NZ DC-10, “Erebus” crash, a great deal of collaboration and co-operation was sought between NZ, USA, UK- at this time of great loss. There was “outstanding commitment from teams from the NTSB, FAA, Mcdonnell-douglas Corporation, General Electric Co, UK Accidents Investigation Branch and ANZ ltd” (Chippendale, 1980).

International Antarctic Governance ensures a safe operating environment with Search and Rescue (SAR) back up for activities in the region. Ultimately, governments at the highest level make decisions and preservation of life is the goal. The NZ Search and Rescue Region (NZSRR) has a Duty to co-ordinate Search and Rescue Response (SRR) in this region. The United States Antarctic Program (USAP) and the Antarctica NZ coordinate the NZSAR response in Antarctica, in the NZ Claimant.

3.3 Economic

The economic impacts of any aviation accident are devastating financially. The ramifications to the reputation of the companies involved and for air transport in general are felt e.g.in a financial loss of stocks price. In the case of the 4th December 2013 helicopter crash involving the UV "Araon", financially the "flight-time" cost for the LC-130 medical evacuation alone was approximately 100,000USD (round trip) (pers. comm, LTC Norman, USANG, 7/12/2013). Economically countries may "negotiate" in compensation to payback via favors.

3.4 Socio-cultural

Having no indigenous population in Antarctica, for the most part the same language and culture is "science", and "scientific advancement thru research and knowledge". Aviation accidents are a devastating event and due to this there can be a "shutting down" of information, organizations can "closing of ranks", unwilling to disclose because it is a "sensitive subject" and because of cultural differences.

4. Temporal dimension

Has Aviation become safer over time?

Aviation has developed technologically and has become safer over-time with the progression and advances in technology like most modern day transportation. Advanced flight systems such as EFD= Electronic flight deck displays- with built in GPS (Global positioning systems) and MLS (Microwave Landing Systems) have all lead to advancement of safety in aviation in Antarctica. Weather forecasting systems are now more accurate than ever with modeling advances in Satellite and up to the minute tracking of where systems are and at many airfields, full time on the ground Meteorological services, such is at NZPG (Pegasus at Mc Murdo).

However it is also found that "inappropriately designed automatic systems introduced to advanced flight decks may reduce situational awareness and thereby put aviation safety at risk." (Sarter, 1991). The pilot can get "caught up" in the automation and not keep "situational awareness". It could also be said that with the advent of automation comes a loss in pilots "stick and rudder skills, very much needed in the Antarctic Mountain flying environment" (pers.comm, F/O W.J.(Bill) Cranfield, TAE , 1955-58, 3/12/2013).

Technological advances with nite flying goggles allowed the successfully completed first landing in Antarctica using night-vision goggles at Pegasus Field on 11 September 2008. (Rejcek, 2008).

Conclusions

Aviation accidents are a devastating event with lasting social, economic, environmental, political impacts and loss to say the least. This review has looked at aviation accidents and their impacts. The review has also looked at the causal factors, which are multi-factorial.

Multi-factorial lessons have been learned from many accidents. The hope is always that in the future the risk of aviation accidents can be lessened thru learning the lessons of the past, good training and using the best available and well maintained equipment.

There is a "gap" in knowledge around the research of aviation accidents in Antarctica. In a brief email correspondence with Prof David Walton (BAS) there was mention that to his knowledge there was "no complied list of aviation accidents". Hopefully this short review has begun the research. Weaknesses may exist in the data as "aviation accidents" are a very sensitive topic. Also at remote outposts full reporting may be subjective.

There is a "gap" in that a further analysis is required to look at the systems of training, the aircraft age and maintenance schedule for each individual accident. Further research could also look at the impacts perceived by the different National Antarctic Programs to accidents.

In Summary, aviation has become safer with time but one must be watchful of the pitfalls of advanced automation in the visual flying environment and keep vigilant Situational Awareness for accident prevention.

The future of aviation in Antarctica could even see the risk to human life mitigated all together with the use of UAVs – Unmanned aerial vehicles. Also future research could be to look at aircraft accidents from the Artic, as a comparison of polar environments and impacts.

To lesson the impacts to the environment, Aviation needs to stay, as far as possible, accident free. Antarctica needs to be a place not remembered for its aviation accidents.

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Personal Communications

It is with much gratitude I had the following personal communication.

LTC Leroy Norman, US NYANG, (pers.comm; 01- 08/12/2013)

F/O Bill Cranfield, TAE, (pers.comm; 1957, 03-08/12/2013)

Professor David W H Walton, Emeritus Fellow, British Antarctic Survey, UK; email correspondence 05/12/2013

Dr Daniel Steinhage, Alfred-Wedener-Institut , Germany; email correspondence, 05/12/2013.

APPENDIX

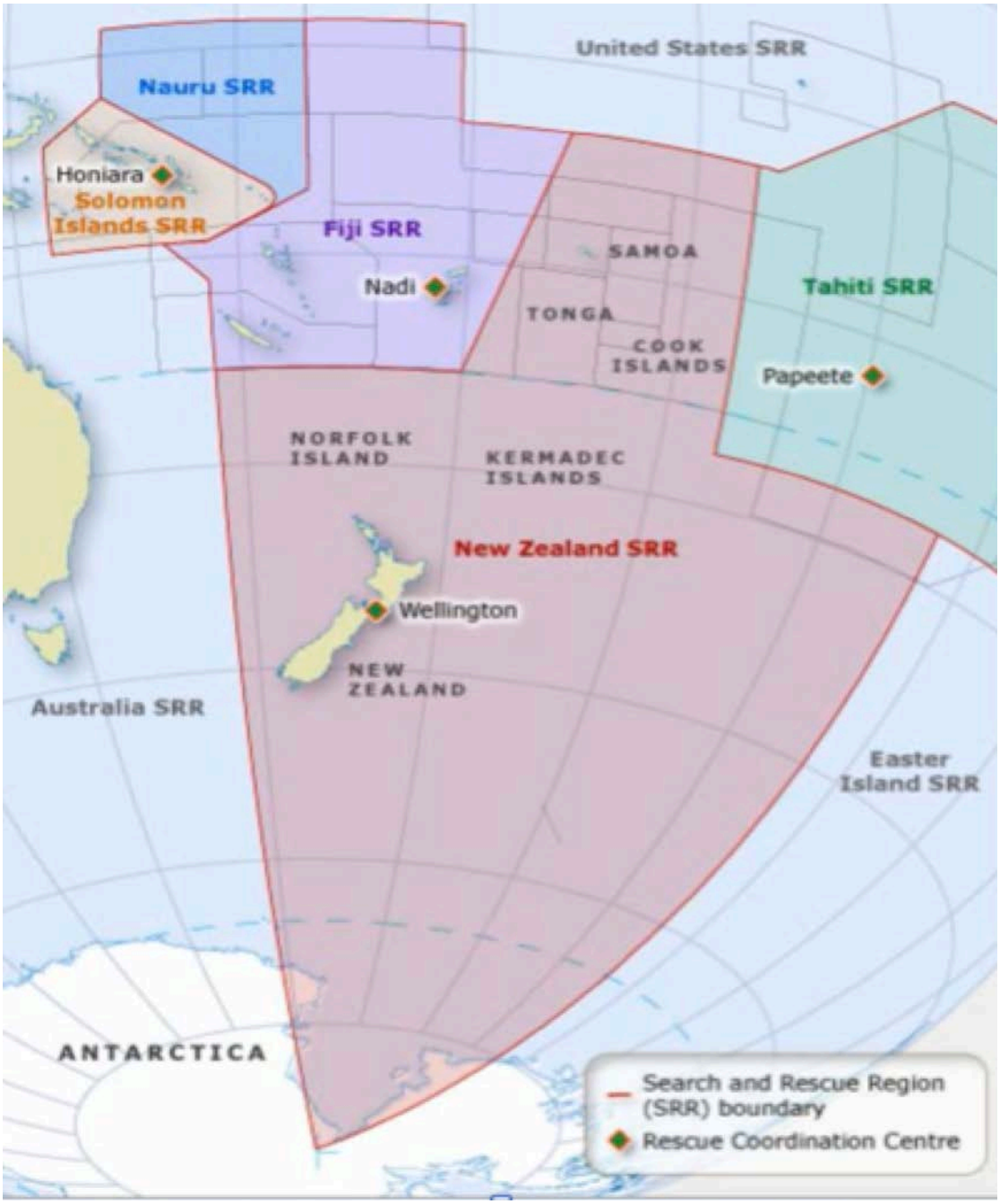
Table 1A. Aircraft losses by season in the U.S. Antarctic program, 1946-1973

Expedition name	Airplanes lost	Helicopters lost	Total aircraft lost
Highjump*	2	2	4
Windmill	0	1	1
Atka	0	1	1
Deep Freeze I	4	1	5
Deep Freeze II	3	3	6
Deep Freeze III	0	1	1
Electronics test unit	0	0	0
Deep Freeze IV	4	1	5
Deep Freeze 60	2	0	2
Deep Freeze 61	1	1	2
Deep Freeze 62	2	0	2
Deep Freeze 63	2	2	4
Deep Freeze 64	0	1	1
Deep Freeze 65	2	2	4
Deep Freeze 66	3	0	3
Deep Freeze 67	0	2	2
Deep Freeze 68	1	0	0
Deep Freeze 69	0	0	0
Deep Freeze 70	0	1	1
Deep Freeze 71	2	1	3
Deep Freeze 72	1	0	1
Deep Freeze 73	1	0	1
TOTALS	30	20	50

(Source : Anderson , 1974.)

**Operation Highjump* (1946-47), largest expedition ever sent to Antarctica by any nation- 4,700men, 19 aeroplanes, 7 helicopters and 13 ships. (Anderson, 1974)

MAP 1A: NZSRR Region.



Reference: Kendall, R. (28/11/2013) MFAT Lecture to PCAS also on (http://www.teara.govt.nz/files/m-13199-enz.jpg)